Appendices for Standards 1-17

Single Subject Matter Preparation Program Proposal
in Biology

San Francisco State University
College of Science and Engineering

July 11, 2009
Appendices for Standards:

Preconditions
See Preconditions Binder For:
Course List
and
Course Syllabi
Appendices for Standards:

Standard 2: Diversity and Equity
Diversity & Expression

One of the top ten universities for campus diversity according to U.S. News and World Report 2003 rankings, SF State's faculty and students represent a range of backgrounds, interests and points of view.

SF State draws students from around the globe to study on campus. The University enrolls more international students than any other master's degree-granting institution in the United States, according to the Institute of International Education. Overall, SF State enrolls 2,016 international students representing 94 countries; 499 are graduate students. Asian countries account for nearly 74 percent of the University's international student body, topped by Japan with 425 students, followed by Taiwan (169 students), South Korea (134), China (117) and Mexico (82).

SF State ranks 16th nationwide in awarding undergraduate degrees to minorities according to Diverse Issues in Higher Education, with 47 percent of its 2005-2006 baccalaureate degrees earned by members of underrepresented minority groups.

Among the nation's top institutions in attracting and supporting Hispanic students, SF State was a Hispanic Outlook in Higher Education "Publisher's Pick" for 2002 and 2003, cited for offering excellent educational opportunities for Hispanic students.

SF State consistently ranks among the highest of the 23 campuses in the California State University system for students studying overseas. In the 2003-2004 academic year, a total of 190 students are exploring different cultures and teaching the world about the United States through overseas experiences.

SF State awards more undergraduate education degrees to Asian Americans than any other school in the nation except University of Hawaii, Manoac, according to Diverse Issues in Higher Education. SF State ranks 10th nationwide in undergraduate degrees awarded to Asian Americans.

San Francisco State ranks 16th in the nation among all U.S. colleges and universities producing Peace Corps volunteers.
Minority students flourish at SF State in part because faculty reflect the diversity of California. Non-white faculty members comprise 43 percent of the University's tenure/tenure-track faculty. In addition, the number of female tenured/tenure-track faculty has increased steadily since 1988, with women now comprising 52 percent of the tenure/tenure-track faculty.

The College of Ethnic Studies is the first and only such academic program in the United States offering undergraduate degrees in black studies, Asian American studies and La Raza studies. The college's graduates go to top doctoral programs, including those at Yale, Stanford and the University of California.

One of the first U.S. universities to offer a master's degree in Asian American Studies, SF State founded the only Vietnamese American Studies Center in the country in 1996.
ONE OF THE TOP TEN UNIVERSITIES
for campus diversity according to U.S. News and World Report 2003 rankings, SFSU's faculty and students represent a range of backgrounds, interests and points of view.

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Jan Hopson,

My supervisor Lucie Field the admission specialist here at SFSU ask me to forward you copies of our sign in sheet for the our single subject information meeting. Please find enclosed sign in sheets from November 2007 up to July 2008. On these sheets you will be able to find the information in regards to students ethnicities that inquire about our program.

Gina Vallejo
Credential Services
San Francisco State University
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Date: 7/8/08

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<td><a href="mailto:timwlee@yahoo.com">timwlee@yahoo.com</a></td>
<td>Math</td>
<td>M</td>
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</tr>
<tr>
<td>Jeffrey Wang</td>
<td><a href="mailto:jswung224@yahoo.com">jswung224@yahoo.com</a></td>
<td>Math</td>
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</tr>
<tr>
<td>Victoria Lu</td>
<td><a href="mailto:Victoria.lu.2003@yahoo.com">Victoria.lu.2003@yahoo.com</a></td>
<td>Chinese</td>
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<tr>
<td>Ken Yeager</td>
<td><a href="mailto:kmylevay@gmail.com">kmylevay@gmail.com</a></td>
<td>English</td>
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<tr>
<td>Marina Bell</td>
<td><a href="mailto:cirquefellegri@icloud.com">cirquefellegri@icloud.com</a></td>
<td>English</td>
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<tr>
<td>Whitney Smith</td>
<td><a href="mailto:whit.r.smith@gmail.com">whit.r.smith@gmail.com</a></td>
<td>Spanish</td>
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<tr>
<td>Doug Boyle</td>
<td><a href="mailto:douglas.bogel@earthlink.net">douglas.bogel@earthlink.net</a></td>
<td>Math</td>
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<tr>
<td>Chris Coak</td>
<td><a href="mailto:christopher.coak@gmail.com">christopher.coak@gmail.com</a></td>
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<tr>
<td>David Rosebrooke</td>
<td><a href="mailto:dave.ro.31@bol.com">dave.ro.31@bol.com</a></td>
<td>EN2</td>
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<tr>
<td>Cliff Schmit</td>
<td><a href="mailto:robsch@ymail.com">robsch@ymail.com</a></td>
<td>SP.CM.Study</td>
<td>M</td>
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<tr>
<td>Julia Bynes</td>
<td><a href="mailto:juannes@jane.com">juannes@jane.com</a></td>
<td>Campbell</td>
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<tr>
<td>Daniel Muxin</td>
<td><a href="mailto:ch230@col.com">ch230@col.com</a></td>
<td>English</td>
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<tr>
<td>Name</td>
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<td>Timothy Hickory</td>
<td><a href="mailto:tjhickey52@yahoo.com">tjhickey52@yahoo.com</a></td>
<td>Physics</td>
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<tr>
<td>Salvador Conteras</td>
<td><a href="mailto:salvacon@gmail.com">salvacon@gmail.com</a></td>
<td>History</td>
<td>M</td>
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<tr>
<td>Leukin Li</td>
<td><a href="mailto:superfunk@stcloud.su">superfunk@stcloud.su</a></td>
<td>Social Sci</td>
<td>F</td>
<td>mixed up</td>
</tr>
<tr>
<td>William Greenwell</td>
<td><a href="mailto:wgg@SFCU.EDU">wgg@SFCU.EDU</a></td>
<td>Biology</td>
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<tr>
<td>MARC ROQUEL</td>
<td><a href="mailto:marc_roquel@gmail.com">marc_roquel@gmail.com</a></td>
<td>HISTORY</td>
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<tr>
<td>Carl Bottger</td>
<td><a href="mailto:wcboettger@yahoo.com">wcboettger@yahoo.com</a></td>
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<tr>
<td>DAMEI PICKRELL</td>
<td><a href="mailto:james@boettger.com">james@boettger.com</a></td>
<td>English</td>
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<tr>
<td>Lauren Greenberg</td>
<td><a href="mailto:greenberglawrence@gmail.com">greenberglawrence@gmail.com</a></td>
<td>Social Sci</td>
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<tr>
<td>Brian Hawkins</td>
<td><a href="mailto:bhawkinson@gmail.com">bhawkinson@gmail.com</a></td>
<td>History/Econ</td>
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</tr>
<tr>
<td>Rachel Russell</td>
<td><a href="mailto:rach13@berkeley.edu">rach13@berkeley.edu</a></td>
<td>Chemistry</td>
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</tr>
<tr>
<td>Name</td>
<td>Institution</td>
<td>Year</td>
<td>Department/Research Focus</td>
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</tr>
<tr>
<td>Gregory Antipa</td>
<td>Illinois</td>
<td>1970</td>
<td>Protozoology; Cell Biology; Electron Microscopy</td>
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<td>Hensill 723/129, Tue 8-10</td>
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<tr>
<td>Alissa Arp</td>
<td>UCSB</td>
<td>1982</td>
<td>Ecological physiology of marine invertebrates</td>
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<td></td>
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<td>RTC; on leave</td>
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<tr>
<td>Frank Bayliss</td>
<td>UC Davis</td>
<td>1971</td>
<td>Molecular genetics; Director of the SEO</td>
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<tr>
<td>Linda Blackwood</td>
<td>Pittsburgh</td>
<td>1979</td>
<td>Wetlands Ecology, Community and Restoration Ecology</td>
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<tr>
<td>Katharyn Boyer</td>
<td>UCLA</td>
<td>2002</td>
<td>Mammalian retinal cell biology; cytoskeletal proteins</td>
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<td>Hensill 426, Wed &amp; Fri 10-11</td>
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<tr>
<td>Jennifer Breckler</td>
<td>UCLA</td>
<td>1980</td>
<td>Molecular mechanisms of chick neural crest and somite patterning</td>
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<td>Hensill 710, Mon &amp; Wed 9:30-10:30</td>
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<tr>
<td>Laura W. Burrus</td>
<td>Wisconsin</td>
<td>1991</td>
<td>Microbial &amp; phytoplankton ecology, marine nutrient cycling</td>
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<td>Tue &amp; Thu 2-3</td>
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<td>Microbiology</td>
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<td>Hensill 668B, Wed 4-6</td>
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<td>Clinical and molecular microbiology</td>
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<td>Chromosome Biology in Reproduction</td>
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<td>Ecological and evolutionary genetics; Marine conservation</td>
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<td>Molecular evolution and ecology of fishes</td>
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<tr>
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<td>Description</td>
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<td>415-405-2760</td>
<td><a href="mailto:crow@sfsu.edu">crow@sfsu.edu</a></td>
<td>Hensill 214, Thu 2-4, &amp; appt</td>
<td></td>
<td>Physiology, ecology and evolution of Archaea</td>
</tr>
<tr>
<td>José R. de la Torre</td>
<td><a href="mailto:jdelator@sfsu.edu">jdelator@sfsu.edu</a></td>
<td>will arrive Fall 2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wilfred Denetclaw</td>
<td><a href="mailto:w8109640@sfsu.edu">w8109640@sfsu.edu</a></td>
<td>UC Berkeley 1991</td>
<td></td>
<td>Cell biology and development</td>
</tr>
<tr>
<td>338-1784/405-0742</td>
<td><a href="mailto:ded@sfsu.edu">ded@sfsu.edu</a></td>
<td>Hensill 704</td>
<td></td>
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</tr>
<tr>
<td>Dennis E. Desjardin</td>
<td><a href="mailto:tennessee99@sfsu.edu">tennessee99@sfsu.edu</a></td>
<td>Tennessee 1989</td>
<td></td>
<td>Systematics and ecology of fleshy fungi</td>
</tr>
<tr>
<td>338-2439</td>
<td><a href="mailto:cdomingo@sfsu.edu">cdomingo@sfsu.edu</a></td>
<td>Hensill 429, Mon &amp; Wed 9:30-11</td>
<td></td>
<td>Vertebrate development and gene regulation</td>
</tr>
<tr>
<td>Carmen R. Domingo</td>
<td><a href="mailto:cdomingo@sfsu.edu">cdomingo@sfsu.edu</a></td>
<td>Hensill 705/708, Mon &amp; Wed 10-11</td>
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<tr>
<td>338-6995/338-6998</td>
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<td>Plant physiological ecology</td>
</tr>
<tr>
<td>Bettina M. J. Engelbrecht</td>
<td><a href="mailto:univdarmstadt1998@sfsu.edu">univdarmstadt1998@sfsu.edu</a></td>
<td>will arrive May 2008</td>
<td></td>
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<tr>
<td>Megumi Fuse</td>
<td><a href="mailto:fuse@sfsu.edu">fuse@sfsu.edu</a></td>
<td>Insect physiology and neurobiology</td>
<td></td>
<td>Hensill 422/831, Thu 11-2 &amp; Fri 1-2</td>
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<tr>
<td>405-0728/338-6843</td>
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<tr>
<td>Michael A. Goldman</td>
<td><a href="mailto:goldman@sfsu.edu">goldman@sfsu.edu</a></td>
<td>Hensill 534, appt only</td>
<td></td>
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</tr>
<tr>
<td>Department Chair</td>
<td><a href="mailto:hafernink@sfsu.edu">hafernink@sfsu.edu</a></td>
<td>Human genetics, developmental biology, chromatin structure, epigenetics, pharmacogenomics, bioethics, X-chromosome inactivation</td>
<td></td>
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<td>38-1549</td>
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<tr>
<td>John Hafernik</td>
<td><a href="mailto:hafernink@sfsu.edu">hafernink@sfsu.edu</a></td>
<td>Evolutionary and population biology; entomology</td>
<td></td>
<td>Hensill 519/812, Wed 9:10-10:10, Thu 8-9 &amp; appt.</td>
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<tr>
<td>Zheng-Hui He</td>
<td><a href="mailto:zhe@sfsu.edu">zhe@sfsu.edu</a></td>
<td>Plant molecular genetics, cell-cell communication</td>
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<td>Hensill 550/618, Thu 2-4</td>
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<tr>
<td>338-6193/405-0365</td>
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<td>Plant population biology and ecology</td>
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<tr>
<td>Gretchen LeBuhn</td>
<td><a href="mailto:lebuhn@sfsu.edu">lebuhn@sfsu.edu</a></td>
<td>sabbatical leave</td>
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<td>Microbial genetics; molecular biology</td>
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<tr>
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<tr>
<td>Leticia Marquez-Magana</td>
<td><a href="mailto:marquez@sfsu.edu">marquez@sfsu.edu</a></td>
<td>Hormonal modulation of neural mechanisms</td>
<td></td>
<td>Hensill 420, Mon &amp; Wed 9-11</td>
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<tr>
<td>338-3289/338-1406</td>
<td></td>
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<td>Plant ecology; mycorrhizae; taxonomy of Arctostaphylos</td>
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<tr>
<td>Christopher Moffatt</td>
<td><a href="mailto:moffatt@sfsu.edu">moffatt@sfsu.edu</a></td>
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<td>V. Thomas Parker</td>
<td><a href="mailto:parker@sfsu.edu">parker@sfsu.edu</a></td>
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<td>38-2375/338-6406</td>
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<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Research Area</th>
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<tbody>
<tr>
<td>Sally Pasion</td>
<td>UCLA 1995</td>
<td>Cell &amp; molecular biology; regulation of the replication of the genome</td>
</tr>
<tr>
<td>505-0736/405-0751</td>
<td><a href="mailto:pasion@sfsu.edu">pasion@sfsu.edu</a></td>
<td>Hensill 668C/619, Mon &amp; Wed 10:15-2:00</td>
</tr>
<tr>
<td>Robert Patterson</td>
<td>UCSB 1975</td>
<td>Plant systematics; phylogeny of Polemoniaceae &amp; Hydrophyllaceae</td>
</tr>
<tr>
<td>338-1237</td>
<td><a href="mailto:patters@sfsu.edu">patters@sfsu.edu</a></td>
<td>Hensill 451, Tue &amp; Thu 8-9, &amp; appt.</td>
</tr>
<tr>
<td>Robert M. Ramirez</td>
<td>UC Davis 1990</td>
<td>Osmoregulation and recombination in yeast</td>
</tr>
<tr>
<td>338-1102/338-1443</td>
<td><a href="mailto:rramirez@sfsu.edu">rramirez@sfsu.edu</a></td>
<td>Mon 10-11, Thu 11:30-12:30</td>
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<tr>
<td>Joseph Romeo</td>
<td>UCSD 1983</td>
<td>Mechanisms of latency in (HIV) infections</td>
</tr>
<tr>
<td>338-6008/338-2835</td>
<td><a href="mailto:iromeo@sfsu.edu">iromeo@sfsu.edu</a></td>
<td>Hensill 513/511, Mon &amp; Wed 2:30-3:30</td>
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<tr>
<td>Barry S. Rothman</td>
<td>Cal Tech 1975</td>
<td>Cellular neurobiology, neuropeptides</td>
</tr>
<tr>
<td>338-2418</td>
<td><a href="mailto:brothman@sfsu.edu">brothman@sfsu.edu</a></td>
<td>Hensill 221, Wed 11:15-1:15 &amp; Thu 2:30-4:30</td>
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<tr>
<td>Eric Routman</td>
<td>Wash. U. St. Louis 1990</td>
<td>Population genetics; quantitative genetics and conservation biology</td>
</tr>
<tr>
<td>338-1196/338-3346</td>
<td><a href="mailto:routman@sfsu.edu">routman@sfsu.edu</a></td>
<td>Hensill 761, Tue 12:30-2 &amp; Thu 1-2:30</td>
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<tr>
<td>Ravinder Sehgal</td>
<td>UCSF 1997</td>
<td>Environmental change on infectious diseases in birds.</td>
</tr>
<tr>
<td>315-405-0329</td>
<td><a href="mailto:sehgal@sfsu.edu">sehgal@sfsu.edu</a></td>
<td>Fri 4-6, &amp; appt</td>
</tr>
<tr>
<td>Chris Smith</td>
<td>UCSF 2001</td>
<td>Bioinformatics</td>
</tr>
<tr>
<td>405-2505</td>
<td><a href="mailto:smithcd@sfsu.edu">smithcd@sfsu.edu</a></td>
<td>Hensill 518, Mon &amp; Wed 10-11</td>
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<tr>
<td>Diana Smith-Beckerman</td>
<td>SUNY 1987</td>
<td>Protein chemistry and cancer research</td>
</tr>
<tr>
<td>338-3467/338-2879</td>
<td><a href="mailto:dmsmithb@sfsu.edu">dmsmithb@sfsu.edu</a></td>
<td>SCI 277, Tue 2:30-4:00 &amp; Thu by appt.</td>
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<tr>
<td>Greg S. Spicer</td>
<td>Univ. Chicago 1990</td>
<td>Evolutionary biology and molecular systematics of insects and birds,</td>
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<tr>
<td>338-6756/338-2497</td>
<td><a href="mailto:gs@sfsu.edu">gs@sfsu.edu</a></td>
<td>Hensill 755, Thu 12:30-2</td>
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<tr>
<td>Jonathon Stillman</td>
<td>Oregon State 1998</td>
<td>Ecological Physiology, Thermal Biology, Functional Genomics</td>
</tr>
<tr>
<td>435-7144</td>
<td><a href="mailto:stillmaj@sfsu.edu">stillmaj@sfsu.edu</a></td>
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<tr>
<td>Kimberly Tanner</td>
<td>UCSF 1997</td>
<td>Biology education</td>
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<td>405-3438</td>
<td><a href="mailto:kdtanner@sfsu.edu">kdtanner@sfsu.edu</a></td>
<td>Hensill 433/243, Tue &amp; Thu 2-3</td>
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<td>Vance Vredenburg</td>
<td>UC Berkeley 2002</td>
<td>Amphibian ecology, evolution and conservation.</td>
</tr>
<tr>
<td>338-7296</td>
<td><a href="mailto:vancev@sfsu.edu">vancev@sfsu.edu</a></td>
<td>Mon 1-3</td>
</tr>
<tr>
<td>Steve Weinstein</td>
<td>UCSF 1992</td>
<td>Signal transduction; macrophages; host response to infection</td>
</tr>
<tr>
<td>Phone</td>
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<td>Office Hours</td>
</tr>
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<td>338-1843/338-3050</td>
<td><a href="mailto:weinst@sfsu.edu">weinst@sfsu.edu</a></td>
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<td>Stanley C. Williams</td>
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<td>38-1695</td>
<td><a href="mailto:williams@sfsu.edu">williams@sfsu.edu</a></td>
<td>Hensill 216, Tue 9:30-12</td>
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<td>Andrew Zink</td>
<td>Cornell 2002</td>
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<td>415-405-2761</td>
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The artwork was created by Bonnie Burleson.

SFSU BIOLOGY DEPARTMENT

A Tradition of Excellence in Educating a Diverse Student Population

San Francisco State University (SFSU) is part of the California State University (CSU) system, which awards the largest number of undergraduate degrees of any public or private institution in the state of California, typically awarding twice as many baccalaureate degrees as the University of California system each year. In 1999-00, SFSU awarded 4,149 undergraduate degrees and 1,161 masterís degrees. The universityís current enrollment is 28,320 students, making it the fourth largest in the CSU system and the 49th largest of all the institutions of higher education in the United States (Chronicle of Higher Education, Vol. 47, No. 1, 9/1/00, p. 24).

Reflecting the ethnic and cultural composition of the San Francisco Bay Area in which it is situated, SFSU is a comprehensive, urban university serving a diverse student population. For the 2000-01 academic year, of those who declared their ethnicity, students of color comprised 66% of the undergraduate student body and 40% of the Graduate students, with a combined overall demographic breakdown as

http://userwww.sfsu.edu/~iburrus/WhySFSU%3F.html
follows: African American 7.4%, American Indian 0.8%, Asian American 29.6%, Chicano/Mexican-American 7.0%, Filipino 11.2%, Other Latino 7.6%, Pacific Islander 0.8%, White Non-Latino 30.8%, All Other (including biracial) 4.8%. This diversity is celebrated and embraced in many ways, from the Cesar Chavez Student Union to the Malcolm X mural that stands at its entrance to the scholarly activities of the students and faculty of the nation's only College of Ethnic Studies. SFSU is proud to be officially recognized by the US Department of Education as a Minority Serving Institution (MSI).

In that regard, SFSU has a distinguished record of not only recruiting and retaining but also graduating minority students. In the annual report published by Black Issues in Higher Education on degrees awarded to minority students in the United States, SFSU consistently ranks among the top 15 colleges and universities in the country in the numbers of baccalaureates awarded to minorities across all disciplines, based on data gathered by the National Center for Education Statistics. For the 1999-00 academic year, SFSU was ranked as #13 in the nation in this regard and #38 in the nation in the total number of master's degrees awarded to minorities (Black Issues in Higher Education, June 7, 2001). Additionally, in the April 2000 issue of Hispanic Magazine, SFSU was ranked 6th in the nation for excellence in recruiting and retaining Latino students, ahead of such universities as UCLA and the University of Texas, and received the highest rating of all the CSU campuses listed.

The Biology Department considers research and teaching to be complementary activities that lead to the development of outstanding investigators. The Department's success in integrating these two activities is reflected in the report from a recent external review team (ERT). The report states the Department's strengths as the following: 1) It ranks first (#1) in the nation of 529 "Master's Degree granting
institutions" in terms of number of graduates going on to higher degrees according to a recent report of the National Science Foundation. (2) With the help of the Dean of Research and Sponsored Programs, it attracted roughly $11 M in external funding in AY 99-00. (3) With the help of the College Dean, it has attracted unusually gifted faculty. (4) The number and level of research projects, graduate research students, and currency of research techniques is approaching that of R1 institutions, a singular achievement for a CSU campus. (5) The faculty showed considerable evidence of dedication to biology and to their students. (6) The established faculty and younger faculty exhibited strong, positive reinforcement and mutual support. (7) The ERT witnessed an unusually good relationship and partnership between department personnel and their College Dean, their Undergraduate Dean, and their Graduate and Sponsored Programs Dean. (8) The involvement of the administration in the program review process, with high levels involved in both entry and exit interviews and ultimately culminating in a MOU signed by the Provost, significantly improves the chances of success in improving department operations. In the judgement of this ERT, the SFSU review process is the best yet encountered in the CSU and should be used as a system-wide model. (9) The curriculum is diverse, attractive to a wide variety of students interested in biology, and does not exhibit significant bottlenecks or numbers of inefficient classes. (10) The product of the department, its graduates, are held in high esteem by professionals in the area, by their prospective employers because of the many lab and field skills they learn from the lab intensive curriculum."
Dear Alumni and Friends:

The electricity is in the air again as we approach graduation time. We’re expecting more than 200 undergraduate and 60 graduate students to celebrate Commencement this spring. Our second annual Baccalaureate and Masters Ceremony is slated for Sunday, May 25. Staff and student volunteers are planning a rousing ceremony followed by a sumptuous buffet. This year’s program speaker is Dr. Elizabeth Blackburn, the UC San Francisco molecular biologist who has been an international leader in the study of telomeres—the ends of chromosomes that, thanks to Blackburn’s work, are now understood to be crucial in cancer and in the biology of aging.

Associate Professor Gretchen LeBuhn has been on the media circuit, featured in national newspapers and Sunset magazine, telling folks about her Great Sunflower Project. Dr. LeBuhn will collect valuable scientific data on the health of pollinating bees—the first national study of its kind. Initially seeking to involve 10,000 citizen scientists of all ages who live in urban, suburban and rural environments across North America, LeBuhn now has over 20,000 community scientists from all 50 states and all the Canadian Provinces. Even if you don’t have a degree in Botany or Entomology, join the crowd by signing up at http://www.greatusunflower.org.

Dan Maher, Mary Fermi and Ken Hitchner, all alumni leaders in the biotechnology industry, have organized an incredibly exciting symposium “Personalized Medicine—It Will Change Your Life” to be held June 5 at SF State’s Jack Adams Hall. The symposium has already attracted an array of top-notch speakers from Genentech, DNA Direct, Monogram, Biomarin and 23andMe. Personalized medicine allows us to harness the power of genomics to predict what drugs will work best in a particular individual. It may well be to the 21st century pharmaceutical industry what aspirin was to the 20th. For more information, and to register, visit http://personalizedmedicine.sfsu.edu.

As you’ve no doubt heard, a very serious budget shortfall at the State level has caused an even more serious, bleak budget outlook for the California State University System. We in the Department are working to ensure that this temporary situation does not adversely affect students. Now more than ever we must be grounded in our mission of advancing global health and the biosphere through educating future generations of scientists, health professionals, teachers and citizens.

Warmest regards,

[Signature]
KIMBERLY TSUI — WORKING BEHIND THE SCENES

Kimberly Tsui, known as Kimmie around the Department, is both an SF State Biology alumn and the newest member of the Biology Instructional Services (BIS) Facility, located in HH 632.

Kimmie developed an interest in science while attending Hillsdale High School in San Mateo, but discovered that her interest came with a challenge. “I decided to go against my counselor’s advice to enroll in a typing class,” recalls Kimmie. “Instead I asked her to sign me up for Biology, Chemistry and Physics—all classes she felt were unnecessary for a girl.”

From 2003-2005, Kimmie attended Skyline College where she also worked part time as a Lab Technician. “That experience was immeasurable,” said Kimmie. “I was able to enhance my breadth of knowledge, and assist others in their quest for information. From then on working behind the scenes was something I knew I would enjoy doing.”

After college, she worked for several hotels, beginning at the front desk to eventually becoming an Accounting Manager. During that time, she learned how to interact with all types of people, and to handle demanding situations.

In 2000, Kimmie was hired as a Finance Program Specialist for Agilent Technologies, and worked in their busy call center until the outsourcing of her position prompted Kimmie to enroll in SF State’s B.S. in Microbiology because she liked the challenges involved with labs, and the “endless opportunities to learn within the field. Many microorganisms have not been discovered yet,” said Kimmie, “simply because we cannot culture them.”

While a Biology student, she was impressed by how the BIS Facility staff and department faculty worked together as a team. “I knew then that the department would be wonderful place to work both for personal growth and professional advancement.” So, in January 2007, after earning her degree, she submitted her resume, and was hired as an Instructional Support Technician.

When asked to describe a typical work day, Kimmie could not do so because “everyday is something new.” The goal of the BIS Facility is to develop innovative lab experiments to nurture students’ ingenuity. To that end, Kimmie, along with supervisor, Darlen Franklin, provide bacteriological media, chemical reagents, and laboratory supplies for upper division Biology courses. Kimmie often works in the teaching labs, and was a guest lecturer for BIOL 431, Medical Microbiology Laboratory, in Fall 2007.

Kimmie plans to eventually further her educational career by earning a Master’s degree from SF State’s Biomedical Laboratory Science or the new Genetic Counseling program. “But, all that will have to wait because Kimmie’s main focus now is on the upcoming birth of her first child in May 2008.”
Steve Fermi credits his SF State thesis advisor, Biology professor, Dr. Robert Beeman, with inspiring his love for research, and for saving his life!

"Dr. Beeman warned a group of us who liked to dive for abalone in kelp forests that if we ever got tangled in the giant kelp, it would be useless to try to free ourselves by pulling the kelp out by the plant’s holdfast or ‘roots’ as these are necessarily strong in order to resist the force of the waves and surf," recalls Steve. “He said that the best way to free yourself was to grab the kelp with both hands, and bend it until it snaps like a dry twig.”

It was fortunate that Steve was paying attention because ten years later, he found himself in 20 feet of water, but tangled in kelp about five feet below the surface. “My lungs were bursting after having held my breath for over a minute while I was searching for abalone. As I jerked my leg to try to break free, the kelp wrapped around it even tighter. Suddenly Dr. Beeman’s advice came back to me. I bent the kelp, and was totally relieved to find that it did indeed snap like a dry twig. A few years later, I saw Dr. Beeman at a class reunion, and thanked him for saving my life.”

Steve grew up in Indiana, and graduated (summa cum laude) with a B.A. in Biology from Ball State University. Partly because he had been a Jacques Cousteau fan as a child, and enjoyed water sports, he wanted to focus his graduate work on marine biology. He applied to SF State because he fell in love with the Bay Area when he and his wife, Mary, visited San Francisco on their honeymoon.

After earning his master’s degree, Steve worked in a six-month temporary position for the California Department of Fish and Game studying rockfish, tuna and other fisheries in the Fort Bragg/Mendocino area. However, he soon came to believe that his prospects for a full-time career as a marine biologist were limited as jobs were in short supply, and the pay scales were far from commensurate with his educational level. He looked for other research career opportunities, and found the career he is still in today — developing medical devices that have the potential to treat human diseases. Once laboratory or animal studies have demonstrated proof of concept, he directs clinical trials as a prelude to market approval.

“I often work on cutting edge technologies,” Steve explains. “For example, I worked for Nellcor to develop and bring to market ‘pulse oximetry’ technology that allows doctors to see a patient’s blood oxygen saturation in real time and non-invasively through a sensor that shines a light through the patient’s fingertip.” Today, pulse oximetry is routinely used in healthcare environments worldwide.

While an Executive Director of Clinical Affairs at Asthmatic, Steve worked on a device designed to help people suffering from asthma, a common and life threatening chronic condition in which the inside walls of the lungs’ airways become inflamed and swollen, the muscles tighten, and air flow is restricted. The device, called Bronchial Theroplasty, uses thermal energy to reduce the airways’ ability to constrict, which may result in reducing the severity and frequency of asthma symptoms. Steve drafted the protocol for the company’s pivotal study, and later heard from several participants whose lives had been transformed after undergoing the procedure. “One man had given up his love for cold water kayaking due to his worsening asthma. He was able to resume his passion after having participated in our clinical trial,” said Steve. “Another asthma sufferer had never been able to participate in a centuries-old sporting contest in his local village in England. After having our procedure done, he was able to participate fully, and even sent us a picture of himself on the front page of his local newspaper with the winner’s trophy hoisted over his head.”

Steve earned an MBA from the University of California, Berkeley in 1990, and is currently Vice President of Clinical Affairs for BaroSense, Inc. in Redwood City, California. BaroSense focuses on the research and development of minimally invasive medical devices for the treatment of obesity — the largest global chronic disease in adults. Steve can be contacted at sfermi@barosense.com.
IN MEMORY

FATHER OF THE LAB

DR. FELIPE-ANDRES RAMIREZ-WEBER

Felipe-Andres Ramirez-Weber died on November 1, 2007 after a 23-month battle with leukemia. He was 43 years old.

Born in Concepción, Chile, Felipe-Andres was the only son of a priest, Father Ivan, and Elena Ramirez. He earned his B.S. (1986) in zoology at George Washington University, and a Ph.D. (1995) in molecular and cell biology at UC Berkeley. As a postdoctoral fellow at UCSF, (1995-2002) he worked with Dr. Thomas Kornberg who recalls that Dr. Ramirez-Weber’s real forte was in using the microscope. This strength enabled him to discover a new cell structure which lead to their proposing a new theory on cell communication. (“Cytomeres: Cellular Processes that Project to the Principal Signaling Center in Drosophila Imaginal Discs” Cell, May 28, 1999)

In 2003, Dr. Ramirez-Weber joined the department as assistant professor. According to Dr. Wilfred Denetclaw, Dr. Ramirez-Weber was “the right person for the position. He was a geneticist, an outstanding scientist, a minority, and perfect for our research synergy.”

Dr. Ramirez-Weber (often called FARW) taught for only two and a half years, but during that short time, he mentored over twenty students, designed a website: http://hedgehog.sfsu.edu, participated in countless committees, helped set up the Center for Computing in Life Sciences, and in the words of his former student Rosa Uribe, “gained the respect of everyone on campus.”

Dr. Ramirez-Weber’s passion for research inspired Rosa to pursue a career in science. She said that he taught her everything she knows about academic research, but admitted that he was not an easy teacher. “Sometimes I felt like he was throwing me into water without a life vest. It was often a stressful way to learn, but it was a very good way to learn because I learned a lot.” Another student, Shiko Kawamura, remembers Dr. Ramirez-Weber as a “very strict teacher, but he was also considerate. If you had a problem, he would ask you to come to his office to talk. He was not judgmental. He was like the father of the lab.”

Dr. Ramirez-Weber also inspired many of the faculty, including Dr. Leticia Marquez-Magana. When she thinks of him, she recalls a day he dropped by her office to talk. “He always looked like he was going to sit, and have a long conversation with you. You know, that was really rare in scientists of his caliber. That day, Felipe-Andres sat back in his chair, his legs crossed, his hands on his lap, making direct eye contact, and we talked about how we would change things at SFSU to make a stronger emphasis on quality research with quality student training.”

Dr. Denetclaw said that Felipe-Andres was troubled that “we have this huge building, but we don’t have the infrastructure to do first class research. So, he looked for ways to develop enough support to build a new science building that was strictly for research—all for the purpose of training our students to be top-notch scientists.”

Biology professor Dr. Carmen Domingo recalls his desire to improve minority access to education. “What bothered him was that underrepresented minorities are not gaining access to the upper echelons of the educational community. Felipe-Andres wanted to make SFSU into a Harvard. And, he really felt that he could do that. And, I admired him for thinking that way.”

Even though he had a quiet demeanor, he was fierce about science and determined that excellent science, stellar science could be done at SFSU.

- L. Marquez-Magana
Professor, Biology

by Maria Ginsbourg
Undergraduate, Creative Writing Major

Editor’s Note: A scholarship to support minority undergraduate and graduate students majoring in Cell and Molecular Biology has been established in Dr. Ramirez-Weber’s memory. Contributions can be made by check payable to “University Corporation at SFSU” (or “SFSU”) with “In memory of FARW” (or “FARW”) on the memo line. Mail to: FARW Scholarship, Department of Biology, San Francisco State University, 1600 Holloway Avenue, San Francisco, CA 94132-1722. To donate online, click on https://www.applyweb.com/public/contribute? s=sfusencg. Select “Biology” on the “I would like to support” drop down form, and type “FARW” in the comment box. The site will accept Visa or MasterCard. You should receive an immediate confirmation by email. Your generosity is greatly appreciated!
LANCE LUND
CULTIVATING THE CONFIDENCE TO LEARN SCIENCE

Lance Lund’s love of teaching began at the College of San Mateo, where a number of exceptional instructors encouraged him to teach others to develop a deeper understanding of nature, and their relationship to it.

As a UC Davis undergraduate (B.S. '97) majoring in genetics with an emphasis in human physiology, Lance worked in Dr. Neelima Sinha's lab researching the role of the T6 tomato plant homeobox (a DNA sequence involved with regulating development) genes in meristem and leaf development. (See Plant Physiology July 1998).

In 2000, Lance worked with terminal TB patients at the Mother Teresa House in Calcutta, taught basic microeconomics principles to school children in Siem Reap, Cambodia, and helped develop a fundraising plan for constructing a village schoolhouse near Bodhgaya.

After returning to the U.S., Lance considered development work, but learned that a master's degree was a minimum entry requirement, so he enrolled in SFSU’s M.S. program in International Relations in 2003. That year he also joined the department, first as a graduate teaching assistant, then as a summer session lab instructor. He earned his M.A. in 2005, and signed on as a full-time Biology lecturer in Spring 2006.

Lance especially values his role in teaching Biology to non-science majors. His goal is to cultivate the confidence to learn science in his students, so they will apply biological concepts towards improving their physical health. In Human Biology (BIOL 100) and Human Biology Lab (BIOL 101), he focuses on health issues as they relate to the body including nutrition, infectious diseases, cancer, cardiovascular and reproductive disorders. To aid learning, Lance writes down everything that is important, repeats material in a conversational style, poses questions to the group, provides detailed study guides and practice exam questions, and always shows his enthusiasm for the subject. Lance also teaches Microbiology and Public Health (BIOL 211) and Human Physiology (BIOL 611) labs, and says that the pre health professionals he encounters inspire him “because they are all such noble young people driven to serve others.”

“Our courses directly impact students, and will promote their well being for years to come.”

His future plans include working with small, under-funded humanitarian relief organizations to enhance new and existing nutrition and clean water delivery services, and secondary school education in developing countries. And, of course, he will continue to teach. Lance can be contacted at llund@sfsu.edu
Understanding Diversity in SFSU’s Biology Department
by Raynelle Rino

The world of an underrepresented minority (URM) student in the sciences can be a lonely place. Language and cultural barriers between students and professors can have major influences on academic performance and retention at the university level. Amelia Rodelo, a native San Franciscoan of Mexican and Native American heritage, is an undergraduate researching marine ecology at the Romberg Tiburon Center. She explains, “In the beginning, it was the feeling of being out of place where the environment is very different. None of it is intentional, but it makes you feel uncomfortable. Many people can’t get used to it, and that determines if you will make it through, and how much culture plays a role in that.”

To gain some insight on how the issue of diversity is being addressed in the Biology Department, I spoke with several Biology faculty, staff and students. Most agreed that hiring more faculty of color, and putting efforts into URM student outreach seem to be important steps in making this feeling of alienation a less common occurrence.

The feeling of inclusion is important for URM students to succeed, and go to graduate school. Building a community of researchers for their expertise is essential in research, but advisors or committee members for minority students are usually not faculty of color, and may lack the understanding of cultural discrepancies. Latino graduate student Pedro Morgado shares his perspective, “It may be hard for a student to bring up issues a non-minority advisor has never experienced. Minority students may have a difficult time bringing up issues that a student of the majority may not have to deal with. For example, the money that I have made, a portion of that money has gone to my family.” Supporting himself and his siblings is a cultural sacrifice Pedro is willing to make, but may not be empathized by scientists in academia.

The good news is that SFSU is home to a very diverse environment with ~36% of its students comprised of URM groups. (Rath et. al., 2007) Some students and faculty agree that it is the diversity of the campus that draws them here. Students in the sub-disciplines of cell biology and health professions are more diverse, and may not have trouble finding similar cultural communities. These careers are familiar and ensure a sense of financial security.

The bad news is that students pursuing ecology careers may not have much support culturally. To remedy this, the department has recently hired two women, Dr. Karen Crow-Sanchez, and Dr. Bettina Engelbrecht. These women serve as role models for future minorities and women.

Department faculty also participate in student outreach programs that give financial support and guidance for URM success in the sciences. Through the National Institute of Health, Dr. Megumi Faye works with the Bridges program which helps URM students at City College of San Francisco pursue Bachelor degrees in biomedical research at SFSU.

I believe that not only must we work towards diversification of cultures, we must also open ourselves up to the diversification of new ways of thinking and teaching. According to Dr. Faye, “There is not enough academic support for diversity, but there is some help there. It’s easy for struggling students to get lost in the cracks, and a student on probation should have someone who they have to see. And, we need to apply other teaching strategies to take into consideration the different types of students on campus—like those who may be more shy or timid.”

Diversification serves as a major advancement of the discipline by promoting collaboration and different approaches to problem solving. “People have to work with each other to deal with global problems,” said Department Co-Chair, Dr. Carmen Domingo. “In research, people come with different interests and social experiences that make them look through different lenses.”

The advancement of science through increasing diversity continues at SFSU, and will serve to resonate to other less diverse institutions as our students further their careers. It is a win-win situation when both participants and the field of scientific research and education advance.

A remarkable student

ROBERTO BARROZO BY RAYNELLE RINO

Roberto Barrozo's journey through academia has been arduous, yet rewarding. Rob, the eldest of eight children, began his academic career at Skyline College majoring in Applied Health. He then transferred to SF State to complete a B.S. in Cell and Molecular Biology in 2004. He currently works with Dr. Steve Weinstein, and is at the tail end of obtaining his Master's degree in Cell and Molecular Biology.

Rob's motivation for immunology research came from a toxicology lab internship at the University of Montana. In Dr. Weinstein's transcription lab, located in HH 670, Rob studies the molecular mechanisms that regulate inflammation. Specifically, he is investigating the role of ATF3 (Activating Transcription Factor 3), a protein that represses the expression of IFN-β (interferon beta) genes. These genes are always present in low levels in the body, but spike up under stressful conditions such as when the body needs defending against infection. ATF3 must come in, and repress the process of IFN-β expression because too much of an increase can lead to autoimmune diseases. The role of ATF3 as a repressor is known, but not well understood, and Rob hopes to contribute a better understanding of ATF3 through his thesis work.

As an NSF-GK12 fellow, Rob has presented his research and poster (right) at major conferences including SACNAS (Society for the Advancement of Chicanos and Native Americans), and ABRCMS (Annual Biomedical Research Conference for Minority Students).

From his graduate school experience, Rob has learned the importance of time management, critical thinking, and the benefits of collaborative research. He says that his experience has been amazing especially considering he met his fiancé while taking a BIOL 402 microbiology lab.

"SFSU has definitely been a nurturing environment, always providing me with the support I could not have received anywhere else."

Rob graduates this summer, and plans to pursue a Ph.D. in immunology at UC Davis. His ultimate goal is to remain in academia as either a university professor or researcher. Rob can be reached at rbarrozo@sfsu.edu

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PHILANTHROPY AT SF STATE'S DEPARTMENT OF BIOLOGY

Conservation Genetics Laboratory
Laboratory Equipment
Scholarships for students in need
Field trips
Faculty and student research
Baccalaureate and Masters Ceremony
Colloquium

Scholarly travel
Science Education Partnership & Assessment Lab
Guest lecturers
Cell and Molecular Imaging Center
Graduate student fellowships
New faculty start-up
Alumni newsletters
Mycology collection

The Department of Biology extends a heartfelt thank you for your generous contributions.
A Newsletter for Alumni and Friends of San Francisco State University’s Department of Biology

Our mission is to engage the talents and resources of alumni, students, faculty, staff, and friends in the life, work, and goals of the Department of Biology. We know that you are community-focused on making a difference in the world. We want to hear about your achievements, read your letters to the Editor, see your photos, cartoons, crossword puzzles, and science-related book recommendations.

Submission Guidelines: We welcome articles that cover Department people, programs, activities, and research. Articles can vary in length between 50-500 words. Please provide captions when submitting photographs and images. Send to bio-news@sfstate.edu.

Want to receive current Department, College, and University news including events, seminars, workshops, course, scholarship, grant, research, employment, and internship opportunities? Email silver@sfstate.edu to receive (or post announcements in) the weekly electronic “Bio Bulletin.”

Advancing Global Health and the Biosphere
Educating Future Generations of Scientists, Health Professionals, Teachers and Citizens
Educational Goals for the Baccalaureate at San Francisco State University

San Francisco State University undergraduates will emerge from their studies with a breadth and depth of knowledge and understanding developed from integrating their course work and academic experiences in both general education and in the major. The abilities, knowledge, and qualities of mind fostered by general education will be reinforced, extended, and deepened in the major. Students should pursue a secondary focus in addition to their major (e.g., a second major, minor, certificate). We expect the following interconnected educational outcomes from a baccalaureate of San Francisco State University:

1. **Competencies for Lifelong Intellectual Endeavor**: San Francisco State University’s baccalaureate graduates will be competent in critical questioning and analysis, creative and independent thought, attentive reading and interpretation of written and other forms of communication, quantitative reasoning, research drawing upon a variety of resources, problem solving, and collaboration. Students should have knowledge of a language other than English.

2. **Intellectual Attainments**: Graduates will be conversant with the principal domains of knowledge associated with liberal learning: the sciences and mathematics, the social sciences, the humanities, and the arts. They will be able to apply the modes of inquiry associated with these domains and will have engaged questions and issues of enduring importance. They will also gain in-depth knowledge and understanding of at least one major course of study. These competencies and attainments will provide graduates with intellectual foundations for careers or for advanced study.

3. **Appreciation of Diversity**: Graduates will know, understand, and appreciate multiple forms and variations of human diversity, both within the United States and globally. Graduates will respect themselves and others. They will have obtained a historical perspective about the development of our diverse nation and will be able to engage in informed civil discourse with persons different from themselves in intellectual and cultural outlook.

4. **Ethical Engagement**: Graduates will have an appreciation of the necessity and difficulty of making ethical choices both private and public, and will be able to identify and analyze the values that inform those choices. Graduates will demonstrate ethical conduct in their own work and their acknowledgement of the work of others. Graduates will recognize their responsibility to work toward social justice and equity by contributing purposefully to the well-being of their local communities, their nations, and the people of the world, as well as to the sustainability of the natural environment.

5. **Integration and Application of Knowledge**: Graduates will know how to make connections among apparently disparate forms of knowledge and modes of inquiry across academic disciplines and between the principal domains of knowledge and their majors. They also will be able to place such knowledge and approaches within their cultural, historical, and sociopolitical contexts. Graduates will be able to apply academic knowledge to what is important in their own lives and to local and global communities.

6. **Qualities of Mind and Spirit**: Graduates will take with them dispositions that facilitate lifelong learning and growth in the areas of curiosity, a sense of wonder, intellectual flexibility and adaptability, a refusal to simplify what is inherently complex and ambiguous, a sense of responsibility and accountability, critical self-reflection, independence of mind, respect for wellness and healthy living, a readiness to assume leadership roles, and reverence for all that unites human beings across time.

http://www.sfsu.edu/~senate/documents/attachments/03.11.08/Educ-Goals-Feb.html
Mission
The mission of San Francisco State University is to create and maintain an environment for learning that promotes respect for and appreciation of scholarship, freedom, human diversity, and the cultural mosaic of the City of San Francisco and the Bay Area; to promote excellence in instruction and intellectual accomplishment; and to provide broadly accessible higher education for residents of the region and state, as well as the nation and world. To fulfill its mission, the university is committed to the following goals:

1. Attracting, retaining, and graduating a highly diverse student body;
2. Providing disciplinary and interdisciplinary liberal arts and professional education that is academically rigorous and intellectually challenging;
3. Providing curricula that reflect all dimensions of human diversity, and that encourage critical thinking and social and cultural awareness;
4. Recruiting, retaining, and supporting a diverse faculty whose teaching demonstrates an active engagement with their individual fields of study and whose creative and scholarly work is an extension of the classroom, laboratory, or studio;
5. Employing a staff and administration reflecting the diversity of the community and the values of the campus;
6. Fostering a collegial and cooperative intellectual environment that includes recognition and appreciation of differing viewpoints and promotes academic freedom within the university community; and
7. Serving the communities with which its students and faculty are engaged.

Segment III: Relationships of Knowledge

Principles and Description
The CSU system requires that students receiving a baccalaureate degree from a CSU campus complete 9 units of upper division general education coursework at the campus granting their degree. SFSU fulfills
this upper division requirement through its Segment III program, Relationships of Knowledge. Students cannot begin Segment III coursework until (or after) the semester in which they achieve junior standing. The goal of G.E. Segment III at SFSU is to “to promote an appreciation of the interrelationships among knowledge, values and skills.” This goal is grounded in a belief that students “benefit from knowledge about:

- The value and significance of human achievements.
- The experiences and achievements of various cultural, ethnic, or social groups.
- The complexity of personal, cultural, and social problems and issues.
- The impacts and consequences of solutions to existing or newly created problems.
- The problems, issues, or solutions confronted by various social, ethnic, or cultural groups and how they may be experienced in different ways.
- The integration of their abilities, knowledge, and experience in making decisions.
- The prevalence of cultural, social, personal, and/or procedural biases.
- The use of effective procedures for investigating problems and issues.

This component of our GE program consists of three upper-division courses that must be selected from an approved, internally cohesive, interdisciplinary or multidisciplinary, thematic cluster. The clusters are each organized around a central, unifying theme and range in size from very small clusters of only 4 courses to very large ones with 30 or more
courses. Many clusters are broken up into 2-3 categories to insure that students are exposed to a range of ideas within the theme.

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**GE Segment III Student Learning Outcomes.** After completion of the 9-unit GE Segment III upper division, residence requirement in a single cluster, students should be capable of:

1. Identifying interdisciplinary perspectives around a theme that focuses on human experiences, achievements, or problems, past and/or present.
2. Integrating knowledge, experience, and abilities around a theme from at least two different disciplinary perspectives.
3. Synthesizing information and engaging in critical analyses, including problem solving, decision making, investigating and/or evaluating the implications of an issue.
4. Engaging in critical analysis in classroom discussions and in writing assignments (minimum of ten, double-spaced pages).
5. Demonstrating an awareness and understanding of cultural, ethnic, or social diversity, whether local, national, or global, and the relationship of diversity to the cluster theme.

I. General Education Program Philosophy and Principles

General education introduces students to a lifetime of learning about themselves and about the world in which they live. Above all, general education should sharpen students’ abilities for continued intellectual growth and should develop an awareness of and appreciation for the tentative nature of human knowledge that must constantly be added to, subtracted from, and modified in light of subsequent discoveries.

**Principle 1:** The first goal of general education is to develop basic competency in communication, critical thinking, and quantitative reasoning.
An educated person should be able to communicate with clarity and force, to read with discrimination and understanding, and to think with precision and creativity. The Segment I GE curriculum develops a disciplined use of language for effective communication, builds disciplined thought processes for sharpened analytical skills, and helps students develop greater ability and confidence to reason and make judgments about mathematically based information. Principle one is achieved in SFSU's GE Segment I - Basic Subjects that consists of four requirements: Written Communication, Oral Communication, Critical Thinking, and Quantitative Reasoning.

**Principle 2:** The second goal of general education is to develop an understanding of the contributions and influences of the physical and biological sciences, the behavioral and social sciences, the humanities and creative arts toward the development of civilization and toward the identification, investigation, and resolution of individual and societal problems. The Arts and Sciences Core helps students develop an understanding of the contributions to and influences on our world of the physical and biological sciences, the social sciences, the humanities, and the creative arts. Through study of the arts and sciences students are introduced to theories and methods of inquiry and assessment particular to these disciplines and how this knowledge is applicable to an understanding and appreciation of others and oneself. Students are exposed to multiple ways of acquiring knowledge and encouraged to participate actively in creative endeavors. Within Segment II, students gain information that will be useful to their lifelong personal development (Lifelong Development-LLD) and to their development as active and constructive participants in a diverse society (American Ethnic and Racial Minorities-AERM).

Through the physical and biological sciences curriculum, students develop skills in applying scientific methods to the search for an understanding of the components and processes that constitute our physical and biological world, and an understanding of the connections between scientific developments and contemporary issues that affect our lives.

Through the behavioral and social sciences curriculum, students enhance the understanding of themselves and others as psychological and social beings. The curriculum develops skills for analyzing human behavior and for evaluating facts and principles relevant to making social policy. Course work is designed to foster civic and global responsibility as well as an appreciation for diverse values and past and present cultural traditions.

Through the humanities and arts curriculum, students are urged to explore the fundamental questions regarding human values, aesthetics, and expression. The curriculum is dedicated to stimulating reflective thinking, imagination, and creativity; to increasing civic and global responsibility; to cultivating moral action; and to building the communication skills needed to express the best of what it means to be a human.

At SFSU one of the premises of GE is to develop an appreciation and an understanding of
the richness, diversity, and heritage of America’s ethnic and racial minorities as well as its cultural ethnic and social pluralism. This element of SFSU’s GE program is achieved in its American Ethnic and Racial Minority AERM courses. A general education should also equip students for lifelong understanding and development of themselves as integrated physiological, social, and psychological individuals. The element of SFSU’s GE program is achieved through its Lifelong Development (LLD) courses. Principle two is achieved in SFSU’s GE Segment II – Arts and Sciences Core which consists of the Physical and Biological Sciences, the Humanities and Creative Arts, the Behavioral and Social Sciences, the American Ethnic and Racial Minorities Requirement, and the Lifelong Development Requirement.

**Principle 3:** The third goal of general education is to promote an appreciation of the interrelationships among knowledge, values and skills. Students benefit from knowledge about:

- The value and significance of human achievements.
- The experiences and achievements of various cultural, ethnic, or social groups.
- The complexity of personal, cultural, and social problems and issues.
- The impacts and consequences of solutions to existing or newly created problems.
- The problems, issues, or solutions confronted by various social, ethnic, or cultural groups and how they may be experienced in different ways.
- The integration of their abilities, knowledge, and experience in making decisions.
- The prevalence of cultural, social, personal, and/or procedural biases.
- The use of effective procedures for investigating problems and issues.

SFSU achieves this principle through its GE Segment III- Relationships of Knowledge requirement. This component of our GE program consists of three upper-division courses that must be selected from an approved, internally cohesive, interdisciplinary or multidisciplinary, thematic cluster.

**Back to top**
CRITERIA AND GUIDELINES FOR THE SEGMENT II
AMERICAN ETHNIC/RACIAL MINORITIES REQUIREMENT

American Ethnic/Racial Minorities: (3-4 units)

The American Ethnic/Racial Minorities Committee will consider a proposed course:

a) if the course has already been approved as a Segment II course, and
b) if the course proposal indicates that it was designed, in addition, to fulfill the American Ethnic/Racial Minorities requirements. The course may be proposed either for the lower or upper division level.

Objectives

Courses/Programs in the area of American Ethnic/Racial Minorities should:

1. be thorough in presenting the views of one or more groups of American Ethnic/Racial Minorities both from the perspective of the group and as an integral part of American society;
2. promote the study of values, attitudes, behaviors, initiatives, and/or creative endeavors which acknowledge and respect the dignity of all groups; and,
3. present a thorough analysis of the historical experiences, social stratification processes, political activism, basic cultural patterns, aesthetic experiences and/or ideologies and include one or more of the historically oppressed groups of color: African American, American Indian, Asian Pacific Islander American, and Latinos.

Learning Outcomes

After completion of the minimum three units in the American Ethnic/Racial Minorities component, students will have been offered the opportunity to apply scholarship in the study of American Ethnic/Racial Minorities and should be able to demonstrate at least two of the following learning outcomes:

1. identify the ways in which the historical, political, and/or cultural/aesthetic experiences of different ethnic/racial minority groups are similar to and different from each other;
2. identify their own value systems and/or styles of creative expression and those of other ethnic/racial groups;
3. develop the understandings and behavioral competencies necessary for effective interpersonal and interethnic group interactions, i.e.,
   a) recognize the diversity of attitudes and values which are projected in verbal and nonverbal behavior;
   b) recognize the dynamics of interpersonal interactions from others' perspectives;
   c) identify and recognize the concerns regarding ethnic/racial minority stereotypes;
   d) recognize the dynamics of racial hierarchies and power relations from others' perspectives;
4. develop their social-cultural participation skills, decision-making abilities, and political awareness in order to be citizens in an ethnically and racially diverse nation.

Developed and approved by the AERM Committee, April 2001
SFSU POLICY & GUIDELINES FOR SEGMENT III - RELATIONSHIPS OF KNOWLEDGE

Incorporating Academic Senate Policy F88-157

February 24, 1989

This document combines and codifies Academic Senate Policy F88-157 and the portions referring to Segment III of the two earlier documents amended by F88-157: "Guidelines for Preparing Proposals and General Education Specific Objectives" (August 1981) and Senate Policy F80-64, as amended. The origin of each section or paragraph is noted in brackets. Sections or paragraphs denoted [Guidelines] or [F80-64] are substantively unchanged by F88-157.

Sections have been rearranged for rational flow, substantial repetition of identical language between the "Guidelines" and F80-64 has been eliminated, a consistent section numbering scheme has been applied, and changes in wording for consistency have been carried out; e.g., "clusters" rather than "blocks" of courses.

CONTENTS

I. Principles

II. Summary

III. Requirements for Upper-Division Transfer Students

IV. General Objectives and Learning Outcomes
   A. General Objectives
   B. General Learning Outcomes

V. Implementation
   A. Relationships of Knowledge (Segment III) Committee
   B. Responsibilities of the Segment III Committee

VI. Specific Objectives
   A. Theme
D. Internal cohesiveness

Each of the clusters must be internally cohesive. Cohesiveness will be judged in terms of the extent to which the various courses are related to one another. The faculties of each cluster are expected to formulate their individual courses with a clear understanding of that the students will be learning in the other courses in the cluster and to demonstrate that the courses complement one another. [F88-157]

E. Cultural, ethnic or social diversity

At least one course in each cluster must have as a central objective that students develop an awareness, appreciation, and understanding of the diversity of human experience, values, and contributions, and of "the contributions to knowledge and civilization that have been made by members of various cultural groups and by women" (E.O. 338). Inherent in this requirement is the concept of cultural pluralism which embraces ethnic, cross-cultural and intercultural studies as well as studies of the relationship between dominant and nondominant social groups. Courses that fulfill this requirement should include a substantial consideration of cultures other than the Western European and North American or a substantial consideration of nondominant social groups in the U.S. Nondominant social groups include but are not limited to women, the aging, the disabled, lesbians and gays, and the poor, as well as ethnic and racial groups who have been excluded from dominant social, economic, or political institutions. Courses meeting the CESD requirement should treat one or more such groups in relationship to the issue or theme of the cluster. [F88-157]

The objective of requiring a course focused substantially on cultural, ethnic or social diversity is to ensure that students will develop an awareness, appreciation, and understanding of the diversity of cultural and social experience, values, and contributions. Inherent in this mandate is the concept of cultural pluralism, which embraces ethnic, cross-cultural, and intercultural studies as well as studies of the relationship between dominant and nondominant social groups. Most courses in the University reflect the experiences, contributions, and values of the Western European and North American tradition and the dominant American culture. Thus, courses that fulfill this requirement should in most cases include a substantial consideration of cultures other than the Western European and North American or a substantial consideration of nondominant social groups in the United States. [Guidelines]

Cultural, ethnic or social diversity should deal with the question of how social groups or foreign cultures are affected by the issues or theme of the Segment cluster. The experience of nondominant social groups distinguished by a status category other than race, ethnicity, or national origin (e.g., women, the aging, the physically disabled, gays, etc.) may be included as part of the fulfillment of this requirement. Cultural, ethnic or social diversity should be interpreted broadly in that: (a) greater emphasis may be placed on either cultural, ethnic or social aspects; (b) culture may have political, ethnic, historical, sexual, religious, language, or class boundaries. Courses should also provide information about socio-economic groups as they are affected by the issue or problem under consideration. [Guidelines]

The requirement for a central focus can be fulfilled in such ways as the following:

1. A course may examine the application of a cluster's theme to one particular cultural, ethnic or social group or foreign culture. Where courses are devoted specifically nondominant groups such as ethnic groups or women, or to the culture of countries other than the United States, they should take into account social and economic variations within the primary group under consideration. [Guidelines]

Among the courses in this category that will be favorably considered, so long as they also fulfill the other criteria for Segment III, are the following:

(a) Courses in Ethnic Studies which expose students to the relationship between dominant and nondominant cultures and to the diversity of the American ethnic heritage.
(b) Courses on the experience or culture and language of non-English speaking peoples, especially those of developing and other non-Western European countries.

(c) Courses that focus on the experience of nondominant social groups defined by a status category other than race, ethnicity, or national origin (e.g., women, the aging, the physically disabled, etc.) if they examine substantially the diversity of ethnicity and/or socio-economic status within the particular social group. [Guidelines]

2. A special portion of the course may be devoted exclusively to the application of the cluster theme to the ethnic, cultural, and social groups defined above. In this case, at least one-third of the course should engage in this endeavor. A portion of these sessions may deal with nondominant groups other than those categorized as ethnic or racial, but at least two weeks should be devoted to ethnic diversity and a portion should deal with socioeconomic differences. Courses that focus this special portion exclusively on ethnicity are acceptable so long as they include a socioeconomic component. [Guidelines]

3. A course may integrate the analysis of ethnic and other cultural groups into each topic as it is presented. Where cultural and nondominant/ethnic groups are considered throughout the course, the course outline should clearly demonstrate how each major topic applies to them. A consideration of socioeconomic differences should be included. [Guidelines]

4. A course may have a central focus on cross-cultural studies (e.g., the comparison of two or more cultures' history, sociopolitical and economic structures, art, religion, etc.) especially if one or more of the cultures is non-Western European. These studies should implement the Segment theme and should consider socioeconomic differences. [Guidelines]

VII. REQUIREMENTS FOR PROPOSALS, CLUSTERS, AND COURSES

[F88-157]

A. Proposals

Proposals must show how the cluster as a whole fulfills the objectives of Segment III and the requirements set forth in this section. Course material must be sufficiently explicit and detailed to show the contributions of each course to the fulfillment of the aims of the cluster. When the requirements for the cluster provide the students with alternative combinations of courses, the justification for the cluster must demonstrate that any acceptable combination of courses meets all the objectives of the Segment.

B. Clusters and courses

1. Low-enrollment clusters

Clusters chosen by fewer than 1 percent of graduates in an academic year shall be reviewed by the Segment III Committee; if such a cluster can not be suitably revised and continues to draw fewer than 1 percent of the graduates, it may be deleted from Segment III.

2. Implementation of CESD requirement

Student completion of the Cultural, Ethnic or Social Diversity requirement must follow from the requirements of the cluster itself. At least one requirement of the cluster must direct the student to take a CESD course or one of a set of courses, all of which have been approved for the CESD requirement.

3. Coordination

a) Each cluster must have a coordinator who is responsible for the cluster and for communications concerning the cluster. The coordinator is responsible for submitting the annual cluster report and proposals for revision of the cluster as needed or as requested by the Segment III Committee. The cluster coordinator
Fall 2006 Syllabus
BIOLOGY 322 HUMAN SEXUALITY – Integrative Science

Instructor  Ann Auleb
Office  Hensill Hall 418 & 419
Office Hours  MW 1-2PM, TH 3:30-4pm, or by appointment
Section 1 MWF 12:10-1PM
Science 210 Course #12181
GA/Office  Lisa Valin
Location  Section 2 Thursday 5:10–7:55PM
Science 101 Course # 23866
Staff  Russell Smith

Course Materials:

Human Sexuality: Integrative Science, GE Segment II, Bionna & Levitan bundled with the
Responsive Innovations RF Response Card (Turning Point)
every class meeting)
2 ParScore test forms #20738-PRI (The blue narrow one – 50 questions each side.)
An e-mail account. SFU provides free e-mail accounts if you don’t already have one. For
information, go to - https://www.sfu.edu/online/accounts.htm. Also, you can easily set your
SFU e-mail account to forward all mail to your existing e-mail account. Please check your e-
mail frequently. We send reminders and new information often. Make sure you verify your e-
mall in iLearn.

Access to the internet. There are computers available on campus for your use. Please see
page 3 of the syllabus for instructions on how to access iLearn.
Mozilla Firefox  Experience shows iLearn, the online learning system used for this course,
operates best on the internet browser Firefox. Firefox can be downloaded for free at
http://www.mozilla.org/products/firefox If using AOL for connection, log in using AOL,
minimize and open Firefox. iLearn does not work with Safari (MAC).

Recommended Reading for class and for your personal library (paperbacks) Barbach, Lonnie.
For Yourself, The Fulfillment of Female Sexuality and For Each Other; Zilbergeld, Bernie. The
New Male Sexuality; Brauer, Alan and Donna. Extended Sexual Orgasm (E.S.O.)

SFU STUDENT I.D.

Description:

Provides G.E. credit for Segment II (Integrative Science). This course does not fulfill Segment III
requirements; BIOL 330 does.

Instructional Methods: Classes include readings, lectures, guest lectures and panels, student panels,
student cameo dramatizations, small group discussion, dyads, role plays, multimedia class
presentations, automated class response system (Turning Point) iLearn quizzes
(http://filearn.sfu.edu). Class discussion is encouraged.

Goals:

To provide students with accurate, up-to-date, and in-depth information about human sexuality. The
course provides a strong biological foundation integrated with the psychological, social, behavioral,
clinical, historical, philosophical, cross-cultural and legal aspects of sexuality. Each topic is examined
from the biological perspective and broadened to show the importance of the other disciplines in the
study of human sexuality. Biology 322 presents evidence for the reciprocal relationship between sex,
culture, and changing values and attitudes. Basic scientific and philosophical methods of
investigation are discussed. The sexes, cultural and ethnic groups and the various sexual orientations will be examined in light of their similarities and differences.

Specifically, we hope that each student will be able to:

- Identify structure and function of the reproductive tract and sexual organs.
- Identify dysfunctions and treatments of the reproductive tract and sexual organs.
- Describe the differentiation/development of the sex organs.
- Outline how knowledge of human sexuality can make a vital, positive contribution to a better understanding of one's personality.
- Describe how the human being is an integrated psychological, social and physiological organism.
- Differentiate the many ways in which Sexologists investigate the subject of sexuality and how they generate new ideas.
- Distinguish and analyze the importance of varying approaches and perspectives to gain a more thorough understanding of human sexuality.
- Differentiate the critically scientific from the pseudo-scientific reports on human sexuality which occur with increasing frequency in the popular media.
- Recognize their own value system and show objectivity and self-confidence when making critical decisions concerning personal and social aspects of sexuality throughout the life span.
- Evaluate and effectively handle the consequences of difficult sexual decisions thereby increasing the integrity of interpersonal relationships throughout the life span.
- Explain why it is important to have understanding, compassion and appreciation for the variety of sexual lifestyles and belief systems and give examples of their own homophobia, racism, etc.
- Illustrate clearly how people function sexually at different stages of life.
- Describe how changes in sexual attitudes and behavior often reflect changes occurring in society and culture in general.
- Perform as well educated consumers of medical/psychological practice in the area of sexuality.
- Explain why it is important to have as much sexual freedom as possible in their current social environment and become liberated from all forms of sexual exploitation by any individual or group.
- Describe the sexes, cultural and ethnic groups and the various sexual orientations in light of their similarities and differences.
- Explain how to prevent unwanted pregnancy and sexually transmissible diseases using various techniques and apparatuses.

As Bernad Goldstein says, "Remember, that both humans and animals show desire for sexual activity. But humans may be the only species that can, at times, laugh about it!"

Requirements:

**Enrollment:** You are responsible for ensuring you are properly enrolled in the course. If you need to add the course, see the instructor or a TA to receive an add slip. You should immediately go online (https://www.sfsu.edu/online/login.htm) and add the course. Upon adding the course, you will have access to iLearn. **If you are making up an incomplete, DO NOT enroll in the course; we will submit a grade change for the semester in which you were originally enrolled in the course.**

**Readings:** Please see below or iLearn for the tentative class outline and required readings. Please be sure to read before coming to class.

**Exams & Quizzes:** You are responsible for the material in the lectures, Blonna & Levitan, multimedia presentations, and all material in the lecture guide, and handouts. Exam and quiz questions are taken from these as well as from the lecture material. No late work is accepted without documented reasons approved by the instructor. Directions will be given in class and/or on iLearn. **Be aware, iLearn quizzes and exams may time out after 4 hours.**

**Quizzes** on iLearn can be taken multiple times; you are encouraged to take them as many times as you can until you get 100%, by the due date.
Pop Quizzes will be given in class using Turning Point Key pad. The only way you can get credit for the pop quizzes is by using your keypad in class.

Cumulative Midterms will also be on iLearn. You may only take the midterms once, by the due date.

Cumulative Final Exam will be in class. Bubble your ParScore form carefully according to the instructions given. Bubbling errors will result in your exam being graded late. Please bring a dark #2 pencil, ParScore 20788-PRT test form (narrow and Blue), and Student ID to class for the final. PHOTO ID IS REQUIRED FOR THE EXAM TO BE COUNTED. You may NOT leave the classroom during the exam. You may bring 1 page (both sides) of HANDWRITTEN notes to the final. The notes must NOT contain: answers to the online quizzes, photocopies, or computer-print outs. If your notes contain any of these, you will have the notes confiscated and/or you will get NO CREDIT for the exam.

YOU MUST PASS THE FINAL TO PASS THE COURSE.

Models: In groups of 4-5 students, you will use your creativity and imagination to build 3-dimensional models of the male and female internal and external genitalia (include latex barrier devices in the model). The model should demonstrate the group's knowledge of the anatomy, including names, of the structures. The group can use any materials it wishes to construct the models. Everyone must participate in creating the ideas for, and construction of, the model. Models will be displayed on campus during the LateExhibition. Only one person needs to come to submit the project and all forms. For safety considerations, we recommend that you do your projects on campus. On 10/17 there will be a workshop available in Jack Adams Hall between 10am and 2pm for students to work on their projects in a supportive environment. You may leave your project overnight, but you MUST come to Centennial Drive by 8:30 on 10/18 to check in your project.

Title your project and put the project number on the project so it is visible.

On Wednesday, 10/18 between 7:30 – 8:30am in front of Student Services Building on Centennial Drive turn in all of the following:

1. The model with the project number clearly visible on the model.
2. The cover sheet we gave you a week prior to the due date, listing the project title, each group member’s name and student number. NO NAMES MAY BE ADDED AFTER THE PROJECT IS TURNED IN.
3. A ParScore form for each group member with the group number written on each form.

On each ParScore form, please fill out the following and bubble carefully where appropriate:

ID NUMBER: YOUR STUDENT NUMBER
YOUR NAME: LAST, FIRST, MIDDLE INITIAL
SUBJECT: BIO 322, Title of Project, Group project number
TEST FORM: A
EXAM NUMBER: 000
DATE: 10/18/06

NOW: Bubble "A" as the answer to question one Write your group # on the Parscore Form

You will receive a receipt for your project that has your group project number on it. Keep the receipt until final grades are received. All members of the group should know the number. We will need the project number to make any corrections.

No projects will be accepted after 9am on 10/18/06. The projects will not be returned to you.
210/211 and Biol 610/611--these courses are NOT accepted for Biology major credit. The following majors do accept these courses for the major:

- B.S. Dietetics
- B.S. Health Education
- B.S. Kinesiology

General Biology Students

As described in the SFSU Bulletin, the Bachelor of Arts in General Biology degree provides breadth, but not depth, in biology. The major is designed to support the students who are interested in obtaining a teaching credential in the Biological Sciences for K-12. While it is true that the major can be structured to give the student the required depth for many career and educational goals, in many cases the Bachelor of Science degree may serve the student's goals better.

Students seeking General Biology Advising should consult the Biology Advising Web Page for information on the following issues:

1. Learn more about a specific biology major
2. Develop a course plan (Recommended 4 year course plans for General Biology major)
3. Obtain approval for transfer courses or substitution courses
4. Improve your performance in your courses
5. Change your major
6. Obtain approval on an academic advising petition
7. Obtain approval for Financial Aid Graduation Plan
8. Obtain approval on your baccalaureate graduation application (Instructions to fill out the Graduation Checklist)
9. Obtain Advanced Placement credit towards your major
10. Organic Chemistry requirement: Chem 130 or Chem 333?

Other Frequently Asked Questions from General Biology Majors:

- Can Chem 333 be used to substitute for Chem 130?
  - Yes, and an equivalency form must be filed to indicate this change.
- How many units can be double-counted to fulfill the major and GE requirements?
  - 12 units, but at least one Segment III must be outside the major.

Recommended 4 year course plans for the General Biology major:

It is essential for a General Biology student to meet with an advisor to develop a course plan tailored to his/her career and educational goals. The recommended course plans below are
suggestions and should be modified upon consultation with a General Biology Advisor. They are listed to demonstrate that:

- All lower division courses need not be completed prior to taking the upper division course work
- It is critical to pay attention to the prerequisites when developing the course plan
- In general, the student should try to limit the science course load to two courses per semester and balance the semester units with General Education courses and electives of interest
- the upper division electives should be selected in consultation with the Biology Advisor
- Description of General Biology major requirements

Version 1: "lower division first"

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<th>Year 1 Spring</th>
<th>Year 2 Fall</th>
<th>Year 2 Spring</th>
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<tr>
<td>Chem 115</td>
<td>Biol 230</td>
<td>Biol 240</td>
<td>Ecol course</td>
<td>Physio w/lab*</td>
<td>Cell Biol w/lab*</td>
<td>Upper Div elective</td>
<td>Upper Div elective</td>
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<td>Phys 111/112</td>
<td>Phys 121/122</td>
<td>Chem 215**</td>
<td>Chem 130</td>
<td>Biol 355</td>
<td>Evol or Org course</td>
<td>Upper Div elective</td>
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<td>Math 124 or 226</td>
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Version 2: "physics later, no Biol 612 (Human Physiology)"

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*consult the Description of General Biology major requirements for the appropriate Cell or Physiology laboratory (only one lab required)

**Chem 215 prerequisites: C- or better in CHEM 115 and in 2 of the following courses: PHYS 111, PHYS 121; PHYS 220, PHYS 230, or PHYS 240; MATH 226, MATH 227; or consent of instructor

- Physiology courses:
- Evolution or Organismal courses:
BIOL 525 Plant Physiology  
BIOL 612 Human Physiology  
BIOL 630 Animal Physiology  

Cell Biology courses:  
BIOL 350 Cell Biology  
BIOL 401 General Microbiology  
BIOL 435 Immunology  
BIOL 450 Biology of the Protozoa  
BIOL 524 Plant Molecular Biology  
CHEM 349 General Biochemistry  

Ecology courses:  
*BIOL 313 Principles of Ecology (only if taken BEFORE Fall 2004)  
BIOL 482 Ecology (4)  
BIOL 529 Plant Ecology (4)  
BIOL 534 Wetlands Ecology (4)  
BIOL 580 Limnology  
BIOL 582 Biological Oceanography  
BIOL 585 Marine Ecology (4) (If 3 unit Biol 585 taken, then 2 unit Biol 586 lab must be taken)  
BIOL 328 Human Anatomy (4)  
BIOL 337 Evolution  
BIOL 380 Comparative Embryology  
BIOL 453/454 General Parasitology/Laboratory (3/1)  
BIOL 459 Arthropod Biology (4)  
BIOL 460 General Entomology (4)  
BIOL 461 Insect Taxonomy (4)  
BIOL 475 Herpetology  
BIOL 478 Ornithology  
BIOL 480 Mammalogy (4)  
BIOL 500 Evolution and Diversity of Plants (4)  
BIOL 502 Biology of the Algae (4)  
BIOL 504 Biology of the Fungi (4)  
BIOL 505 Comparative Anatomy of Vascular Plants (4)  
BIOL 514 Plant Taxonomy (5)  
BIOL 555 Marine Invertebrate Zoology (4)  
BIOL 570 Biology of Fishes (4)

*As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

Note:
The following courses are generally taught both Fall and Spring semesters (check Class Schedule)  
Chem 115, Chem 215, Chem 130  
Math 124, Math 226  
Phys 111/112, Phys 121/122

The following courses are generally taught during the Summer semester (check Class Schedule, required courses are in bold)  
BIOL 328, BIOL 355  
CHEM 115, CHEM 215
MATH 124 or MATH 226
PHYS 111/112, PHYS 121/122

Turn to top of page

Minor in Biology

In order to obtain a Minor in Biology, the student must meet with a General Biology Advisor and develop a course plan to fulfill the following requirements (as indicated in the SFSU Bulletin description of the Minor in Biology).

Requirements:

- 23 units total
- All courses for a letter grade (CR/NCR is not acceptable)

Introductory Biology courses or the equivalent (as a prerequisite for other courses)
*Biol 230 and Biol 240 (10 units)

Physiology course (the lab is not an official requirement)
*Note that 610/611 may also be used depending upon the background or goals of the individual
       units, +2 units if lab is taken)
*BIOL 525 Plant Physiology
*BIOL 526 Plant Physiology Lab
*BIOL 612 Human Physiology
*BIOL 613 Human Physiology Lab
*BIOL 630 Animal Physiology
*BIOL 631 Animal Physiology Lab

Ecology, one of the following (3 or 4 units, including field work)
*#BIOL 313 Principles of Ecology (3)
*BIOL 482 Ecology (4)
*BIOL 529 Plant Ecology (4)
*BIOL 534 Wetlands Ecology (4)
*BIOL 580 Limnology (3)
*BIOL 582 Biological Oceanography (4)
*BIOL 585 Marine Ecology (4) (If 3 unit Biol 585 taken, then 2 unit Biol 586 lab must be taken)

As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and
not be taken for credit towards any Biology undergraduate degree. Students who have taken
Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

- Genetics/Evolution (3 units), one of the following
  * Biol 355 Genetics
  * Biol 337 Evolution (note that Biol 355 Genetics is a prerequisite)

In the remaining 23 units, which is basically one more class, the student should try to get some depth in one of the fields above. The requirements above are actually pretty flexible so depending on the background or goals of the student, he/she may be able to substitute one of the "requirements" for a course that will give them more depth in a given area. Consult the description for the General Biology B.A. major for suggested upper division courses.

The student should refer to the SFSU Bulletin description of Minor Programs for additional policies for an approved minor degree. These policies include:

- Double Counting Courses Between Major and Minor. Courses may count for both a major and a minor where there is a clearly stated overlap in the Bulletin requirements.
- Double Counting Between Minor and GE. No limitations.
- Upper Division/Residence Units. At least half of the units making up the minor must be taken in residence and at least half must be upper division.
- No Minor in Major. Students cannot complete a minor in the same field as the major.
- Grade Point Average. A minimum 2.0 grade point average is required in the minor.

*return to top of page

Subject Matter Competency/Single Subject Credential in Biological Sciences

*return to top of page

Candidates for teaching credential programs who wish to meet the SFSU requirements for subject matter competency for the single subject credential in Science: (Concentration in Biological Sciences) must meet both depth in biology requirements and breadth requirements in chemistry, geosciences, and physics.

Candidates for the teaching credential program who wish to have their transcripts evaluated for subject matter competency must contact a General Biology Advisor to arrange a meeting. The candidate must supply transcripts and additional supporting documentation to confirm completion of the required course work. This documentation may include course catalogs and course syllabi if the courses were not taken at SFSU. Prior to meeting with the General
Biology Advisor, the candidate should download and fill out the Biology Single Subject Credential Worksheet to assist the Advisor in determining subject matter competency.

For the student matriculating at SFSU, the course work for the BA in General Biology, with minor modifications, and additional course work in the geosciences combined meet both the depth and breadth requirements.

The course work (modified SFSU Bachelor of Arts Requirements in General Biology with additional classes):

- BIOL 230/240, General Biology I and II
- CHEM 115*, CHEM 215/216* General Chemistry I and II (with lab)
- CHEM 130, Organic Chemistry
- PHYS 111/112, PHYS 121/122, General Physics I/II
- MATH/STAT 124, Statistics, OR MATH 226, Calculus I
- BIOL 355, Genetics
- BIOL 525, 612, OR 630, a Physiology course
- BIOL 343, 350, 401, OR 450, a Cell Biology course
- Physiology or Cell Biology lab
- BIOL 313#, 482, 529, 534, 580,582, 585, an Ecology course
- BIOL 337, Evolution*
- BIOL (upper division, see General Biology B.A. major), an organismal biology course
- CIS 510, Search for Solutions** (substitute for geology, astronomy, meteorology, if appropriate)
- Additional upper division biology electives to total 57 units for the major (at SFSU)
  - Electives selected when combined with other upper division biology courses should clearly demonstrate coverage of human, plant, animal, and microbial biology. For example, the student may take the human physiology lecture, general microbiology, plant ecology, and marine invertebrate zoology. It would be inappropriate for the student to take courses that focus on only plant biology or only organismal biology.
- Geosciences, 2-5 courses
  - The Geosciences breadth requirement covers astronomy, geology, meteorology, and oceanography, but the material need not be covered in four separate courses. These are the SFSU course options:
    - Current Requirements (as approved by CTC): Student takes 5 courses
      1. Astr 115/116: Introduction to Astronomy, 3 units, and Lab, 1 unit
      2. Geol 110: Physical Geology, 4 units (includes lab)
      3. Our Violent Planet, a GE Segment III cluster that includes:
a. Geog 402: The Climatic Challenge, 3 units
b. Geol 302: The Violent Earth, 3 units
c. Metr 302: The Violent Atmosphere and Ocean, 3 units

- Alternative: Student takes 3 courses
  1. Astr 115/116: Introduction to Astronomy, 3 units, and Lab, 1 unit
  2. Geol 110: Physical Geology, 4 units (includes lab)
  3. Metr 302: The Violent Atmosphere and Ocean, 3 units OR CIS 510: Search for Solutions (if Global Climate Change)
- Alternative: Student takes 2 courses
  1. Astr 115/116: Introduction to Astronomy, 3 units, and Lab, 1 unit
  2. Geol 405 (formerly Geol 310)[also offered as METR/OCN 405]: Planetary Climate Change, 4 units (includes lab), covers geology, meteorology, and oceanography

*Required for single subject science competence, although not for the BA
**Counts as an upper division elective; see also geosciences breadth requirement
***Needed to meet the breadth requirements

As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and not be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

Students with degrees from other institutions:
If the course work was done at a different institution, the biology course work must include a year of general biology, and classes in genetics, physiology, ecology, evolution, and organismal biology. For breadth requirements, the course work in chemistry, physics, astronomy, geology, meteorology, and oceanography must total at least 24 semester (or 36 quarter) units.

The California Commission on Teacher Credentialing now has a new, specialized, and limited credential in science: Biological Sciences (Specialized). To be eligible for the subject matter competency in this Biological Sciences (Specialized) credential, a candidate needs either a post baccalaureate degree or 30 semester units of postgraduate course work in the subject (or a closely related) subject. Teaching certification would be only for Biological Sciences. A teacher with this limited credential would not be able to teach general science, integrated science, or introductory science.

Additional links of interest:
• SFSU College of Education Credential Services Teacher Preparation Center
  • single subject teaching credential information
    o single subject credential program application (pdf)
    o single subject credential program information/application packet (pdf)
    o single subject credential program information meetings
  • SFSU bulletin for the specific courses for the BA in General Biology.
  • Biology course descriptions
  • Course descriptions for courses in other departments

> return to top of page

Updated 1/09/08 SFSU home
Questions on web page?
Biology Advising Information

This web page provides general information and links to additional web pages of interest to SFSU Biology majors. An SFSU Biology Major should meet with his/her major-specific Biology Advisor on a regular basis to ensure timely progress to the baccalaureate degree. **ALWAYS BRING YOUR UNOFFICIAL SFSU TRANSCRIPTS, DARS/ASE, AND FORMS WHEN YOU MEET WITH YOUR MAJOR-SPECIFIC ADVISOR.**

**Biology Advising for Summer 2008:**
If you wish to meet with a Biology Advisor during the summer, please make sure that you
• **STOP** at the Department of Biology Office HH534
• **PICK UP** the BIOLOGY ADVISING CHECKLIST or **DOWNLOAD** the Biology Advising Checklist (click here to download) BEFORE you visit the Summer Biology Advisor.
• **READ** the BIOLOGY ADVISING CHECKLIST
• **BRING** all the required paperwork indicated in the Checklist for your meeting with your Advisor.

### Summer Biology Advisors (as of 7/11/08)

<table>
<thead>
<tr>
<th>Advisor Name</th>
<th>Office Address</th>
<th>Office Hours</th>
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<tbody>
<tr>
<td>Peter Ingmire</td>
<td><a href="mailto:ping@sfsu.edu">ping@sfsu.edu</a> HH531</td>
<td>7/14 – 7/28: Mondays and Thursdays 9:30am-12:30pm, Thursday, 8/14, 10:30am-12:30pm, Tues, 8/19, and Wed, 8/20, 2-4pm</td>
</tr>
<tr>
<td>Sally Pasion</td>
<td><a href="mailto:pasion@sfsu.edu">pasion@sfsu.edu</a> HH668C</td>
<td>Office Hours DROP-IN OFFICE HOURS...FIRST COME, FIRST SERVED 7/14 to 7/31: Mondays and Thursdays, 12noon - 2pm Mon 8/18, and Wed 8/20, 12noon - 2pm</td>
</tr>
<tr>
<td>Anne Thilges</td>
<td><a href="mailto:athilges@sfsu.edu">athilges@sfsu.edu</a> HH128</td>
<td>Office Hours 7/14 – 7/31: Mondays, Tuesdays, Wednesdays, and Thursdays 9:15-10:15am</td>
</tr>
</tbody>
</table>

**Additional Advising Information**

NEW! **Recommended Chemistry Sequence for Biology Majors** (pdf)
Download a flow chart of the recommended order to complete the required Chemistry courses for all Biology Majors.

**Graduation Checklists for Biology Majors**

**Summer 2008** Graduating students must fill out an ONLINE SURVEY—see the Graduation Checklist web page!

<table>
<thead>
<tr>
<th>Information for TRANSFER STUDENTS</th>
<th>Biology Major Advisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFSU Bulletin description of Biology Degree Programs</td>
<td>Department of Biology</td>
</tr>
</tbody>
</table>

http://online.sfsu.edu/K7Epasion/AdvisingWeb/biologyadvising.htm
Department of Biology Equivalency form
(pdf, Adobe Acrobat reader required)

Beginning Fall 2004, Biol 313 Principles of Ecology not accepted for Biology degree

Interested in Teaching K-12 Biology? Single Subject Credential in Biological Sciences

Class Schedule

Substitution form
(pdf, Adobe Acrobat reader required)

Department of Biology Majors Requirements

Health Professions at SFSU home page

Biology Course descriptions

NSF Noyce Scholarship Opportunity for Spring and Fall 2007 for students preparing to become K-12 science or mathematics teachers!! Click here for more information

Typical reasons to see your Biology Advisor:

1. Learn more about a specific biology major
2. Develop a course plan. NEW 4-year Course Plans AVAILABLE
3. Obtain approval for transfer courses or substitution courses. Lower Division Articulation chart
4. Improve your performance in your courses
5. Change your major. ATTENTION UNDECLARED MAJORS
6. Obtain approval on an academic advising petition. ATTENTION PROBATION STUDENTS
7. Obtain approval for Financial Aid Graduation Plan
8. Obtain approval on your baccalaureate graduation application
9. Obtain Advanced Placement credit towards your major
10. Organic Chemistry requirement: Chem 130 or Chem 333?
11. Obtain approval to take a course at SFSU Consortium campuses (including UCSF and UC Berkeley) for major credit

Please click on the following links if you are interested in:
B.A., General Biology
Minor in Biology
Subject Matter Competency/Single Subject Credential in Biological Sciences

As of Fall 2004, Biol 313 Principles of Ecology has restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Biol 482 Ecology has revised course content and serves as a broad Ecology course intended for Biology majors. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (PLEASE CHECK WITH YOUR BIOLOGY ADVISOR).
1 To learn more about the specific biology major that interests you

- SFSU Biology student should consult his/her Biology Advisor and take advantage of various College resources to develop his/her career goals, to discuss employment options after obtaining the degree, or to obtain information on pre-health professional or graduate schools.
  - SFSU Bulletin description of Department of Biology degree programs
  - SFSU Career Center
  - College of Science and Engineering Student Resource Center
  - What can I do with a major in...?
  - Health Professions at SFSU home page
  - Pre-Health Professions program
  - SFSU Pre-Health Professions Undergraduate Program

**Students Interested in a career as a Forensics Criminalist:**
It is REQUIRED that your college transcripts contain the following courses: Genetics, Molecular Biology, Biochemistry, Statistics, and Analytical Chemistry.

- So you want to be a Forensic Scientist
- Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students
- CSU Fresno Professional Science Master's Degree in Forensic Science
- San Jose State University Criminal Justice Administration-Biological Emphasis (this downloads a pdf)
- Council on Forensic Science Education home page

[return to top of page]

2 To develop a course plan for your major course work

It is essential for each student to develop a course plan for his/her majors course work. In developing a good course plan:

- it is important to check the prerequisites for each course. The prerequisites listed for a given course are classes required to be completed prior to taking the course. In some cases, the class may be taken concurrently if indicated in the course description. Click [here](http://online.sfsu.edu/%7Epsasion/AdvisingWeb/biologyadvising.htm) to check the Biology Course Descriptions.
- it is important to check whether a course is taught both fall and spring semesters, only fall or spring semester, or taught during the summer semester. This will allow the student flexibility in developing the course plan. Click [here](http://online.sfsu.edu/%7Epsasion/AdvisingWeb/biologyadvising.htm) to check the Biology Course Descriptions.
- an SFSU Biology student should consult with his/her Biology Advisor for approval of the course plan for the majors course work. This way the student can balance the majors course work with the General Education requirements, and better gauge the time to degree.
- the student should also meet with a GE Advisor at the Undergraduate Advising Center to determine an equivalent GE course plan. The DARS/ASE reports also track progress toward completion of the GE requirements.
Suggested 4-year course plans

QTE: All Biology majors are required to take Biol230/240 (General Biology I/II). It is generally
recommended that students take Chem115 (General Chemistry I) BEFORE taking Biol230/Biol240
(General Biology I/II).

Four-year course plans are available for the following Biology majors.
These are SUGGESTED course plans—students should meet with their Biology Advisors to
develop an optimal course plan for meeting their degree requirements.

B.A. in Biology, General
B.S. in Biology: Concentration in Botany (pdf)
B.S. in Biology: Concentration in Cell and Molecular Biology (pdf)
B.S. in Biology: Concentration in Ecology (pdf)
B.S. in Biology: Concentration in Marine Biology and Limnology (pdf)
B.S. in Biology: Concentration in Microbiology (pdf)
B.S. in Biology: Concentration in Physiology (pdf)
B.S. in Biology: Concentration in Zoology (pdf)

Click here for a worksheet for planning majors course work.

>return to top of page

3 To transfer courses into your specific major

In SFSU Biology student plans to use a course taken at another university to satisfy a Biology majors
requirement, the student must have this approved by a Biology Advisor and the Chair of the Department
of Biology. This transfer to the major is a TWO STEP process. First, the University must approve the
transfer. Second, the Department must approve the transfer.

STEP ONE: UNIVERSITY APPROVAL. Before the Department can consider accepting the course for
major credit, the University must approve the transfer of the course, designated on the Advanced
Standing Evaluation (see "How to read your ASE") or the Degree Audit Report (DARS). Transfer
students submit their transcripts prior to entering the University. Approved courses are transferred for
specified units as indicated on the ASE (or DARS, "About Your Degree Audit Report"). The student
cannot receive more units than the University has awarded on the ASE (or DARS) and cannot receive
more units than the equivalent SFSU course.

Courses taken at a junior college (two-year college) can ONLY FULFILL LOWER DIVISION
REQUIREMENTS. However, such course work may be given "content only" credit if the course work is
deemed equivalent to an SFSU upper division course. The upper division units must be made up by
taking another upper division elective.

To determine equivalency of a transfer course, the following resources may be of use:
--Articulation web site (www.assist.org)
--Click here to download a Lower Division Articulation chart. This chart shows which courses at Bay
Area colleges transfer for lower division courses required for the SFSU Biology degrees. The information
in the chart was obtained using the Assist.org articulation web site.

STEP TWO: DEPARTMENT APPROVAL. The student must meet with the Biology Advisor to confirm
that a specific transfer course is equivalent to a majors requirement. Once a course has been deemed
equivalent, the student must fill out the Department of Biology Equivalency Form (download here, or

http://online.sfsu.edu/37Epasion/AdvisingWeb/biologyadvising.htm
pick up at Department Office), obtain the approval of the Biology Advisor, and submit the form to the Department of Biology for approval by the Chair of the Department. **If the course equivalency is shown on the www. assist.org articulation website, the student must print out this articulation agreement and attach the agreement to the Equivalency Form.** If the course equivalency is based on the analysis of course materials by faculty, the course syllabus or course catalog description must be attached to the Equivalency Form. It is recommended that the Equivalency Forms be filled out sooner than later--do not wait until graduation to get the equivalency forms approved.

In addition, if the student plans to take a course as an upper division elective for the major, but that course is not listed in the official list of electives for the major, then the student must fill out the Department of Biology **Substitution Form** (download here, or pick up at the Department Office), obtain the approval of the Biology Advisor, and submit the form to the Department of Biology for approval by the Chair of the Department. **If the substitution is replacing an upper division course required for the Major, the required course being must replaced must be listed and an explanation provided on the Substitution Form.** In general, the student should consult with a Biology Advisor for approval of the substitution PRIOR to taking the course. It is recommended that the Substitution Forms be filled out sooner than later--do not wait until graduation to get the substitution forms approved.

*Note that it is the responsibility of the student to keep all signed Equivalency and Substitution Forms to submit with the graduation application.*

>return to top of page

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### 4 To develop strategies to improve performance in your Biology courses

Biology Faculty maintain regular office hours during the semester to meet with students in their classes in order to provide assistance with course work and preparation for exams and assignments. Students are encouraged to meet with their professors during these office hours. In addition, the following resources are available:

- **Overview of SFSU tutoring resources**
- **Learning Assistance Center--Biology tutoring**
- **Community Access and Retention Program tutoring**
- **SFSU Testing Center**
  - **Academic Skills online workshops**
  - **Academic Skills Workshops on Videotapes**
  - **Academic Skills Internet Links**

>return to top of page

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### 5 To change your major

In order to change one's major, one must have a minimum 2.0 GPA in the current major. The student must make an appointment with the appropriate Biology Advisor for the major you are changing to, and bring to this meeting the following paperwork:

- current unofficial SFSU transcripts
- a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
• current course enrollment
• prospective course plan
• change of major form (available on internet as downloadable pdf here, or at the Department of Biology Office)

After the advisor approves the change of major, the student must take the form to the Department of Biology for the signature of the Chair of the Department.

**ATTENTION UNDECLARED STUDENTS** who wish to change their major to a Biology degree: NEW INFO

Please be certain that the Biology major is the appropriate major for YOU. If you are considering applying for the B.S. Nursing degree, you should select your new major based on the course requirements that overlap with the Nursing major. Please consider the fact that the Nursing major is an impacted major (more students apply than can be accepted). A better strategy to obtain your degree in a reasonable time may be to select a major that will accept the Nursing-related courses for credit towards the major, so that you will not have to start from scratch with a new major if you are not accepted into the Nursing degree program. This is particularly important if you have already taken Biol. 210/211 and Biol 610/611—these courses are NOT accepted for Biology major credit. The following majors do accept some of these courses for the major:

- B.S. Dietetics
- B.S. Health Education
- B.S. Kinesiology

> return to top of page

6 To get academic advising petitions signed

Students who are on academic probation, mandatory advising, or subject to disqualification are required to meet with their advisors for approval of the academic advising petition prior to registration. Additional information is available at the Advising Center web page on Mandatory Academic Probation. In addition, the College of Science and Engineering Student Resource Center provides useful Probation Help information as well as a Grade Point Deficiency Calculator.

The student should bring to the meeting with the Biology Advisor:

- copies of PREVIOUS ACADEMIC STANDING PETITIONS/PROBATION CONTRACTS (available at the Department of Biology Office, Franciscan Building). This is a NEW REQUIREMENT.
- the current Academic Standing Petition (mailed to the student, available from Student Services Center, available on internet as downloadable pdf here, or at the Department of Biology Office)
- a copy of his/her unofficial SFSU transcripts
- a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
- current course enrollment
- a list of courses the student wishes to take the next semester
- any documents to support serious and compelling reasons which may have contributed to his/her poor academic performance

After the student meets with the advisor, the student brings the signed petition to the Department of
Biology for the approval by the Chair of the Department, then takes the form to the Dean's office for approval.

7 To get a financial aid graduation plan signed

Students on financial aid are sometimes asked by the Financial Aid office to prepare a Financial Aid Graduation Plan. The student should make an appointment with his/her advisor and come to the meeting with the following items:

- unofficial SFSU transcripts
- a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
- a copy of the Financial Aid Graduation Plan, filled out by the student prior to the meeting
- the original Financial Aid Graduation Plan to be filled out by the student in consultation with the advisor

Once the advisor approves the plan, the student takes the form to the Department of Biology office for department approval and then to the Financial Aid office.

To get approval for your graduate application

All Biology Major graduation applicants for Spring 2008 MUST complete an ONLINE SURVEY before the Department will approve the graduation application. Your input will help the Department improve its programs and courses for all Biology students. Go to the Graduation Checklist web page to find out more about the survey.

Click here to fill out the online Baccalaureate Degree Application for Graduation. This downloadable graduation application form also has useful graduation FAQs. Please note that students should apply for graduation only if they believe they will have satisfied all degree requirements by the end of the term in which they have applied. In addition, students must have completed at minimum of 100 units in order to apply for graduation and walk during the commencement ceremony.

Note: SFSU Registrar policy allows students to apply for graduation, indicating the Spring or Summer Graduation dates on the graduation application, by Feb 15, 2008, in order to walk during the May 2008 commencement. The student must complete the "in progress" courses during the semesters indicated. You cannot submit your graduation application for approval (to walk in the May Commencement) if you have units remaining in the Fall Semester. If the student does apply for graduation, and does not complete the required units, the graduation application will be denied until the completion of the remaining courses for the degree. The student will be required to re-apply for graduation when the units are completed (SFSU Registrar deadlines).

- student must meet with the Biology Advisor and bring the following:
• a Department of Biology Graduation Checklist filled out prior to meeting with the advisor
• the Graduation Application, with the majors course work listed in the same order the classes appear in the Biology Major descriptions listed in the Graduation Checklist
• a copy of his/her unofficial SFSU transcripts
• a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
• current course enrollment
• signed Department of Biology Equivalency and Substitution forms for necessary course work
  ○ Blank Department of Biology Equivalency and Substitution forms may be obtained from the
    Department of Biology Office (Franciscan Building) or may be downloaded from the links
    below.
  ○ The Equivalency forms are used to obtain permission from your major advisor to use an off-
    campus course as part of your major program. You must consult with a major advisor well in
    advance to discuss every single class in the major that you take at another college, including
    courses in math, chemistry, biology, and physics. The transfer course must first be accepted
    by the University for credit (ASE/DARS). Once a course has been deemed equivalent, the
    student must fill out the Department of Biology Equivalency Form (download here, or pick up
    at Department Office), obtain the approval of the Biology Advisor, and submit the form to the
    Department of Biology for approval by the Chair of the Department. This process is
    necessary because the University approved-transfer of the course to SFSU does not
    guarantee that the course will be accepted for the major. It is recommended that the
    EQUIVALENCY FORMS be filled out sooner than later--do not wait until graduation to get the
    equivalency forms approved.
  ○ The Substitution forms are used to obtain permission from your major advisor to use an
    SFSU upper division Biology course as an approved upper division elective if the course is
    not specifically listed in the official elective list for the major. The student must fill out the
    Department of Biology Substitution Form (download here, or pick up at the Department
    Office), obtain the approval of the Biology Advisor, and submit the form to the Department of
    Biology for approval by the Chair of the Department. In general, the student should consult
    with a Biology Advisor for approval of the substitution PRIOR to taking the course. It is
    recommended that the SUBSTITUTION FORMS be filled out sooner than later--do not wait
    until graduation to get the substitution forms approved.

Note:

• Courses transferred into the major must be listed as they appear on the transcript from the transfer
  institution.
• Upper division GE courses are not generally allowed as upper division electives. In some cases,
  one course can be used if it is appropriate to the student's career/educational goals.
• The graduation petition must be signed by the Biology Advisor and by the Chair of the Department
  of Biology. After obtaining the Advisor's signature, the student drops off the petition at the
  Department of Biology Office where it will be reviewed (the student does not need to meet with
  the Chair of the Department). Note that the transcripts and Department forms must accompany
  the application.
• After the petition has been reviewed and approved, the student is responsible for picking up the
  petition from the Department Office and taking it to the Administration Building to pay the
  graduation application fee or to the One Stop Student Services Center.
To obtain Advanced Placement Exam Credit in the Department of Biology

Students may receive credit towards the lower division requirements for the major with the appropriate scores on Advanced Placement Exams. It is up to the discretion of the Chair of the Department whether the AP exam credit will be accepted for the major (this applies to all lower division requirements for the major).

For the Department of Biology, a Biology AP exam score of 4 or 5 in general will be accepted towards the Biol 230 requirement. Advanced Placement Exam Credit appears on the ASE. Note that the restrictions for double counting also apply towards the AP exam credit: a maximum of 12 units may be double counted between the GE requirements and the major requirements. If a student wishes to apply AP exam credit for the degree, the student must consult the Biology Advisor and the Chair of the Department.

10 Organic Chemistry requirement: Chem 130 or Chem 333?

All Biology degrees require completion of at least one semester of Organic Chemistry. Most of them require the lower division Organic Chemistry I lecture, Chem 130. However, the Microbiology B.S. and the Cell & Molecular Biology B.S. degrees require the upper division Organic Chemistry I lecture, Chem 333 (as well as the second semester Organic Chemistry II lecture, Chem 335). A biology course lists Chem 130 as a prerequisite, Chem 333 is acceptable in lieu of Chem 130. Students may elect to take the upper division Chem 333 instead of Chem 130. The student must file a Department of Biology Equivalency Form (pdf) to indicate this change.

Pre-health profession students should note that the upper division Organic Chemistry I and II with labs (Chem 333/334/335/336) are considered part of the minimal science requirements for applying to the health profession programs (including medical school, veterinary medicine, dental school, pharmacy school).

11 Obtain approval to take a course at SFSU Consortium campuses (including UCSF and UC Berkeley) for major credit

SFSU students may wish to take advantage of the SFSU cooperative programs with UCSF, UC Berkeley, or other institutions that participate in the San Francisco Consortium.

In general, during the regular sessions (summer and winter sessions and extension classes excluded) a matriculated, full-time SFSU student may take up to one course per semester at an SFSU consortium campus on a space available basis if they are unable to take the equivalent course at SFSU. The instructor of this non-SFSU course must be willing to accept the SFSU student. The SFSU student must have SFSU Biology Department approval (Faculty Advisor and Department Chair) and SFSU registrar approval. The specific requirements are outlined in the SFSU Bulletin and the appropriate enrollment forms below.
Detailed information is available in the SFSU Bulletin:
Special Enrollment Programs information (http://www.sfsu.edu/~bulletin/current/spenroll.htm)
Forms for enrollment in special programs (consortium enrollment, cross enrollment at California
Community Colleges or CSU campuses or cross registration at UC Berkeley) are available at:
Special Enrollment Programs Forms (http://www.sfsu.edu/~admisrec/forms/formstoc.htm#special)

>return to top of page
Mathematics and Science Teacher Education Program

What is MASTEP?

The MASTEP Collaborative is a five year systemic project to improve mathematics and science teacher education in the greater San Francisco Bay Area. Funded primarily by a 5.5 million dollar grant from the National Science Foundation, MASTEP officially began on July 1, 1996. This Collaborative effort is a partnership between institutions of higher education, selected K-12 schools, participating industries, and many informal education institutions. Our main offices are located in Room 213 of Duncan Hall of Science at San Jose State University, with a branch office at San Francisco State University. In addition to these two premiere teacher preparation universities, four Community Colleges are also integral members of the MASTEP Collaborative: City College of San Francisco, College of San Mateo, Evergreen Valley College, and San Jose City College.

The Collaborative activities can be separated into three main components:

1. Development of innovative and highly effective coursework in math and science
2. Increase recruitment of more people into science and mathematics teaching at K-12 levels through Future Teacher Clubs and interaction with professional development sites.
3. Formation of a network of local K-12 schools that will participate in the education of our future teachers
4. A support network and professional development program for our newly
graduated math and science teachers

Other partners in MASTEP are informal education institutions and sponsoring industries, which are providing expertise and resources to the project. These include the Tech Museum of Innovation, The Exploratorium, NASA Ames Research Center, Lawrence Livermore National Laboratory, Intel, Digital, Sega, and Genentech.

MASTEP provides many services to future math and science teachers, including financial support in the forms of scholarships and paid internships, state-of-the-art multi-media training, summer training and employment opportunities, and personal mentoring by an outstanding local teacher. If you want to be a math or science teacher, the MASTEP programs are the places to be in all of Northern California.

TOP

MASTEP / SFSU
Mathematics and Science Teachers Education Program

home | course development projects | resources | faculty development workshops | technology workshops | fall 1999 faculty development workshops | conferences | future teachers club | k-12 professional development sites

Questions or comments about the site? fiar@sfsu.edu
Mathematics and Science Teacher Education Program

The Future Teachers Club is an Associated Students organization on the SFSU campus which gives support to future teachers in all disciplines, but specializes in math and science.

The Future Teachers Club offers monthly meetings featuring dynamic guest speakers and seasoned educators, internship opportunities for early field experience, social events, opportunities to network with your peers and meet area educators, and scholarships.

Fall 1999 semester calendar of events

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 29</td>
<td>1-2:30 pm</td>
<td>Blakeslee room</td>
</tr>
<tr>
<td>Oct. 2</td>
<td>1-2:30 pm</td>
<td>Kayaking in Elkhorn Slough</td>
</tr>
<tr>
<td>Oct. 13</td>
<td>5-6:30 pm</td>
<td>Hensil Hall room 501</td>
</tr>
<tr>
<td>Oct. 27</td>
<td>1-2:30 pm</td>
<td>Hensil Hall room 501</td>
</tr>
<tr>
<td>Nov. 3</td>
<td>5-6:30 pm</td>
<td>Hensil Hall room 501</td>
</tr>
<tr>
<td>Nov. 22 or 23</td>
<td>1-2:30 pm</td>
<td>TBA</td>
</tr>
<tr>
<td>Dec. 1</td>
<td>1-2:30 pm</td>
<td>TBA (ADVISING DAY)</td>
</tr>
</tbody>
</table>

If you are interested in attending the meetings or activities, please contact us at mastep1@sfsu.edu or (415) 338-6459.

Please check this web site for updates.

Other MASTEP COLLABORATIVE Future Teachers Clubs:

<table>
<thead>
<tr>
<th>School</th>
<th>Faculty Advisor</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Jose State University</td>
<td>Jim Paolini</td>
<td><a href="mailto:jpaolini@biomail.sjsu.edu">jpaolini@biomail.sjsu.edu</a></td>
</tr>
<tr>
<td>City College of San Francisco</td>
<td>Ron Drucker</td>
<td><a href="mailto:rdrucker@ccsf.cc.ca.us">rdrucker@ccsf.cc.ca.us</a></td>
</tr>
<tr>
<td>San Jose City College</td>
<td>Wilbur Mellema</td>
<td><a href="mailto:mellema@sjeccd.cc.ca.us">mellema@sjeccd.cc.ca.us</a></td>
</tr>
<tr>
<td>College of San Mateo</td>
<td>Barbara Uchida</td>
<td><a href="mailto:uchida@smccd.cc.ca.us">uchida@smccd.cc.ca.us</a></td>
</tr>
</tbody>
</table>

http://userwww.sfsu.edu/~mastep/ftc.html
Evergreen Valley College  Mike Masuda  masuda@webnexus.com

TOP

MASTEP / SFSU
Main Office - SJSU
Mathematics and Science Teachers Education Program

home | course development projects | resources | faculty development workshops | technology workshops | fall 1999 faculty development workshops | conferences | future teachers club | k-12 professional development sites

Questions or comments about the site? fnrc@sfsu.edu

http://usenwww.sfsu.edu/~mastep/ftc.html
Center for
Science and Mathematics Education

San Francisco State University's Center for Science and Mathematics Education has been established to address the nation's lack of high quality scientific, technological, engineering and mathematics professionals. The Center's intent is to:
- recruit, prepare, and support good science and mathematics teachers;
- foster research into science and mathematics education and promote its application; and
- establish a community of science and mathematics education scholars, practitioners, and students.

The Center has been established on the premise that communication and interaction among science and mathematics educational researchers, teachers who train and support in-service and future science and mathematics teachers, and those who teach science and mathematics at all education levels will generate greater advances in science and mathematics than individual efforts in any one of these areas. To this end, the Center facilitates collaboration among faculty in the Colleges of Education and Science and Engineering, supports the development of innovative science and math curricula and pedagogy, and sponsors programs to disseminate developments in science and mathematics education. The Center provides a lending library of equipment and supplies for local K-12 science and math teachers, and provides a focus for the growing community of science and mathematics educators, including students, teachers and other interested parties. The Center also facilitates the integration of partnership and outreach activities into courses offered by the University, with the intention of inspiring more undergraduates to become committed science and mathematics teachers, and to improve the proficiency of current science and mathematics instructors and faculty, increasing the educational opportunities available to science and mathematics students at every level.

Funds and plans to establish the Center were approved by President Corrigan and Provost and Vice President Gemello in August 2006 in response to a request from faculty in, and the Deans of, the Colleges of Education and Science & Engineering. We invite you to explore our site to learn more about the activities of the Center, and to join our efforts, or to contribute to our work in any way you can.

- CSMF's Mission Statement
Contact Information

Jamie Chan  jmchan@sfsu.edu
Jan Mokros  jmokros@sfsu.edu
Ray Trautman trautman@sfsu.edu

The CSME is a collaboration of the CoE and the CoSE.
College of Education

College of Science & Engineering
Math and Science Teaching Initiative (MSTI) Fellowship Program for Spring 2008

We are excited to announce a new funding opportunity for SFSU undergraduate students who are considering becoming a middle- or high-school math or science teacher, and for current math and science credential-program students.

As a Fellow in the Math and Science Teaching Initiative, you will receive:

- A $2,000 stipend for the Spring 2008 semester
- Continued funding of $2,000 each semester you are a Fellow
- Extra advising and mentoring about pathways into science and math teaching
- Opportunities to meet with other Fellows and advisors two or three times a semester
- Support for meeting requirements for math/science teaching credentials
- Assistance in applying for additional scholarships
- Access to special teaching opportunities

Application Procedure

Applications are available from the CSME office, SCI 211, or online here: msti_application.doc (MS Word document) or msti_application.pdf (Acrobat PDF document).

For more information, call Dr. Jan Mokros, at 415-405-4092, or send her an e-mail message at JMokros@sfu.edu.

The application deadline is November 30, 2007.
The CSME is a collaboration of the COE and the COSE.
College of Education
College of Science & Engineering
MSTI Fellowship Program
Mathematics and Science Teaching Initiative
Spring Semester, 2008

Sponsored by the Center for Science and Mathematics Education
San Francisco State University

Application Information

We are pleased to encourage applications for MSTI Fellowships, to be awarded to students who are pursuing careers in mathematics or science teaching at the 6th - 12th grade levels. Students who are sophomores, juniors, seniors, or enrolled in the post-baccalaureate teaching credential program are eligible to apply. You must be majoring in or have a degree in a mathematics or science area (physics, biology, chemistry, geosciences, engineering, or computer science.)

Students who are selected for the Fellowships will receive $2,000 per semester for a period of up to three years ($12,000 total). Fellowships are based on merit, and are not dependent upon financial aid status. Fellows will:

- Meet together two or three times per semester to learn about pathways and opportunities for mathematics and science teachers;
- Receive mentoring and special advising from staff at the Center for Science and mathematics Education, professors in the College of Science and Engineering and the College of Education;
- Participate in an average of one hour per week of teaching activities per semester, in a range of school and out-of-school settings;
- Receive assistance in applying for special scholarships and summer internships;
- Participate in one teaching conference per year.

To apply, complete the application form and supporting materials and return these to SCI 211 by November 30, 2007. Those selected as finalists will be invited for a 20-minute interview between December 5th and 14th.

The completed application should include:
- Data form (attached)
- Transcripts for the last two years (or one year, if applying as a sophomore)
- Personal statement, not to exceed two typed pages. Indicate your previous experience with 6-12th grade students, if any, and discuss your future career goals.
- Résumé

Have questions or need help with your application?
Call Jan Mokros at 415-405-4092 or e-mail JMokros@sfsu.edu.
SFSU MSTI 2007-2008 Fellowship Data Form – Page 1 of 2

1. Name: ___________________________________________       First       MI

2. SFSU ID: ___________________________________________

3. Preferred Phone: (    ) ____________________________

4. School Address:
   Street
   City  State  Zip

5. Permanent Address:
   Street
   City  State  Zip

6. Email: ____________________________________________

7. Major: [ ] Math  [ ] Science  [ ] Engineering  [ ] Other

8. Current Status: [ ] Freshman  [ ] Sophomore  [ ] Junior  [ ] Senior

   [ ] Credential  [ ] Other

9. Cumulative GPA: _______

10. Career Goal: [ ] Middle School Teacher  [ ] High School Teacher

    [ ] Undecided  [ ] Other ____________________________

11. Current Degree/Credential Program: _______________________

    Estimated Completion Date: __________________
    Month/Year
SFSU MSTI 2007-2008 Fellowship Data Form – Page 2 of 2

12. References:
List two references and telephone numbers of individuals who are acquainted with your academic achievements and your potential success as a teacher. These individuals will be contacted if you are chosen as a finalist.

1. Name: ___________________________ Title: ___________________________
   Address: ___________________________ Telephone: ___________________________

2. Name: ___________________________ Title: ___________________________
   Address: ___________________________ Telephone: ___________________________

13. Certification:
I understand that the above information is voluntary and will be used for scholarship award eligibility and selection.

I affirm that the information provided is true and complete to the best of my knowledge.

I hereby give the MSTI Scholarship Selection Committee permission to release the above information at the discretion of the Committee.

_____________________________  ______________________________
Signature of Applicant          Date

For additional information, please contact:

Jan Mokros, Ph.D.
Director of Center for Science and Math Education
San Francisco State University
1600 Holloway Avenue, Science 211
San Francisco, CA 94132
Phone: 415-405-4092
Email: jmokros@sfsu.edu

Remember to attach:
1. Transcripts form the last two years (or one year, if applying as a sophomore)
2. Personal statement, not to exceed two typed pages (double-space). Indicate your previous experience with K-12 students (if any) and discuss you future career goals.
3. Resume
4. Turn in at SCI 211

DEADLINE: November 30th, 2007

00078
The Student Resource Center Mission

The purpose of the College of Science and Engineering Student Resource Center is to support students in achieving their educational objectives. We assist students with General Education, University graduation requirements, academic probation issues, troubleshooting academic problems, pre-major advising, and career advising. The Center works with the College departments and SFSU's Advising and Career centers to support students in successfully obtaining an undergraduate degree from the College.

Get help with:

**General Education Advising**

To help students understand the G.E. program requirements and to select appropriate courses to meet these requirements. This will enable students to complete G.E. in a timely manner.

**Graduation Preparation**

To help students understand the University regulations for graduation, so that they can graduate in a timely manner. We assist students review graduation checklists.

**Probation Advising**

To help students develop strategies for getting off probation and having a successful educational experience. When useful, we refer students to appropriate campus support services. We review probation contracts with students after the major advisor and department chair has signed their contracts.

**Troubleshooting**

To assist students understand University regulations and policies, and to guide them in the
submission of petitions and paperwork. If appropriate, we provide advice on study skills improvement and suggest potentially helpful University resources such as counseling, financial aid, tutoring, etc.

**Pre-major Support**

To advise students interested in careers in engineering, mathematics, or science, but who have not determined the best area for themselves. For these students we help clarify academic and career goals and help them select a major compatible with those goals. We refer students to major field advisors in the departments for more detailed information about specific degree programs and career opportunities.

**Change-of-major Support**

To support students considering changing their major with information on College programs and referrals to program advisors.

**Career Advising**

To support the departments and the Career Center in their efforts to provide career advising.

E-mail: cosesrc@sfsu.edu -- Phone: (415) 405-3955 -- Science Building, Room 247

This page was last modified on May 2007

San Francisco State University
Career Planning

Do you need help with career planning? Do you ask yourself...

- What might be the most effective career choice for me?
- How do I research careers in science, computers, mathematics, and engineering?
- How do I find a job?
- Are internships useful for future jobs?

Laura Carter is the person to see! She is the Career Counselor specifically for students in the College of Science and Engineering. Laura has an extensive background in counseling, coaching, and training individuals and groups of all ages to make career decisions based on values, skills, and interests. She holds a graduate degree in Career Development from John F. Kennedy University.

Visit Laura at these locations:

- **Student Resource Center** (SCI 247)
  Wednesday 12pm - 2pm

- **Career Center**, Student Services Building, Room 256
  Thursday 11am - 1 pm

Drop-in counselors are available between 11am-1pm Mon-Fri at the Career Center (Students Services room 206)
Drop in for quick answer or quick resume critique. **Or make an appointment** for longer discussion. Contact Laura Carter at 338-1762, lcarter@sfsu.edu or the SRC at 405-3955.

**Laura Carter will help you:**

- **Assess your interests, skills and values** so you can focus on the most effective career choice for you.
  - **Research careers** in science and engineering using videos and the Internet. She will help you answer questions such as:
    - What do I do with my major?
    - What is the future in this industry?
- **Develop Job Search Strategies.** You'll learn about:
  - Networking and informational interviewing
  - Revving up your resume
  - Acing that interview
  - Conducting a professional job search
  - Negotiating your salary
- **Learn about internships**
  - How important are they?
  - How do I find one?
  - How do I succeed at an internship?
  - Career Center internship information

**Career Center resources for finding employment:**

- **MonsterTRAK** Call 338-0161 for password.
- **Career Center Binders** in SSB 206
- **Student Job Search Handouts** from the Career Center website such as career fair announcements, on-campus interviewing schedules, and MonsterTRAK listings (call 338-0161 for password)

E-mail: cosesrc@sfsu.edu  --  Phone: (415) 405-3955  --  Science Building, Room 247

This page was last modified on Sept 20, 2005

San Francisco State University
GE Requirements

SFSU General Education Program

The description of the GE Program can be found in the:

- SFSU Class Schedule booklet. Starting on approximately page 165. (Varies from semester to semester.)

- SFSU Bulletin. Buy copy or look on-line: Online SF state Bulletin

NOTE: Engineering students follow a slightly different GE Program. Obtain a copy from the School of Engineering, (SCI 163)

How to Plan Your GE Program:

Talk to your friends? Sometimes it is good advice. Most times it is BAD ADVICE. You'd be doing yourself a favor by talking to your departmental advisor instead:

<table>
<thead>
<tr>
<th>Department</th>
<th>GE Advisor</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>Contact Dept. Office</td>
<td>Franciscan Bldg</td>
</tr>
<tr>
<td>Chemistry &amp; Biochemistry</td>
<td>Palmer, P.</td>
<td>TH 730</td>
</tr>
<tr>
<td>Computer Science</td>
<td>Singh, R.</td>
<td>TH 969</td>
</tr>
<tr>
<td></td>
<td>Dujmovik, J.</td>
<td>TH 946</td>
</tr>
</tbody>
</table>
Before You See a GE Advisor:

1. Get official records of your current GE status.
   - Degree Audit Reporting System (DARS) printout. You can obtain these at the One Stop Student Services Center for a small fee.
   - Advanced Standing Evaluation (ASE). This printout is only for transfer students coming from 4-year or out-of-state community colleges. Transferrable credit from most California community college will automatically appear on your DARS report.

2. Get a GE worksheet.
   - Engineering students get worksheet from School of Engineering office, SCI 163
   - All other students use worksheet from end of SFSU Class Schedule booklet.

3. Fill out the worksheet the best you can.

4. Organize theses records in a file folder.

5. Bring the folder with you when you see your GE advisor.

E-mail: cosesrc@sfsu.edu -- Phone: (415) 405-3955 -- Science Building, Room 247

This page was last modified on May 2007

San Francisco State University
CREDENTIAL SERVICES TEACHER PREPARATION CENTER

CSTPC
Location  Burk Hall 244
Phone #  415-405-3594
Fax #  415-338-1940
Email  credinfo@sfsu.edu
Website  http://www.sfsu.edu/~cstpc

ANNOUNCEMENTS
- SB 2042
- Limited Foreign Language Openings in Single Subject Program

Financial Aid Information
Click Here for Details

Calendar

Prospective Students
Apply
Programs
Information Meetings
Forms and Links
FAQ

Credential Processing Services
SFSU Credential Students
Non-SFSU Credential Students
Credential Processing Forms & Links

Exit Surveys
Click here to fill out your exit survey
- Once you click on the link,
- Select "Guest Account"
- Click on 'Login' button to begin survey
- Click here to begin

The Credential Services Teacher Preparation Center provides credential services available through San Francisco State University. In addition, our credential analysts are the university's liaison between SFSU and the California Commission on Teacher Credentialing.

Office Hours
Monday - Thursday:
10:00am - 12:00pm
1:00pm - 4:30pm
Friday:
1:00pm - 3:00pm

Mailing Address
Credential Services/Teacher Prep Center
College of Education
San Francisco State University
1600 Holloway Ave
San Francisco, CA 94132

http://www.sfsu.edu/~cstpc/
Notes for Nan on Bio 355
10/12/2004

Nan,

You can abstract from these notes as needed.

We consider ethics at frequent intervals throughout the course. The textbook offers short segments on bioethics in most chapters. We integrate discussion extensives. Most examples we stress are bioethical issues, like genetic testing, the consequences of knowing one’s genetic future, and the possibility of gene therapy. In discussing recombinant DNA technology, we also consider whether or not scientists should do work just because they can. In the area of ethical issues in the practice of science, we talk about the idea Mendel may have fudged some of his data. I encourage students to present their opinions of current issues in the press. One example of textbook coverage is the “Genetics and Society” section on page 142. In addition, there are thought questions about ethical and social issues at the end of many chapters.

I stress the multicultural nature of human genetics, paying attention to gender and ethnic differences as well as the broad representation of ethnic groups and genders among practicing geneticists. E. E. Just and Barbara McClintock are two good examples. I also explain how mutations can be used as a means of tracing population histories, and how certain genetic conditions are more common in some populations (ethnic groups) than in others, partly as an adaptation to environmental challenges these groups have faced in the past. Prominent examples include the high frequency of sickle cell anemia in African Black populations, and of hereditary breast cancer in Eastern European Jews. Response to drugs also differs because of genetic polymorphisms influencing drug metabolism; one example is the response of Black as compared with Asian children to the asthma medication, albuterol. We thus cover not only the diversity of scientists, but health disparities related to genetics as well.

Although some facts of genetics are presented in a purely didactic manner, most are presented in the context of experimental findings. I stop in class and ask students to help with the interpretation of experiments, although the opportunities to do this in a class of 60-120 students is often limited. Exams involve the interpretation and analysis of experimental data.

Some sample exam questions:

Q6. 20 Points.
Experiments by Griffith using virulent (S) and nonvirulent (R) strains of bacteria showed that there was a "transforming principle." Subsequent work by Avery, McCleod and McCarty showed that this transforming material was DNA. Explain these experiments.

Q7. 20 Points
S. Benzer crossed two rII mutant strains that had mutations within the same cistron. He obtained 10,000,000 plaques on E. coli B, but only 500 on E. coli K. What is the map distance, in cM, between these two mutations?

Q8. 20 Points
Mutations isolated in two separate laboratories and named clueless and dunce lead to a similar phenotype of abnormally small brains in Drosophila. When a homozygous clueless mutant is mated to a homozygous dunce mutant, the F1 offspring aren't too bright either, having small brains.

Are the two mutations in cis or in trans in the F1 progeny? Explain or illustrate your answer.

Are clueless and dunce in the same or in different cistrons? Explain.

Give a biochemical interpretation to the statement that mutations are in the same or in different cistrons.

Question 19. 15 pts.
A 24-year-old woman has had two children; both had the typical phenotypic characteristics of Down syndrome. She is considering a third pregnancy, and she wants your advice concerning her chances of having a third child with Down syndrome. (A) What would you tell her? (B) Would you suggest further medical testing? (C) If so, what test would you suggest and what could you expect to learn from it? (D) What is your best guess at the chances that her next child will have Down syndrome?
Accessibility at SF State

San Francisco State University is a university dedicated to accessibility. To that end, a number of projects and initiatives are underway to ensure that everyone at SF State is allowed equal and complete access to all that SF State offers. A wide range of people coming to San Francisco State University in differing capacities necessitates a strong commitment to improved access and flexibility. This commitment will shape the way the University serves its students and delivers academic programs; the access to resources it provides its employees; and the efforts it makes to meet the needs of the community by providing educational and other services to a wide audience.

From the San Francisco State University Strategic Plan, 2005 page 16 Read the University Strategic Plan Online on the Academic Planning and Educational Effectiveness Web Site

Accessibility Related Services on Campus

ACCESS: Accessible Technology Initiative

ACCESS: Accessible Technology Initiative (ATI) is SF State’s commitment to ensuring full and equal access to electronic and information technology to individuals with disabilities. The ACCESS taskforce is responsible for developing a work plan and providing guidance and resources to assist the campus-at-large in and is a reflection of the University’s ongoing commitment to equity and social justice.

Visit the ACCESS Web Site

Universal Design for Learning

Universal Design for Learning (UDL) is a process of making course concepts accessible and skills attainable regardless of learning style, physical or sensory abilities. SF State has

http://ctfd.sfsu.edu/accessibility-at-sf-state.htm
joined grant originator Sonoma State and others as a partner campus in the EnACT (Ensuring Access through Collaboration And Technology) grant from the Department of Education.

Visit the Universal Design for Learning Page on the CTFD Web Site

Disability Programs and Resource Center

The Disability Programs and Resource Center (DPRC) "provides the university with resources, education and direct services in order that people with disabilities may have greater opportunity to achieve social justice and equity."

Visit the Disability Programs and Resource Center Web Site

All-University Committee on Students, Faculty and Staff with Disabilities

The All-University Committee on Students, Faculty and Staff with Disabilities (AUCSFSD) assists academic and non-academic programs with researching and developing policies and resources for faculty and staff training relative to meeting the needs of the disabled community.

Visit the All-University Committee on Students, Faculty and Staff with Disabilities Page on the DPRC Web Site

Return to top of the Document

University Accomplishments and Milestones

Offered faculty workshops on Universal Design for Learning
Created Faculty Learning Communities that apply Universal Design for Learning
Offered workshops and support on using Accessible Instructional Material (AIM) such as Turnitin and DIVA
Launched the FIPSE funded ELIXR faculty project wherein digital case stories illustrate UDL best practices
Established a President's Task Force on Accessible Electronic and Information Technology
Completed first-year Web assessment
Secured over $200,000.00 for funding Accessible Technology Initiatives
Created new staff positions, including Information Access Specialist, Accessibility Technology Trainer, Disability Access Compliance Analyst
Restructured DPRC and created the Assistant Director for Information Access Services
Conducted base-line assessments of all campus web sites in the A-Z directory
Recruited over 20 staff members to serve as Electronic and Technology Advisors for procurement
Developed a branding plan for the Accessible Technology Initiative
Provided extensive consultation and technical assistance to enterprise level projects such as SF State Careers and online voting
Strengthened collaboration between disability services and the SFSU Bookstore
Developed a plan for captioning new and existing media in university collections
Approved the Senate policy on the timely adoption of course materials in order to allow adequate time for professors to secure diversely formatted materials
Home
San Francisco State Accessible Technology Initiative

In the fall of 2006, San Francisco State University (SFSU) launched the Accessible Technology Initiative (ATI) in order to develop a work plan, guidance, and resources to assist the campus-at-large in ensuring full and equal access to electronic and information technology to individuals with disabilities. The SF State ATI is a reflection of the University's ongoing commitment to equity and social justice.

CSU Policy, Federal and State Laws

This commitment is informed by the California State University (CSU) Board of Trustees Policy on Disability Support and Accommodations, Executive Order 926 (EO 926):

"It is the policy of the CSU to make information technology resources and services accessible to all CSU students, faculty, staff and the general public regardless of disability."

The CSU issued a coded memorandum to provide campuses with a direction for implementing EO 926. The coded memorandum sets forth the roadmap for ensuring accessibility of information technology and resources in compliance with federal and state laws and CSU policy.

Coded Memorandum AA-2007-04 - Access to Electronic and Information Technology for Persons with Disabilities - PDF

Download the free Acrobat Reader.

EO 926 and the Coded Memorandum are premised on federal and state laws including but not limited to Section 504 of the 1973 Rehabilitation Act; the Americans with Disabilities Act of 1990; Section 255 of the Telecommunications Act of 1996; and California Government Code 11135 of 2003 which applies Section 508 of the Rehabilitation Act as amended in 1998 to the CSU.

On April 2, 2007, President Corrigan reiterated the University's commitment to access for all individuals in a letter e-mailed to all University faculty and staff. His message highlights how the University is further addressing disability access issues with respect to the changing information landscape.

Read President Corrigan's letter - Word document

Download the free Word Viewer

Primary Elements of the SF State Accessible Technology Initiative

Vision: To create a culture of access for inclusive teaching, learning and working environments.
Mission: To assist the campus in carrying out EO926 implementation by developing policies, procedures, best practices, tools, and, most importantly, an informed campus community.

Principle: To apply universal design (an approach to the design of products and services to be usable by the greatest number of people including individuals with disabilities).

Strategy: To stimulate cross-campus collaborations to effect changes that will ultimately benefit all.
Accessible Technology Initiative

Instructional Materials

Introduction

The CSU is committed to ensuring that all campus Information Resources and Technologies are fully accessible for persons with disabilities. This commitment reflects a goal to provide the most effective learning environment for all students—rather than simply to ensure compliance with various federal and state laws.

Instructional Materials (IM) are considered to be forms of communication and must therefore be delivered in a manner that is equally effective for persons with disabilities. Communication is considered to be equally effective when it is:

- comparable in quality to those received by students without disabilities
- comparable in timeliness of delivery and availability
- provided in a manner and medium appropriate to the significance of the message and the abilities of the person receiving the material

Policy Development

Each campus is directed to adopt and submit an Instructional Materials Accessibility Plan (IMAP) no later than June 15, 2007. The plan should address, at a minimum, the specific actions to be taken by the campus for the following areas:

- Timely adoption of textbooks by faculty
- Ensuring textbook selection/ordering for courses with late-hired faculty
- Early identification of students with disabilities who require modified instructional materials
- Use of the campus learning management system both for delivering technology-enabled course content, and for posting syllabi and instructional materials in both traditional and hybrid courses
- Incorporation of accessible E&IT procurement requirements when purchasing instructional materials (e.g. transcripts for audio, captions for videos)
- Alignment of academic technology resources to assist faculty in the creation of technology-enabled courses
- Communication and training processes to educate students, staff, and faculty about the campus IMAP
- Identification of specific roles and responsibilities for responsible parties
- Identification of an evaluation process (including milestones and timelines) to measure the effectiveness of the plan

A comprehensive set of IMAP guidelines will be developed in consultation with IM campus representatives during Winter, 2007 and released in early Spring, 2007. These guidelines will provide greater clarification on scope of coverage, technical standards, and recommended procedures/tools. In the interim, campuses are encouraged to consider the following factors when developing their IMAP:
Consider each of the unique activities associated with accessible instructional materials (procurement, authoring, delivery, modification, delivery).

Consider the unique accessibility issues associated with various IM formats including, but not limited to paper-based resources (e.g. textbooks), electronic resources (e.g. Learning Management Systems files), and multimedia (e.g. streaming audio/video).

Consider the communication issues associated with coordinating the procurement, authoring, and delivery of IM across diverse campus groups (e.g. Faculty, IT staff, Library staff, support staff, vendors).

Consider the capacity-building issues associated with training large numbers of people on your campus—including the issue of wide variations in technical interest and background.

Consider the manner in which the campus will address significant differences in financial and technological resources between State and non-State entities (University foundations, contractors, vendors, etc.)

**Timelines**

**June 15, 2007:** Draft submission of the campus Instructional Materials Accessibility Plan (IMAP)

**July 1, 2007:** Campuses will implement the IMAP provisions related to timeliness of alternate formats for print-based instructional materials such as those reflected in points #1 to #4 of Coded Memo AA-2007-04. These provisions should impact the timeliness of materials for the first academic term of Calendar Year, 2008.

**Fall Term, 2008:** New courses and new course content, including instructional materials and instructional websites, will be designed and authored in a manner that incorporates accessibility. If incorporating accessibility is not possible or would constitute an undue burden, then a plan to provide an equally effective alternate form of access must be developed, documented, and communicated. Existing course content will be made accessible at the point of course redesign or when a student with a disability enrolls in the course.

**November 15, 2007:** Final submission of the campus Instructional Materials Accessibility Plan (IMAP)

**Fall Term, 2012:** Instructional materials and instructional websites for all course offerings will be accessible. Once again, undue burden plan requirements (as described above) apply.

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Deborah Kaplan
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http://calstate.edu/accessibility/instructional/materials/index.shtml
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Email: seo@sfsu.edu

Last updated: November 13, 2007
Helping Minorities Succeed in the Sciences

by Charles Brigham

After spending over thirty years conducting laboratory experiments, San Francisco State University microbiologist Dr. Frank Bayliss decided to take on a different type of experiment: the Student Enrichment Opportunities Program (SEO), designed to improve the future of minorities in science.

"The ultimate goal of our programs is to take a non-traditional pool of students and get them into Ph.D. programs at the best institutions," he says. This non-traditional pool represents African American, Native American, Hispanic American, Pacific Islander, and other masters and bachelor students in the sciences bound for Ph.D. programs after SFSU. "It's not just getting them into third rate schools, it's getting them into first rate schools."

Bayliss and six staff members operate the SEO out of a small office in the SFSU Sciences building. He, along with other SFSU teaching and administration faculty, encourage students to ignore traditional barriers and pursue their interests in the sciences. As director, Bayliss oversees several programs in the SEO aimed at raising the number of minority students in prestigious Ph.D. programs.

As to how he came to take on such a responsibility, Bayliss says, "I had a grandfather who was a socialist who had a lot of axes to grind after losing everything in the depression. My grandfather wanted people to have opportunities that were denied to him, and I didn't realize he had such a large influence on me."

Bayliss himself represents a story of great academic accomplishment. Raised in Watts, Los Angeles, he came from a low-income family that lived in substandard housing. He worked, attended school and experienced obstacles similar to the ones minority students confront today.

"Students should not be judged on their ability to learn based solely on their GPA", says Bayliss, "Many other components of their life must be considered, such as their job and living situation." Many students have tremendous difficulty keeping life outside of school in order, which can interfere with their academic studies.

A student may come to the SEO with a 2.2 GPA overall and maybe a slightly higher GPA in their major. Bayliss and his staff work with a student to see what in their life may be keeping them from doing better work. "I am in essence a horse trainer. You put a 200 pound jockey on a horse, he doesn't run as fast. You put a 100 pound jockey on them and show them how to run, they run." For example, Bayliss describes a student who works thirty hours per week and whose income goes to rent and food. Nothing is left to buy books and supplies and so school suffers. If you lighten a student's load by providing a program where more time is spent on academic pursuits, the student performs better. Grades of students in the program typically jump up a full letter grade.

Janis Allen, a SFSU cellular and molecular biology student was working two jobs while going to school in Texas before she enrolled in the SFSU SEO Research In Science Education program. "Any minority student that wants a secondary degree
A listing of the top 100 degree producers in the nation cited SFSU as having the tenth highest number of bachelor's degrees earned by minorities for the 2001-2002 academic year. This gain accounts for a 15% increase in degree holders over the previous year.

When Bayliss started the SEO program at SFSU in 1992 it had only a few students. Today 120 undergraduate and 52 graduate students are in the program. "Of the students entering Ph.D. programs, none have flunked out of the programs and only a few have left the programs for life reasons," says Bayliss. He uses data from SEO's 12 years of operation to persuade faculty at other institutions to adopt such programs.

Similar programs exist at California State University Los Angeles and New Mexico State University but are not widespread. Major funding for new grants and scholarships comes from agencies such as the National Science Foundation, National Institute of Health, Department of Defense, Department of Energy, and U.S. Department of Education.

The programs provide a voice for minorities in the sciences. "People must be seen as individuals," says Bayliss, "the system is not working and many minorities are excluded or written off early. A more inclusive and equitable academic environment will serve to better education."
Science and Math Supplemental Instruction Program

Overview

The College of Science and Engineering's supplemental instruction program (often referred to as the workshop program) was started around 1999 with funding from the NIH to improve student success in science classes—biology, math, chemistry and physics—by providing focused, high quality interactive learning situations to reinforce students understanding of material presented in the primary lecture courses. Initiated by Prof. Frank Bayliss and colleagues as an integral component of the enrichment and support activities provided by the Student Enrichment Opportunities office at SFSU, the program began as weekly "workshop" sessions that SEO-supported students were required to attend. The program evolved to formal courses, offered under the AU (all university) or SCI (science) prefixes. The courses are currently available to all SFSU students enrolled in the corresponding primary course, on a first-come, first-served basis.

The goal of the program is to provide an environment that enables students to pose questions, examine and explore logical approaches to solve problems and communicate succinct solutions in a comfortable, relaxed environment. The workshop instructors are committed to student success, excited about science and enjoy the thrills of thinking about and solving challenging questions.

To create this environment, each supplemental instruction course is typically composed of a small group of students (max ~20) and an instructor who recently completed the primary course. The structure promotes both good student-instructor interactions and student-student interactions, which are invaluable for learning.

The number of supplemental instruction courses offered has almost tripled from the initial year of operation, to meet student demand. External evaluations of this program have been favorable. The analysis suggests that students who attend the workshops earn a grade in the primary course about one-half grade unit higher than would be predicted from their academic records. There is also evidence that participation in the supplemental instruction program increases student retention (Rath, et. al., 2007; Peterfreund, et. al., 2007)

SCI SI Course Schedules

Spring 2008 SCI SI Course Schedule

Fall 2007 SCI SI Course Schedule

SCI SI Course Instructors:

Are you interested in helping other aspiring science students? Gain teaching experience? Increase your science or math knowledge? Consider becoming a SCI SI instructor! A former instructor writes: I assure you, teaching the SCI courses is an extremely rewarding experience.

To apply, please complete the SCI instructor application (MS Word doc) and return to the CSME office, SCI 211.
References:


Abstract:
Supplemental instruction classes have been shown in many studies to enhance performance in the supported courses and even to improve graduation rates. Generally, there has been little evidence of a differential impact on students from different ethnic/racial backgrounds. At San Francisco State University, however, supplemental instruction in the Introductory Biology I class is associated with even more dramatic gains among students from underrepresented minority populations than the gains found among their peers. These gains do not seem to be the product of better students availing themselves of supplemental instruction or other outside factors. The Introductory Biology I class consists of a team-taught lecture component, taught in a large lecture classroom, and a laboratory component where students participate in smaller lab sections. Students are expected to master an understanding of basic concepts, content, and vocabulary in biology as well as gain laboratory investigation skills and experience applying scientific methodology. In this context, supplemental instruction classes are cooperative learning environments where students participate in learning activities that complement the course material, focusing on student misconceptions and difficulties, construction of a scaffolded knowledge base, applications involving problem solving, and articulation of constructs with peers.


Abstract:
Comparisons between participants and non-participants in supplemental instruction classes at San Francisco State University over a six-year period show positive impacts in terms of increased student performance and progression through subsequent courses in a sequence, despite the lower academic indicators of the supplemental instruction participants. More females participated than were represented in the course as a whole, but the effects were greater for males. Effects were particularly striking for students from underrepresented minority groups, particularly in introductory courses.
The CSME is a collaboration of the COE and the COSE.
College of Education
College of Science & Engineering
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MATH 227  in Trailer P-3  Maoujoudi  abdelhak@sfsu.edu

Thu 4:00 -
SCI 227.02 / 5:30 in Trailer  David
MATH 227  P-4  Reber  dreber@sfsu.edu

Mon/Wed 1:10
SCI 205.01 / 2:00 in SCI  Hezekiel
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Article

Supplemental Instruction in Introductory Biology I: Enhancing the Performance and Retention of Underrepresented Minority Students

Kenneth A. Rath,* Alan R. Peterfreund,* Samuel P. Xenos,* Frank Bayliss,† and Nancy Carnal†

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Supplemental instruction classes have been shown in many studies to enhance performance in the supported courses and even to improve graduation rates. Generally, there has been little evidence of a differential impact on students from different ethnic/racial backgrounds. At San Francisco State University, however, supplemental instruction in the Introductory Biology I class is associated with even more dramatic gains among students from underrepresented minority populations than the gains found among their peers. These gains do not seem to be the product of better students availing themselves of supplemental instruction or other outside factors. The Introductory Biology I class consists of a team-taught lecture component, taught in a large lecture classroom, and a laboratory component where students participate in smaller lab sections. Students are expected to master an understanding of basic concepts, content, and vocabulary in biology as well as gain laboratory investigation skills and experience applying scientific methodology. In this context, supplemental instruction classes are cooperative learning environments where students participate in learning activities that complement the course material, focusing on student misconceptions and difficulties, construction of a scaffolded knowledge base, applications involving problem solving, and articulation of constructs with peers.

UNDERREPRESENTED MINORITY STUDENTS IN BIOLOGY

Students from groups termed "underrepresented"—students who are black, Hispanic, American Indian/Alaska Native, or from the Pacific Islands—are far less likely to get degrees in the biological and biomedical sciences than their peers.

In 2002–2003, the most recent year for which data were available, approximately 61,500 bachelor’s degrees, 7700 master’s degrees, and 5200 doctoral degrees in the biological and biomedical sciences were awarded across all postsecondary institutions in the United States. Of these, approximately 59,900 bachelor’s degrees, 6500 master’s degrees, and 3900 doctoral degrees were awarded to U.S. residents. Figure 1 shows the breakdown of these degrees by racial/ethnic status, as taken from data published by the U.S. Department of Education (2005), compared with the National Center for Evaluation Statistics (2000) data showing the proportion of these groups in the general populace, aged 18–29 years.

A quick look at the figure shows that among U.S. residents, underrepresented minority (URM) students (black, Hispanic, and American Indian/Alaskan Native students) account for 15.3% of bachelor’s degrees, 12.0% of master’s degrees, and only 9.0% of doctoral degrees awarded in the biological and biomedical sciences, compared with 22.9% of the U.S. population between ages 18 and 29, of whom 14.3% were black, 8.1% Hispanic, and 0.5% Native American. If anything, the proportion of individuals from underrepresented minorities in the overall population has increased since the data were collected in the late 1990s (Figobs and Stoops, 2002). Ignoring the minor discrepancy in Native American numbers between the two data sources, probably

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an artifact of differences in determining racial status, it is clear that these students are underrepresented in degrees awarded in the biological and biomedical fields, particularly at the graduate studies level.

This, of course, is not news to most educators: There is a reason why students from these racial/ethnic groups are termed "underrepresented." There are also a number of posited reasons for this. A good overview of the various explanations, about which there is still considerable controversy, can be found in Massey et al. (2002). Without going into detail here, it can be said that the explanations for why URM students do not complete degrees in the sciences (or in other fields) at a rate as high as their non-URM peers are complex and multidimensional. However, for our purposes, we focus only on those explanations that are addressable through interventions such as supplemental instruction (SI). From Massey et al. (2002), these explanations are as follows:

1. URM students come from backgrounds where, for whatever reason (and there are several hypothesized reasons), they are less likely to have access to the knowledge and skills necessary for navigating the college environment.
2. Students from socioeconomically disadvantaged backgrounds and lower-quality schools are less likely to have the content knowledge and rigorous course work from high school to support success in college. URM students are more likely to come from such backgrounds than their non-URM peers.
3. Because of internalization of stereotypes, URM students often believe that they are not likely to succeed, regardless of their ability level.
4. URM students are less able to find a niche for themselves in college and are thus less inclined to stay in the face of hardship.

Likely, URM underperformance is the result of these and other factors working in parallel. The collective consequence is that URM students are less likely to pursue a college education, and, when they do, they are less likely to succeed (National Center for Education Statistics, 2006).

Historically, this has been the case at San Francisco State University (SFSU), including in biology, which is the most popular undergraduate science major on campus. A key course for entry into the major is Introductory Biology I, which is the first required biology course for all students who wish to pursue biology and biology-related degrees. Students who do not succeed in this course often do not go on to pursue more science courses; some drop out of school entirely. Before spring 1999, when SI was introduced to support the Introductory Biology I class, 31% of the complete set of 1,172 students taking the course between fall 1994 and fall 1998 ultimately did not receive a grade of "C−" or greater, the grade required by science majors to progress to subsequent courses in the major. And that number represents the final proportion that was successful; 11% of all course takers took the course multiple times before receiving their final grade. Forty percent of the students did not pass the course with a "C−" or greater the first time they took the course.

Clearly, a substantial number of students found the course to be difficult. But, the statistics for URM students are of even greater concern. Of the 185 URM students taking the course between fall 1994 and fall 1998, 44% ultimately did not pass the course with a "C−" or greater, with 13% taking the course multiple times, and a disturbing 56% not passing at the "C−" level on the first try.

Of the 81 URM students who did not receive a "C−" or greater in Introductory Biology I at the "C−" level, only 40% eventually graduated from SFSU, compared with 72% of those passing (defined as those achieving a "C−" or higher). Among non-URM students (students from all other groups), the graduation rates were 45% for nonpassers and 75% for passers, respectively. So, a greater proportion of URM students do not pass Introductory Biology I than their non-URM peers; and of those who fail, a smaller proportion graduate from SFSU. This represents a tremendous relative loss of URM talent.

These were troubling statistics. Too many young URM students were being lost from the pool of future scientists, doctors, nurses, etc., because of the same problems that have plagued the URM communities for years.

Figure 1. Change in proportionate representation of racial/ethnic groups in the total population of 18- to 29-year-olds and in receipt of degrees in the biological sciences.

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1 SFSU is an urban, predominantly commuter campus that supports approximately 30,000 students, most of whom come from the Bay Area of California. It serves substantially larger proportions of URM and Asian students than are found in most areas of the United States.
2 Data collection for this article included all students who took Introductory Biology I from fall 1994 to spring 2005.
3 For the purposes of this article, URM status is given to all students who were identified in the university's records as being from the following groups: American Indian, black, Pacific Islander, and various Hispanic/Latino groups. This represents the National Institutes of Health's (NIH's) definition of URM students, chosen both because it is a fair representation of those groups who have been underrepresented in the sciences and because the research was funded by NIH.
ADDRESSING THE PROBLEM

As shown above, the problem of underrepresentation in the sciences among certain groups is widely recognized, and it has led to the development of a large number of national programs focused on improving URM access to and success in science careers (U.S. Government Accountability Office, 2005), including the National Institutes of Health's Minority Opportunities in Research (NIH MORE) programs, which funded both the SI courses at SFSU and this research. These programs have supported a number of responses to the crisis of minority underrepresentation in the sciences with varying levels of success. We have neither the space nor the intention to go into detail on the breadth of responses with their shortcomings and successes here, but reasonable summaries can be found in the U.S. Government Accountability Office report (2005).

Various MORE programs have been set up at SFSU to help address the overall problem of low minority participation in the sciences, starting as early as 1993 (and thus before data collection for this article began). These programs provide qualified URM students with research experiences and financial support, among other benefits, but they generally support students who are farther along in their academic careers; relatively few students were selected for these programs at an early enough point in their careers to have been receiving benefits at the time they were taking Introductory Biology 1.

In 1999, money from one of the NIH MORE grants, the Research Initiative for Scientific Enhancement (RISE) program, was used to start an SI program in support of a number of challenging science and math courses, among them Introductory Biology 1.

SI began at the University of Missouri-Kansas City in 1974, under the leadership of Deanna Martin (Martin and Arendale, 1992). As explained in several sources (Arendale, 1994; Martin and Arendale, 1992), SI was conceived as a means of increasing student performance by targeting difficult courses rather than high-risk students. To do this, SI classes were developed alongside difficult courses with the intention of “supplementing”, the regular course work. In most cases, classes termed "supplemental instruction" are peer-facilitated, involve engaging students in cooperative work, focus on problems that supplement rather than remediate course material, and attempt to develop study skills. Generally, participation is wholly voluntary on the part of participants.

Most studies of the outcomes associated with SI show very positive outcomes. Compared with other students in the class, students who take SI classes alongside their regular course work commonly show better average course grades, and they are more likely to complete the course with a grade above a "D" (Arendale, 1997; Hensen and Shelley, 2003; Lyle and Robinson, 2003; Peled and Kim, 1996). In the long term, these SI participants proved more apt to graduate from their institution than others (Arendale, 1997), a phenomenon that was calculated to result in a considerable cost savings for the college or university (Martin and Arendale, 1992; Congos, 2001). Also, despite showing better performance, SI takers typically seem to have lower academic indicators than their peers in terms of SAT I and ACT scores (Hensen and Shelley, 2003); the increase in performance associated with taking SI does not seem to be due to academically stronger students self-selecting into the program. The results of SI use at SFSU show the same patterns, albeit with some variation by course type (Peterfreund et al., 2007).

The idea of using SI to specifically support students from URM groups more properly stems from the work done by Uri Treisman while teaching at the University of California, Berkeley (Treisman, 1992). Treisman found that URM students were underperforming in their classes compared with their peers despite being a highly motivated and select group; due to his position at the university, his particular focus was African-American students in calculus. By introducing an SI class directly focused on these students, he was able to raise their performance in calculus to a level on par with or better than the average performance among all other groups at the university.

Other studies that have looked at the differential effects of SI across ethnic/racial groups generally have shown that all groups seem to benefit to about the same degree (Arendale, 1997). The SI adopters at SFSU chose to make SI available to all students, expecting that it would equally benefit everyone and that the URM population progressing through the major would increase as would the number of URM students earning biology degrees. These outcomes would contribute to addressing underrepresentation of these groups among SFSU biology graduates. Our analysis of the effects of SI at SFSU from its inception in spring 1999 through spring 2005 (detailed in Peterfreund et al., 2007) found something much more surprising. We did indeed find substantial SI benefits among all groups, but the benefits among the URM population were higher than among all others, particularly in the critical introductory Biology 1 course.

In this article, we tell the story of SI as it relates to URM students at SFSU, and we present what we know (and surmise) about its consequences.

INTRODUCTORY BIOLOGY I AT SFSU

Introductory Biology I at SFSU is the first of a two-course introductory biology sequence. Both Introductory Biology I and II are 5-unit (U) courses that include lecture and laboratory components. The course is taught in both the fall and spring semesters, with two lecture sections in the fall and one section in the spring. The course focuses on a subset of introductory biology topics: cell biology, genetics, and tissue/organ structure and physiology. Learning goals include the ability to articulate and apply relevant conceptual understanding, the mastery of sufficient detail to support conceptual understanding, and the acquisition of vocabulary to communicate understanding.

During the course of this study, the lecture component of the course was conducted in a large room seating approximately 160 students and involved 3 h of contact time per week. Each lecture section was team-taught by two professors, with different teams teaching in the fall and spring; a total of five professors taught the course during the period of this study. The lead professor for the fall instruction team also served as the lab instruction coordinator, and, starting in 1999, as the coordinator for the SI workshops associated with the course.

Lab sections enrolled approximately 24 students each, and met for two 3-h blocks per week. Ten lab sections were
taught in fall semesters, and five or six sections were taught in the spring. Each lab section was led by a different instructor, although individual instructors often taught several semesters in a row. Lab instructors were selected from a pool of graduate students and lecturer applicants for these teaching positions.

All sections of Introductory Biology I used a common syllabus and textbook. Additionally, each lecture team prepared a lecture supplement booklet that contained course information, resource information (e.g., study approaches, study guides, SI course information, other learning assistance resources), and, to facilitate note-taking, copies of all or most visuals projected for each lecture. The supplements for fall and spring differed in visuals and detail provided, but they appropriately matched the lecture presentations by respective instruction teams. The units covered in the course are summarized in Table 1. The order in which they were presented and some of the specific details taught varied among instructors. Lectures were generally accompanied by PowerPoint presentations that included visuals and animation clips. Materials (e.g., PowerPoint slides, exams) for various semesters were available as resources for new instruction team members.

Labs focused on hands-on observations and experiments wherein students explored aspects of targeted topics for the course: the 25 lab exercises for the class, all of which were linked to the units in Table 1. Each lab required the students to complete a lab report; a few labs were preceded by preparatory worksheets that required the students to do research in the library or through online sources. Learning objectives and required graded elements were consistent for all sections. Minor variation in the relative proportion of the grade allocated to quizzes versus worksheets, lab notebooks, and outside research assignments was allowed among lab sections; however, collectively these elements of student work constituted the same overall percentage of grade; major elements, including lab practical exams, written exams, and a formal journal-style lab report were fixed percentages of the lab grade for all sections.

There was a single coordinator for the lab instruction—one of the professors of record for the course in the fall semesters. She provided a lab orientation workshop before the beginning of the semester as well as hosting 2-h weekly meetings with the lab instructors.

Grades for the course were a combination of the lab and lecture components, with performance in the lecture (3 U) determining 60% of the overall grade and the 2-U lab determining 40% of the overall grade. The lecture grade was based on performance on four exams covering segments of the class, worth approximately 21% of the total lecture grade each; a cumulative final exam, worth 10%; and online, take-home, and/or in-class quizzes worth approximately 5%. The lab grade was determined by three lab exams (50% of grade); a formal, journal-style lab report; brief lab reports on all lab exercises (with a focus on data analysis and interpretation);

<table>
<thead>
<tr>
<th>Unit</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry for Biologists</td>
<td>Chemical elements, atoms, bonds; properties of water; biologically relevant monomers and macromolecules; synthesis and degradation of macromolecules</td>
</tr>
<tr>
<td>Cell Biology</td>
<td>Prokaryotic and eukaryotic organisms and general evolutionary history; prokaryotic cells and eukaryotic cells: structure and functions of subcellular organelles and inclusions; extracellular matrix and cell walls; membrane structure, function, and transport; diffusion of molecules across membranes/osmosis</td>
</tr>
<tr>
<td>Cell Division and Metabolism</td>
<td>Fission; mitosis/cytokinesis; Metabolism; energetics; coupled reactions; enzymology; fermentation; aerobic respiration; photosynthesis; use of photosynthesis products; producer-consumer relationships</td>
</tr>
<tr>
<td>Plant Growth, Anatomy, and Physiology</td>
<td>Primary and secondary growth; meristems and cell differentiation; mature plant cells: structure and functions; plant tissues: organization in plant organs and functions; environmental and internal cue perception; regulation of growth and development</td>
</tr>
<tr>
<td>Animal Structure and Physiology</td>
<td>Animal tissues: structure, functions, arrangement in organs; digestive systems; respiratory systems; circulatory systems; excretory systems; nervous system and neuron function; immune system; endocrine system, hormone perception and signal transduction</td>
</tr>
<tr>
<td>Genetics</td>
<td>Classical Mendelian genetics; introduction to non-Mendelian genetics; meiosis, segregation, independent assortment; gene linkage and inheritance patterns for linked genes; molecular genetics</td>
</tr>
</tbody>
</table>
range, and discretion about assigning grades to points re-
-sided with professors for the course. The basic distribution
of grades across semesters and instructors did not vary to
any great extent.

Lecture exams in fall semesters were multiple-choice ex-
ams; in spring semesters, exams consisted of 50% multiple-
choice and 50% short-answer questions. Individual instruc-
tion teams constructed lecture exams to match their
approaches and styles; thus, exams were not common across
instructors. Questions on exams included general recall and
comprehension questions, but they emphasized higher-
order learning skills, especially application, analysis, and
explanation. Lab exams included a common lab practical por-
tion requiring short written responses to questions about
displayed lab materials (50%) and a more conceptual portion
that involved short-answer essay questions and problems
(50%). The practical portion of lab exams required students
to relate structure and function, explain functions of proto-
col steps, demonstrate laboratory skills, apply understand-
ing of protocols to draw conclusions, and interpret dis-
played analysis results (e.g., a set of test tubes showing the
results of a chemical assay) or numerical data presented
graphically or in tables. Written portions of exams required
students to interpret data, work problems, synthesize infor-
mation, and provide explanations supported by evidence.

SI CLASSES FOR IntroDUCTORY BIOLOGY I
AT SFsu

The SI classes,\(^5\) which began in 1999, were coordinated by
the same professor who taught Introductory Biology I in the
fall and coordinated the labs. In 1999 and 2000, the facili-
tors of these classes were experienced lecturers, graduate
student instructors, and professors, but by 2001, postbac-
calaureates who had completed the course were also becoming
facilitators, and in later semesters these students made up
the majority, and occasionally the totality, of SI facilitators.
On average, SI facilitators were involved for two semesters,
allowing for some continuity from semester to semester.

Potential facilitators applied for positions, and there was
always a large enough applicant pool. The coordinator chose
facilitators based on their experience and a number of per-
sonal characteristics, but all had either taken the course
previously at SFsu or taught a lab section for the course.

Facilitators were provided some professional development
that included the mechanics of running a course and pedagogical
issues specific to the class. General course goals,
guidelines for teaching strategies to be used, and all of the
materials associated with the regular course (e.g., textbook,
lecture supplement, lab manual) were provided. From 2003
onward, a CD with session-specific worksheets was also
provided. The specific activities to be performed in each
class session were determined and designed by each facilita-
tor, with coordinator input, as desired. Casual weekly or bi-
weekly meetings served as hubs for coordinating SI activ-
ity focus with lecture or lab challenges for the upcoming
weeks, for idea and material exchanges, and for collabora-
tion among instructors.

The SI classes were based on a model of cooperative
learning around activities that complemented the content
covered in the main course, addressing student misconcep-
tions and difficulties and exploring difficult concepts in
greater depth. Typical activities included guided discussions
with extensive class participation (often following small
group work), worksheets that were completed both individ-
ually and in groups, peer instruction, preparation of study
resources, kinesthetic and visual modeling of problems,
practice tests, and trivia-style games. Particular emphasis
was placed on the concepts, content, and vocabulary from
the lecture, but before lab exams some time was spent re-
viewing methods, data analysis, and the interpretation and
principles underlying observed outcomes of various labora-
tory experiments. Active-learning approaches, including co-
operative learning, were stressed, based on literature indi-
cating learning achievements for students using these
methods (e.g., Treisman, 1992).

Contact between the SI facilitators and the professors
of the class were good in the fall semesters, because the
primary course instructor was also the SI coordinator.
Although direct contact with lecture professors was reduced
in the spring semesters, the coordinator was intimately fami-
lar with the lecture approach in the spring semesters;
thus, appropriate concordance was maintained.

During the period of this study, SI classes were capped at
20 students each. The number of workshops offered was
based on expectations of enrollment estimated from previ-
ous semesters. Additional sections were added if unmet
demand was high and funds allowed. The SI classes were
listed in the course catalog, available online, and announced
in lecture, lab, and through campus flyers. Students also
learned of SI courses via other students who had taken SI
workshops.

The SI courses met once a week for 1.5 h for 1 U of credit.
The credit earned could be counted toward the unit require-
ment for graduation; however, units were not applicable to
the major. It is also noteworthy that SI courses were coupled
to a number of science and math courses. Students could
elect to enroll in any number of these courses, but a maxi-
mum of 4 U total could be applied toward the graduation
unit requirement. Enrollment was paid through regular tu-
ition.

DESCRIPTION OF DATA

This study focuses on a particular aspect of the overall
examination of SI at SFsu, presented in summary form in
Peterfreund et al. (2007). The data used for this focused study
come from a larger database of information from SFsu's
institutional records\(^6\) regarding the approximately 12,000
students who had taken one or more of a set of introductory
science and math courses, including Introductory Biology I,
between fall 1994 and spring 2005. In total, 2698 students
took Introductory Biology I during that time frame, 1526
within the time when SI was offered (from spring 1999

\(^5\) Funded under National Institutes of Health grant 5 R25 GM59298-
04, "MERS RISE at San Francisco State University."

\(^6\) We thank Michael Garrity at SFsu's Student Systems Support and
Development office for making this possible.
Data collected for these students included the following:

1. Grades and semesters taken for all science-related courses and SI classes.
2. Demographic information, including SAT I scores, high school GPA, race/ethnicity, gender, and major.

Because the data are from institutional records, there are certain caveats that must be kept in mind when interpreting our findings.

First, because SI at SFSU is a course for which students register and receive 1 U, records of the roster are kept in the institutional database, along with a grade associated with participation. This is the only way that we have been able to track who did and who did not take SI. Even so, discussions with SI program administrators and results from student surveys conducted over the past few years suggest that participation in SI is greater than what is officially noted in the institutional records used in this study, because an unknown number of students (although relatively few in the Biology SI courses) attend the SI classes without registering. Information collected on surveys of chemistry courses in 2006 suggests that for every 20 students registered in SI, between 5 and 10 come to the sessions without being registered. The comparisons of participants and nonparticipants presented here place these unrecorded SI participants in the nonparticipant category and thus may underestimate the differences between the groups.

Second, although the composite number of students from URM groups at SFSU is quite large, making up ~36% of the entire undergraduate population (SFSU, 2006), when examining a subgroup such as those taking SI within a certain time frame, the total number of individuals from specific racial/ethnic groups (such as African-Americans) becomes too small to maintain a reasonable level of statistical power. Because of this, all analyses examine URM students as a whole and compare them to all non-URM students. The URM group includes individuals identified in the institutional records as American-Indian, black, various Latino/Hispanic groups, and various Pacific Islander groups (e.g., Guam, Native Hawaiian, Filipino), as per NIH definitions of who may receive funding earmarked for underrepresented minorities. Non-URMs include whites, various Asian groups, and No Response. Because null responses were placed in the latter group, it is possible that some students who actually belong in the URM group were incorrectly placed.

Third, to have only one entry per student, most analyses are done using the final grade achieved in Introductory Biology I. Because approximately 15% of students take the course multiple times due to grades they deem unsatisfactory the first time around (and which are often too low to allow them to progress to the next course), the numbers reported tend to overstate the actual course averages found in any given year. It also means that there are more low grades associated with the last semester or two, because students have not had the chance to retake the course since then, meaning that students in the SI period would be expected to have slightly lower grades than those in the pre-SI period. Because this situation affects all groups during the SI period on an approximately equal basis, we have not tried to use statistical methods to correct for it.

Finally, many analyses do not take into consideration the group of students who, for whatever reason, did not get grades in the course. These students generally dropped, withdrew, or received incompletes, and experience has shown that the reasons for doing so vary considerably and are difficult to associate with issues surrounding SI. We have made every effort to keep it clear whether we are talking about the entire group of students or just the subset with grades. The issue of withdrawals also comes into consideration with the SI course itself, because some students registered for SI eventually withdrew or received failing grades, indicating that they did not take full advantage of the class. Analyses where SI status is confined to those receiving grades in the class are specifically noted.

**DESCRIPTION OF STUDENTS**

In the analyses to follow, we examined three separate groups: those students who took SI during the period in which it was offered (1999–2005); those who did not; and those who took Introductory Biology I before the advent of SI (1994–1998), who serve as a baseline group.

Table 2 displays demographic information about these three groups. A comparison between the complete group of students taking Introductory Biology I in the pre-SI years to those taking it in the years when SI was offered shows that there are few differences between the groups. In both cases, women outnumber men by ~2:1. Also, the percentage of URM students in the Biology I class is lower than in the current overall SFSU population (36%) (SFSU, 2006).

Comparing the SI takers to the nontakers, again the differences are not great. Within the SI group, there are more women, more URM students, and more in the general group of biology majors. But these differences are not huge; there is no reason to believe that the SI and non-SI groups are fundamentally different from one another based on their demographics.

Table 3 shows the demographics across the groups for URM students only, and Table 4 shows the same for the other students. These data show few differences between the SI and non-SI groups among the URM students, although gender differences and differences in the proportion of biology students are more apparent among the non-URM SI and non-SI students.

**GENERAL RESULTS**

We start with an overview of the course, some of which has already been presented. Before spring 1999, before SI was introduced, 813 or 69% of the 1172 students registered for the course ultimately received a grade of "C-" or higher (Table 5). Of these 1172, 67 (6%) did not receive a grade, making the total "pass rate" 74% of those who did receive grades in the class. The average final grade achieved in the class was a 2.10 (on a scale of 0.0–4.0). Eleven percent of all course takers took the course multiple times to achieve that grade. Finally, 65% of all students taking Introductory Biology
I at SFSU before 1999 eventually graduated from the university. Table 5 shows these data for both the period before 1999 and for the semesters from spring 1999 through spring 2005. The table also splits the 1999–2005 data into SI and non-SI groups to compare these student groups.

Before we begin exploring these results, a note needs to be made about the last entry on the table. Because Introductory Biology I is a freshman-level course and because our data only go up to spring 2005, we would not expect students who took the course in later years to have graduated by the time the data were collected. Because of this, for the graduation figures on this and subsequent tables we have only examined students who took the course before fall 2002, recognizing that even for this time frame there are still a number of people who graduated after spring 2005. This reduced our pool to 236 among the SI takers and 572 among the nontakers.

A quick examination shows little difference between the 1994–1998 and overall 1999–2005 data (Table 5). Graduation rates are slightly lower in 1999–2005, which is to be expected (see above). Retaking rates are somewhat higher. Otherwise, there are few differences.

However, when we examine the SI versus non-SI groups, we do see differences. The SI group shows higher “pass rates,” higher average final grades, and higher graduation rates, all similar to findings from other studies in the literature. The difference in graduation rates is not statistically

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### Table 2. Introductory Biology I course demographics (percentages), examined compared with SI use

<table>
<thead>
<tr>
<th>Metric</th>
<th>All students</th>
<th>All students</th>
<th>SI takers&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Non-SI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of students in group</td>
<td>1172</td>
<td>1526</td>
<td>437</td>
<td>1089</td>
</tr>
<tr>
<td>Male</td>
<td>39</td>
<td>34</td>
<td>29</td>
<td>36</td>
</tr>
<tr>
<td>Female</td>
<td>62</td>
<td>66</td>
<td>71</td>
<td>64</td>
</tr>
<tr>
<td>White</td>
<td>27</td>
<td>23</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>Asian</td>
<td>44</td>
<td>43</td>
<td>41</td>
<td>43</td>
</tr>
<tr>
<td>Underrepresented minorities</td>
<td>16</td>
<td>19</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Not specified</td>
<td>13</td>
<td>16</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Major: chemistry or biochemistry</td>
<td>9</td>
<td>10</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Major: biology—general, botany, ecology, physiology, zoology, etc.</td>
<td>32</td>
<td>30</td>
<td>37</td>
<td>28</td>
</tr>
<tr>
<td>Major: biology—cell and molecular</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Major: biology—microbiology</td>
<td>3</td>
<td>1.7</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Major: engineering</td>
<td>0.3</td>
<td>1.8</td>
<td>1.1</td>
<td>2</td>
</tr>
<tr>
<td>Major: computer science</td>
<td>0.4</td>
<td>1.9</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Other majors</td>
<td>49</td>
<td>49</td>
<td>47</td>
<td>50</td>
</tr>
</tbody>
</table>

<sup>a</sup> This includes all students who were registered for SI. As a subsequent analysis will show with greater clarity, some students were registered for the SI course, but they did not complete it. Taking these students out of the group changes the results somewhat, to the SI group’s favor.

<sup>b</sup> The majors shown on this table are the majors initially chosen by the students rather than the ones they graduated with. Because Introductory Biology I is generally taken in the first or second year at SFSU, the initial major was judged to be a more accurate reflection of the students’ plans at the time they took the course.

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### Table 3. Introductory Biology I course demographics (percentages) for underrepresented minority students, examined compared with SI use

<table>
<thead>
<tr>
<th>Metric</th>
<th>All URM students</th>
<th>All URM students</th>
<th>URM SI takers</th>
<th>URM non-SI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of students in group</td>
<td>185</td>
<td>101</td>
<td>101</td>
<td>185</td>
</tr>
<tr>
<td>Male</td>
<td>37</td>
<td>33</td>
<td>31</td>
<td>34</td>
</tr>
<tr>
<td>Female</td>
<td>63</td>
<td>67</td>
<td>69</td>
<td>66</td>
</tr>
<tr>
<td>Asian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underrepresented minorities</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Not specified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major: chemistry or biochemistry</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Major: biology—general, botany, ecology, physiology, zoology, etc.</td>
<td>30</td>
<td>36</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>Major: biology—cell and molecular</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Major: biology—microbiology</td>
<td>1.1</td>
<td>3</td>
<td>5</td>
<td>1.6</td>
</tr>
<tr>
<td>Major: engineering</td>
<td>0.5</td>
<td>1.8</td>
<td>1.0</td>
<td>2</td>
</tr>
<tr>
<td>Major: computer science</td>
<td>0.4</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other majors</td>
<td>57</td>
<td>47</td>
<td>42</td>
<td>50</td>
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</tbody>
</table>
Table 4. Introductory Biology I course demographics (percentages) for other (non-URM) students, examined compared with SI use

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of students in group</td>
<td>987</td>
<td>1242</td>
<td>336</td>
<td>906</td>
</tr>
<tr>
<td>Male</td>
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<td>34</td>
<td>29</td>
<td>36</td>
</tr>
<tr>
<td>Female</td>
<td>61</td>
<td>66</td>
<td>71</td>
<td>64</td>
</tr>
<tr>
<td>White</td>
<td>33</td>
<td>29</td>
<td>24</td>
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</tr>
<tr>
<td>Asian</td>
<td>52</td>
<td>52</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>Underrepresented minorities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not specified</td>
<td>16</td>
<td>19</td>
<td>23</td>
<td>18</td>
</tr>
<tr>
<td>Major: chemistry or biochemistry</td>
<td>10</td>
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<td>7</td>
<td>11</td>
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<tr>
<td>Major: biology—general, botany, ecology,</td>
<td>32</td>
<td>29</td>
<td>36</td>
<td>26</td>
</tr>
<tr>
<td>physiology, zoology, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major: biology—cell and molecular</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Major: biology—microbiology</td>
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<td>1.4</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Major: engineering</td>
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<td>1.8</td>
<td>1.2</td>
<td>2</td>
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<tr>
<td>Major: computer science</td>
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<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Other majors</td>
<td>48</td>
<td>50</td>
<td>49</td>
<td>50</td>
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</tbody>
</table>

Table 5. Introductory Biology I course statistics, examined compared with SI use

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of total receiving a &quot;C−&quot; or greater</td>
<td>69%</td>
<td>70%</td>
<td>78%</td>
<td>67%</td>
</tr>
<tr>
<td>n = 1172</td>
<td>n = 1526</td>
<td>n = 437</td>
<td>n = 1089</td>
<td></td>
</tr>
<tr>
<td>Proportion of total receiving no grade</td>
<td>6%</td>
<td>6%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>n = 1172</td>
<td>n = 1526</td>
<td>n = 437</td>
<td>n = 1089</td>
<td></td>
</tr>
<tr>
<td>Proportion of those receiving a &quot;C−&quot; or greater</td>
<td>74%</td>
<td>75%</td>
<td>82%</td>
<td>72%</td>
</tr>
<tr>
<td>n = 1105</td>
<td>n = 1428</td>
<td>n = 412</td>
<td>n = 1016</td>
<td></td>
</tr>
<tr>
<td>Average final grade</td>
<td>2.10</td>
<td>2.08</td>
<td>2.29</td>
<td>1.99</td>
</tr>
<tr>
<td>n = 1105</td>
<td>n = 1428</td>
<td>n = 412</td>
<td>n = 1016</td>
<td></td>
</tr>
<tr>
<td>Proportion of total taking the course multiple times</td>
<td>11%</td>
<td>17%</td>
<td>19%</td>
<td>16%</td>
</tr>
<tr>
<td>n = 1172</td>
<td>n = 1526</td>
<td>n = 437</td>
<td>n = 1089</td>
<td></td>
</tr>
<tr>
<td>Proportion of total ultimately graduating from SFSU*</td>
<td>65%</td>
<td>62%</td>
<td>67%</td>
<td>59%</td>
</tr>
<tr>
<td>n = 1172</td>
<td>n = 808</td>
<td>n = 236</td>
<td>n = 572</td>
<td></td>
</tr>
</tbody>
</table>

* Data for students from the SI period only include those taking the course before fall 2002.

significant, but those relating to pass rates and grades are statistically significant, and substantially so.

Also interesting, and statistically significant, is that more students from the SI group are retakers—19 versus 16% of the non-SI group. We think this is because a disproportionate number of retakers come to the realization that after doing poorly the first time, they will need extra help to get the grade they desire and thus they become more likely to seek out SI the second (or third) time around than their nonrudely awakened peers.

However, the SI status data presented above include people in the analysis who registered for SI (and are thus counted in that group), but who did not receive a grade in the SI class, indicating that they did not complete the SI course. Discounting these individuals and only examining those students who received a grade in the Biology I class (because students who withdraw from the class also withdraw from SI and receive grades in neither class) gives us the data shown on Table 6. Statistical significance figures for the differences are provided as well. Significantly, 82% of students in SI sections who completed the course for a grade earned a ”C−” or better, compared with 73% of students not taking SI. Likewise, average final grades and graduation percentages were also higher for SI than for non-SI students. Once again, the total numbers of students used in the examination of graduation rates are lower than for the other data in the table due to the 2002 cut-off: only 202 students were in the SI group and 515 students in the non-SI group.

Figure 2 shows the distribution of grades in the class for this group of students. Clearly, the SI group received higher course grades than the non-SI group; particularly evident is the large decrease in the students receiving an ”F” (0.0).

So, there is clear evidence that students taking SI outperform students not doing so on a variety of metrics. However,
Table 6. Introductory Biology I course statistics for students with grades and secure SI status only, examined compared with SI use

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion receiving a &quot;C-&quot; or greater</td>
<td>85%</td>
<td>73%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>n = 390</td>
<td>n = 990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average final grade</td>
<td>2.35</td>
<td>2.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>n = 390</td>
<td>n = 990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion taking the course multiple times</td>
<td>19%</td>
<td>17%</td>
<td>0.220</td>
</tr>
<tr>
<td>n = 390</td>
<td>n = 990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion ultimately graduating from SFSU</td>
<td>67%</td>
<td>59%</td>
<td>0.060</td>
</tr>
<tr>
<td>n = 202</td>
<td>n = 515</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A look at the data in Table 5 might lead one to believe that what is really happening is that the more academically fit students are opting to take SI and the less fit students are not, with SI merely dividing the course into high- and low-academic fitness groups (despite the number of retakers in the SI group). But, this is not the case. As Table 7 demonstrates, the SI-taking students are actually less academically fit than their peers as measured by SAT I scores and about the same as measured by high school GPA. It should be noted that not all students in the database had these academic fitness indicators, so the averages represent a subset of the total student body.

We have no clear explanation, then, for why the average data from 1999 to 2005 in Table 5 are so similar to those from 1994 to 1998; one would predict that the non-SI data should be essentially the same as the 1994–1998 data and that the SI data should be higher. We can suggest four possible explanations, but there is no clear way to know which (if any) is correct.

First, the decrease in performance from the 1994–1998 students to that of the non-SI students in 1999–2005 may be due to the presence of the SI students in the class. If this is the case, it may be that the presence of a cadre of well-prepared students in the classroom (the SI takers) created a climate where professors felt comfortable presenting more challenging material or less explanation in class, presenting an even more difficult class scenario for those students not in SI. However, the course instructors do not believe this to be the case.

Second, the courses could be graded on an implicit curve, which would keep the average grade constant despite any increases in learning. However, this would not be the case for multiple-choice exams, and they comprise a large enough component of the course that they should at least partially mitigate any implicit curving in other areas.

A third option is that the change may be due to variations in instructor grading policies, significant events in student life, or other such things unrelated to the introduction of SI. However, there was no explicit change in grading policies over the course of the study.

Finally, SI may be splitting the class into two groups: 1) those who are highly motivated and willing to take advantage of outside help, and who would do well in the class regardless of what help was available; and 2) those who are not. However, it would be strange for the motivated students to have significantly lower average SAT I scores, given the oft-demonstrated relationship between SAT I scores and course grades\(^8\) (Camara and Echternacht, 2000). We do not have any way of actually determining how motivated these students are because we are using historical data from institutional records, but we do not personally find the motivation argument to be very compelling. Further study with

\(^8\) In our data set, for example, for the period from 1999 to 2005 the correlation between math SAT scores and final grade in Introductory Biology I is 0.298 and that for verbal SAT scores is 0.213. Both are statistically significant at the p < 0.001 level.

Table 7. Academic fitness statistics compared with SI use

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average SAT I math score</td>
<td>490</td>
<td>518</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>n = 251</td>
<td>n = 565</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average SAT I verbal score</td>
<td>473</td>
<td>498</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>n = 251</td>
<td>n = 565</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average high school GPA</td>
<td>3.21</td>
<td>3.17</td>
<td>0.196</td>
</tr>
<tr>
<td>n = 331</td>
<td>n = 767</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Second, the courses could be graded on an implicit curve, which would keep the average grade constant despite any increases in learning. However, this would not be the case for multiple-choice exams, and they comprise a large enough component of the course that they should at least partially mitigate any implicit curving in other areas.

A third option is that the change may be due to variations in instructor grading policies, significant events in student life, or other such things unrelated to the introduction of SI. However, there was no explicit change in grading policies over the course of the study.

Finally, SI may be splitting the class into two groups: 1) those who are highly motivated and willing to take advantage of outside help, and who would do well in the class regardless of what help was available; and 2) those who are not. However, it would be strange for the motivated students to have significantly lower average SAT I scores, given the oft-demonstrated relationship between SAT I scores and course grades\(^8\) (Camara and Echternacht, 2000). We do not have any way of actually determining how motivated these students are because we are using historical data from institutional records, but we do not personally find the motivation argument to be very compelling. Further study with
K. A. Rath et al.

a new group of students and a motivational measure would be necessary to ultimately resolve the question.

This, then, is the picture of the effect of SI on the course as a whole. However, more interesting is the relationship of SI to the performance of URM students.

UNDERREPRESENTED MINORITIES AND SI

Of the 1526 students who enrolled in Introductory Biology I from 1999 to 2005, 284 (19%) were identified as being from URM groups (Table 2). Already, it becomes clear that URM students are underrepresented among those opting to take the class compared with the population of such students at SFSU—~36% of all undergraduates.

Of the 437 SI takers, 101 (23%) were URM students, compared with 183 (17%) of the 1089 students who did not take SI. Thus, URM students form a proportionately higher portion of the SI class. We think that this is because the SI courses are offered through an NIH-funded program targeted at URM students, and efforts are made to appeal specifically to these students; we discuss this hypothesis in greater detail below.

We begin this discussion with the presentation of a flurry of data in the same vein as that shown above. Tables 8 and 9 present information analogous to that in Table 5 (i.e., as related to the entire group of registered students), but for URM and other (non-URM) students, respectively. Tables 10 and 11 provide information pertaining specifically to only those students from both groups with grades in Introductory Biology I and clear SI status, analogous to Table 6. Figures 3 and 4 show the distribution of grades in the course for each group, analogous to Figure 2. Finally, Tables 12 and 13 show the academic fitness statistics for both groups, analogous to Table 7.

A look at the data presented in these tables and figures shows a very consistent picture. First, both URM and other students show performance benefits as a result of SI. Students in SI are more likely to pass the course with a "C−" or higher, they have higher average grades, and, for URM students, they are more likely to graduate from SFSU. This is shown numerically on Tables 8–11 and graphically on Figures 3 and 4. However, the differences between the SI and non-SI groups are much greater for the URM students than the non-URM students. Even more interestingly, the non-URM students show no differences in ultimate graduation.

<table>
<thead>
<tr>
<th>Metric</th>
<th>All URM students</th>
<th>All URM students</th>
<th>URM SI takers</th>
<th>URM non-SI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56%</td>
<td>60%</td>
<td>76%</td>
<td>51%</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 284</td>
<td>n = 101</td>
<td>n = 183</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9%</td>
<td>6%</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 284</td>
<td>n = 101</td>
<td>n = 183</td>
<td></td>
</tr>
<tr>
<td></td>
<td>62%</td>
<td>64%</td>
<td>80%</td>
<td>55%</td>
</tr>
<tr>
<td>n = 168</td>
<td>n = 267</td>
<td>n = 96</td>
<td>n = 171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.66</td>
<td>1.75</td>
<td>2.22</td>
<td>1.49</td>
</tr>
<tr>
<td>n = 168</td>
<td>n = 267</td>
<td>n = 96</td>
<td>n = 171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15%</td>
<td>19%</td>
<td>25%</td>
<td>16%</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 284</td>
<td>n = 101</td>
<td>n = 183</td>
<td></td>
</tr>
<tr>
<td></td>
<td>58%</td>
<td>58%</td>
<td>73%</td>
<td>50%</td>
</tr>
<tr>
<td>n = 185</td>
<td>n = 453</td>
<td>n = 52</td>
<td>n = 101</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metric</th>
<th>All other students</th>
<th>All other students</th>
<th>Other SI takers</th>
<th>Other non-SI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>72%</td>
<td>72%</td>
<td>78%</td>
<td>70%</td>
</tr>
<tr>
<td>n = 987</td>
<td>n = 1242</td>
<td>n = 336</td>
<td>n = 906</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>7%</td>
<td>6%</td>
<td>7%</td>
</tr>
<tr>
<td>n = 987</td>
<td>n = 1242</td>
<td>n = 336</td>
<td>n = 906</td>
<td></td>
</tr>
<tr>
<td></td>
<td>76%</td>
<td>77%</td>
<td>83%</td>
<td>75%</td>
</tr>
<tr>
<td>n = 937</td>
<td>n = 1161</td>
<td>n = 316</td>
<td>n = 845</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.18</td>
<td>2.13</td>
<td>2.31</td>
<td>2.09</td>
</tr>
<tr>
<td>n = 937</td>
<td>n = 1161</td>
<td>n = 316</td>
<td>n = 845</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11%</td>
<td>17%</td>
<td>18%</td>
<td>16%</td>
</tr>
<tr>
<td>n = 987</td>
<td>n = 1242</td>
<td>n = 336</td>
<td>n = 906</td>
<td></td>
</tr>
<tr>
<td></td>
<td>67%</td>
<td>62%</td>
<td>65%</td>
<td>62%</td>
</tr>
<tr>
<td>n = 987</td>
<td>n = 655</td>
<td>n = 184</td>
<td>n = 471</td>
<td></td>
</tr>
</tbody>
</table>
Table 10. Introductory Biology I course statistics for URM students with grades and secure SI status only, examined compared with SI use

<table>
<thead>
<tr>
<th>Metric</th>
<th>URM SI takers</th>
<th>URM non-SI</th>
<th>Significance of difference (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion receiving a &quot;C-&quot; or greater</td>
<td>1999-2005</td>
<td>1999-2005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>82%</td>
<td>57%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>n = 89</td>
<td>n = 164</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average final grade</td>
<td>2.27</td>
<td>1.55</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>n = 89</td>
<td>n = 164</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion taking the course multiple times</td>
<td>23%</td>
<td>18%</td>
<td>0.515</td>
</tr>
<tr>
<td>n = 89</td>
<td>n = 164</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion ultimately graduating from SFSU</td>
<td>73%</td>
<td>52%</td>
<td>0.015</td>
</tr>
<tr>
<td>n = 45</td>
<td>n = 91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 11. Introductory Biology I course statistics for other (non-URM) students with grades and secure SI status only, examined compared with SI use

<table>
<thead>
<tr>
<th>Metric</th>
<th>Other SI takers</th>
<th>Other non-SI</th>
<th>Significance of difference (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion receiving a &quot;C-&quot; or greater</td>
<td>1999-2005</td>
<td>1999-2005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>85%</td>
<td>77%</td>
<td>0.001</td>
</tr>
<tr>
<td>n = 301</td>
<td>n = 826</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average final grade</td>
<td>2.37</td>
<td>2.14</td>
<td>0.003</td>
</tr>
<tr>
<td>n = 301</td>
<td>n = 826</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion taking the course multiple times</td>
<td>18%</td>
<td>17%</td>
<td>0.444</td>
</tr>
<tr>
<td>n = 301</td>
<td>n = 826</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion ultimately graduating from SFSU</td>
<td>65%</td>
<td>64%</td>
<td>0.855</td>
</tr>
<tr>
<td>n = 157</td>
<td>n = 424</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

rates between the SI and non-SI groups. As seen in Tables 12 and 13, the academic fitness indicators for both groups suggest that, if anything, the SI takers are less fit than the nontakers.

The ramifications of these data are profound, portraying a real impact of SI on students in the biological sciences, particularly URM students. What we mean is this: If the 101 URM SI takers did not take SI, we would expect that they would receive grades with the same distribution as the non-SI students, meaning that we would expect 52 students to pass the course with a "C-" or better rather than the 78 who actually did so. This means that 26 students achieved grades allowing them to pursue majors in the biological sciences, whereas not taking SI, one would have predicted that they would not have been able to pursue these majors.

The same can be said about graduation from SFSU. Again, note that we are dealing with a smaller group of students (only those taking the course through spring 2002), when we look at graduation rates of URM students, we are examining 45 SI takers and 91 nontakers (Table 10). If the SI takers graduated at the 50% rate found among nontakers (Table 8), we would expect 23 students to graduate from SFSU. In fact, among SI takers, we found that 33 actually did so. SI seems to have provided a gateway for 10 URM students to graduate from SFSU who would not otherwise have done so.

Twenty-six additional students progressing in the major and 10 additional students graduating may not seem like large numbers, but we are dealing with a small group (101 taking SI and only 45 whom one might expect to have graduated); thus, these figures each represent about one-quarter of the students examined, and that is a very substantial proportion.

These increased graduation rates also translate into more URM students with degrees in biology. Of the 107 URM students who took Introductory Biology I before 1999 and graduated from SFSU, 40 (37%) graduated with majors in biology, which is an average of 8.9 graduates per year (nine semesters examined). Of the 88 graduating students who took the course between spring 1999 and spring 2002, 42 (48%) graduated with biology majors, an average of 16.8 per year (five semesters examined). The number of biology students coming out of the Introductory Biology I class per year has nearly doubled since the introduction of SI.

As stated above, the benefits we find associated with SI are similar to those found in other studies. But, no study that we are aware of has shown what was just demonstrated: a

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9 This is not entirely accurate. Because the SI students tend to have lower academic fitness indicators than the non-SI students, we would actually predict that they would get low grades at a slightly higher rate than the non-SI population. Conversely, the rates of achieving grades of "C-" and higher are somewhat higher among the 1994–1999 population, suggesting that the overall predicted rates perhaps ought to be slightly higher. To avoid unnecessary complication, we have decided to ignore both of these issues, assuming that they will essentially cancel each other out.

10 Biology majors at SFSU include general biology, botany, cell and molecular biology, conservation biology, marine biology/limnology, microbiology, physiology, and physiology and behavior.
profound effect on URM students well above that for other students. The obvious question that begs answering is why we find this relationship.

WHY DO URM STUDENTS BENEFIT TO A GREATER EXTENT?

The short answer is that we are not entirely sure. But, there are some clear possibilities.

From the research summarized by Massey et al. (2002), it is clear that URM students come to college at a disadvantage relative to their non-URM peers. These disadvantages may be causing the URM students to perform so poorly without SI that they have a much greater potential for improvement than do the non-URM students. It is certainly true that even though there is a large difference relative to the non-SI group, the average course performance among SI-taking URM students still does not reach the average of non-URM students taking SI (Tables 10 and 11), although it does come close. Perhaps there is only so far that SI can pull grades up, regardless of the students’ starting point, but URM students have more potential for increase. As for graduation rates, which are higher among URM SI students than other SI students, these may be higher because of other interventions that many URM students continue to receive at SPUSU over the course of their academic careers.

These other interventions are important factors that need to be considered. The funding that NIH provides for the SI program is only part of the support provided through the MORE programs. These programs provide URM students with a number of experiences in the hopes of increasing their likelihood of pursuing Ph.D.s in the biomedical sciences.

Until very recently, other programs were in place through the Department of Defense that provided similar benefits to URM and non-URM students in a wider range of fields. These benefits include direct funding of students, freeing them from the need to work to generate money; guided research experiences associated with on-campus research labs and faculty mentors; seminar series designed to introduce students to the culture of science, prepare them for graduate school, and develop a sense of community; advising and advocacy from the program leaders; and several other important benefits. Successful students are often supported for several years, including help in being placed into Ph.D. programs should they choose to take that route.

Entrance into these programs is not automatic for URM students. There is a selection process in which the program managers attempt to determine the students’ potential for being able to attain a Ph.D. in the sciences. Although some students with lower grades are admitted in lieu of other identified strengths, many are high achievers, and all tend to be highly motivated to succeed in their fields.

As Table 14 shows, a higher proportion of URM students were involved in these funded programs than non-URM students, reflecting the emphasis of the MORE programs. But the majority of these funded students only receive funding after taking Introductory Biology 1—on the table, they are not involved in the programs at the time of the course. Interestingly, among URM students, a much higher number of students who took SI go on to be involved in the programs compared with nontakers—either taking the SI course is asso-
Table 14. Participation in funded programs by SI status

<table>
<thead>
<tr>
<th>Group</th>
<th>Total in group</th>
<th>No. in funded programs at time of course</th>
<th>% in funded programs at time of course</th>
<th>No. ever in funded programs</th>
<th>% Ever in funded programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>URM students in SI</td>
<td>101</td>
<td>12</td>
<td>12</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>URM students not in SI</td>
<td>183</td>
<td>7</td>
<td>4</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Other students in SI</td>
<td>336</td>
<td>19</td>
<td>6</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>Other students not in SI</td>
<td>906</td>
<td>4</td>
<td>6</td>
<td>31</td>
<td>3</td>
</tr>
</tbody>
</table>

...continued with the motivation to succeed that would be expected of program applicants, a not-unlikely scenario, the SI course is important toward preparing students for entrance into these programs, or both. We expect that both are the case.

That only a small number of students are involved in the MORE programs at the time they take Introductory Biology I means that the experience of these students has little bearing on that of the entire group—the performance gains associated with SI cannot be explained by activities associated with other programs.

That leaves us with the assertion that the URM students have more potential to gain from SI than the non-URM students and that this is the reason they benefit more. The explanations for this greater potential are likely the same as those for why URM students are underrepresented in the first place, as discussed above: from backgrounds that are less college-supportive, lower-quality schooling, stereotypes, and isolation. That SI seems to go a good way toward overcoming these barriers is, in our opinions, of terrific import.

It seems that the use of SI in critical, introductory courses such as Introductory Biology I not only enhances the outcomes of students taking the course, as would be suggested by the SI literature, but also can be instrumental in helping to alleviate the issues that cause URM students to be underrepresented in biology, and, presumably, the other sciences.

There are three factors specific to SFSU that may explain why SI is particularly successful with URM students at this institution. It is entirely possible that an institution with a different makeup may have less impressive results.

First, SFSU's student body contains a larger proportion of URM students than most postsecondary institutions in the United States—some 36% of the undergraduates. This means that SI courses are very likely to have a cadre of URM students, reducing the isolation individual students may feel if they are the only ones from their particular background in a class, and, thus presumably enhancing the impact of the class.

Second, because the SI courses are funded by the NIH MORE program, efforts are made to specifically attract URM students. These are probably at least partly responsible for the greater representation of URM students in the SI classes than in Introductory Biology I as a whole. This makes it even easier for URM students to build a sense of community through the SI courses.

Third, in interviews students have told us that they often hear about SI not from the supporting course instructors or other institutionally affiliated source but from their friends and family members. The community of URM students on the campus, in part developed through the efforts of the NIH MORE program, has likely led many new URM students to the SI courses when they would otherwise not have known about them, or, knowing about them, been willing and motivated to enroll.

Fourth, as mentioned above, there is a single person who interviews, selects, and provides professional development for facilitators who coordinates all of the biology SI classes at SFSU. This has led to high-quality facilitators in Introductory Biology I SI classes (as rated by students on attitudinal surveys) who have undoubtedly had a considerable impact on the effectiveness of the SI class. Not having someone in this supervisory position would likely decrease the impact of SI.11

11In fact, no such person is in position for the SI classes in mathematics and physics, and we have seen consistently less impressive results in these classes. There are, however, a number of other factors that make these different from Introductory Biology I, which make it difficult to say what the true impact of having an overall SI supervisor is.
We do, however, feel confident making the case that incorporating SI into challenging, entry-level classes, particularly in subjects such as biology, has the potential to drive progress toward increasing the number of URM students succeeding in the class, and thus the number proceeding to earn a degree in that field. There are still a number of questions that we intend to address in subsequent papers as our research efforts continue that will be necessary to fully understand SI and its impact. Some of these questions, briefly, are as follows:

1. What is the relationship between student motivation to succeed, SI use, and grades in the class?
2. What are the necessary aspects of an SI course (in terms of how it is run and what it offers) to optimize student outcomes?
3. In addition to the differential benefits for URM students, are there differences associated with gender and other such variables?
4. Are these results replicable at different institutions?

Although we have uncovered some very intriguing findings about SI, there is a lot left to learn. In time, we hope to be able to not only demonstrate SI’s effectiveness but also to be able to confidently explain why it works.

ACKNOWLEDGMENTS

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REFERENCES


BIOLOGY, CHEMISTRY, AND BIOCHEMISTRY

The LAC offers tutoring for these subjects. With an LAC tutor, you can learn and practice how to effectively study biology and chemistry by discovering patterns and making connections and developing textbook reading, lecture note-taking, and test-taking strategies.

If you're an EOP student, you may contact the EOP office (338-1085) for tutor availability for this subject.

LAC: Learning Assistance Center

HSS 348
M-TH 9-4, F 9-12
Front Desk: 338-1993
E-mail: lac@sfsu.edu
www.sfsu.edu/~lac

COURSES TUTORED

Please contact the LAC to see which biology, biochemistry, and chemistry courses are being supported this semester.

SERVICES

Individual and small group tutoring: weekly, one-time, same-day appointments. For a detailed same-day schedule, go to HSS 348.

NOTES

Staffed by teachers, graduate and undergraduate trained tutors

return to top
INFORMATION FOR FACULTY AND STAFF

The LAC provides individual and group tutoring for SF State students for a wide range of courses. Tutors are trained to focus on teaching transferable skills (annotating texts, for example) so that students can independently apply these new skills to their work for all courses at the university.

To find out more about how tutoring works, go to "Tutoring at the LAC" or click here.

To find out whether the LAC offers tutoring for courses you teach, click here. You can also call the LAC faculty at 338-1993 or 338-1994.

To find out whether other campus services offer tutoring for your courses, go to "All SF State Tutoring Services" or click here.

Click here if you'd like to view or print our brochure.

Referring Students

If you'd like to refer a student, you may print the referral form. Please describe what skills or areas you feel the student you're referring to the center needs to work on in order to do well in your course. You may also pick up referral forms at the center (HSS 348).

Other Types of Support

The LAC offers additional support to students and tutors. Click here if you'd like to learn more about our LAC Writing Workshops, a one-unit program for
students taking freshman-level English classes. The LAC staff will be happy to visit your class to introduce campus tutoring services to your students. Please contact us at 338-1993 or at lac@sfsu.edu to discuss your class composition and goals and to set up a convenient time to visit.

The LAC faculty also supports SF State instructors. In the past, as examples, the LAC faculty has taught a 20 minute lesson during regular class time on citation skills, worked with a teacher to redesign writing assignments; supported new instructors in giving effective feedback to multilingual writers. Give the LAC faculty a call at 338-1994 to discuss your needs.
Frequently Asked Questions for Faculty

Captioning Access

- What is captioning?
- What are the benefits of captioning?
- What is the difference between closed and open-captioning?
- What is the difference between captioning and subtitling?
- How do I know if my videos are captioned?
- Where can I reserve a closed-caption decoder?
- Which classrooms on campus already have a closed-caption decoder?

Disability Access in Classrooms

- Do you have a Disability
Access Statement that I can add to my course syllabus?

- Can I require students who I think have a disability to register with the DPRC for support services?

- What do I do if I suspect a student has a disability?

- Is a student required to divulge the nature of the disability?

- Do I need to accommodate the student's disability without any written verification from the DPRC?

Exacerbated Symptoms Accommodation

- What is the Exacerbated Symptoms accommodation?

- How do I know if a student may be eligible for the Exacerbated Symptoms accommodation?

- How do I determine whether or not this accommodation is reasonable in my class?

- How will I know if a student's absence or late assignment is disability-related?

- How do I figure out how much leeway to give in
attendance or deadlines?

- **What do I do if a student doesn't meet the agreement we made about attendance or due dates?**

**Notetaking Accommodation**

- **What are notetaking accommodations?**
- **What is the difference between a "volunteer" notetaker and a "paid" notetaker?**
- **How can I assist a student in getting a notetaker from the class?**

**Test Accommodations**

- **What test accommodations are available for students with disabilities?**
- **How do students with disabilities become eligible for test accommodations?**
- **Am I supposed to receive a test accommodation memo from the DPRC before a student can make arrangements for test accommodations with me?**
- **How can I give the extended test time when I have to**
teach another class?

- Do I need to give one-and-a-half or double the usual test time?

- What is a F.A.S.T. form?

- What is a Low Distraction Environment (LDE)?

- What are the deadlines for turning in the F.A.S.T. form?

**Captioning Access**

*What is captioning?*

It is a text display of spoken words and sound effects on a television or movie screen or in multimedia platforms (i.e., streaming Internet videos).

*What are the benefits of captioning?*

Captioning affords deaf and hard-of-hearing individuals access to the spoken language and sound effects. It also aids individuals for whom English is a second language in developing proficiency in the English language. For individuals with learning disabilities, captioning may help increase their language and reading comprehension and improve their self-confidence.
What is the difference between closed and open-captioning?

Closed-captions can be displayed only with the use of a closed-caption decoder. Decoders can be connected to a TV or built into TVs, 13" or larger, manufactured after July 1993. Open-captions, on the other hand, can be displayed without the closed-caption decoder. They are, in fact, "permanently part of the picture" and cannot be turned off.

What is the difference between captioning and subtitling?

Captioning not only captures the spoken dialogue, but it also conveys various sound effects (i.e., infant crying, knocking on door, phone ringing, screaming, and the like) in a text format, whereas subtitling only captures the spoken conversation. However, due to the popularity of DVDs, there are "subtitles for the deaf and hard-of-hearing" (SDH) that essentially function the same way as captioning does.

How do I know if my videos are captioned?

Most commercial videos produced after 1984, most television
programs broadcast today, and DVDs are closed-captioned. Often commercial videotapes and DVDs will either state on the packaging or box that they are closed-captioned or they will be stamped with one of the following icons:

**Closed Captioned for the Hearing Impaired**

If you bring in a video that you have recorded at home, be sure to consult the TV listings to see if the program you have recorded is identified with one of the closed-caption icons. Academic Technology can check your videos to see if they are captioned.

**Where can I reserve a closed-caption decoder?**

If the television set in your classroom is manufactured before July 1993 or smaller than 13 inches, you can request that the media be sent via the campus television lines from the Academic Technology (AT) Center in the library. Please ask AT to use a closed-caption decoder for your media. They prefer at least one day's advance notice.
You can also request a separate TV cart with VCR/DVD player with a closed-caption decoder connected from Academic Technology to be delivered to your classroom.

If the television set in your classroom is manufactured after July 1993 and larger than 13 inches, you can utilize the internal closed-caption decoder. To turn it on, please use a remote control or the menu settings at the bottom of the TV set through the internal menu in your television; please set the captioning to "C1" to reveal the closed captions.

If you are showing DVDs with English subtitles or subtitles for the deaf and hard-of-hearing (SDH) or any videos that are "open-captioned," you will not need a closed-caption decoder to display the subtitles. The decoder is only needed if the videos, DVDs, or any TV programs are "closed-captioned" and once activated, it helps reveal the captions that are hidden in the program.

Which classrooms on campus already have a closed-caption decoder?

Please visit [SFSU Closed Captioning Information](http://www.sfsu.edu/~dprc/facultyfaq.html) for the most updated listing of classrooms.
with a closed-caption decoder available.

**Disability Access in Classrooms**

**Do you have a Disability Access Statement that I can add to my course syllabus?**

Yes, the DPRC has developed the following Disability Access Statement for course syllabi:

"Students with disabilities who need reasonable accommodations are encouraged to contact the instructor. The Disability Programs and Resource Center is available to facilitate the reasonable accommodations process. The DPRC, located in SSB 110, can be reached by telephone at 338-2472 (voice/TTY) or by e-mail at dprc@sfsu.edu."

It is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities that may affect their ability to participate in course activities or to meet course requirements. Students with documented disabilities must register with the DPRC to facilitate the reasonable accommodations process. Students with disabilities are encouraged to contact their instructors to discuss their
individual needs for accommodation; instructors are encouraged to contact the DPRC for assistance in providing accommodations.

**Can I require students who I think have a disability to register with the DPRC for reasonable accommodations?**

No student can be required to register with the DPRC; it is an individual choice. However, a student must be registered with the DPRC in order to receive reasonable accommodations on campus.

**What do I do if I suspect a student has a disability?**

Do not tell a student you think he/she has a disability! Approach the student as you would any other student having difficulty in the class. Inquire about what might be impacting the student's progress in the class. A student with a disability will likely disclose at this time if the difficulties are disability-related. Refer the student to the DPRC if he/she discloses a disability or indicates he/she suspects a disability. If neither of these scenarios occurs, we recommend providing the student with a list of campus resources, including the DPRC.
Is a student required to divulge the nature of the disability?

No, students are not required to tell you the nature of their disabilities or to provide copies of their disability documentation. Students requesting reasonable accommodations do have to provide you with a letter from the DPRC confirming that they have a documented disability and listing the approved accommodations. The DPRC is the authorized entity charged with documenting disabilities and recommending reasonable accommodations at SFSU.

Do I need to accommodate the student's disability without any written verification from the DPRC?

No. Students who have been verified for services have written confirmation from the DPRC. If a student does not have a DPRC verification memo, please refer him/her to our office in the Student Services building, Room 110.

Exacerbated Symptoms Accommodation

What is the Exacerbated Symptoms accommodation?
This accommodation may provide flexibility with deadlines or attendance for students whose disabilities cause unpredictable exacerbations of symptoms that can interfere with the student's ability to do academic work. It is reasonable as long as it does not require the instructor to alter an essential feature of the curriculum. For example, it may work well in a lecture class but not be possible in a seminar where class participation is an essential component of the class.

**How do I know if a student may be eligible for the Exacerbated Symptoms accommodation?**

The student will provide a memo from the DPRC verifying eligibility for the accommodation. Attachments to this memo give information about student and faculty responsibilities in negotiating the accommodation, provide an option to make a written agreement and identify guidelines for determining if the accommodation is reasonable in a given class.

Students who present you with this memo have provided the DPRC comprehensive documentation from an appropriate professional establishing the disability-related
need for the accommodation. If a student tells you she/he needs this accommodation but does not have DPRC verification, please refer her/him to the DPRC.

**How do I determine whether or not this accommodation is reasonable in my class?**

The following questions are designed to assist you in determining if the accommodation is reasonable in your class. In the event of a disagreement between faculty and student about the use of the accommodation, these are the questions the DPRC would consider:

- Is there regular classroom interaction between the instructor and students and among the students themselves?
- Do student contributions in class constitute an essential component of the learning process?
- Does the fundamental nature of the course rely upon student participation as an essential method of learning?
- To what degree does a student’s failure to attend class constitute a significant loss of the educational experience of other students in the class?
- What do the course
description and syllabus say regarding attendance?
○ What is the method by which the final course grade is calculated?

**How will I know that a student's absence or late assignment is disability-related?**

You can request documentation of a specific exacerbation. For privacy reasons, the student has the treating professional provide the documentation to the DPRC, and then we confirm that the exacerbation has been verified. Typically it is appropriate to ask for specific documentation only after an extended period of absence; for a shorter exacerbation, a student may not need to see a doctor. This practice is similar to that used in the employment setting, where as employees, we provide a doctor's note only after an absence of three or more consecutive days.

**How do I figure out how much leeway to give in attendance or deadlines?**

This is an individual decision; formulas are not very helpful here. The amount of leeway with attendance may depend a lot on the nature of the course and the
importance of class participation. Sometimes students can do a great deal of work independently; in other instances the need for interaction and feedback would reduce the amount of leeway you can give. It may be helpful for you to consider what you have done in the past for students who have accidents or family emergencies that disrupt their attendance. If at any time you believe that the student’s absence from class is beginning to jeopardize the academic integrity of the class, please contact the DPRC to discuss whether the student’s continued enrollment in the class is viable.

What do I do if a student doesn't meet the agreement we made about attendance or due dates?

There is no easy answer to this question because exacerbations by their very nature are so unpredictable. Students and faculty may sometimes need to renegotiate agreements. However, there may come a time when a withdrawal or incomplete needs to be considered. The DPRC is always available to consult about the implementation of this (or any other) accommodation.

Notetaking
Accommodations

What are notetaking accommodations?

Some students with disabilities have difficulty taking notes in class because of a disability. To accommodate this disability, the DPRC provides an opportunity for the student to receive copies of someone else's notes. The accommodation is provided only when the student is in class; it is not a substitute for attendance.

What is the difference between a "volunteer" notetaker and a "paid" notetaker?

Volunteer notetakers are other students in the class; paid notetakers are DPRC academic assistants hired to go to class to take notes. Volunteer notetakers in the class can become paid notetakers if they qualify for the position and are willing to go through the payroll procedures.

How can I assist a student in getting a notetaker from the class?

A student who wants an in-class notetaker will give you a memo asking for your assistance in recruiting a volunteer from the
class. For privacy reasons, it is important not to identify the student with the disability, so the memo contains a suggested script for you to use. The student will provide the volunteer with special paper known as "NCR paper" that makes an immediate copy or will arrange to have the notes copied at the DRPC. The student will also let the volunteer know how to become a paid notetaker if so desired.

**Test Accommodations**

*What test accommodations are available for students with disabilities?*

Test accommodations are individually determined for each student based on the specific impact the student's disability has on the test process. The student will present you with a test accommodation verification memo that will list the accommodations necessary for that student.

Accommodations can include but are not limited to: extended time, low-distraction environment, calculator, spell check, private room, reader, writer, interpreter, computer, adaptive equipment (screen reader, voice output, CCTV), Braille, large print, breaks, and accessible furniture.
The University needs to provide any accommodation that minimizes the effect of the disability on the testing process as long as the accommodation does not alter any essential feature of the curriculum and is not prohibitively expensive.

**How do students with disabilities become eligible for test accommodations?**

The students have to provide the DPRC with detailed documentation that shows the specific ways in which their disability limits test-taking. While the detailed information contained in the documentation is confidential, the fact that a student is verified for test accommodations through a "Test Accommodation Verification" memo tells you that the necessary information determining the student's eligibility for test accommodations is on file in the DPRC.

**Am I supposed to receive a test accommodation memo from the DPRC before a student can make arrangements for test accommodations with me?**

Yes, in order for students with disabilities to be eligible for test accommodations, they must
provide you with a document known as a "Test Accommodation Verification" memo which lists the specific accommodations the student needs in order to take a test. We recommend that students give the memos to faculty at the start of the semester whenever possible.

**How can I give the extended test time when I have to teach another class?**

If you are unable to provide the extended test time as per the student's "Test Accommodation Verification" memo prepared by our office, the DPROC can administer the exam. In order for us to make arrangements for the exam to be proctored, the student will need to bring you a form known as the F.A.S.T. form.

**Do I need to give one-and-a-half or double the usual test time?**

A student who is eligible for disability-related test accommodations should bring to you a "Test Accommodation Verification" memo from our office indicating the specific amount of extended test time for which he/she is eligible. You and the student can work out the test arrangements between yourselves.
if you wish to. If not, the DPRC can provide a secure test environment.

What is the F.A.S.T. form?

A F.A.S.T. form (that stands for "Faculty Authorization for Scheduling Tests") is a form that the student with a disability who is eligible for test accommodations brings to you if you are unable to provide the test accommodations yourself and you want the DPRC to administer the exam. You, as an instructor, will need to complete the "Instructor" section, indicating the regular length of the exam, any special conditions, such as "open book/open notes," how the DPRC will get the test, and how we will return it to you. The student is responsible for bringing the F.A.S.T. form back to the DPRC by the published deadlines.

The DPRC will arrange the test space, proctor, etc. You just need to follow through with the arrangements you made to get the test to the DPRC on time.

What is a Low Distraction Environment (LDE)?

A low distraction environment is a test setting that has as few distractions as possible compared to the classroom setting. It can be but does not have to be a private
room. It should be an environment with reduced noise (no phones, talking, etc.) and reduced distractions like people coming and going. If you need assistance determining whether a specific environment qualifies as "low distraction", please contact the DPRC.

What are the deadlines for turning in the F.A.S.T. form?

The deadlines for Fall 2006 are as follows:

- Regular exams: One Week before
- Midterms & Tests Requiring a Computer: Two Weeks before
- Fall 2006 Final Exams: By Wednesday, November 29, 2006

Back to Faculty Resources Page
Blind/Visual Impairments

Approximately 500,000 Americans have vision impairments to the extent that they are considered "legally blind." There are three degrees of vision loss:

1. Visual acuity of 20/200 - the legally blind person can see at 20 feet what the average-sighted person can see at 200;

2. Low vision - limited or diminished vision that cannot be corrected with standard lenses; and

3. Partial sight - the field of vision is impaired because of an illness, a degenerative syndrome, or trauma.

Only two percent of the people with vision impairments are totally blind; most blind people have some amount of usable vision.

Some considerations:

- Some students with vision loss use canes or guide dogs for mobility purposes; however, many navigate without them.

- Like anybody, students with vision impairments appreciate being asked if help is needed before it is given. Ask a student if he or she would like some help and then wait for a response before acting.

- Words and phrases that refer to sight, such as "I'll see you later," are commonly used expressions and usually go unnoticed unless a speaker is particularly self-conscious. Students with vision loss can still "see" what is meant by such expressions.
When talking with or greeting a student with vision impairment, speak in a normal voice; most people with vision impairments are not deaf. Speak to the student, not through a third party or companion, and use the student's name when directing the conversation to him or her. When entering a room, identify yourself to the student.

When giving directions, say "left" or "right," "step up" or "step down." Convert directions to the vision-impaired student's perspective. When guiding a student (into a room, for example), offer your arm and let him or her take it rather than pulling the person's sleeve.

If a student has a harnessed guide dog, it is working and should not be petted.

Common accommodations for students with vision impairments include alternative print formats, magnification devices, bright incandescent lighting, raised lettering, tactile cues, adaptive computer equipment, readers for exams, print scanners, early syllabus, priority registration, taped lectures, and lab or library assistants.

**Instructional Strategies**

The following strategies are suggested to enhance the accessibility of course instruction, materials, and activities. They are general strategies designed to support individualized reasonable accommodations.

- Include a Disability Access Statement on the syllabus, inviting students with disabilities to request accommodations.

- Have copies of the syllabus and reading assignments ready three to five weeks prior to the beginning of classes, so documents are available for taping or Braille transcription.
- Provide vision-impaired students with materials in alternate formats at the same time the materials are given to the rest of the class. The student must advise as to the format: large print, Braille, electronic, or tape.

- When using an overhead projector with transparencies, use a larger font size (at least 18 point). Provide additional time for students with visual disabilities to copy the material on the transparencies, or provide them with printed copies.

- Repeat aloud what is written on the board and in handouts, and/or presented on overheads.

- Pace the presentation of material: if referring to a textbook or handout, allow time for students to find the information.

- Allow students to tape-record lectures.

- When lecturing, avoid making statements that cannot be understood by people with visual impairments (e.g. "This diagram sums up what I am saying about statistics").

- When appropriate, ask for a sighted volunteer to team up with a vision-impaired student for in-class assignments.

- Keep a front row seat open for a student with vision impairment. A corner seat is especially convenient for a student with a guide dog.

- Assist the student with finding an effective notetaker or lab assistant from the class, if the student is eligible for these services.

- Make arrangements early for field trips and ensure that accommodations will be in place on the given day (e.g., transportation, site accessibility).

- Be flexible with deadlines if assignments are held up by the alternate media process.
- When in doubt about how to assist the student, ask him or her.

- Allow the student the same anonymity as other students (i.e., avoid pointing out the student or the alternative arrangements to the rest of the class).

Back to Disabilities and Instructional Strategies Main Page
Deaf/Hard-of-Hearing *

The causes and degrees of hearing loss vary across the Deaf and hard-of-hearing community, as do methods of communication and attitudes toward deafness. In general, there are three types of hearing loss:

- Conductive loss affects the sound-conducting paths of the outer and middle ear. The degree of loss can be decreased through the use of a hearing aid or by surgery. People with conductive loss might speak softly, hear better in noisy surroundings than people with normal hearing, and experience ringing in their ears.

- Sensorineural loss affects the inner ear and the auditory nerve and can range from mild to profound. People with sensorineural loss might speak loudly, experience greater high-frequency loss, have difficulty distinguishing consonant sounds, and not hear well in noisy environments.

- Mixed loss results from both a conductive and sensorineural loss.

Given the close relationship between oral language and hearing, Deaf and hard-of-hearing students with hearing loss might also have speech impairments. One's age at the time of the loss determines whether one is prelingually deaf (hearing loss before oral language acquisition) or adventitiously deaf (normal hearing during language acquisition). Those born deaf or who become deaf as very young children might have more limited speech development.

Some considerations:
• The inability to hear does not affect an individual's native intelligence or the physical ability to produce sounds.

• Some Deaf and hard-of-hearing students are skilled lipreaders, but many are not. Many speech sounds have identical mouth movements, which can make lipreading particularly difficult. For example "p," "b," and "m" look exactly alike on the lips, and many sounds (vowels, for example) are produced without using clearly differentiated lip movements.

• Make sure you have a Deaf or hard-of-hearing student's attention before speaking. A light touch on the shoulder, a wave, or other visual signal will help.

• Look directly at a Deaf or hard-of-hearing person during a conversation, even when an interpreter is present. Speak clearly, without shouting. If you have problems being understood, rephrase your thoughts. Writing is also a good way to clarify. E-mailing and using the Relay Service (see Other SFSU Disability Resources on the DPRC website) are very good communication alternatives outside of class.

• Make sure that your face is clearly visible. Keep your hands away from your face and mouth while speaking. Sitting with your back to a window, gum chewing, cigarette smoking, pencil biting, and similar obstructions of the lips can also interfere with the effectiveness of communication.

• Common accommodations for Deaf or hard-of-hearing students include sign language interpreters, stenocaptioners, assistive listening devices, TTY/relay services, volume control telephones, signaling devices (e.g., a flashing light to alert individuals to a door knock or ringing telephone), priority
registration, early syllabus, notetakers, and captions for films and videos.

Modes of Communication

Not all Deaf or hard-of-hearing students are fluent users of all of the communication modes used in the Deaf community, just as users of spoken language are not fluent in all oral languages. For example, not all Deaf or hard-of-hearing students lipread; many Deaf individuals use sign language but there are several types of sign language systems. American Sign Language (ASL) is a natural, visual language having its own syntax and grammatical structure. Fingerspelling is the use of the manual alphabet to form words. Pidgin Sign English (PSE) combines aspects of ASL and English and is used in educational situations often combined with speech. Nearly every spoken language has an accompanying sign language. It is important to assign interpreters who will match the communication needs and preferences of each student. Interpreters convey all information in a given situation, including instructor's comments, class discussion, and environmental sounds.

Instructional Strategies

The following strategies are suggested in order to enhance the accessibility of course instruction, materials, and activities. They are general strategies designed to support individualized reasonable accommodations.

- Include a Disability Access Statement on the syllabus, inviting students with disabilities to request accommodations.

- Circular seating arrangements offer Deaf or hard-of-hearing students the advantage of seeing all class participants, especially in a seminar setting.

- For the lecture setting, keep front seats open for students who are Deaf or hard-of-hearing
and their interpreters.

- Repeat the comments and questions of other students, especially those from the back rows; acknowledge who has made the comment so the Deaf or hard-of-hearing student can focus on the speaker.

- When appropriate, ask for a hearing volunteer to team up with a Deaf or hard-of-hearing student for in-class assignments.

- Assist the student with finding an effective notetaker or lab assistant from the class, if the student is eligible for these services.

- If possible, provide transcripts of audio information.

- Face the class while speaking. If an interpreter is present, make sure the student can see both you and the interpreter. Request the handout "Guidelines for Working with an Interpreter" from the DPRC.

- If there is a break in the class, get the Deaf or hard-of-hearing student's attention before resuming class.

- Because visual information is a Deaf student's primary means of receiving information, films, overheads, diagrams, and other visual aids are useful instructional tools. Spoken dialogue and commentary in films, videotapes, DVDs, and online course websites, should either be presented in captions or other alternate means, such as a transcript.

- Be flexible: allow a Deaf or hard-of-hearing student to work with audio-visual material independently and for a longer period of time.

- When in doubt about how to assist the student, ask him or her.

- Allow the student the same anonymity as
other students (i.e., avoid pointing out the student or the alternative arrangements to the rest of the class)

Back to Disabilities and Instructional Strategies Main Page

SFSU Home  |  DPRC Home  |  Search  |  Need Help?

Disability Programs and Resource Center
Student Services Building 110
1600 Holloway Ave.
San Francisco, CA 94132-4046
Phone: 415/338-2472 (voice/TTY); Fax: 415/338-1041

Last Modified March 15, 2006, by the dprc@sfsu.edu

http://www.sfsu.edu/~dprc/dho/hsrc/dhh.html
Mobility Impairments *

Mobility impairments range in severity from limitations on stamina to paralysis. Some mobility impairments are caused by conditions present at birth while others are the result of illness or physical injury. Injuries cause different types of mobility impairments, depending on what area of the spine is affected.

Quadriplegia, paralysis of the extremities and trunk, is caused by a neck injury. Students with quadriplegia have limited or no use of their arms and hands and often use electric wheelchairs.

Paraplegia, paralysis of the lower extremities and the lower trunk, is caused by an injury to the mid-back. Students often use a manual wheelchair and have full movement of arms and hands. Below are brief descriptions of other causes of mobility impairments.

Amputation is the removal of one or more limbs, sometimes caused by trauma or another condition.

Arthritis is the inflammation of the body's joints, causing pain, swelling, and difficulty in body movement.

Back disorders can limit a student's ability to sit, stand, walk, bend, or carry objects. They include, but are not limited to, degenerative disk disease, scoliosis, and herniated disks.

Cerebral palsy is the result of damage to the brain prior to or shortly after birth. It can prevent or inhibit walking and cause a lack of muscle coordination, spasms, and speech difficulty.

Neuromuscular disorders include a variety of
disorders, such as muscular dystrophy, multiple sclerosis, and ataxia, that result in degeneration and atrophy of muscle or nerve tissues.

Some considerations:

- Many students with mobility impairments lead lives similar to those without impairments. Dependency and helplessness are not characteristics of physical disability.

- A physical disability is often separate from matters of cognition and general health; it does not imply that a student has other health problems or difficulty with intellectual functioning.

- People adjust to disabilities in a myriad of ways; students should not be assumed to be brave and courageous on the basis of disability.

- When talking with a wheelchair user, attempt to converse at eye level as opposed to standing and looking down. If a student has a communication impairment as well as a mobility impairment, take time to understand the person. Repeat what you understand, and when you don't understand, say so.

- A student with a physical disability may or may not want assistance in a particular situation. Ask before giving assistance, and wait for a response. Listen to any instructions the student may give; by virtue of experience, the student likely knows the safest and most efficient way to accomplish the task at hand.

- Be considerate of the extra time it might take a disabled student to speak or act. Allow the student to set the pace walking or talking.

- A wheelchair should be viewed as a personal-assistance device rather than something one is "confined to." It is also part of a student's personal space; do not lean on or touch the
chair, and do not push the chair, unless asked.

- Mobility impairments vary over a wide range, from temporary (e.g., a broken arm) to permanent (e.g., a form of paralysis). Other conditions, such as respiratory conditions, affect coordination and endurance; these can also affect a student's ability to perform in class.

- Physical access to a classroom may not be the first barrier a student with a mobility impairment encounters on campus. A temporary construction project on a pathway, a lack of reliable transportation, or mechanical problems with a wheelchair can significantly impact a student's experience.

- Common accommodations for students with mobility impairments include priority registration, notetakers, accessible classroom/location/furniture, alternative ways of completing assignments, lab or library assistants, adaptive computer technology, exam modifications, and conveniently located parking.

**Instructional Strategies**

The following strategies are suggested to enhance the accessibility of course instruction, materials, and activities. They are general strategies designed to support individualized reasonable accommodations.

- Include a Disability Access Statement on the syllabus, inviting students with disabilities to request accommodations.

- If necessary, arrange for a room change before the term begins.

- Special seating arrangements may be necessary to meet student needs. Students may require special chairs, lowered tables on
which to write, or spaces for wheelchairs. In laboratory courses, students who use wheelchairs may need lower lab tables to accommodate their chairs and allow the use of equipment.

- If possible, try not to seat wheelchair users in the back row. Move a desk or rearrange seating at a table so the student is part of regular classroom seating.

- Students with upper body weakness may not be able to raise their hands to participate in class discussion. Establish eye contact with the students and call on them when they indicate that they wish to contribute.

- Make arrangements early for field trips and ensure that accommodations will be in place on the given day (e.g., transportation, site accessibility).

- Make sure accommodations are in place for in-class written work (e.g., allowing the student to use a scribe, to use adaptive computer technology, or to complete the assignment outside of class).

- Be flexible with deadlines: assignments that require library work or access to sites off-campus will consume more time for a student with a mobility impairment.

- Please understand that for reasons beyond their control, students with severe mobility impairments may be late to class. Some are unable to move quickly from one location to another due to architectural barriers, inadequate public transportation or temporary obstacles on campus.

- Not all mobility impairments are constant and unchanging; some students experience exacerbations or relapses requiring bed rest or hospitalization. In most cases, students are able to make up the incomplete work, but they
may need extra time.

- When in doubt about how to assist the student, ask him or her.
- Allow the student the same anonymity as other students (i.e., avoid pointing out the student or the alternative arrangements to the rest of the class).

Back to Disabilities and Instructional Strategies Main Page

SFSU Home  |  DPRC Home  |  Search  |  Need Help?

Disability Programs and Resource Center
Student Services Building 110
1600 Holloway Ave.
San Francisco, CA 94132-4046
Phone: 415/338-2472 (voice/TTY); Fax: 415/338-1041

Last Modified March 15, 2006, by the dprc@sfsu.edu
Systemic Disabilities

Systemic disabilities are conditions affecting one or more of the body's systems. These include the respiratory, immunological, neurological, and circulatory systems. There are many kinds of systemic impairments, varying significantly in their effects and symptoms; below are brief descriptions of some of the more common types.

Cancer is a malignant growth that can affect any part of the body. Treatment can be time-consuming, painful, and sometimes result in permanent disability.

Chemical dependency is considered a disabling condition when it is documented that a person has received treatment for a drug or alcohol addiction and is not currently using. Chemical dependency can cause permanent cognitive impairments and carries with it a great deal of stigma.

Diabetes mellitus causes a person to lose the ability to regulate blood sugar. People with diabetes often need to follow a strict diet and may require insulin injections. During a diabetic reaction, a person may experience confusion, sudden personality changes, or loss of consciousness. In extreme cases, diabetes can also cause vision loss, cardiovascular disease, kidney failure, stroke, or can necessitate the amputation of limbs.

Epilepsy/seizure disorder causes a person to experience a loss of consciousness. Episodes, or seizures, vary from short absence or "petit mal" seizures to the less common "grand mal." Seizures are frequently controlled by medications and are most often not emergency situations.
Epstein Barr virus/chronic fatigue syndrome is an autoimmune disorder which causes extreme fatigue, loss of appetite, and depression. Physical or emotional stress may especially adversely affect a person with this condition.

Human immunodeficiency virus (HIV+), which causes AIDS, inhibits one's ability to fight off illness and infections. Symptoms vary greatly. People with HIV or AIDS are often stigmatized.

Lyme's disease is a multisystemic condition which can cause paralysis, fatigue, fever, dermatitis, sleeping problems, memory dysfunction, cognitive difficulties, and depression.

Lupus erythematosus can cause inflammatory lesions, neurological problems, extreme fatigue, persistent flu-like symptoms, impaired cognitive ability, connective tissue dysfunction, and mobility impairments. Lupus most often affects young women.

Multiple chemical sensitivity (MCS) often results from prolonged exposure to chemicals. A person with MCS becomes increasingly sensitive to chemicals found in everyday environments. Reactions can be caused by cleaning products, pesticides, petroleum products, vehicle exhaust, tobacco smoke, room deodorizers, perfumes, and scented personal products. Though reactions vary, nausea, rashes, lightheadedness, and respiratory distress are common to MCS.

Multiple sclerosis (MS) is a progressive neurological condition with a variety of symptoms, such as loss of strength, numbness, vision impairments, tremors, and depression. The intensity of MS symptoms can vary greatly; one day a person might be extremely fatigued and the next day feel strong. Extreme temperature can also especially adversely affect a person with MS.

Renal disease/failure can result in loss of bladder control, extreme fatigue, pain and toxic reactions that can cause cognitive difficulties. Some people
with renal disease are on dialysis and have to adhere to a rigid schedule.

Some considerations:

- Students affected by systemic disabilities differ from those with other disabilities because systemic disabilities are often unstable. This causes a person's condition to vary; therefore, the need for and type of reasonable accommodations may also change.

- Some common accommodations for students with systemic disabilities include conveniently located parking, notetakers, extended time to complete a task, modified course or workload, flexible deadlines, relocation of a meeting or class, early syllabus, priority registration, and exam modifications.

**Instructional Strategies**

Systemic disabilities often require instructional strategies similar to those listed for other disability conditions. The use of such strategies will depend on how the disability is manifested. In addition to strategies listed for other disabilities, the following are suggested to enhance accessibility of course instruction, materials, and activities. They are general strategies designed to support individualized reasonable accommodations.

- Include a Disability Access Statement on your syllabus, inviting students with disabilities to request accommodations.

- Medical conditions, including medication side effects, can cause problems with fatigue and stamina, which adversely affect attention and concentration. For these reasons, students with medical conditions may need extended time on exams.

- Students with some medical conditions may become dizzy and disoriented, or may lack
physical stamina. Thus they may be unable to get from one location to another on campus within the expected time frame. Be considerate if they are late to class.

- Preferential seating may be necessary to meet student needs. In a few instances, students may be unable to use the furniture of a particular classroom and may need to request furniture assistance. If students are forced to stand during class, students may need podiums on which to rest open books or to write.

- Instructors in courses requiring field trips or internships need to work with their students to ensure that the students' needs are met. For example, the students may need assistance with transportation, special seating or frequent rest-breaks.

- Some students experience recurrence of a chronic condition requiring bed rest and/or hospitalization. In most situations students are able to make up the incomplete work, but they may need extra time.

Back to Disabilities and Instructional Strategies
Main Page

SAN FRANCISCO STATE UNIVERSITY

Disability Programs and Resource Center
Student Services Building 110
1600 Holloway Ave.
San Francisco, CA 94132-4046
Phone: 415/338-2472 (voice/TTY); Fax: 415/338-1041

Last Modified March 15, 2006, by the dprc@sfsu.edu
Learning Disabilities

Learning disabilities are neurologically-based conditions that interfere with the acquisition, storage, organization, and use of skills and knowledge. They are identified by the existence of deficits in academic functioning and in processing memory, auditory, visual, and linguistic information. The diagnosis of a learning disability in an adult requires documentation of at least average intellectual functioning along with deficits in such areas as:

- Auditory processing
- Visual processing
- Information processing speed
- Abstract reasoning
- Memory (long-term, short-term, visual, auditory)
- Spoken and written language skills
- Reading skills
- Mathematical skills
- Visual spatial skills
- Motor skills
- Executive functioning (planning)

Some considerations:

- A learning disability is not a disorder that a student "grows out of." It is a permanent disorder affecting how students with normal or
above-average intelligence process incoming information, outgoing information, or both.

- Learning disabilities are often inconsistent. They may be manifested in only one specific academic area, such as math or foreign language. There might be problems in grade school, none in high school, and again in college.

- Learning disabilities are not the same as mental retardation or emotional disorders.

- Common accommodations for students with learning disabilities are alternative print formats, taped lectures, notetakers, adaptive technology, course substitutions, early syllabus, exam modifications, priority registration, and study skills and strategies training.

**Instructional Strategies**

The following strategies are suggested to enhance the accessibility of course instruction, materials, and activities. They are general strategies designed to support individualized reasonable accommodations.

- Include a Disability Access Statement on the syllabus, inviting students with disabilities to request accommodations.

- Keep instructions brief and as uncomplicated as possible.

- Assist the student with finding an effective notetaker or lab assistant from the class, if the student is eligible for these services.

- Allow the student to tape-record lectures.

- Clearly define course requirements, the dates of exams, and when assignments are due; provide advance notice of any changes.
- Provide handouts and visual aids.
- When appropriate, team a reader with a non-reading student during in-class assignments.
- Use more than one way to demonstrate or explain information.
- Have copies of the syllabus ready three to five weeks prior to the beginning of classes so textbooks are available for taping.
- Break information into small steps when teaching many new tasks in one lesson (state objectives, review previous lesson, summarize periodically).
- Allow time for clarification of directions and essential information.
- Provide study guides or review sheets for exams.
- Provide alternative ways for the students to do tasks, such as dictations or oral presentations.
- Provide assistance with proofreading written work.
- Stress organization and ideas rather than mechanics when grading in-class writing assignments.
- Allow the use of spell-check and grammar-assistive devices.
- When in doubt about how to assist the student, ask him or her.
- Allow the student the same anonymity as other students (i.e., avoid pointing out the student or the alternative arrangements to the rest of the class).

Back to Disabilities and Instructional Strategies Main Page
Last Modified March 15, 2006, by the dprc@sfsu.edu
GENERAL INFORMATION

The Educational Opportunity Program is designed to improve access and retention of low-income and educationally disadvantaged students. EOP students have the potential to perform satisfactorily in CSU but have not been able to realize their potential because of their economic or educational background. The program provides admission, academic, and financial assistance to EOP-eligible undergraduate students. Once admitted as an EOP student, you can enroll in an EOP summer program to strengthen your math, reading, or other skills. Orientation sessions are provided to help you learn about college services and programs. During your enrollment in college, you can receive counseling, tutoring, and advising services. If you are eligible, an EOP grant may be awarded.

Students must apply to EOP during the admissions process in order to be eligible. Click here to learn more about the History of EOP.

EOP ANNOUNCEMENTS

- EOP Scholarships
- Fall 2008 Dates to Remember
- Fall 2008 Workshop Schedule

*To use the interactive forms, you must have Adobe 7.0 Reader.

San Francisco State University
Educational Opportunity Program
1600 Holloway Avenue, Student Services, 201
San Francisco, CA 94132

Phone: 415.338.1085 or 415.338.1646
Fax: 415.338.0541
Email: eop@sfsu.edu

Hours: Monday - Friday, 8 AM - 5 PM

For printing purposes, set Orientation to "Landscape" on your Page Setup screen. This page is best viewed with Internet Explorer (click to download).
Welcome!

Welcome to the Community Access & Retention Program (CARP). We are a free tutorial and academic support program at San Francisco State (SF State), open to all SF State students. CARP is open predominately in the evenings. Learn more about CARP's unique contributions to SF State.

Tutoring Hours

CARP tutoring will conclude for the Spring 2008 semester at 7pm on May 15th.

We will begin tutoring for the Summer semester on June 9th at 10 am.

Spring Semester Hours
Mondays through Thursdays from 4 pm to 8 pm
Fridays from 11 am to 2 pm

Summer Semester Hours
Mondays through Thursdays from 10 am to 3 pm
Fridays from 10 am to 2 pm

If you would like tutoring, please either call (415) 405-0971 to make an appointment or simply stop by HSS 344 during our tutoring hours.

Contact Information
CARP's Unique Contributions to SFSU

- CARP is an evening academic support program.
- During the summer, CARP is the only major tutoring center open to all SFSU students.
- CARP is student run.
- CARP conducts In-Class outreach in which members of our staff visit an assortment of classes and introduce CARP to the students and give the students advice on how to best make use of our services.
- CARP offers a series of free workshops developed to help SF State students develop college success skills and to prepare for a variety of campus exams.
- Moreover, CARP places tutors in remedial math courses.
- CARP works in conjunction with the Advising Center to identify at risk students and develop personalized academic support.
- CARP exemplifies SF State’s commitment to Community Service Learning.

- CARP is an evening academic support program.

1. Many students who are either first generation college students or members of traditionally underrepresented groups on campus frequently find themselves unable to attend academic support services whose hours of operation are during traditional school hours. So by maintaining evening hours of operation, CARP fills this void.

Back to Top

- CARP is student run.

1. With the exception of the Senior Coordinator, every member of CARP is either a Graduate or Undergraduate student at San Francisco State. CARP provides students the opportunity to develop ‘real world’ skills in a professional academic support environment. Whether Coordinators, Tutors, Receptionists or Office Support Specialists, CARP members are held to exacting standards of professionalism as they develop the skills necessary to succeed outside of SF State. As an illustration of such professionalism, student coordinators routinely meet with SFSU administration, staff and faculty in order to elucidate CARP’s philosophy and methods.

2. Additionally, CARP’s student coordinators meet with SF State faculty to address the instructor’s specific academic concerns regarding both their students as a whole and specific referrals so that CARP’s tutors can develop an academic support program that focuses on specific needs and issues.
• CARP offers a series of free workshops developed to help SFSU students develop college success skills and to prepare for a variety of campus exams.

1. CARP routinely offers 4-5 JEPET preparation workshops prior to every JEPET offering. These workshops are popular with SF State students and usually reach capacity in a short time.
2. CARP also offers ELM preparation workshops and is in the process of developing and launching GET preparation workshops.
3. Additionally, CARP provides JEPET, ELM and GET support sessions in a one-on-one format.
4. Time Management: One of our more popular workshops. In this workshop we discuss and model strategies for realizing where one’s time goes as well as how schedule effectively. Other components touched on in this workshop include, but are not limited to, how to study smarter and not harder, and recognizing needs versus wants while maintaining the perspective of a college student.
5. Overcoming test anxiety: This workshop breaks down the various types of exams typically administered to college students and discusses various strategies for systematically approaching these tests.
6. Research methods and strategies: With this workshop we model effective research strategies by highlighting many of the various services offered by SFSU, services which often go unnoticed by students. Presenters of this workshop also offer real life advice culled from their extensive experience as students.
7. Timed writing tips and strategies: This workshop addresses the specific issues relating to timed in-class writing and offers systematic suggestions for approaching these exams.
8. Study Skills: How to study smarter not harder. We offer various suggestions aimed at becoming a successful student while still maintaining a healthy social life.

• Moreover, CARP places tutors in remedial math courses.

1. Tutors assist instructors by working with students as they complete their class assignments. Tutors facilitate both individual and group session environments.

• CARP exemplifies SFSU’s commitment to Community Service Learning.

1. At CARP both tutors and coordinators are SF State students engaged in providing academic support for the University community. In order to achieve this aim, coordinators and tutors conduct best practice research related to learning theory and tutorial techniques and put this research into action within the SF State learning community.

«Back to About Us
Community Access & Retention Program

"Serving The SF State Community For 10 Years"

Mathematics, Science & Business

CARP's mathematics, science & business staff assists tutees with developing the tools necessary in becoming independent and successful learners. Our tutors are upper-division and graduate students who are pursuing their degrees in these respective fields. They are trained individuals who set up a comfortable environment for their tutees and are dedicated to helping students achieve their academic goals.

Download the free Acrobat Reader

Information about our tutoring styles - PDF

To make an appointment for mathematics, science, or business tutoring, call (415) 405-0971 or stop by HSS 344 during our regular hours of operation.

Mathematics, Science, & Business Courses We Tutor Include*

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MATH 376   BIOL 350
MATH 565   BIOL 355
PSY 171    ENGR 205
PSY 371    ENGR 206
CSC 201
CSC 210
CSC 212
CSC 510

* This list of courses is always subject to change.

«Back to Free Tutoring

Community Access & Retention Program • San Francisco State • HSS 346 • (415) 405-0316 • carp1@sfsu.edu

Fall hours
Mon-Thurs 4 pm to 8 pm
Fri 11 am to 2 pm

http://www.sfsu.edu/~carp1/math.htm
Upcoming Workshops

We are always interested in broadening our offerings and meeting faculty requests. Check out the list of workshops below to see what is currently being offered by The Center. If you have an idea for us to explore, we'd love to hear about it. Please either email The Center or give us a call.

Blurring the Boundaries of Space and Time - the HyFlex Approach to Course Design

Presented by Brian Beatty, Assistant Professor, Instructional Technologies
Date and Time: Thursday, October 16, 2008 12:00 PM - 2:00 PM
Location: Burk Hall 210

What happens when students are given viable options for participating in learning events? If you had the option of participating live in person, live online, or asynchronously online, which would you choose? With Hyflex design you can build an online program that complements an existing in-person program, provide flexible participation modes for students struggling with the demands of school, work, family, and travel/commuting, and allow students to take multiple courses that "meet" at the same time, enabling a quicker path through a degree program without adding more resources. In
this session, we'll review the HyFlex design and discuss great ideas for reaching learning targets through multiple participation paths.

Register for the Blurring the Boundaries of Space and Time - the HyFlex Approach to Course Design workshop

Understanding the Distressed Student: Enhancing Communication in the Classroom

Presented by Pat Davis, Coordinator of Faculty and Staff Services/Clinical Counselor
Taghi Amjadi, Clinical Counselor, Counseling and Psychological Services
Date and Time: Wednesday, November 5, 2008 12:00 PM - 2:00 PM
Location: Burk Hall 333

In this workshop we will discuss how to talk to and enhance communication with your diverse student population. What do you do when confronted with stressed out, misbehaving, difficult and disruptive students? How do you support your students and set appropriate boundaries that allow you to gain and maintain control of your classroom? When do you ask for help with student problems? From where do you seek assistance?

Register for the Understanding the Distressed Student: Enhancing Communication in the Classroom workshop

The Culture of San Francisco State and the City

Presented by Joel Kassiola, Dean, College of Behavioral and Social Sciences
Date and Time: November 6, 2008, 3:00 - 5:00 PM
Location: Administration 460

Discover a new perspective on San Francisco culture from Joel Kassiola, Dean of the College of Behavioral and Social Sciences for the past thirteen years. As a native New Yorker, Dean Kassiola offers observations on the city and campus from an East Coast-West Coast point of view. Attendees will be able to pose questions about both San Francisco and the University based on their first impressions of a few months. Discussion promises to be both enlightening and fun.

Register for The Culture of San Francisco State and the City workshop

Return to top of the Document
Appendices for Standards:

Standard 3: Technology
Congratulations! You've taken the first step towards using the power of the Internet to improve your teaching. There are many ways to use iLearn (SF State's Learning Management System) and other online tools to improve your courses, and possibly make your job easier.

There are quite a few instructors on campus who are using the Internet to teach. Some of the ways they are using the Internet include:

1. Provide important resources and content for 24/7 student access
   - syllabus, lecture notes, handouts, etc.

2. Facilitate interaction
   - e-mail announcements
   - online threaded discussions anywhere, anytime
   - group work with wikis

3. Assess your learning
   - self-assessment quizzes
   - rubrics for for written assignments that you turn in online

All of this may seem a bit overwhelming at first. To be honest, if you tried to do it all at once it would definitely be overwhelming. So take your time, take a small piece, and begin to experience the power of teaching "with a net"--the Internet.

iLearn is an alternative Learning Management System (LMS) that many SF State instructors have adopted to enhance online student learning and collaboration.

iLearn is based on Moodle, an open-source software package. It is designed using sound pedagogical
principles, to help educators create effective online learning communities.
Visit - http://iLearn.sfsu.edu

Resources For iLearn
• Frequently Asked Questions
• iLearn Help
Welcome

If you are taking a video-streamed course, click on the college name to see a listing of the courses and to access the live webcast or view the course archives. Or you can check below for Upcoming Streaming Course and/or recently archived streamed courses.

Recommended browser: Firefox

SFSU wireless is unstable and sometimes loses part of data, so we do not recommend using SFSU wireless to watch a live lecture stream. You should not have trouble with live stream if you are wired.

Please take the time to do the CourseStream Assessment.
The password: CourseStream!
We greatly appreciate your feedback.

If you need any assistance please refer the Help Page or email us.

Upcoming Streams

This section will feature upcoming streams for the day.

No live streaming until the fall semester.

Recent Archives

This section will feature streams that have been recently archived
College of Science and Engineering

We have updated the files so you should be able to see the slides with the lecture video or audio in the same window even with the newest version of QuickTime player.

**Live Cast**  **Archive**  **Podcast**  **Search**  **Course**

BIOL 330 Section 2
12:10 - 13:00 MWF Moffatt

If you need any assistance please refer the Help Page or email us at cvstream@sfsu.edu
Interested in creating your own ePortfolio?

Students, faculty, departments, and institutions are increasingly using electronic portfolios. SFSU now offers support for students who would like to create and publish an electronic portfolio. To get started and learn more about ePortfolios, please visit the ePortfolio at SFSU site.

Overview

Students, faculty, departments, and institutions are increasingly using electronic portfolios in higher education. The National Learning Infrastructure Initiative (NLII, 2003) defines an electronic portfolio as a collection of authentic and diverse evidence, drawn from a larger archive representing what a person or organization has learned over time on which the person or organization has reflected, and designed for presentation to one or more audiences for a particular rhetorical purpose.

Electronic portfolios provide new opportunities for assessing achievement and learning outcomes over time as well as presenting an evolution of work in response to interactions with instructors, mentors, and classmates. This student-centered, outcome-oriented approach is being seen to provide new models for improving student learning and achievement (read more about portfolio development).

There are generally three types of portfolios: Formative Portfolios, created on an ongoing basis supporting academic/professional development; Summative Portfolios, created within the context of a formal evaluation process; and Presentation Portfolios, which are used for culminating projects/competencies and seeking employment. (overview of ePortfolios.)

Project Goals

Working with the assumption that several departments are utilizing electronic portfolios at SFSU, in the fall of 2005 Academic Resources sponsored a needs assessment review of campus-wide e-portfolio use.
The goals of this study (Phase 1) are to:

- Investigate and research a variety of portfolios required in different disciplines at SFSU;
- Improve the electronic portfolio development processes by building campus-wide knowledge of electronic portfolio use within SFSU and its broader CSU community (read more about the CSU portfolio project) through research, collaboration, experimentation, and sharing;
- Draft a report summarizing preliminary research findings and propose a process for a campus-wide longer-term approach to the creation of student electronic portfolios (Coming in 2006).

---

ePortfolio Community

An electronic portfolio interest group and iLearn online portfolio community site have also been established, with specific examples, and a growing library of links related to e-portfolio use at SFSU and elsewhere. This iLearn online ePortfolio community is open to anyone interested in this topic. We welcome your involvement.

---

Project Contact

For further information on any aspect of the e-portfolio work, to request an informational presentation, or if you’d like to join the iLearn group, please write to: [LINK..] ruthcox@sfsu.edu [...LINK]. You may also view an informational PowerPoint presentation on e-portfolios at: http://lis.sfsu.edu/node/74.

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ePortfolio Projects at SFSU

Health Education Department

In the spring of 2004, the Health Education Department launched a pilot project requiring the MPH students to create their culminating portfolios using E-folio software (Avnet, Minn., www.avenetfolio.com). There are now 70 Master of Public Health students utilizing efolios to fulfill their portfolio requirements.

Here are some examples of MPH student "E-folios":

- http://donnawillmott.sfsu.myefolio.com
- http://rachelpeulain.sfsu.myefolio.com
- http://catherinemagee.sfsu.myefolio.com

College of Extended Learning

The College of Extended Learning's Multimedia Studies Program (MSP) has utilized electronic portfolios for several years. They offer a Portfolio Development class that all Certificate students take at the end of their studies. Students vary from Web Development to Print and Graphics Production to 3D Arts. Most students create a Web site (online
portfolio) that includes work from their core discipline.

Here are a few specific examples:

Jose Versiani Martins Portfolio Links
- Jose Versiani Martins' portfolio
- http://www.versiani.com/

Elizabeth Paik Portfolio Links
- Elizabeth Paik's portfolio
- http://www.elizabethpaik.com/

Sandrine Lacorie Portfolio Links
- Sandrine Lacorie's portfolio
- http://www.lacorie.com/

View many examples of student ePortfolios in the full archive:
- View the full archive here

Other Departments

Other departments requiring electronic portfolios at SFSU include: The School of Education (Secondary Education, Internet based Candidate Assessment Portfolio (ICAP) program)
- Assessment Program (ICAP)
- Public Administration Program
- The Department of Recreation and Leisure Studies

San Francisco State University in partnership with the Golden Gate National Parks Conservancy and the National Park Service offers undergraduate and graduate students internships in the Golden Gate National Recreation Area (GGNRA). Students construct and present portfolios of their projects: View the student portfolios here

We will be adding other departments and more information as the project evolves. Please check back!
INFORMATION RESOURCES: LIBRARY, ACADEMIC TECHNOLOGY, AND INFORMATION TECHNOLOGY

ACADEMIC TECHNOLOGY

Web Site: http://academic.sfsu.edu/ar/at/

The Academic Technology unit supports and advances effective learning, teaching, scholarship, and community service with technology. Academic Technology:

- Actively collaborates to provide universally accessible solutions
- Researches, implements, promotes, and evaluates innovations and best practices
- Develops expertise and competencies through training, consultations, and professional development
- Designs, equips, maintains, and supports virtual and physical learning environments

There are 4 core areas of service within Academic Technology:

- **Online Teaching and Learning** delivers SF State’s Learning Management System iLearn, ePortfolios, CourseStreaming, webconferencing, and other online services and workshops.
- **Media Distribution and Support** provides audiovisual equipment for teaching, support through training and troubleshooting, and access to more than 17,000 films and videos.
- **Learning Spaces** constructs and maintains more than 100 electronically enhanced classrooms, meeting rooms, and lecture theaters across campus, as well as 2 experimental classrooms.
- **Creative Services** provides assistance with graphics, posters, photos, videoconferencing and teleconferencing.

Consultations and recommendations on technical specifications for grant proposals are available to the campus community.

Online Teaching and Learning

Online Teaching and Learning continues to grow at San Francisco State University. Today's students need SF State to accommodate flexible schedules, alternative course locations, different learning preferences, various levels of background preparation, unequal access to technology, and much more. Using the online environment can improve curricular and co-curricular success, by allowing faculty and students to share files, to interact and collaborate, and to assess progress as students, teachers, and experts in our disciplines. Currently, Academic Technology leads and coordinates development, training, and support for several different online teaching and learning tools, including:
presentations. AT provides a valuable service to students when advising them to bring in their laptops to determine their compatibility with our LCD projectors and troubleshooting their problems before their presentations.

Learning Spaces

Academic Technology currently oversees and maintains 100 enhanced classrooms, 6 enhanced meeting rooms, and 2 enhanced theaters. AT plans, designs, builds, installs, and maintains instructional electronic equipment throughout the campus. The campus television network, electronic classrooms, and mobile electronic teaching platforms are examples of services provided by this area. AT also has a comprehensive electronic/optic/mechanical facility for equipment fabrication, maintenance, and repair.

DIVISION OF INFORMATION TECHNOLOGY

Web Site: www.sfsu.edu/~doit

The Division of Information Technology (DoIT) offers a wide range of technology services to the campus community: Internet/e-mail accounts, 24-hour computing lab, help desk support, campus-wide software licenses, and on-line services via the web. Students have access to on-line registration, grades, financial statements, class schedule searches, class schedules, address changes, transcripts, and Internet/e-mail account requests. Internet/e-mail accounts can be used for e-mail, dial-in modem access, publishing a personal web page, programming course work, and on-line research. Additional instructional computing labs are available to students in support of curricular activities provided through agreements with other campuses: social science database archives, business databases, geographic information systems, etc.

Some of the current campus-wide software licenses DoIT distributes include Microsoft Office and Visual Development Tools, Oracle databases and application development tools, and anti-virus software. Faculty have access to on-line class rosters which list student names, e-mail addresses, web page links, and some prerequisite information. DoIT also provides instructional computing support to faculty requiring on-line course work, video streaming, database administration, specialized IT training for classes, and administering listservs.

The John F. True 24-hour computing lab allows students to have access to computing resources with connectivity to the Internet and standard software applications. In total, over 1,500 PCs and Macintoshes are available to students supported by the colleges at SFSU. Many are general purpose computing labs, offering standard software applications; others are specialty labs, with discipline-specific software (www.sfsu.edu/~doit/labs.htm). Over 300 dial-in modems provide remote access for the campus community. All classrooms, computer labs, and on-campus housing have high-speed network access. There are a number of computer workstations on campus designed to meet the needs of students with various kinds of disabilities.

The Division of Information Technology offers free short courses and workshops throughout the year to faculty, staff, and students on basic, intermediate, and advanced skills in computers--from word processing and spreadsheets to graphics, databases, and web pages. In addition to the courses, technical assistance is provided via the web (www.sfsu.edu/~helpdesk), e-mail (helpdesk@sfsu.edu), phone (415-338-1420), and walk-in (ADM 110).
iLearn (http://ilearn.sfsu.edu) is SF State’s supported-learning management system which allows faculty, students, staff, and community groups to share course or project materials, facilitate interaction opportunities, and assess performance in many ways. Increasing numbers of faculty and staff use iLearn to coordinate committee work, funded projects, community service learning interactions, and more. The iLearn home page lists the latest announcements and system status, useful tips and tricks for using iLearn, and links to help and technical support resources for both students and faculty.

CourseStream (http://coursestream.sfsu.edu) is an online environment which provides a variety of streaming media options to students enrolled in certain large classes. Students can view a live webcast, with synchronized PowerPoint slides and video recorded lecture, or review the archive in webcast or podcast format. Students can also search an entire semester of lectures by keyword and then jump right to a specific point in a video clip for easy review.

ePortfolios (http://eportfolio.sfsu.edu) are electronic portfolios of student and faculty work, which provide new opportunities for assessing achievement and learning outcomes over time, as well as presenting an evolution of work in response to interactions with instructors, mentors, and classmates. ePortfolios are also being actively used by students to connect with and further their career development.

Online Teaching and Learning responds to emerging needs with new technologies and approaches that enable engaging teaching and learning experiences both in and out of the classroom. Online meeting spaces with web-based video conferencing (e.g., Elluminate) allow students to participate in interactive class meetings from home, work, or other off-campus locations. Online collaborative software, (e.g. ThinkTank), facilitates 100% student participation in brainstorming, critical thinking, peer review, and other interactive exercises. Plagiarism detection software, (e.g. Turnitin), allows students to check their written work for proper citation before submitting it to an instructor. More needs and solutions, such as podcasting, will continue to emerge each year.

Media Distribution and Support

Media Distribution and Support (“Distribution”) provides faculty with formatted media and technical equipment to meet their classroom and other instructional purposes. The university media collection includes over 20,000 videotapes, DVDs, laserdiscs, CD-ROMs, films, and multimedia kits. Academic Technology acquires these materials based on faculty input and provides a web catalog of all holdings at <www.sfsu.edu/~avtv/AV.mediacatalog.html>. This is the major university collection, though separate film and video archives exist in the university Library. The Library’s Media Access Center, built and maintained by the Library and AT, provides students and faculty with access to both digital and analog video and computer tools, and with a cable television connection to all types of media held by the unit.

Equipment provided by AT to faculty in support of classroom instruction includes laptop computers, video projectors, multimedia integrated carts, slide projectors, audio and videotape recorders, video presentation carts, student response systems (clickers), and digital cameras. A complete listing is available at our distribution web site (www.sfsu.edu/~avtv/distribution.html). AT distributes and maintains media and equipment either over the counter, through requested delivery & pick up, or via Cablecast.

Though the Library provides the core technological services for students, AT also works with students by assisting them at the distribution counter, answering their technical questions, and showing them various uses of equipment. AT also shows students how to set up the equipment they want to use for their
Administrative functions within the division support the technology infrastructure that is key to running the university. In addition to the areas named above, there are staff which enhance and maintain the intercampus networking, Internet/e-mail servers, web application development, telephone services, campus-wide ministrative systems (student information, financial and human resources), data center operations, and equipment services.

THE J. PAUL LEONARD LIBRARY

Web Site: www.library.sfsu.edu

During the next few years, the Library building will be under construction for an expansion, renovation, and seismic retrofit. Check the Library's web site for the most up-to-date information regarding services and collections www.library.sfsu.edu/about/building/index.php.

The mission of the J. Paul Leonard Library (JPLL) is to empower its university constituency with lifelong learning skills to identify, find, evaluate, use, and communicate information in promotion of excellence in scholarship, knowledge, and understanding. To fulfill its mission within the context of the missions of San Francisco State University (SFSU) and the California State University (CSU) system, the library is committed to the following goals:

- Collaborating with departmental faculty in incorporating information competence into the curriculum to ensure that all SFSU graduates are competent in locating, retrieving, organizing, critically evaluating, analyzing, synthesizing, and communicating information in a cohesive, logical, and ethical manner;
- Creating a learning environment that promotes study, research, and scholarly interaction in the context of a diverse campus community;
- Supporting excellent teaching and learning by providing equally for all university constituents on-site and remote access to relevant materials in support of the curriculum in any format, whether owned by or at JPLL or elsewhere;
- Encouraging through collections and access exploration of the broadest spectrum of viewpoints, constructs, cultures, beliefs, and methodologies;
- Evaluating, selecting, and teaching information sources and search strategies relevant to the SFSU curriculum;
- Providing leadership to the university community in exploring and incorporating changing information technologies and formats;
- Supporting an understanding and appreciation of diversity through collections, programs, and instruction; and through recruitment and retention of diverse faculty and staff;
- Preserving cultural heritage through unique primary source materials;
- Promoting, supporting, and encouraging the transfer and sharing of information and knowledge within the broader community, and the sharing of intellectual and creative resources locally, regionally, and internationally.

The J. Paul Leonard Library collections number over four million items, including books, periodicals, electronic resources, government publications, microforms, audio-visual media, computer software, and maps. Electronic resources include electronic full-text journals, e-books, and databases used to locate journal articles and reference information. Information about these materials is accessible via the library’s catalog, InvestiGator, and the Library’s web site. Computer stations on campus offer access to InvestiGator.
electronic resources and other information available on the Internet. Computers and quiet study areas are available to students during extended hours. Off-campus access to the library's electronic resources is available to the campus community at any time once you have chosen a Library PIN.

The Information and Research Assistance service points, library faculty and staff offer advice on library research and assistance using library resources. Appointments may be made with subject specialists for research advice on term papers and similar projects.

**ADA Compliance:** the library's temporary locations are accessible to people with disabilities; the J. Paul Leonard Library expansion and renovation will follow universal design principles.

Borrowing: students may borrow from the library's main collection and many of its specialized collections by presenting their OneCard (university identification card). Neither the card nor books borrowed on it may be transferred to another person. Loss of a student ID or change of address should be reported immediately to the library registration desk and to the Registrar's Office. Other CSU campus students may borrow books directly from the J. Paul Leonard Library if they present a current CSU identification card and register with JPLL to obtain a special borrower's card.

During the construction period, items in the collection must be requested in advance and will be available for review, borrowing, viewing or listening within 24 hours.

Borrowing from Other Libraries: you may request items such as books, dissertations, and copies of journal articles not available at this library. Register for a Library PIN to use the LINK+ service for ILLiad for all other requests.

**Friends of the J. Paul Leonard Library:** established in 1980 to promote the love of books, strengthen relationships between the university and the community, and to raise funds beyond those available in the regular budget for library services. Membership is open to SFSU students, faculty, staff, and community adults. Privileges include borrowing books and use of many library services. The Friends maintain a Book Sale Room and accept used books and other donations.

**Government Publications:** the Library is a selective government depository housing federal, state, international, and local government publications. Most government publications are included in the library's catalog, InvestiGator. For other online sources, check the Library web site under FIND Government Information.

**Information Literacy:** the library administers the Basic Information Competence Requirement that must be completed by all undergraduate students before graduation. Most students will fulfill the requirement by completing a self-paced tutorial called OASIS (On-line Advancement of Student Information Skills), available on the web (http://oasis.sfsu.edu). The library also offers course-related instructional sessions, individual research advice, and research guides by subject.

**Media Access Center (MAC):** provides access to the library's media collection such as videotapes, compact discs, audiotaapes, and computer software. Production equipment is available for digital video editing. The Information Commons features computer workstations for general use and offers access to printing and scanning, the Internet, and a variety of software applications. Computers are available for student use; diversity ID is required.
Periodicals/Microforms: current periodicals and newspapers are in Library Annex I; microfiche, microfilm and bound periodicals must be requested in advance.

Reserve Materials: the Reserve Collection provides materials in high demand for assigned readings in courses. Articles and other short readings are available through ERes (electronic reserves). Print and non-print materials on reserve are available at the Library's distribution location on campus.

Special Collections: Special Collections/Archives houses archival material about the history of San Francisco State University, the Archer Collection of Historic Children's Books, and other rare or unusual materials. It also maintains the San Francisco Bay Area Television News Archives with KQED and KPIX historical film and video footage as its core. Some rare or valuable items will not be available during the construction project.

The Frank V. de Bellis Collection of The California State University is a library-museum representing the civilization of ancient and modern Italy, particularly in the areas of history, literature, fine arts, and music. Holdings include rare books, music scores, archival sound recordings, manuscripts, periodicals, microfilms, art prints, artifacts, and coins. Most rare or valuable books will not be available during the construction project. The artifacts and coins will be on loan to Museum Studies.

The Labor Archives and Research Center, located at 480 Winston Drive, collects, organizes, preserves, and makes accessible the records documenting the lives of working men and women and their labor organizations in the Bay Area. The Labor Archives shares a building with the Sutro Library, a branch of the California State Library, which enjoys a special cooperative relationship with San Francisco State University.

Sutro Library collection is open to all citizens of California and includes some 140,000 volumes and 40,000 historical pamphlets. Among its collection strengths are natural history, Mexicana, Shakespeareana, records of the Pacific voyages of discovery, the history of printing, genealogy, and local history.

More information about the library, including descriptions of services and policies, is available via the library web site: www.library.sfsu.edu.
Phone: 338-1494

Where are we?
Frequently Asked Questions
What's on?
What kind of equipment do we have?
For the techhead in all of us:
How does this thing work?

Equipment Check-out Procedures:
Start here: See how your classroom is configured
If your room has a console, learn more about it here
Get equipment delivered to your class
If you only need equipment occasionally
Do you use an overhead 3 or more times a week?
Consider a long loan

Media Information:
Who, what and when of Media Checkout
broadcast from the AV Center to your classroom

Miscellaneous:
Tell your students about this page
Here are tips to make student presentations easier
To access the internet in classrooms
Information for Laptop Users
Mac laptop users—you need an adapter
Having a Guest Speaker in your class?
What we do when you're not looking

Service Hours and Location
FAQ
Audio-Visual Glossary | Illustrated Version
Current AV Equipment
Equipment Tutorials
Training information and contacts

Online Classroom Database
Electronically Enhanced Classrooms
Delivery/Pick-up Service
Over the Counter
Long Loan

Media Checkout
Cablecast

Student Presentation Information
Reserving equipment for STUDENT presentations
Ethernet Information
Laptop Mirroring Activation Chart
Mac Laptop Adapters
Tips for Guest Speakers
News and Updates

This page current as of: Tue Jul 15 2008 14:58:09 GMT-0700 (PDT)
Electronic Resources Collection

About
The Library subscribes to a wide range of electronic resources such as full-text electronic databases, citation and index databases, electronic journals, and e-books. Currently we subscribe to over 200 databases, which provide access to approximately 24,000 electronic journals. Most of our Electronic Resources are restricted to SFSU students, faculty and staff only for licensing reasons.

Using the Collection
- Find Articles and Databases
- Electronic Journal List
- Off Campus Access
Spring 1999

More Labs for CSE Students

These laboratories are new additions for the College of Science and Engineering and are in need for more funds and equipment. If you or your company can support these labs, please contact them directly.

SEGA Multimedia Laboratory for Science and Mathematics

The new SEGA Multimedia Laboratory for Science and Mathematics was established with a $55,000 grant from the SEGA Foundation to MASTEP (Math and Science Teacher Education Program) and matching funding from the College of Science and Engineering for data line installation and room renovation. Additional funding awarded to MASTEP by PG&E and Adobe's generous donation of software licenses for a broad spectrum of the company's renowned multimedia development applications have brought the lab closer to its planned configuration and capability.

The new lab, located in 249 Science, is a teaching facility that supports in-class, computer enhanced instruction for students in science, mathematics and in science/mathematics credential programs. The lab also supports MASTEP program elements. MASTEP, one of 16 collaboratives for excellence in teacher preparation across the nation, utilizes its National Science Foundation funding to promote course and curriculum development in science, math and teacher credential programs, recruit talented K-12, community college and SFSU students into careers in math and science teaching, and to facilitate continued professional development and retention of new teachers from SFSU's credential programs. The SEGA lab supports these programs as a facility for 1) SFSU and community college science and math faculty development workshops and curriculum projects that facilitate incorporation of computer and internet resources into courses, 2) development of educational multimedia materials for class and student use, 3) intern experiences for science, math and engineering undergraduates exploring teaching as a career option, 4) outreach programs to enhance science and math experiences for talented K-12 students, and 5) professional development, networking, and other programs for new science and math teachers to facilitate their transition into teaching and retention in the profession.

The lab allows faculty to provide rich, technologically current in-class instruction for students in science, mathematics, and math/science teacher credential programs. Incorporation of computer assisted instruction, including simulations, models, application of professional data analysis tools, and access and utilization of on-line resources enhances learning and professional preparation of all students. It is critical that future science and math teachers experience effective use of these cutting-edge tools and resources, so they may incorporate them appropriately into their own teaching.

The critical shortage of qualified math and science teachers and the low performance of U.S. students in the recent TIMSS (Third International Math and Science Study) report underscore the nationwide need to attract talented students to teaching and to engage them in a science and math curriculum that integrates content with effective teaching methodologies, including technology assisted instruction.

Currently, the new lab houses 15 PowerMac 6500/250MHz computers, a digital projector, 2 printers (laser, inkjet color), and one multimedia development station with an Epson flatbed scanner, Polaroid slide scanner, and CD recorder. The lab is networked with Internet and connected to the Internet. Dr. Nan Carnal, Co-PI for the MASTEP grant, notes the most pressing needs are 1) upgrading ones to include a PC environment (via PC cards) to meet software needs for many courses and 2) funds to employ a full time lab
manager to manage lab scheduling, student access, computer maintenance, software requirements for courses, instruct faculty, teachers, and students in hardware and software use, and to develop instructional materials. Additional needs are 1) expanded multimedia development capability (digital video creation/manipulation, additional set of scanners, software tools for multimedia authoring), 2) a server for web hosting, storage of digital resources, etc. 3) 8 workstations to complete the desired 24 station lab, 4) is for instructional software acquisition.

For further information contact MASTEP at (415) 338-7681 or Nan Carnal at (415) 338-1853.

Biomedical Mass Spectrometry Facility At SFSU

SFSU has a new facility for modern mass spectrometry which was funded by the university and a new biomedical research program from the National Institutes of Health. The facility is directed by Drs. Scott Gronert, Peter Palmer and Bruce Machar from the Department of Chemistry and Biochemistry. The facility manager is Dr. Robert Yen who came to SFSU after completing post doctoral training at the University of North Carolina. (Alumni are invited to visit the new facility in the Science building, please contact Dr. Yen at 415-338-6413). Dr. Scott Gronert is collaborating with scientists from the University of California, Davis on a project to develop new approaches for peptide sequencing. Dr. Palmer’s research focuses on monitoring air pollutants and the air aboard the space station MIR. Research in Dr. Machar’s laboratory is aimed at the characterization of enzymes involved in the synthesis of compounds which function in the normal inflammatory response and in diseases related to abnormal inflammatory responses.

In addition, the mass spectrometry facility provides state-of-the-art analytical support for faculty engaged in biomedical research in the College of Science and Engineering. The facility currently has a range of instruments that are being utilized by undergraduate and graduate students, post-doctoral fellows and faculty. Over the next few years, the directors of the facility hope to add new instruments to extend the range of analyses that can be performed and thus to provide an even more versatile laboratory for supporting research in chemistry and biochemistry.

Currently, the directors are seeking a matrix assisted, laser desorption-time of flight mass spectrometer (MALDI-TOF). This instrument is extremely useful for characterizing very small quantities of peptides generated by proteolytic digestion of proteins and complements the electrospray mass spectrometers presently in the lab. The fund raising goal for the new instrument is $100,000-$250,000. Please contact Dr. Bruce Machar at (415) 338-1288 or macher@sfsu.edu if you need more information about this lab.

Back to Newsletters

SFSU : College of Science & Engineering : Featured Sites : Home

Updated by Lannie Nguyen-Tang on August 3rd, 2000

Welcome to the newly formed SFSU Center for Computing for Life Sciences (CCLS)

The Center for Computing in Life Sciences (CCLS) is part of a University-wide strategic thrust towards interdisciplinary research and education. It addresses the emerging trend of integration of life sciences and computational and mathematical sciences. It involves faculty, researchers, and students from the SFSU departments of Biology, Biochemistry, Computer Science, Mathematics, and Physics. The broad research program of the center emphasizes investigations in topics varying from Bioinformatics and Computational Drug Discovery to complex data visualization and development of new paradigms for data modeling, user interfaces and web-engineering in contexts involving life sciences. The CCLS provides an environment for faculty to cooperate, for students to work on multidisciplinary projects including those involving culmination degrees and for collaboration with industrial and academic partners. The center also hosts a number of external advisors and collaborators.

Prof. Dragutin Petkovic
Chair, Department of Computer Science
Director, SFSU Center for Computing for Life Sciences
The Center for Computing in Life Sciences (CCLS)
Collaboration Website

Welcome to the Center for Computing in Life Sciences Collaboration Website

The purpose of this website is to support faculty, students, and CCLS affiliates for CCLS research. For information about CCLS, please visit the main CCLS website. We invite you to read about our software services, research projects, facilities and lab and high-performance computing cluster.

New Users

Guests are welcome to browse the website to learn more about the research done in conjunction with CCLS. Faculty and student researchers...

- Must request project approval to get access to CCLS resources.
- May request a cluster account to get access to the CCLS clusters.
- May request software engineering services by registering.
- May request access to the facilities to work, meet with other members of your research group, or meet with your faculty advisor.

CCLS at Hensil Hall

News

BAMBAIV to be held at UC Davis

Supported in part by CCLS. See:
http://koehllab.genomemcenter.ucdavis.edu/bamba4
for more information.

Dr. Chris Smith from SFSU Biology
Department wins prestigious NIH grant

Argentine Ants: A system for studying genes involved in human behavioral diseases

  - June 2008 Poster
  - August 2008 Poster

CSUPERB Fall 2008 Travel Grants

Proposals are due midnight Sunday, October 5, 2008.

These grants programs are intended to support
travel to biotechnology related professional meetings and workshops, held between July 1, 2008 and March 31, 2009. Another RFP will be issued in the spring for travel between January 1 and June 30, 2009.

More news...

Last revised: r53 - 10 Jul 2008 - 20:22:12 - Mike Wong
The OASIS Tutorial

OASIS Tutorial Overview

OASIS: Online Advancement of Student Information Skills is a tutorial that fulfills the Basic Information Competence Requirement. It is an online, self-paced program consisting of eight chapters with quizzes. After completing OASIS, you will be able to understand the basic strategies for determining information requirements for various research projects, as well as locating, retrieving, using, and evaluating information in both electronic and print formats.

The amount of time it takes to complete OASIS may vary, depending on your familiarity with computers, research methods, and information sources. Most students spend a cumulative total of 6 to 8 hours reading the eight chapters and taking the quizzes. You can view the OASIS chapters and take the quizzes at your leisure and it is not necessary to do them in one sitting. You must complete the OASIS tutorial within one year of the date you first began OASIS.

Getting started

Go to the OASIS home page and follow the "Begin OASIS" link. From this page, which provides a short overview, you can link to the OASIS chapters. Read a chapter or chapters and then link to the quizzes from the Summary page of any chapter. You will need your student number and your PAC (Personal Access Code) to access the quizzes (see below for further info).

If you do not know your PAC, or if your PAC does not work, you must talk to SF State Student Services about re-establishing your PAC. The PAC Information Web page is at https://www.sfsu.edu/online/pacinfo.htm. The phone number for Student Services is: (415) 338-2350.

Getting HELP

Assistance with OASIS is available:

- by visiting the Research Assistance Desk (Library, 1st Floor)
- by sending an email message to infcomp@sfsu.edu
- by calling 415-338-2972

Accessing OASIS

Since OASIS is an online, web-based tutorial, it is accessible from any computer with an Internet connection. In addition to accessing OASIS from home, you may also use computers located in the Library or the campus computer labs.

For security purposes, you must access the quizzes with your student ID and PAC from the OASIS Quiz login page, linked from the Summary page of each OASIS chapter.

Quizzes

There are eight chapters in OASIS. Each chapter has a quiz. Each quiz consists of ten questions about the material covered in the chapter. A successful quiz score is 80 or higher. If you do not receive a score of 80 or higher, you may retake the quiz up to five times. If you do not pass a quiz by the sixth attempt, you will need to make an appointment to see an OASIS instructor by sending an email to infcomp@sfsu.edu.

You must complete the quizzes sequentially. In other words, you must successfully pass Quiz 1 before advancing to Quiz 2. When you have passed all eight quizzes, you have completed OASIS and your...
fulfillment of the Basic Information Competence Requirement will show up on your SF State Test Score report and your DARS.

Deadline for completing OASIS
In general, you must complete the OASIS tutorial within one year of the date you take Quiz 1. If OASIS is a requirement for a class, please check with your instructor about deadlines. Other deadlines may also apply (see information about the Basic Information Competence Requirement).

Verification of completion
Once you have successfully completed OASIS, your student record will be updated to indicate that you have fulfilled the Basic Information Competence Requirement. "Completed" status will appear on your Test Score Report and on your Degree Audit Report (DARS), but not on your unofficial transcript. You can obtain a copy of your Test Score Report from the MySFSU (Student Information Service) web page.

What if I'm not currently enrolled in classes?
You do not need to be enrolled in classes in order to complete OASIS. However, you do need to have a valid SF State Personal Access Code (PAC).

If you do not know your PAC, or if your PAC does not work, you must talk to SF State Student Services about re-establishing your PAC. The PAC Information Web page is at http://www.sfsu.edu/online/pacinfo.htm. The phone number for Student Services is: (415) 338-2350.

What if I've already fulfilled the Library Requirement?
If you have successfully completed a version of the Library workbook (it was graded and you received a certificate), you have fulfilled the Library Requirement. You do not need to complete OASIS.

If you are enrolled in a class that requires the completion of OASIS, you may need to complete OASIS even if you have previously done the workbook. Please check with your instructor about requirements for the course. If you have already completed the workbook and need to complete the OASIS Tutorial, you must send an email message to infocomp@sfsu.edu in order to gain access to the quizzes.
What is a Student Response System?

Student Response Systems allow you to pose questions to a class of any size, gather results, and display them to the class in real time. Students respond by clicking a response keypad, also known as a “clicker”. This process can be done in conjunction with or embedded in a PowerPoint presentation.

Why should I consider using a Student Response System?

More and more SF State faculty have begun to adopt electronic Student Response Systems to facilitate class discussions, interaction in large classrooms, and overall student participation. Adoption of the response system technology can lead to great success in the classroom.

What should I consider when choosing a Student Response System?

Right now, there is some confusion due to the fact that different publishers have sold so many different systems on campus. We are coordinating the effort to reduce the number of systems, so there can be centralized support for instructors and students. In the meantime, consider the following:

- **infrared vs. Radio Frequency**: There are two ways that the response keypads communicate with the receivers: infrared or radio frequency. Even though they are more expensive, we recommend radio frequency systems. They are easier for everyone:
  - Instructors can use them in any classroom and can set up the receiver easily
  - Students do not have to worry about “line of sight” issues between the keypad and the receiver when responding
  - Campus support staff do not need to outfit specials rooms with receivers

- **Mac vs. PC**: Of the top two radio frequency systems, one works on both Mac and PC platforms, while the other will not be available for the Mac until December. [Update] Both systems now work on both PC and Apple platforms.

- **Functionality**: One system allows cross-tabulation and other analysis features in real-time, while others offer limited analysis functions and/or limited real-time capabilities.

- **Communication with publishers**: Different publishers present different response systems to go with their textbooks. However, this does not necessarily mean you must
use a specific response system.

- **Confusion for Students:** Students enrolled in more than one class using a student response technology may need to purchase a different type of "clicker" (response pad) for use with each class that adopts a different system. In Spring 2005, some students had to purchase three different "clickers"! In Fall 2005, there will be five systems in use on campus. Talk to your department and college peers and academic technology support staff to see who is using a Student Response System. You may be able to use one that they are using.

- **Cost to students:** Some systems are cheaper, but they require the students to pay a registration fee each semester to use the keypads.

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**How do students get the response keypads?**

The response keypads are distributed in two different ways:

- The department, college or university buys a set of keypads to check out for use in the classroom.
- Students buy keypads from the bookstore. The keypads are sold individually or bundled with textbooks.

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**How do I get more information about Student Response Systems?**

Information is available in many different forms:

- Check out one of the three demo units from Academic Technology. They are available at the Academic Technology checkout counter in the ground floor of the library and come complete with RF receiver, student clickers, a laptop with installed software, and instructions.
- Find out more information on two systems currently in use on campus by visiting Academic Technologies site on elinstruction and Turing Technologies. (Still under construction)
- Contact us directly. We are always happy to discuss various solutions on campus and put you in contact with other experienced faculty members.
LABORATORY MANUAL

BIOLOGY 230
INTRODUCTORY BIOLOGY I

SAN FRANCISCO STATE UNIVERSITY

Spring 2008

Nan Carnal
Hideo Yonenaka
Jim Duncan
Information of Interest Related to Chromosomes, Mitosis, Genetic Diseases

Under construction!!
If you find good web (or other) resources, let us know*

Web Sites:
1. Web site that allows you to construct karyotypes:
   http://www.biology.arizona.edu/human_bio/activities/karyotyping/karyotyping.html
2. Nucleus and Chromosome Organization (good electron micrographs, text, and presentation of techniques used to study the nucleus and chromosomes)
   http://cellbio.utmb.edu/cellbio/nucleus.html
3. Mitosis Sites (sent to us, we haven’t checked them all out!)
   http://www.biology.uc.edu/ygenetic/mitosis/mitosis.htm
   http://www.mcgill.ca/nrs/mitosis.htm
   http://www.biology.arizona.edu/cell_biol/tutorials/cell_cycle/main.html
   http://www.life.uiuc.edu/bio100/lessons/mitosis_and_meristems.html
   http://geded.emc.maricopa.edu/bio/bio181/BIOBK/BioBookmito.html
   http://biog-104-104.bio.cornell.edu/BioG101-104/tutorials/cell_division.html
   (includes whitefish blastula and onion root tip pictures)
   http://tidepool.st.usm.edu/crswr/pages/mitosismov.html
   http://www.ug.cs.dal.ca/disapproj/celldiv.html
4. Map of the human chromosomes showing locations of known genes. (Human genome map—may be better sites?)
5. Web sites on chromosome abnormalities and genetic diseases:
   http://www.hgmp.mrc.ac.uk/GenomeWeb/diseases.html#0
   (this site is a page of links to home pages for many genetic diseases)
   http://mccr2.med.nyu.edu/murphp01/homenew.htm (genetic diseases affecting children)
   http://www.nas.com/downsyn/ Down Syndrome page

Other Sources:
   Ch. 12. The Cell Cycle
   Ch 47, pp 936-944. Animal Development from mitotic division of zygote to blastula and beyond.
   Ch 19, pp 344-346. Chromatin structure and levels of condensation

*Send url for web site and comment regarding topic to ncarnal@sfsu.edu
Reconstructing Phylogenies

It is well and good to read phylogenies and to use them to hypothesize about relationships. But how do systematic biologists go about the process of reconstructing a phylogeny?

(A) Requirements for comparing taxa
Three components are necessary to undertake a phylogenetic (or any other kind of) classification:

1) The taxa that are to be classified must be determined (unless you have some idea of what the entities are that must be classified, what are you classifying)?

2) Classifications are founded on differences in features among different taxa. Thus, characters (morphological, molecular, or otherwise) must be identified.

3) Once characters are identified, the different character states must be decided upon. For example, just to say that flower color (a character) will be used to classify plants is not very helpful; we need to decide which and how many colors (character states) there are that can be used to differentiate taxa. Ideally, the changes from one character state to another will reflect evolutionary changes.

(B) Organizing your data
Once you have gathered enough data with which to compare the taxa you’re studying, you can create a data matrix. Data matrices are organized in two dimensions with the names of taxa along one axis and the names of characters along the other axis. Characters states are recorded in the corresponding positions in the matrix. For example, here’s a data matrix that you might create when shopping for dinner:

<table>
<thead>
<tr>
<th></th>
<th>Color</th>
<th>Legs</th>
<th>Expense</th>
<th>Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken</td>
<td>white</td>
<td>two</td>
<td>$</td>
<td>yes</td>
</tr>
<tr>
<td>Duck</td>
<td>red</td>
<td>two</td>
<td>$$$</td>
<td>yes</td>
</tr>
<tr>
<td>Pork</td>
<td>white</td>
<td>four</td>
<td>$$</td>
<td>no</td>
</tr>
<tr>
<td>Beef</td>
<td>red</td>
<td>four</td>
<td>$$$</td>
<td>no</td>
</tr>
<tr>
<td>Tofu</td>
<td>white</td>
<td>none</td>
<td>$</td>
<td>sometimes</td>
</tr>
</tbody>
</table>

This matrix is a simple one; more commonly in biology there are many more taxa and characters, and often the character states are much more complex. Fortunately we have computers to facilitate the computations and explore all possibilities for comparing taxa based on our characters.

(C) Phylogenetic Assumptions - Parsimony
There are many approaches to reconstructing phylogenies, most of which have their different advantages and purposes. We will use only one approach in today’s lab - parsimony - and it happens to be the most commonly-used approach by biologists. Parsimony argues that a reasonable
estimate of evolutionary history is one that requires us to make the fewest additional assumptions about our data. This does not necessarily argue that evolution actually works that way - only that we should use that plan to infer evolutionary history from our data. We use the parsimony approach to seek the tree with the fewest number of evolutionary steps; that is, the tree with the fewest number of character state changes. If we can measure the “size” of a phylogenetic tree by the number of steps, then the most reasonable tree is the shortest tree. In truth the TRUE phylogeny may involve more than the minimum number of steps possible. But because we may never know the exact number of evolutionary changes that have occurred in the history of a group, we are reliant on estimating phylogenetic history using the best set of assumptions that we can obtain.

Bottom line: The shortest tree is the best estimate using parsimony criteria.

(D) Phylogenetic Assumptions - Polarity
We stressed earlier that in phylogenetic inference relationships among taxa are based on shared derived traits (synapomorphies), and that shared ancestral traits (symplesiomorphies) are not used to reconstruct phylogenies. Fine, but how do we know, for each character, which traits (character states) are apomorphic and which are plesiomorphic? The answer is, we really don’t know (how could we possibly know unless we already knew precisely how evolution progressed in our group of taxa?); however, once again we can make some assumptions that allow us to estimate relationships. Determining the polarity of characters (which are apomorphic and which are plesiomorphic) is most commonly done using the outgroup method. The entire group of taxa that you are studying is called the ingroup. An outgroup is any taxon that presumably shares recent common ancestry with the ingroup, but that has diverged from the ingroup prior to further diversification within the ingroup. Ideally our outgroup should be the sister group to the ingroup; but again, we rarely know the identity of the sister group. We certainly can guess as to some reasonably candidates, and these guesses are our outgroups.

Here’s how the outgroup method to assess character polarity works:
1) Choose an outgroup (often several are chosen)
2) Assume that the outgroup has all plesiomorphic characters (and why is this a reasonable assumption)?
3) Code your characters however you wish (0, 1, 2, 3, .... is typical).
4) When the outgroup method is employed, the program that generates your trees will use all character states that are shared among taxa EXCEPT the character states possessed by the outgroup.

Bottom line: The outgroup is used to determine which character states are plesiomorphic.

(E) Let’s Reconstruct a Phylogeny

For this part of the exercise you can develop a phylogenetic analysis for your own set of taxa and characters, or you can use one of two sets of predefined character sets. The two predefined character sets are “Vertebrates” and “Fish Key.” The Vertebrates data set concerns the classification of vertebrates, and the fish key data set concerns the classification of the taxa of fish in the fish-key exercise. If you want to develop your own data set, read the section below, but if you want to use one of the predefined data sets skip to “Using MacClade.” In either case, you will use the program MacClade to carry out your phylogenetic analysis.

Defining your own data set: The most difficult steps in developing your own data set are the first ones - choosing the group that you want to study, the characters and their states, and
finally an outgroup (or 2, or 3). For this exercise you needn’t worry about the accuracy of your phylogeny. You will learn the most by starting from the beginning and making the same kinds of decisions that systematists make.

- Choose 10 taxa to represent your ingroup.
- Then select at least 10 characters that occur in members of the ingroup.
- Then identify the different character states for each character.
- Then assign a code for each character state within a character.
- Then create a data matrix.

Creating a Data Matrix

1. **Double click the MacClade icon to open the program** - you’ll get a dialogue box asking which file to open, or in your case, **create a new file**.

2. When you create a new file you’ll get an abbreviated matrix that looks somewhat like the beginning of a blank spreadsheet.

   a. To create a blank matrix for a certain number of taxa, simply drag the square box at the left down until enough rows are available to type in the names of the taxa.

   b. Do the same with the square box at right to create enough columns for the appropriate number of characters.

   c. When you have done this you will have a \( n_0 \) by \( n_t \) size matrix into which you will type the names of your taxa, your characters, and the codes for the character states for each taxon.

   d. You can modify the size of your matrix at any time. **Remember to save the file after any changes.**

*Using MacClade*

- MacClade is pretty user friendly. You should be able to navigate through the program without any problem. Be aware, however, that the only way in which to become fluent in MacClade (and any other program, for that matter) is to use it. The manual for MacClade is good, but it won’t tell you anything that you can’t learn from prowling through the program.

- Open a data set (either the “Vertebrates,” “Fish key,” or your own). Open the tree window (by selecting “Display” and “Tree”), and you will see a tree of the taxa in your analysis. This is **not the most parsimonious tree**; in fact, it’s simply a tree with a uniform branching pattern holding the taxa in the same order as you entered them into the data matrix. To look for the shortest tree, drag and drop taxa from one place to another, and see if the “treelength” changes. Keep moving taxa until you find the shortest tree. There may actually be more than one equally parsimonious tree for your data set. This is common in phylogenetic analysis, and suggests that more data is needed.

- The “Trace – Character” option is very useful, especially once the shortest trees are determined. This option overlays the states for each character on the tree, and displays a small box at the bottom of the screen showing the character name and its states. You can
switch from one character to the next using the small scroll bar at the bottom of this window. Using this tool, you can see which characters seem to be synapomorphies for various clades, which seem to autapomorphies for single clades, and which are not consistent with the classification ("homoplasies" in the parlance). This tool can be used throughout the effort to arrive at the shortest trees, but is probably most useful once the shortest trees have been discovered.

Interpreting your phylogenetic analysis

1. Once you have found the shortest tree(s) and determined how many equally (most) parsimonious trees exist, you can:

2. For the equally parsimonious trees, determine which taxa cannot be placed unambiguously (i.e., the tree length doesn’t change when the taxon is moved to another spot).

3. Later, try to determine why these taxa are difficult to place (i.e., if there are any contradictory characters, one favoring one placement and another favoring another placement).

4. For the equally most parsimonious trees, determine the synapomorphies that define various clades in the diagram. Are many of the clades supported by more than one synapomorphy?

5. Are there any autapomorphic characters (which define only one clade)?

6. Are any of the characters inconsistent with the tree? That is, does the same character state appear on different branches? How would you interpret these characters? That is, do there seem to be characters in which an ancestral character state is lost in some, but not other, lineages, and therefore remains in distant branches in the cladogram? Or is a derived character state lost in some clades, seeming to reverse to an ancestral character state (therefore making the reversed character state derived in itself)? Or is does a derived character state seem to appear independently in two or more lineages (evolving convergently, perhaps)?

8. What parts of the cladogram seem to be solid, and which seem to require more study, and why?
5 PHYLOGENY AND CLASSIFICATION

Goals:
1. Understand the meaning and importance of phylogeny as a major component of biology.
2. Understand the importance of classification as a major component of biology.
3. Be able to write a workable key to organisms.
4. Be able to identify organisms using a dichotomous key.
5. Reconstruct a phylogeny of a group

Outline:
Introduction
Classification
 Taxonomy
 Systematics- the Study of Phylogeny
 Approaches to reconstructing Phylogeny
 Overview of this exercise
 The Hierarchical System of Classification
 Species Concepts: definitions and limitations
 Above the Species Level
 Taxonomic Keys
 Using a taxonomic key: identification of conifer trees
 Constructing A Taxonomic Key
 Using Phylogenetic Information to Reclassify Vertebrates
 Phylogenetic systematics/ Cladistics
 Reconstructing Phylogenies
 Requirements for comparing taxa
 Organizing your data
 Phylogenetic Assumptions - Parsimony
 Phylogenetic Assumptions - Polarity
 Reconstruct a Phylogeny

Introduction

Biology is largely a comparative science. This should be easy to understand, considering the nature of variation in the natural world (see exercise 1). We see organisms as composites of characters, and character states, which are identifiable expressions of the genetic makeup of organisms. If you were to describe a giraffe, you might consider its long neck, its brown and yellow coat, and its long, black tongue. Thus, you have described a number of characters - neck length, coat color and pattern, and tongue size and color. It is important to recognize characters and character states when describing organisms, and as you'll see below, it is even more important to think in these terms when classifying organisms.

(A) Classification
Here's how the outgroup method to assess character polarity works:

1) Choose an outgroup (often several are chosen)
2) Assume that the outgroup has all plesiomorphic characters (and why is this a reasonable assumption)?
3) Code your characters however you wish (0, 1, 2, 3, ..., is typical)
4) When the outgroup method is employed, the program that generates your trees will use all character states that are shared among taxa EXCEPT the character states possessed by the outgroup.

Bottom line: The plesiomorphic traits are whichever are present in the outgroup.

(Ε) Let's Reconstruct a Phylogeny

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8. What parts of the cladogram seem to be solid, and which seem to require more study, and why?
New view of coelomate evolution

- Data from nucleotide sequences, as well as from anatomy and development, have produced a newer view of animal relationships.
- Note different placement of arthropods, the demise of the pseudocoelomates, and the elevated placement of flatworms.

Another view of the new phylogeny, with fewer taxa but better defined clades.

Comparison of characters between traditional and alternative classification:

Traditional scheme

Alternative scheme

A. Trophophore larva
BIOL 613
Manuguid
Human Physiology Laboratory

NO REFUNDS OR EXCHANGES
The course reader program at San Francisco State University is a joint venture of The Bookstore at San Francisco State University and the Rapid Copy Center of the J. Paul Leonard Library.
Sample Data File

This Tutorial is designed for you to follow along with a sample data file on a computer without Biopac Student Lab hardware attached. This means that you can complete the Tutorial on a computer outside of the classroom/lab—perhaps at the library, computer lab or home—just as you will always have those options for analyzing data outside the lab. Open the SampleData-L02 file as directed below.

1. Turn the computer ON.
2. Use the desktop icon or the Windows Start menu to open BSL Lessons 3.7.
3. In the No Hardware mode, the BSL software will open to a standard Open Dialog.
   - For this tutorial (and all future analysis), click OK to enter the Review Saved Data mode.

To launch the program use desktop icon or use the Windows® Start menu, click Programs and then select:

- Biopac Student Lab
- BSL Lessons 3.7
- BSL PRO 3.7

Note: A hardware dialog may be generated.

If the program was installed with the hardware option but there is no hardware connected, the following dialog may be generated:

Open the Data Files folder, which is in the Biopac Student Lab program folder.

- The program may open the Data Files for you. If so, skip to the next step.
- For future analysis, use this dialog to browse to your data files.
5. Open the Sample Data folder.

6. Open the SampleData-L02 file.

Select and open the SampleData-L02 file, which is in the Sample Data folder.

Don't worry — you can't lose or damage the SampleData-L02 file.
Independent Research Projects
INDEPENDENT PROJECT: GROUP WRITTEN PROJECT PROPOSAL (10 POINTS)
Proposal must be type-written and double-spaced

- Develop ONE (1) possible independent research project you are interested in pursuing, using information you have garnered from the previous labs, as well as information you gather from online research (i.e. PubMed, primary research articles).

Title
Provide a title specifically describing the experiment (1 point)

Introduction
Research Question, Background Information, & Hypotheses
Briefly explain your proposed research project/question. What are the main questions/problems being addressed? Provide background information on your topic, using the relevant peer-review literature obtained, textbooks, and the Biopac Laboratory Manual.

Include information on the physiological system(s) being tested, physiological relevance, significance, or application of the project, and how it relates to published research? (i.e. you should show development of previous research ideas or untested hypotheses, not replication).

What are the proposed hypotheses? Support your hypotheses with physiological information obtained through reading peer-reviewed literature, and include proper citations.

Methods
(4 points)

Experimental design
Include detailed information on what will be measured, how it will be measured, and under what conditions it will be measured. Your experimental design must control all variables that could affect the outcome of the results.

Describe the experimental groups/conditions, control group(s), and all controlled variables, including information on sample size, subject demographics, written pre-protocols, protocols, questionnaires, etc.

Describe all recording methods, including information on electrode placement, body position, calibration, data recording (duration, measurement type w/ units, etc.) and data analysis.

References
(2 points)
- Include full citations for three (3) references from peer-reviewed sources.
- Print and attach one (1) full-text, peer-reviewed journal article.
- Print and attach one article abstract (must be different from above)
- References must be relevant to the topic & will be checked.
The Placebo Effect of Caffeine on Urine Flow Rate, Urine Volume Voided, and Specific Density

Amanda de la Vega
Melissa Evangelista
Gevrey Trunnel

Caffeine

Renal System

- Renin-Aldosterone
- Antidiuretic Hormone

Placebo

According to the Webster’s Dictionary...

Placebo a. an inert medicament or preparation given for its psychological effect

(Flies et al., 2003)
(Johnson et al., 2003)
Hypothesis

- Comparable diuretic results due to placebo effect
- Increased urine flow rate
- Increased volume voided
- Increased specific density

Methods

- Pre-Experiment
  - Subject questionnaire

<table>
<thead>
<tr>
<th>Set-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
</tr>
<tr>
<td>Control Caffeinated Coffee</td>
</tr>
</tbody>
</table>

Methods

- Experiment
  - Dietary guidelines
  - Equipment
  - Verbal protocol
Methods
- Post-Experiment
  - Temperature
  - Specific gravity
  - Volume voided

Average Urine Flow Rate

Average Urine Volume Voided

Average Specific Density
Total Urine Output

![Graph showing total urine output for different groups.]

Discussion

- ADH
- Renin-Aldosterone

![Graph showing average urine flow rate over time.]

Discussion

- Caffeinated coffee is an unconditioned stimulus
- Decaffeinated coffee is a conditioned response

![Graph showing average urine volume voided over time.]

Discussion

- Caffeine concentration peaks at T=80
- Metabolized into many other metabolites
- Specific Density is physiological NOT psychological

![Graph showing average specific density over time.]

(Plasen and Blumenthal, 1995)

(Wiener et al., 2006)

(Plasen and Blumenthal, 1999)
Conclusion

- Psychological vs. Physiological

![Graph showing total urine output for different conditions]

Sources of Error

- Coffee cups
- Amount of coffee
- Dosage per body mass data
- Preference of coffee additives
- Insufficient urine volume
- Hydration status prior to experiment
- Other sources of caffeine

Future Experiments

- Effects of a caffeine pill on renin secretion
- Effects of other sources of caffeine on renal system
- Nocebo effect

Acknowledgments

- Megumi Fuse
- Christine Manugul
- All participating subjects
- Café 101
- Tully's Coffee
- Starbucks Coffee
- ...and YOU!
Appendices for Standards:

Standard 4: Literacy
Goal II - Writing has become a part of WASC Re-accreditation Review

San Francisco State University makes writing central to education and ensures that its graduates write proficiently.

Objectives
1. SFSU promotes excellence in its students' writing.
2. SFSU values and supports research and scholarship in the field of writing, including the pedagogy of writing.

Outcomes
1. Within two years of approval of the strategic plan, all departments will set forth criteria, at all levels including the master's thesis, that define performance expectations for writing. These criteria will measure students' proficiency in writing and their capacity to reflect critically on work in their chosen discipline.
2. There will be more student, department, college, and University journals and forums devoted to the production, dissemination, and scholarly discussion of writing.
3. Greater numbers of papers on writing pedagogy by faculty, students, and staff will appear in refereed journals.
4. All General Education Segment III courses will conform to the requirements for proficient student writing, including the revision process and attention to style as well as content.

Strategies
1. Assess current writing programs and policies.
2. Provide adequate support services for students, faculty, and staff to develop and improve writing and writing pedagogy at all levels.
3. Encourage capstone and/or portfolio reviews of student writing at the program level.
4. Seek external funds to establish a campus center or institute devoted to writing and writing pedagogy, support special writing programs, and endow a chair in composition.
5. Identify a person or committee to take the lead in implementing strategies for improving writing.
6. Hold all students to stated standards for writing, including critical analysis in written exposition, by basing assessments on the explicit criteria articulated by departments and providing students with examples of poor, good, and excellent writing.
7. Integrate into General Education and the various majors specific requirements for student writing.
GENERAL EDUCATION PROGRAM

The SFSU Bulletin describes the requirements in effect for the current year. Refer to the Bulletin Rights section of the university Bulletin for additional information about GE Program requirements and other important graduation requirements.

SEGMENT I: BASIC SUBJECTS--12 units

All students must complete a minimum of twelve units in Segment I including a minimum of three units in each of the following four areas: Written Communication, Oral Communication, Critical Thinking, and Quantitative Reasoning.

Specific test and course prerequisites are printed in the Undergraduate Graduation Requirements section of the Bulletin.

Summary of Written English Requirements

Note: All SFSU undergraduate baccalaureate degree candidates are required to complete both First-Year and Second-Year Composition or their equivalent courses.

1. English Placement Test (EPT): All newly-admitted undergraduate students must take the California State University English Placement Test (CSU-EPT) prior to their first semester of matriculated attendance at SFSU, except those with an approved EPT or course exemption listed in the University Bulletin. Non-native speakers of English must also take the English as a Second Language Placement Test (ESLPT) prior to enrollment.

2. First Year Composition: Three equivalent pathways satisfy the First Year Composition Requirement: Integrated Reading-Writing (ENG 104-105 course sequence or ENG 106), Composition for Multilingual Students (CMS) or ENG 114. See the Undergraduate Graduation Requirements section of the Bulletin for specific course requirements and prerequisites.

3. Second Year Composition: Prerequisite is grade of Credit (CR) or C- or better in ENG 104-105 sequence, ENG 106, or ENG 114, or equivalent. ENG 214, or an equivalent course, fulfills the GE Segment I, Written Communications requirement.

Written Communication (3 units required) *

Courses that fulfill the Written Communication requirement in General Education are listed below. Courses offered in a given semester are listed under the heading English Composition Requirement, Second Year, at the end of the listing of English courses in the Class Schedule for the semester.

Courses

A S 214 Second Year Written Composition: Asian American Studies

http://www.sfsu.edu/~bulletin/current/ge.htm
AFRS 214  Second Year Written Composition: Africana Studies
AIS 214  Second Year Written Composition: American Indian Studies
BUS 214  Second Year Written Composition: Business
VL 214  Second Year Written Composition: Comparative and World Literature
ENG 214  Second Year Written Composition: English
ENG 310  Second Year Composition-Multilingual
RAZA 214  Second Year Written Composition: Raza

Oral Communication (3 units required)  *

Courses

COMM 150  Fundamentals of Oral Communication
ENG 210  Oral Communication - Multilingual

Critical Thinking (3 units required)

Courses

AFRS 110  Critical Thinking and The Africana Experience
AIS 110  Critical Thinking and the American Indian Experience
COMM 250  Argumentation and Advocacy (4)
ENG 200  Writing Logically
ETHS 110  Critical Thinking and the Ethnic Studies Experience
PHIL 110  Introduction to Critical Thinking I
PSY 111  The Logic and Psychology of Critical Thinking
RAZA 110  Critical Thinking and the Raza Experience

Quantitative Reasoning (3 units required)

Details on test and course prerequisites are printed in the Undergraduate Graduation Requirements section of the Bulletin.

Summary of Quantitative Reasoning Requirements

Students who register for a GE quantitative reasoning course at SFSU must (1) have passed the ELM examination with a score of 50 or above; or (2) have obtained an approved ELM exemption; or (3) after taking the ELM examination, have passed Algebra II (MATH 70) at SFSU or an equivalent course elsewhere with a grade of credit (CR) or C- or better.

Courses
SEGMENT II: ARTS AND SCIENCES CORE--27 units

General Requirements

**Freshman Student Pattern**

1. In each Segment II Area, students must complete a minimum of nine units and satisfy the specific category requirements for the Area.
2. In each Segment II Area (PBS, BSS, and HCA), students must select courses from at least two different departments. That is, at least three units of the nine-unit minimum must have a different departmental prefix.
3. Within Segment II, students must complete one course that is designated as fulfilling the American Ethnic and Racial Minorities (AERM) requirement and one course that is designated as fulfilling the Lifelong Development (LLD) requirement.

**Transfer Student Pattern**

1. In each Segment II Area (i.e., PBS, BSS, and HCA), students must complete a minimum of nine units, but are not held to completion of the specific category requirements within each Segment II Area, except as required in the Physical and Biological Sciences Area.
2. Within each Segment II Area, students must select courses from at least two different departments. That is, at least three units of the nine-unit minimum must have a different departmental prefix.
3. Within Segment II, students must complete one course that is designated as fulfilling the Lifelong Development (LLD) requirement. While transfer students are not required to complete the American Ethnic and Racial Minorities (AERM) requirement, they are encouraged to select courses that address this important area.
4. Students must complete a minimum of 27 units in Segment II. Students on the six-unit system pattern for the Physical and Biological Sciences Area must make up any unit deficiencies in this Area by selecting additional course work in Segment II.

**Physical and Biological Sciences Area--PBS (9 units)**

Category A: Physical Sciences; Category B: Biological Sciences; Category C: Integrative Science
III. General Education Segment I: Basic Subjects Requirements

A. Underlying Principles of the GE Segment I Basic Subjects Requirements. An educated person should be able to communicate with clarity and force, to read with discrimination and understanding, and to think with precision and creativity. The Segment I GE curriculum develops a disciplined use of language for effective communication, builds disciplined thought processes for sharpened analytical skills, and helps students develop greater ability and confidence to reason and make judgments about mathematically based information. SFSU’s GE Segment I: Basic Subjects requirements include: Written Communication, Oral Communication, Critical Thinking, and Quantitative Reasoning.

B. GE Segment I Course Expectations and Student Learning Outcomes. The following course expectations and student learning outcomes have been developed by the GE Segment I Committee. Courses proposed for specific GE Segment I requirements will be evaluated on the extent to which they meet the course expectations and student learning outcomes specified below.

GE Segment I - Critical Thinking - Course Expectations (see Appendix B1). Courses approved for GE Segment I Critical Thinking should:

1. Develop skills of inquiry and critical thinking.
2. Encourage students to employ these skills (inquiry, critical thinking) on themselves and society.

GE Segment I - Critical Thinking - Student Learning Outcomes (see Appendix B2). After completion of a GE Segment I Critical Thinking course, students should be capable of:

1. Recognizing, articulating, and questioning assumptions and presuppositions underlying discourse, including one's own.
2. Identifying formal and informal fallacies of language and thought.
3. Distinguishing arguments from other forms of discourse, and premises from conclusions.
5. Identifying suppressed and overlooked evidence.
6. Writing reasoned discourse that provides a detailed evaluation of a complex argument, including possible objections to it.

GE Segment I - Oral Communication - Course Expectations (see Appendix C1). Courses approved for GE Segment I Oral Communication should:

1. Emphasize the content of speech as well as its form.
2. Explain how an individual's background, identity, or perceptions influence communication.
3. Explore the social significance of communication, including how it operates in various situations.
4. Take a rhetorical perspective, emphasizing reasoning and advocacy, organization and accuracy as well as the discovery, critical evaluation, and reporting of information.
5. Require active participation in oral communication.

**GE Segment I - Oral Communication - Student Learning Outcomes (see Appendix C2).**

After completion of a GE Segment I Oral Communication course, students should be capable of:

1. Demonstrating awareness of the complexity of communication in terms of its psychological, social, political, cultural, and ethical dimensions.
2. Demonstrating knowledge about verbal and nonverbal communication in various contexts (e.g., interpersonal, small group, public speaking, intercultural).
3. Reducing their own speech anxiety and projecting greater confidence as a speaker.
4. Listening actively and providing constructive feedback.
5. Considering an audience's knowledge, background and attitudes when constructing a message.
6. Recognizing and articulating issues from one's own perspective, while acknowledging the perspectives of others.
7. Locating, evaluating and reporting information in support of a point of view.
8. Assessing claims or arguments as a speaker and listener.
9. Organizing, constructing, and delivering prepared and spontaneous presentations.
10. Demonstrating effective verbal and nonverbal delivery skills.

**GE Segment I - Quantitative Reasoning - Course Expectations (see Appendix D1).** Courses approved for GE Segment I Quantitative Reasoning should:

1. Improve student abilities to incorporate mathematical ideas in their thinking and discourse.
2. Develop skills and confidence in interpreting, creating, and using mathematical expressions.
3. Provide for conceptual understanding of mathematical reasoning and its application.
4. Increase students’ appreciation for the importance of quantitative skills and the relevance of quantitative reasoning to everyday life.
5. Increase awareness of issues concerning the appropriate use of quantitative data and procedures.
6. Improve students’ ability to use mathematics.

**GE Segment I - Quantitative Reasoning - Student Learning Outcomes (see Appendix D2).**

After completion of a GE Segment I Quantitative Reasoning course, students should be capable of:

1. Translating between verbal statements and mathematical expressions.
2. Understanding mathematics both as a descriptive language and a set of techniques.
3. Applying quantitative information and procedures to contexts both inside and outside the classroom.
4. Presenting and summarizing information in quantitative form.
5. Interpreting, making judgments about, and drawing conclusions from quantitative material.
6. Performing mathematical calculations.
7. Using appropriate technology for mathematical operations.
8. Evaluating critically the uses of quantitative procedures and descriptions, including identifying appropriate applications and deceptive or erroneous reasoning.
9. Constructing mathematical models.

GE Segment I - Written Communication - Course Expectations (see Appendix E1). Courses approved for GE Segment I Written Communication should:

1. Require the reading of substantial texts worthy of critique and analysis.
2. Provide students with opportunities to read critically and analyze discipline-specific texts.
3. Provide students with ample opportunities to practice their writing.
4. Provide for thorough and demanding instructor critique of student writing.
5. Require significant amounts of writing in order to enhance student composition skills.
6. Require individual papers (drafts and final) ranging in length from 500 to 2,000 words.
7. Require total writing assignments (drafts and final) ranging from 8,000 to 10,000 words.
8. Require composition practice exercises in the use of clear reasoning, organization, accuracy in language use, and the ability to discover, critically evaluate, and report information.

GE Segment I - Written Communication - Student Learning Outcomes (see Appendix E2). After completion of a GE Segment I Written Communication course, students should be capable of:

1. Attaining writing skills suitable for upper division course work.
2. Understanding discipline-specific texts thoroughly and using them as a basis for their writing assignments.
3. Formulating a thesis based on their readings.
4. Substantiating a thesis through appropriate references to primary and secondary texts, and through personal insights.
5. Distinguishing between adequate and inadequate substantiation of a thesis or topic, both at the essay and the paragraph levels.
6. Writing essays and paragraphs that are well focused and relevant to the subject identified in their theses and topics.
7. Demonstrating knowledge of the principles of sentence development through the ability to develop ideas within a single, complex sentence, rather than in an accretion of simple sentences.
8. Writing compositions that are mainly free of significant errors in usage, writing mechanics, and spelling.

C. GE Segment I Committee Charge, Membership, Terms of Service, and Chair.

1. Committee Charge: The GE Segment I Basic Subjects Committee will evaluate and recommend to the GEC course proposals for GE Segment I based on their adequacy in fulfilling the stated GE course expectations and student learning outcomes for the specific Segment I Basic Subject requirement for which they are proposed. The Segment I Committee's reasons for recommending the disapproval of courses will be stated in writing to
the GEC and to the appropriate department chairs and college deans in terms of the stated course expectations and student learning outcomes for the Segment I requirement for which the courses were proposed. At the request of the GEC, the GE Segment I Committee shall periodically review Segment I course expectations and student learning outcomes for their continued currency and adequacy for satisfying GE assessment requirements. The chair of the Segment I Committee is responsible for submitting a comprehensive written report to the GEC summarizing the committee's actions, deliberations, and recommendations. The Segment I Committee shall consult and coordinate its work with that of the Committee on Written English Proficiency (CWEP).

2. Committee Membership, Charge, Terms of Service, and Chair: Seven (7) Members.
The GE Segment I Committee shall be composed of the following seven members:

- One representative from the Department of English
- One representative from the Department of Speech
- One representative from the Department of Philosophy
- One representative from the Department of Mathematics
- Two At-Large Representatives: The Academic Senate shall solicit nominees from a pool of qualified candidates from among those colleges/areas not currently represented on this committee to include the colleges/areas of Behavioral and Social Sciences, Business, Creative Arts, Education, Ethnic Studies, Health and Human Services, the Library, and Student Affairs; but not from the colleges of Humanities or Science and Engineering. The Academic Senate will conduct "At Large" elections and disseminate the election results to the GEC and to the deans/administrators for those "At Large" candidates elected by their respective colleges/areas.
- One Student Representative: The Academic Senate shall request from the President of the Associated Student government a student nominee to serve on the GE Segment I Committee. The President of the Associated Students shall nominate/select a student to serve on the Segment I Committee for a one-year term. The Academic Senate will forward the name of the student nominee to the GEC Chair by the fourth week of the fall semester of each academic year.

The Academic Senate shall notify college deans when there are Segment I Committee vacancies in their colleges. College representatives shall be nominated and elected to Segment I Committee vacancies by faculty members in their respective colleges.

3. Committee Terms of Service: All terms are for three years and shall be staggered and rotated among the members, except for the student representative who will only serve for one year.

4. Committee Chair: The chair will be elected by the members of the GE Segment I Committee.

D. Criteria and Guidelines for Submitting and Reviewing GE Segment I Course Proposals. When submitting GE courses for review by the GE Segment I Committee, departments must:
1. Receive the approval of the University Course Review Committee (CRC). Courses that are not first approved by the University Course Review Committee will not be considered for inclusion in GE Segment I.

2. Submit to the Office of Undergraduate Studies, for transmittal to the Segment I Committee, a copy of the approved course proposal form, a current course syllabus, a completed Course Expectations Matrix, and a completed Student Learning Outcomes Matrix for each proposed course. Proposed Segment I courses will be evaluated on the extent to which they fulfill the course expectations and the student learning outcomes specified in this policy for each Segment I requirement.

3. Prepare and submit a GE Segment I course proposal in accordance with those submission requirements and guidelines that may be developed by the GEC in consultation with the GE Segment I Committee and in accordance with criteria, guidelines, and procedures contained in this policy and its appendices (see Appendices F and G).

E. Assessment of Segment I Course Offerings: The GE Segment I Committee will evaluate and recommend to the GEC course proposals for the Segment I requirements for which the courses are proposed based on their adequacy in fulfilling the stated course expectations and student learning outcomes for the specific Segment I requirement (see Appendices B1-E1 - GE Segment I Course Expectations Matrices and Appendices B2-E2 - GE Segment I Student Learning Outcomes Matrices). The roles and responsibilities of each of the parties to the GE course and program assessment processes are specified in Appendix G: GE Program Assessment Plan, Roles, and Responsibilities.

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415/338-2206

Website design and maintenance by David Apelt - last update 1/27/05
Biology 230 - 01

Lab Write-Up

Spectrophotometry and Organic Molecules
The objective of the write-up is to help you
1) understand the relationship between light and absorbing molecules,
2) understand the basis of an absorption and transmission curve,
3) understand the use of a standard curve,
4) understand the basis of the reaction of the reagent molecules and what they test for, and
5) to begin learning how to write using a standard scientific format.

Introduction
Give the background of how and why spectrophotometry works.
Describe briefly how the reagent interacts with the organic molecule it is being used to test.
Give the result of that interaction – describe what happens when the two interact. Mention how you will make use of that interaction to do the following exercises.

Methods
Briefly list the tool and the reagents and solutions used. Don’t bother to go into detail.

Results
Include the following information in your results section:
A graph showing the transmission spectrum of iodine/starch
A graph showing the absorption spectrum of iodine/starch
A standard curve using the known iodine/starch concentrations.
A standard curve using the known biuret/protein concentrations
A table of the reagent, the organic molecule it reacts with, and the result of the reaction (ex., Benedict’s, reducing sugars, forms a…)

Using the standard curve, determine the concentration of the unknown starch solution.

Describe the qualitative results of the tests you did for starch, reducing sugars and lipids.

Describe the quantitative results of the protein assay.
Include the calculations of seed proteins (soy and wheat). You will need to get data from your table to do this. The data you need is their estimation of the protein concentration in mg/ml, not their absorption data. Do not use their absorption data for the seed protein with your protein standard curve. (Why shouldn’t you?)

Organize your results section so it flows. You will be putting together a mixture of graphical and tabular data with text to describe the data.
Discussion

Explain the data you have described in the results section. Some of it won't need much explanation. An area to focus on is the seed data, particularly the difference between monocot seeds and dicot seeds. Use the starch and protein data to explain the difference between the two seed types.

In addition, address the following questions in your discussion:

The unknown starch solution was found to have suspended particulates. How does this affect your absorption data?

What would the absorption value at A_{425} be of the starch/iodine solution if the solution were 1/3 as strong, using your data?

Can you accurately predict what would the transmission value be, given the same above parameters? Why or why not?

The biuret reagent reacts with protein and causes a color change. Using the color line on pg. 35 of the Lab Manual, describe the color shift.
Biology 230.01
Fall 2004
T & Th 9-12 p.m.
Mailbox in Franciscan Building
appt.

Peter Ingmire
Office: HSS 351, 338-1994
e-mail: ping@sfsu.edu
Office hrs: T 4-5, F 1-2 and by

LAB OBJECTIVES: The Bio 230 lab course, in conjunction with the
lecture, is designed to give students the opportunity to gain the
essential knowledge and lab skills required for upper division
biology courses. You will work with team members analyzing data
gathered from lab exercises. Often members of your team will be
responsible for doing certain activities, but all members of the
team are expected to fully understand the principles behind each
lab. You are expected to attend all lab meetings and come prepared
to work with members of your team.

GRADING: You do not receive a letter grade in this part of the
course. You earn points for the lab which will be added to what
you earn in lecture that you earn. There are 650 total possible
points for the lab. The breakdown is as follows:

1) 3 lab practicals, 100 pts each  300 pts total
2) 6 quizzes, 20 pts each   120 pts total
3) Lab write-up  20 pts
4) Formal lab write-up  50 pts
5) 2 library assignments, 20/30 pts  50 pts total
6) Lab notebook, 20/40 pts  60 pts total
7) Mitosis/Meiosis lab  .50 pts

The lab practicals cover material from lab and involve short
answer and essay questions. Each of the practicals will cover
a third of the course and are not cumulative. The practicals
will be described in detail later in the semester.

The quizzes will be announced. In-class quizzes will be given
at the beginning of the lab and will cover material presented
in the previous week's labs. Take-home exercises will be due
at the beginning of the next lab period. There will be no
make-up quizzes.

The lab write-up will involve written descriptions of data
and what was observed during a particular lab. The emphasis
will be on presentation and analysis of data and
observations, and must follow the basic standard scientific
format.

The formal write-up will involve one of the labs we cover and
writing a more extensive report. You should include at least
two outside references (not the lab manual or the textbook)
and incorporate them into your report. Follow the standard
scientific format. This will be due in early November.

The library assignments will expose you to primary
literature. The first assignment is to familiarize yourself
with the format of how research articles are written. You

CELL PHONES MUST BE TURNED OFF DURING
will be given an article to read over, not for content, but for learning the format.
The second assignment is more open and will involve browsing through scientific journals, selecting a paper of your choosing and critiquing it. This will be due before Thanksgiving. Break.

The lab notebook is where you always record data and observations for the lab while in the lab. Keep it current. It is where you will write hypotheses and ideas. It is the working copy of everything you do in lab. Keep it neat, organized and up to date.
The notebooks will be picked up and spot-checked a couple of times during the semester. Follow the standard scientific format.

Standard Scientific Format - the five main features:

1) **Title** - concisely and clearly stating what the write-up is about. For notebooks, include the date.

2) **Introduction** - background information on the concepts being discussed and a clear statement covering the objectives and hypotheses being tested. This is where you introduce what you did. For notebooks, give a brief listing of lab objectives and goals. Use appropriate tense (future and present).

3) **Methods** - a description of what was done in the lab about the materials and equipment that were used. For notebooks, a single summary sentence about the equipment and procedures used. Use past tense.

4) **Results** - this is where you will record your data - any charts, tables, or simply raw numbers etc... and observations you make or draw. **Label and number all graphs, charts and tables. Always include units. Always include power of magnification for drawings of specimens under the microscope.** The data you record should be organized, which means use of tables or charts, for quick reference. Be sure to include a sentence or two explaining what the table, graph or diagram is about so that you can refer back to it when you study for the practical. Use past tense.

5) **Discussion** - what the lab was about. This will be written up following the lab. Here is where you will tie in the background concepts to the work done in the lab. For formal write-ups, discuss the results; do not simply talk about what the lab means. Discussing results means that you have to explain ALL the data - not just a general summary. For notebooks, write a short paragraph describing/interpreting/explaining the data and what concepts the data are demonstrating. Do not repeat your results section here, nor do the converse of mixing conclusions in with your results. Use appropriate tense.
WHAT TO BRING FOR LAB: There is a list of supplies you need on the back of the schedule of lab exercises in the SFSU lab manual. Be sure to bring a lab notebook (preferable one with grids for drawing graphs), a pen for writing in your notebook (not pencil), a Sharpie glass-marking pen, and either the SFSU lab exercise manual, or the Dolphin lab manual, depending on the lab (see lab schedule in the SFSU Lab Exercise Manual). The Van de Graaff photo atlas is recommended but optional.

READ THE LAB EXERCISE FOR THE DAY PRIOR TO COMING TO LAB

<table>
<thead>
<tr>
<th>Important dates</th>
<th>September 22</th>
<th>Last day to Add/Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>October 20</td>
<td>Cr/NC option ends</td>
</tr>
<tr>
<td></td>
<td>November 15</td>
<td>Last day to Withdraw</td>
</tr>
<tr>
<td>Day</td>
<td>November 25-26</td>
<td>Thanksgiving</td>
</tr>
<tr>
<td></td>
<td>November 3-</td>
<td>No class due to Advising</td>
</tr>
<tr>
<td></td>
<td>December 10</td>
<td>Last day of instruction</td>
</tr>
</tbody>
</table>
## LECTURE & READING SCHEDULE

### INSTRUCTORS
- **Dr. Nan Cansal**: Compass Trailer, Rm 7
  - Hours: Tu 4-5; W 10-11 & by appt.
  - Phone: 338-1853
  - e-Mail: ncansal@fsu.edu
- **Dr. Chris Moffatt**: Hensill Hall Rm 745A
  - Hours: M&W 10:30-11:30 & by appt.
  - Phone: 338-1631
  - e-Mail: moffatt@fsu.edu

### REQUIRED MATERIALS:
- **Lecture Supplement Booklet**: Set of handouts used in lecture (sold by GSCB, sale site as announced)
- **Exam Forms**: 4 ZEUS answer forms for lecture exams (Scantron forms are NOT used)
- **For Lab**: 1) SFSU Lab Manual (sold by GSCB, sale site as announced)
  3) Optional: Van De Graaff, K and J Crawley, Photographic Atlas for the Biology Laboratory

### DATE | LECTURE TOPIC | EXPANSION ASSIGNMENT
--- | --- | ---
8/25 | Introduction; Begin Basic Chemistry for Biologists (I) | 
8/26-8/27 | Lab Sections Begin: Take & Pass Qualifying Exam to remain enrolled or to add Biol 230 | 
8/27 | Basic Chemistry for Biologists (I continued) | 
8/30-9/3 | Basic Chemistry for Biologists (II-IV) | 
Monday 9/6 | HOLIDAY: Labor Day (No Class) | 
9/8-9/17 | Cells, Cell Structures and Functions (I-IV) | 
9/20 | Membranes: Structure, Permeability, Osmosis, Transport | 
9/22 | Cell Division **LAST DAY TO DROP** | 
9/24 | Thermodynamics | 
Monday 9/27 | LECTURE EXAM I (covers material through 9/22) | 
9/29 | Enzymes | 
10/1-10/8 | Energy for Cell Work 1) Basics of Energy Transduction, 2) Glycolysis, 3) Aerobic Respiration, ATP synthesis | 
10/8-10/13 | Photosynthesis (I-III) | Ch 9
10/15 | Plant Growth, Structure and Function I | Ch 10
10/16-10/18 | LECTURE EXAM II (covers material 9/22-10/13) | 
10/20-10/27 | Plant Structure and Function (II-IV) | Ch 12
10/27 | Plant Hormones: Role in Plant Growth and Development | 
Thurs 10/28 | LAST DAY TO WITHDRAW with RELAXED RULES | 
10/29 | Animal Structure & Function: Tissues & 1) Digestion | Tissues Ch 40; Digestion Ch 41
11/10-11/12 | Cell Communication: Nervous System I-II | 
Monday 11/15 | LECTURE EXAM III (covers material 10/15-11/11) | 
11/17-11/19 | Immune System I-II | 
11/22, 24, 29 | Genetics I, II, III | Ch 16
11/25-11/26 | HOLIDAY - Thanksgiving (No Class) | 
Wed. 12/1 | ADVISING DAY (No Class) | 
12/3-12/8 | Molecular Genetics I, II, III | 
12/10 | Endocrine System | 
Wed. 12/15 | EXAM IV (covers material 11/10-12/10) AND FINAL Comprehensive Exam (first part, of course) | MWF 9 am class, 8:00-10:30am

NO EARLY FINAL EXAMS WILL BE GIVEN; plan your holiday travel accordingly
Section switching for final exam IS NOT PERMITTED unless pre-arranged with instructors.
Biology 230  Schedule of Laboratory Exercises – Fall 2004

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Dolphin manual</th>
<th>SFSU manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 2-3</td>
<td>LABORATORY PRACTICAL II ........................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td>Animal System Function: Digestion &amp; Absorption</td>
<td>Ex. 27a (Dolphin)</td>
<td>-----</td>
</tr>
<tr>
<td>9-10</td>
<td>Gas Exchange and Circulatory Systems</td>
<td>Ex. 27b; Ex. 28</td>
<td>T-1, T-4a</td>
</tr>
<tr>
<td>11-12</td>
<td>Excretion Systems: Osmoregulation in Paramecium</td>
<td>Ex. 29; Ex 4</td>
<td></td>
</tr>
<tr>
<td>16-17</td>
<td>Genes, Alleles and Metabolic Pathways; Genetics I: Transformation in the Bacterium, Acinetobacter</td>
<td>22 152-154</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red and White Yeast Complementation</td>
<td>23 155-166</td>
<td></td>
</tr>
<tr>
<td>18-19</td>
<td>Genetics II: Continue Transformation and Yeast Complementation</td>
<td>152-166</td>
<td>p167-169, 175</td>
</tr>
<tr>
<td></td>
<td>Option: Begin Classical Genetics</td>
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<tr>
<td></td>
<td>Solve problems involving inheritance of information at one gene locus - on p172, 173, 174</td>
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<td></td>
</tr>
<tr>
<td>23-24</td>
<td>Genetics III: Complete Transformation and Yeast Complementation; Classical Genetics</td>
<td>152-166</td>
<td>167-176</td>
</tr>
<tr>
<td></td>
<td>(begin or continue problems listed for Nov 20-21, add inheritance of information at two loci for linked and unlinked genes (solve problems) May consider X-linked inheritance or defer until Genetics IV)</td>
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<tr>
<td>25-26</td>
<td>THANKSGIVING HOLIDAY</td>
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<tr>
<td>30-1 Dec</td>
<td>ADVISING DAY (Dec 1) – NO LABS Tue (Nov 30) or Wed (Dec 1)</td>
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<tr>
<td>2-3</td>
<td>Genetics IV: Classical Genetics continued</td>
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<tr>
<td>7-8</td>
<td>Complete Classical Genetics ; Review for Practical</td>
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<tr>
<td>9-10</td>
<td>LABORATORY PRACTICAL III ........................................</td>
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</tbody>
</table>

Manuals and Supplies Required for Lab

Laboratory Manuals:
2. Required: Laboratory Manual: Introductory Biology I (Biology 230). Purchase first day of class, sale site will be announced in lecture and lab
3. Recommended: A Photographic Atlas for the Biology Laboratory. Van de Graff & Crawley, 4th ed. SFSU Book Store. This atlas is also recommended for Biol 240.

Supplies needed by each student: laboratory notebook and marking pen (e.g. "Sharpie") for labeling glassware; gloves (optional)

For this semester the following general supplies will be provided. However, if you wish to purchase any or all of these for your personal use, here is a list of supplies and where you may purchase them.
(Note: you will need to bring any supplies you purchase for your personal use to each lab. Our relocation to the Trailer Labs for this semester does not allow us to provide any storage space.

From Biol stockroom Trl Q-3: microscope slides & cover slips, pipette bulb, safety goggles, surgical gloves (optional) purchase by the pair, if desired (these will not be supplied)
From Bookstore: dissecting kit with forceps, fine point scissors, mm ruler, blunt probe, scalpel (replaceable blade type) and blades
**Biology 482. Ecology 4 units**  
**Fall, 2004**

**Format:** 3 units classwork; 1 unit lab and fieldwork

**Learning Objectives:** Students in this course will study and develop an understanding of the science of ecology at the levels of the individual, population, community, and ecosystem.

**Course Content by Topical Sequence**

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture/Discussion Topic</th>
<th>Laboratory Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 8/26</td>
<td>Introduction, Distributions Diamond Lab Experiments, Field Experiments, &amp; Natural Experiments (not a critique paper) Krebs Chapter 1, 3-6</td>
<td>Sampling and basic statistics</td>
</tr>
<tr>
<td>2. 8/31</td>
<td>Ants at the Cal Academy Ant distributions</td>
<td>Ant distributions</td>
</tr>
<tr>
<td>3. 9/7</td>
<td>Demography</td>
<td>Field: Cemetery demography</td>
</tr>
<tr>
<td></td>
<td>Birkeland <em>The Faustian Traits of the Crown-of-Thorns Starfish</em>. Krebs chapter 9-10</td>
<td>Lab: Cemetery demography</td>
</tr>
<tr>
<td>4. 9/14</td>
<td>Demography</td>
<td></td>
</tr>
<tr>
<td>5. 9/21</td>
<td>Population Growth and regulation 1 2 Computer: Life tables/population gr. Harrison et al., <em>Distribution of the Bay Checkerspot Butterfly</em> ... Krebs chapter 11</td>
<td>Field assignment</td>
</tr>
<tr>
<td>6. 9/28</td>
<td>Life-history theory</td>
<td>Computer: simulations</td>
</tr>
<tr>
<td></td>
<td>Exam 9/30</td>
<td></td>
</tr>
<tr>
<td>7. 10/5</td>
<td>Competition Krebs chapter 12</td>
<td></td>
</tr>
<tr>
<td>8. 10/12</td>
<td>Competition Critique 1 due</td>
<td>Field: Dunes</td>
</tr>
<tr>
<td>9. 10/19</td>
<td>Predation Krebs chapter 13, 14</td>
<td>Field: Dunes</td>
</tr>
<tr>
<td>10. 10/26</td>
<td>Predation Krebs chapter 16, 17</td>
<td>Field: Dunes</td>
</tr>
<tr>
<td>11. 11/2</td>
<td>Mutualism Krebs chapter 14</td>
<td>Field assignment</td>
</tr>
<tr>
<td></td>
<td><strong>Exam 11/4</strong></td>
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<tr>
<td>12. 11/9</td>
<td>Ecological Communities Peterson <em>Intertidal Zonation of Marine Invertebrates in Sand and Mud</em> Krebs Chapter 20-21</td>
<td>Field: Structural complexity &amp; diversity</td>
</tr>
<tr>
<td>13. 11/16</td>
<td>Ecological Communities Krebs Chapter 22-24</td>
<td>Lab: Structural complexity</td>
</tr>
</tbody>
</table>
Critique 2 due
14. 11/23 Ecosystems
   Krebs chapter 25-26
15. 11/30 Ecosystems
   Krebs chapter 28
16. 12/6 Conservation Biology
   Final exam:
   Evaluation of Student Performance:
   
   Two midterm exams                      40%
   Final exam                              25%
   Critiques                               10%
   Laboratory papers (two)                 10%
   Field assignment                        10%
   Participation                           5%

Critiques

The primary form of communication in science is the publication of research. New research is
published in “the primary literature” which consists of scientific journals. These journals are
published regularly and use a peer review system to evaluate manuscripts submitted to the journal.
Peer review means that reviewers are asked to comment on the quality of the research and whether
the research contributes to advancing the field. These reviews determine whether the manuscript is
accepted by the journal for publication. Reviews also provide feedback on the manuscript itself
which often enhances the writing and sometimes the thinking.

While you may not be ready to be an official review for Ecology, writing a review is a great way to
delve deeply into understanding theory and experimental methods and to sharpen your critical
thinking.

Assignment.

You will write two critiques of papers we discuss in class. A critique is a critical assessment of a
paper, not a review or summary. It should convey your understanding of the paper on an advanced
level and have critically evaluated the research, including its implications and interpretations. You
should address the following:

What was the main question of the paper?
What were the specific hypotheses? Were they stated explicitly and made clear?
Was evaluation of the research easily understood by the description of the methods?
   The study system
   The experiment
   The analyses
Were there any problems with the methods
Were the results presented clearly? Were they sufficient to address the hypotheses?
Can you think of an alternative explanations for the results?
Are there other explanations for the results?
Is there additional work that would strengthen the conclusions?
Are the results applicable to other systems?
Do the conclusions help advance theory in an area?
Do the results and conclusions have implications for future research?
Was the article well written (organized, clear, fun to read)?

Format

2-3 pages, double spaced, 12 point Times New Roman font, 1 inch margins. Critique should be in essay form and provide an assessment of strengths and weaknesses of the paper (avoiding trivia). Follow the citation format from the journal Ecology. The tone should be formal. The paper should be incredibly concise but not a list of answers to the questions list above. You can contact me early about the assignment (i.e. not the night before it is due)!!
<table>
<thead>
<tr>
<th>Date</th>
<th>Laboratory Lecture &amp; Exercise Topic</th>
<th>Reports &amp; Due Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 27</td>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>September 3</td>
<td>Renal function</td>
<td></td>
</tr>
<tr>
<td>September 10</td>
<td>Analysis of renal function</td>
<td></td>
</tr>
<tr>
<td>September 17</td>
<td>Acid-base balance</td>
<td>R 1: Renal function report due</td>
</tr>
<tr>
<td>September 24</td>
<td>Circadian rhythms</td>
<td></td>
</tr>
<tr>
<td>October 1</td>
<td>EMG</td>
<td>R 2: Acid-base report due</td>
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<tr>
<td>October 8</td>
<td>Proprioception and muscle spindles</td>
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<tr>
<td>October 15</td>
<td>Insect digestive enzymes</td>
<td>R 3: EMG report due</td>
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<tr>
<td>October 22</td>
<td>Diving response</td>
<td>R 4: Proprioception report due</td>
</tr>
<tr>
<td>October 29</td>
<td>Chick heart: autonomic control</td>
<td>R 5: Digestive enzyme report due</td>
</tr>
<tr>
<td>November 5</td>
<td>Chick heart: alcohol and caffeine</td>
<td>R 6: Diving response report due</td>
</tr>
<tr>
<td>November 12</td>
<td>Olfactory sensitivity tests</td>
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<td>November 19</td>
<td>Immunohistochemistry &amp; Testosterone ELISA</td>
<td>R 7: Chick heart report due (based on 10/22 and 10/29)</td>
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<tr>
<td>November 26</td>
<td>Analysis of circadian rhythm study and preparation for presentations</td>
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<tr>
<td>December 3</td>
<td>Presentations</td>
<td>R 8: Olfactory report due (based on 11/12 and 11/19)</td>
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<tr>
<td>December 10</td>
<td>Presentations</td>
<td></td>
</tr>
<tr>
<td>December 17</td>
<td></td>
<td>R 9: Circadian report due</td>
</tr>
</tbody>
</table>
end of each class you will be asked to enter the raw data from your experiments into an Excel spreadsheet that will be e-mailed to all the members of the class for analysis.

Lab Reports. There is a formal format that must be followed when reporting the results of an experiment. Your report must contain the following six divisions: abstract, introduction, materials and methods, results, discussion, and literature cited. You must follow this format. If your first lab report does not follow this rigid format, it will be handed back to you for revision and will have 5% deducted from the grade for each day that it is late. The parts of the lab reports are described in more detail below. Each lab report should be about five pages long (not counting figures and appendices) and contain references to at least five articles or books.

Abstract. A brief description of the experiment and its major results and conclusions. The abstract should summarize each section of the paper except the bibliography. One way to organize the abstract is to include one or two sentences encapsulating each of the major sections of the paper: introduction, methods and materials, results, and discussion. The conclusions must be stated clearly at the end of the abstract. Below are examples taken from published papers with two approaches to writing abstracts. Use these as examples, but for the purpose of this class please limit abstracts to 100 words or less.

Abstract 1
Lactating females express rapid extremes in behavior, ranging from gentle nurturance toward offspring to fiercely protective aggression against intruders. Although males often behave aggressively against intruders, female rodents usually express aggression only when rearing and protecting pups. Nitric oxide (NO) inhibits male aggression; however, its role in maternal aggression is unknown. In the present study, female mice with targeted disruption of the neuronal nitric oxide synthase gene (nNOS/-) displayed significant deficits in maternal aggression relative to wild-type (WT) mice in terms of percentage displaying aggression, the average number of attacks against a male intruder, and the total time spent attacking the male intruder. The nNOS/- mice displayed normal pup retrieval behavior. Because the specific deficits in maternal aggression in the nNOS/- mice suggested a possible role for NO in maternal aggression, we combined behavioral testing of WT mice with immunohistochemistry for citrulline, an indirect marker of NO synthesis, to examine indirectly NO synthesis during maternal aggression. A significant increase in the number of citrulline-positive cells was identified in the medial preoptic nucleus, the supraoptic nucleus, and the subparaventricular zone regions of the hypothalamus in aggressive lactating females relative to control mice. In other regions of the brain, no changes in the number of citrulline-positive cells were observed across either groups or treatments. These results provide two indirect lines of evidence that NO release is associated with maternal aggression. [Gammie and Nelson (1999) J. Neurosci. 19(18):8027-35]
Abstract 2
The circadian clock consists of a feedback loop in which clock genes are rhythmically expressed, giving rise to cycling levels of RNA and proteins. Four of the five circadian genes identified to date influence responsiveness to freebase cocaine in the fruit fly, Drosophila melanogaster. Sensitization to repeated cocaine exposures, a phenomenon also seen in humans and animal models and associated with enhanced drug craving, is eliminated in flies mutant for period, clock, cycle, and doubletime, but not in flies lacking the gene timeless. Flies that do not sensitize owing to lack of these genes do not show the induction of tyrosine decarboxylase normally seen after cocaine exposure. These findings indicate unexpected roles for these genes in regulating cocaine sensitization and indicate that they function as regulators of tyrosine decarboxylase. [Andretic et al., (1999) Science 285(5430): 1066-1068]

Introduction. A brief indication of what you knew about the project before you started and, as appropriate, a brief description of why the project was undertaken. The introduction outlines the problem and provides background information useful to understanding the remainder of the paper. This section of the paper should include the research of others, which leads to your own experimental design. Reference everyone!! In scientific reports, other authors are not generally quoted, just paraphrased or cited. The introduction begins with general background about the subject and gives more specific details about the experiment and finally ends with a hypothesis that can be either accepted or rejected in the Discussion section of the paper. The introduction should probably not be any longer than two paragraphs.

Materials and Methods. You must provide a thorough description of how you performed the experiment and obtained your results. Ideally, a reader should be able to duplicate your experiment exactly simply by following what you have written in this section. Your report may refer to the laboratory manual, although you should report any deviations from the procedure. When describing aspects of the methodology such as solutions you used, it is generally sufficient to report the molarity of the solution rather than the specific volumes and masses of reagents you used. You will provide specifics from photocopies of your lab notes in the appendix. If in later sections you find that you have to describe in detail what you did, your Methods and Results were not written appropriately.

Results. The Results section of the paper should describe verbally and graphically what you found in your experiment. It should generally be written in the past tense. This section should not consist merely of tabulated data and statistical tests. And, each figure and table as well as statistical outcome should be referred to in writing somewhere in this section. Do not provide any interpretation of your data in this section of your paper; save the interpretation for the discussion section.
Fig. 6 Timing the onset of eclosion (A) and wing inflation (B) in adult moths. (A) Animals were treated with CO2 gas at the time marked with a gray bar. Concentrations of gas were 0% (solid line, solid circle), 5% (dashed line, open squares) or 95% (dashed line, solid squares). The number of animals eclosing are represented as the cumulative percentage of the entire group (n=300). (B) Time of wing inflation in control moths (C; solid bar) and 5% CO2-treated moths (CO2; stippled bar) are the mean values with the standard errors of the mean. Sample size is denoted by (n).

Figures:
Figure legends should provide enough information that the reader knows what the figure is about without having to go through the article or report (figure legends go beneath the figure, table legends go above the table. Otherwise, content should be the same). Put titles and units on the X/Y-axes. Labels in the figure, and color coding are referenced in the legend.

Data presentation can include histograms (means and standard errors), dots (scattered or connected), etc. Above all, present data for clarity. Decide whether a figure or table is more appropriate. Few of the reports will generate enough data to warrant the use of more than one or two figures. Too many figures detracts from a paper, so use them thoughtfully.

Discussion. The purpose of the discussion section is to interpret your data and the statistical tests that were performed on your data. While referring to the appropriate tables and figures, use your data to build a logical argument for your interpretation of the data. Do NOT merely discuss the results in chronological order. The goal is to integrate the material from the previous sections into a coherent whole. How do the data you gathered answer the question asked in the introduction? Use your results to answer questions posed in the lab and to create arguments for or against your hypothesis. Are there, for instance, any potential sources of error in your experiment and in the measurements you made? Be careful, however, to not simply describe what the sources of error might have been. Rather, explain how these sources of error may have affected your experiment. How do the results of your experiment compare with those of other groups? Explaining the sources of error, including differences between groups in your lab, and proposing further experiments or even experiments that address a separate but related question are excellent ways of broadening the context of your paper. Questions posed in the lab manual are there as guides for your discussion. Please note that your discussion is not well written if it consists mainly of summaries of other peoples’ work, either described in a text or in the primary literature.

Literature cited. The work of others is cited by author and year in the text of your report, and by author, year, title, journal, volume, and page number in the bibliography. Examples are given below:
EXAMPLE TEXT
Experiments aimed at studying osmoregulation in small nematodes have been complicated by difficulties in obtaining adequate samples of body fluids for precise measurements of ionic and osmotic concentrations. The only reliable studies on the osmotic pressure of the body fluids of a nematode have been conducted on Ascaris lumbricoides (Schopfer, 1925, 1932; Hobson et al. 1952; Harpur and Popkin, 1965). However, when Ascaris is removed from its normal environment in the intestines of pigs, it enters a physiological decline from which it never recovers, and measurements taken during this period are thus of limited applicability (Harpur, 1963a, 1963b; Davey, 1964; Harpur and Popkin, 1965). A variety of indirect methods has been used to study osmoregulation in nematodes, but definitive experiments have not been possible (Wright and Newall, 1976, 1980). [Taken from Fuse et al. (1993) J. Exp. Biol. 175:127-142]

Journal article, single author:

Journal article, two authors:

Journal article, multiple authors:
Hobson, A. D., Stephenson, W. and Beadle, L. C. (1952). Studies on the physiology of Ascaris lumbricoides I. The relation of the total osmotic pressure, conductivity and chloride content of the body fluid to that of the external environment. J. exp. Biol. 29, 1ñ21. In the text, this is cited as (Hobson et al., 1952)

Books, parts of (follow the same conventions as above for citing single, double, and multiple authors):

Books, volumes:
Grant Proposal and Presentation

You will develop and present a short grant proposal. This grant proposal will describe the rational and justification for two or more experiments that address a specific physiological problem or question. This means that you will have to explain what is currently known about a given topic, what is not known, why the topic interesting and/or important and then where your experiments fit into the larger scheme of things. Having done that, you will also have to describe how you will perform the experiments and what you expect to find. In other words, this is essentially a lab report without any data that explains what you plan to do and why. More formally, the proposal itself should be at least five pages in length and include references to no fewer than ten papers from the primary literature. The presentation you will give in conjunction with the proposal should be approximately 15 minutes in length and must be in PowerPoint format. Nine people from the class will present their proposals on each of the final two days of class.

I will be giving a short tutorial on PowerPoint presentations during the latter half of the semester and will work in conjunction with you to develop these proposals. To facilitate this process, you will be asked to hand in an abstract of your proposal on October 9, 2002. We will then schedule individual meetings to discuss these proposals in more detail.
Contents

Preface xi

PART 1
INTRODUCTION 1

CHAPTER 1
A Case for Evolutionary Thinking: Understanding HIV 3
1.1 The Natural History of the HIV/AIDS Epidemic 4
1.2 Why Does AZT Work in the Short Run, But Fail in the Long Run? 10
Box 1.1 Can understanding how resistance evolves help researchers design better treatments? 14
1.3 Why is HIV Fatal? 17
1.4 Why Are Some People Resistant to Infection by HIV? 22
1.5 Where Did HIV Come From? 24
Box 1.2 When did HIV move from chimpanzees to humans? 28
Summary 29 • Questions 30
Exploring the Literature 31 • Citations 31

CHAPTER 2
The Evidence for Evolution 35
2.1 Evidence of Change through Time 36
Box 2.1 A brief history of ideas on evolution 37
2.2 Evidence of Common Ancestry 47
Box 2.2 Homology and model organisms 56
2.3 The Age of Earth 57
Box 2.3 A closer look at radiometric dating 61
2.4 Is There Necessarily a Conflict between Evolutionary Biology and Religion? 62
Summary 64 • Questions 65
Exploring the Literature 66 • Citations 67

CHAPTER 3
Darwinian Natural Selection 69
3.1 Artificial Selection: Domestic Animals and Plants 70
3.2 Evolution by Natural Selection 72
3.3 The Evolution of Flower Color in an Experimental Snapdragon Population 74
3.4 The Evolution of Beak Shape in Galápagos Finches 76
Box 3.1 Issues that complicate how heritabilities are estimated 82
3.5 The Nature of Natural Selection 87
3.6 The Evolution of Darwinism 92
3.7 The Debate over "Scientific Creationism" and Intelligent Design Theory 95
Summary 104 • Questions 104
Exploring the Literature 105 • Citations 105
Natural Selection

Let's talk about natural selection from the population genetics point of view. One of the easiest ways to start is to ignore all the stages at which selection can occur and to just lump them all together into a term that we will call Fitness. Fitness is defined as the (probability of survival) $X$ (the probability of successful mating) $X$ (fecundity). This is just the success of different genotypes at producing new individuals. Now we will assign a fitness value to genotypes that have been produced by random mating. At generation 0, before selection, we will have allele frequencies of $p$ and $q$ and genotype frequencies of $p^2$, $2pq$, and $q^2$. Now let's introduce differential fitnesses of $w_{BB}$, $w_{Bb}$, $w_{bb}$ which represent the average fitnesses of the individuals with each genotype. It is convenient but not necessary that the $w's$ are expressed as relative fitnesses, with one of the fitnesses (usually the highest) set equal to 1 and the others expressed as a proportion of that fitness. After selection, the genotypes will be represented in the following relative numbers:

<table>
<thead>
<tr>
<th>Genotype</th>
<th>BB</th>
<th>Bb</th>
<th>bb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>$p^2w_{BB}$</td>
<td>$2pqw_{Bb}$</td>
<td>$q^2w_{bb}$</td>
</tr>
</tbody>
</table>

These are just (the probability of getting the genotype with random mating) times (the genotypes' average viability, mating success, and fecundity). It is easier to think about fitnesses by considering only viability selection, but the math works with selection at any stage in the life cycle.

Note that these are not frequencies anymore. [A good way to visualize this is to let $p = .5$, $q = .5$, $w_{BB} = 1$ and $w_{Bb} = w_{bb} = 0$. Now all of our individuals are BB, but $p^2w_{BB} = p^2$, which not 1.] In order to make them frequencies, we need to divide these numbers by the total number. The total number is just the sum of the three genotype numbers:

$$p^2w_{BB} + 2pqw_{Bb} + q^2w_{bb} = W$$

Note that $W$ = the average fitness of the population (since the sum of frequencies of a class times the value of the class equals the average value. See, I told you that you Problem Set 1 would be useful! Note also that $W$ is the average of all the individuals in the population, not just the average of the 3 genotype fitnesses.)

So now our genotype frequencies after selection are:

<table>
<thead>
<tr>
<th>BB</th>
<th>Bb</th>
<th>bb</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p^2w_{BB} / W$</td>
<td>$2pqw_{Bb} / W$</td>
<td>$q^2w_{bb} / W$</td>
</tr>
</tbody>
</table>

We can calculate our allele frequencies after selection as the sum of homozygote frequency and $1/2$ the heterozygote frequency, just as we did before:

$$p_{\text{after selection}} = [p^2w_{BB} / W] + [pqw_{Bb} / W] = (p/W)(p^2w_{BB} + qw_{Bb})$$

if all $w$'s are the same (= no selection) then $p_{\text{after selection}} = p$ but if they differ then $p_{\text{after selection}}$ will not necessarily equal $p$. That is, if there is differential fitness among genotypes, allele frequencies may change due to selection.

Since we will now mate randomly among this post-selection population, it also follows that:

$$p_{\text{after selection}} = p'$$ (the allele frequency in the next generation.)
Now let's examine what happens between generations. Let's let the frequency of B before selection be $p = P_{BB} + 1/2 \cdot P_{Bb} = p^2 + pq$. We have shown above that the frequency of B in the next generation ($p^*$) is $(\frac{p^2w_{BB} + pqw_{Bb}}{W})$.

Let $\Delta p = p^* - p$. In order to get the whole thing with W as the denominator, we multiply p by 1 in the form $\frac{W}{W}$. That turns p into $(\frac{p^2W - pqW}{W})$.

Now $\Delta p = (\frac{p^2w_{BB} + pqw_{Bb} - p^2W - pqW}{W})$

$\quad = (\frac{p(w_{BB} - pW + qw_{Bb} - qW)}{W})$

$\quad = (\frac{p(W - pW + qW)}{W})$

$\quad = (\frac{p(W - qW)}{W})$

The quantity $(p(w_{BB} - W) + q(w_{Bb} - W))$ is a very special one that can be easily understood if we examine its parts. The fitnesses are expressed as the fitnesses of genotypes minus the average fitness of the population. That is, the fitnesses are now expressed as deviations from the average. The variable p is the probability that the B allele is part of a BB homozygote. The variable q is the probability that the B allele is part of a Bb heterozygote. So the whole quantity represents the average fitness deviation (from the population average) of carriers of the B allele. This quantity is given the special name AVERAGE EXCESS for fitness. The average excess is the mean difference between the fitness of individuals bearing the B allele and the fitness of the population as a whole. The average excess is really a way of assigning a fitness value to an allele, despite the fact that the allele has no phenotype of its own. This remarkable result allows us to see the relationship between the allele and fitness.

We can now write the equation for $\Delta p$ as:

$\Delta p = (\frac{p}{W})a_B$

where $a_B$ is the average excess of the B allele.

Note that, because p and W are always greater than 0, whether $\Delta p$ is positive (B is increasing in frequency) or negative (B is decreasing in frequency) is totally determined by the sign of $a_B$.

Note also that $a_B$ depends not only on the fitnesses but also on allele frequencies. That means that the effects of an allele in a population depends on the population context in which it is found. For example, two populations with identical fitnesses for the three genotypes could have totally different average excesses if the populations have different allele frequencies. The influence of allele frequency also means that as allele frequencies change, average excesses also change.

In the manner just described above, we can also calculate the average excess for the b allele:

$a_b = (\frac{p(w_{bb} - W) + q(w_{Bb} - W)}{W})$

Therefore $\Delta q = (\frac{q}{W})a_b$

As an example of the use of the average excess to predict the change in allele frequencies, we will next discuss the case of sickle-cell anemia in humans.
Prior to about 2000 years ago, people living in Central and West African rainforests were hunter-gatherers, with minimal impact on the forests in which they lived. These forests were unsuitable habitat for malaria mosquitoes, which require open habitat and lots of standing water to reproduce. About 2000 years ago agriculture developed or was introduced to the African rainforest. This had two effects:
1. The density of people increased, because of the more abundant food supply and the creation of permanent villages.
2) Land was cleared, providing habitat for mosquitoes.
The result was an increase in the occurrence of malaria, a major parasite-induced disease that is probably the leading cause of disease related deaths in the world.

What was the evolutionary response of African people to the increase in malaria? The answer involves the Hemoglobin β locus - which has several alleles. Two of these are A and S. Individuals homozygous for the S allele experience a deformity of their red blood cells that causes severe anemia. This condition is referred to as sickle-cell anemia. AA and AS individuals are normal, except for the fact that AS individuals are resistant to malaria. Let's see how this complex system evolved, both before and after the introduction of malaria.

In the pre-malarial environment, we can characterize the phenotypes and fitnesses of the population as:

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>AA</th>
<th>AS</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitness</td>
<td>Normal</td>
<td>Normal</td>
<td>Anemic</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>.2</td>
</tr>
</tbody>
</table>

Because the population was almost entirely AA, p = 1 and q = 0. Therefore W = 1.
The average excesses of A and S are:

\[ a_A = (p(w_{AA} - W) + q(w_{AS} - W)) = [p(1) + q(1)] = 1(0) + 0(0) = 0 \]
\[ a_S = (p(w_{AS} - W) + q(w_{SS} - W)) = [p(1) + q(-1)] = 1(0) + 0(-.8) = 0 \]

In both cases, the average excesses effectively equal 0, which means that Δp and Δq are also 0.
We will only keep track of the average excesses, because they determine the direction of evolution. The allele frequencies don't change, and the S allele can't increase its frequency in this population.

Now let's see what happens after malaria has become a problem. We have new phenotypes and fitnesses to define, because of the change in environment.

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>AA</th>
<th>AS</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(anemia)</td>
<td>Normal</td>
<td>Normal</td>
<td>Anemic</td>
</tr>
<tr>
<td>(susceptible)</td>
<td>Susceptible</td>
<td>Resistant</td>
<td>Susceptible and anemic</td>
</tr>
<tr>
<td>Fitness</td>
<td>.9</td>
<td>1</td>
<td>.2</td>
</tr>
</tbody>
</table>

\[ p = 1, q = 0, \text{approximately and } W = 1(.9) + 0(1) + 0(.2) = .9 \]

Now,
\[ a_A = [p(.9) + q(-.9)] = 1(0) + 0(1) = 1(1) + 0(-.7) = 1 \]
\[ a_S = [p(-.9) + q(2.9)] = 1(1) + 0(-.7) = 1 \]

Note that \[ a_S \] is now a fairly large positive number and therefore S will increase in frequency. How could S have such a low fitness as an SS homozygote and such a minimal fitness advantage as a heterozygote, and still increase? The answer is that the gene frequencies are such that, with random mating, there are almost no SS homozygotes. So the detrimental effects of anemia are not important, and the fitness advantage of being resistant to malaria is all that counts (since most S alleles are in AS individuals).
Now let the frequency of S increase until it is 0.1 (p=0.9).
Now \( W = 0.81(0.9) + 0.18(1) + 0.01(2) = 0.911 \) (Note that we are not approximating anymore)

\[
a_A = [0.9(0.911) + 0.1(1-0.911)] = 0.0009999
a_S = [0.9(1-0.911) + 0.1(2-0.911)] = 0.009
\]

Note that \( a_S \) is still positive, but not as large as it was, so S will not be increasing as fast. The deleterious effects of SS anemias are becoming more important as S becomes more common.

Now let \( p = 0.8 \) and \( q = 0.2 \). With the same math, \( a_A = +0.016 \) and \( a_S = -0.064 \). This means that now A will increase and S will decrease. The relative fitnesses are the same, just the allele frequencies have changed.

The sickle cell anemia example demonstrates that whether an allele is favored depends strongly on its frequency and the frequency of other alleles in the population, as well as its effects on fitness.

The Real Story of Evolution and Malaria.
To reinforce the idea that natural selection depends on both fitnesses and allele frequencies, I would now like to tell you the "whole story" of sickle cell anemia and malaria. What we have talked about before is a 2 allele system with the A and S alleles. This is the example that is given in most biology textbooks. But in reality there is a third allele at the hemoglobin B locus, the C allele. This allele is also due to a mutation in the 6th codon of the Hb locus, but different from the mutation that causes the S allele. Individuals homozygous for the C allele are resistant to malaria yet not anemic. Since a population of CC individuals would produce offspring that are all healthy and resistant to malaria, it would seem intuitively obvious that the C allele should spread throughout the population and eventually become fixed. But instead, the C allele is extremely rare. Why? Let's do the math.

In the premalarial environment:

<table>
<thead>
<tr>
<th></th>
<th>AA</th>
<th>AS</th>
<th>SS</th>
<th>AC</th>
<th>SC</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>w</td>
<td>1</td>
<td>1</td>
<td>.2</td>
<td>1</td>
<td>.71</td>
<td>1</td>
</tr>
</tbody>
</table>

Pheno. normal normal s.cell normal anemic normal

Again, the A allele is the overwhelmingly most common allele, so our allele frequencies are:

\[ p \equiv 1 \quad q \equiv 0 \quad r \equiv 0 \]

where \( r \) is now the frequency of the C allele.

\[
W \equiv p^2(1) + 2pq(1) + q^2(2) + 2pr(1) + 2qr(.71) + r^2(1) \equiv 1
\]

\[
a_A \equiv [p(1-1) + q(1-1) + r(1-1)] \equiv 0
a_S \equiv [p(1-1) + q(.2-1) + r(.71-1)] \equiv 0
a_C \equiv [p(1-1) + q(.71-1) + r(1-1)] \equiv 0
\]

In the premalarial environment, the average excesses for all three alleles are zero - therefore the \( \Delta p \), \( \Delta q \), and \( \Delta r \) are all 0. The reason is that the C and S alleles are very rare and almost always found as AC and AS heterozygotes, which have no difference in fitness from the very common BB heterozygotes.
Now let's look at the changes induced by malaria.

<table>
<thead>
<tr>
<th></th>
<th>AA</th>
<th>AS</th>
<th>SS</th>
<th>AC</th>
<th>SC</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>w</td>
<td>.9</td>
<td>1</td>
<td>.2</td>
<td>.9</td>
<td>.71</td>
<td>1.31</td>
</tr>
</tbody>
</table>

Pheno.  susceptible  resistant  s.cell  susceptible  anemic  very resistant  no anemia  no anemia

Again, the A allele is the overwhelmingly most common allele, so our allele frequencies are:

\[ p = 1 \quad q = 0 \quad r = 0 \]

\[ W = p^2(.9) + 2pq(1) + q^2(.2) + 2pr(.9) + 2qr(.71) + r^2(1.31) = .9 \]

\[ a_A = [p(.9 - .9) + q(1 - .9) + r(.9 - .9)] = 0 \]
\[ a_S = [p(1 - .9) + q(.2 - .9) + r(.71 - .9)] = .1 \]
\[ a_C = [p(.9 - .9) + q(.71 - .9) + r(1.31 - .9)] = 0 \]

Note that the A and C allele have 0 (actually very slightly negative) average excesses, while the S allele has a fairly large positive average excess (.1). The S allele is still found mostly in AS hets., but these individuals now have a fitness advantage. The C allele is still found mostly in AC hets, which have no fitness advantage on average. So the S allele will increase in frequency while the C allele will remain rare. Now what happens if the S allele increases to a measurable but small frequency? Let's say that the S allele has increased, by natural selection, to a frequency of .009. Further, let's say that the C allele frequency is measured at 0.001, so that we can stop approximating. Now our situation is as follows:

\[ p = .99 \quad q = .009 \quad r = .001 \]

\[ W = p^2(.9) + 2pq(1) + q^2(.2) + 2pr(.9) + 2qr(.71) + r^2(1.31) = .901732 = .9 \]

Now let's look at the average excess for the C allele.

\[ a_C = [p(.9 - .9) + q(.71 - .9) + r(1.31 - .9)] \]
\[ = [0 + .009(.19) + .001(1.31 - .9)] = .000171 + .000041 = .000213 \]

Now we have increased the frequency of both SC hets (slightly bad, fitness-wise) and CC homos (very good, fitness-wise), but because selection has increased the S allele frequency, many more of our C alleles are combined with S than with other C's. So the bad effect of the hets outweighs the beneficial effects of the CC homozygotes, and natural selection actually eliminates the C allele from the population.

So much for the survival of the fittest! At least, we can't talk about survival of the fittest genotype, or the fittest individual. We need to change our definition to survival of the fittest allele, or more correctly, the survival of the allele that produces the fittest offspring in a given population. This complication arises because of sex - intact genotypes are not passed down intact from parent to offspring. Therefore, not only are genotype fitnesses important, but so are the factors influencing the ways in which alleles combine to form the next generation. Such factors include system of mating and allele frequencies. For example, what if the allele frequency of the S allele is exactly 0 (no S alleles exist in the population) and C is at .001?
Then:

<table>
<thead>
<tr>
<th></th>
<th>AA</th>
<th>AC</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>w-</td>
<td>.9</td>
<td>.9</td>
<td>1.31</td>
</tr>
</tbody>
</table>

Now W = .9992(.9) + 2(.999)(.001)(.9) + .0012(1.31) = .9

\[ a_C = [p(.9 \cdot .9) + r(1.31 \cdot .9)] = 0 + .000410 = + \]

Therefore, \( \Delta r \) will tend to increase ever so slightly. As \( r \) increases, more and more CC's will be formed, causing C to increase even more. Eventually, C would become fixed in the population.

So you can see that the history of the population is important as well. Humans in Africa did have the S allele present in the population, and this prevented the spread of the C allele. If the C allele had come first, we could show, using the same mathematics, that the spread of the S allele would have been prevented. Also, the math we used is predicated on the fact that humans in this area mate randomly. If there had been even a slight tendency toward inbreeding, (which, as you recall, causes increased homozygosity) the C allele would have been found in sufficient homozygotes that the C allele would have a positive average excess, even with the S allele present.
# Biology 230 Schedule of Laboratory Exercises
## Fall 2004

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Dolphin manual</th>
<th>SFSU manual</th>
</tr>
</thead>
</table>
| Aug 26-27 | First lab meeting: Orientation; Scientific Method<br>
Diagnostic Quiz: If you do not pass, you will be dropped. Please 1) see your advisor<br>2) enroll in an appropriate math and/or English (comprehension & writing) course to develop the skills needed to do well in Biology 230. |                |             |
| Sept 31-1 | Safety Instruction and Contract.<br>Scientific Method; Lab Skills: Pipetting & Microscopy.<br>Diversity of Organisms: Exercise 1. Collecting microorganisms |                |             |
| 2-3 | Spectrophotometry: Absorption Spectra & Standard Curves |                |             |
| 7-8 | Organic Molecules: Qualitative & Quantitative Analysis |                |             |
| 9-10 | Microscopy I: Prokaryotic Cells; Gram Staining |                |             |
| 16-17 | Diffusion, Osmosis and Membranes<br>(omit: diffusion in gels (Dolphin)) | Dolphin Ex4 | 7 69-70 |
| 21-22 | pH and Buffers |                |             |
| 23-24 | Mitosis (pre-lab homework due at beginning of lab period) |                |             |
| 28-29 | Mitosis continued/Mitosis & Sexual Reproduction (pre-lab homework due) |                |             |
| Oct 30-1 | Meiosis & Sexual Reproduction continued |                |             |
| 5-6 | LABORATORY PRACTICAL I .......................................................... |                | see page 177 |
| 7-8 | Enzymology | Dolphin Ex97 | 8 71-75 |
| 12-13 | Cellular Energetics |                | 12 107-116 |
| 14-15 | Photosynthesis, Leaf Structure |                | 13 117-128 |
| 19-20 | Primary Plant Body; Primary Growth; Plant Cells & Tissues |                | 2 15-19 & 14 129-136 |
| 21-22 | Stomata and Transpiration; Vascular Tissues-Structure and Functions: Water Movement-in Xylem; Translocation-in Phloem |                | 15 137-142 |
| 26-27 | Secondary Plant Growth |                | 16 143-150 |
| 28-29 | Plant Growth Regulators & Growth Responses |                | 17 151.1-151.5 |
APPENDIX D

Writing Lab Reports and Scientific Papers

Verbal communication is temporal and easily forgotten, but written reports exist for long periods and yield long-term benefits for the author and others. Gregor Mendel’s work is a perfect example. When he finished his research he gave a verbal presentation to a scientific meeting, but few understood it. That was in 1872. Fortunately, he also wrote a paper and published it. About 30 years later that paper was read by scientists who understood it and Mendel was given credit for founding the modern study of genetics.

Scientific research is a group activity. Individual scientists perform experiments to test hypotheses about biological phenomena. After experiments are completed and duplicated, researchers attempt to persuade others to accept or reject their hypotheses by presenting the data and their interpretations. The lab report or the scientific paper is the vehicle of persuasion; when it is published, it is available to other scientists for review. If the results stand up to criticism, they become part of the accepted body of scientific knowledge unless later disproved.

In some cases, a report may not be persuasive in nature but instead is an archival record for future generations. For example, data on the distribution and frequency of rabid skunks in a certain year may be of use to future epidemiologists in deciding whether the incidence of rabies is increasing. Regardless of whether a report is persuasive or archival, the following guidelines apply.

Format

A scientific report usually consists of the following:

1. Title
2. Abstract
3. Introduction
4. Materials and methods
5. Results
6. Discussion
7. Literature cited

There is general agreement among scientists that each section of the report should contain specific types of information.

Title

The title should be less than ten words and should reflect the factual content of the paper. Scientific titles are not designed to catch the reader’s fancy. A good title is straightforward and uses keywords that researchers in a particular field will recognize.

Abstract

The purpose of an abstract is to allow the reader to judge whether it would serve his or her purposes to read the entire report. A good abstract is a concise (about 100 words) summary of the purpose of the report (hypotheses tested), the data obtained, and the author’s major conclusions.

Introduction

The introduction defines the subject of the report. It must outline the scientific purpose(s) and hypotheses tested, giving the reader sufficient background to understand the rest of the report. Care should be taken to limit the background to whatever is pertinent to the experiment. A good introduction will answer several questions, including the following:

Why was this study performed?
Answers to this question may be derived from observations of nature or from the literature.

What knowledge already exists about this subject?
The answer to this question must review what is known about the topics, showing the historical development of an idea and including the conflicts and gaps in existing knowledge.

What is the purpose of the study?
The specific hypotheses being tested should be stated and the experimental design described.

Materials and Methods

As the name implies, the materials and methods used in the experiments should be reported in this section. The difficulty in writing this section is to provide enough detail for the reader to understand the experiment without overwhelming him or her. When procedures from a lab book or another report are followed exactly, simply cite the work, noting that details can be found there. However, it is still necessary to describe special pieces of equipment and the general theory of the assays used. This can usually be done in a short paragraph, possibly along with a drawing of the experimental apparatus. Generally, this section attempts to answer the following questions:

What materials were used?

How were they used?

Where and when was the work done? (This question is most important in field studies.)
Results

The results section should summarize the data from the experiments without discussing their implications. The data should be organized into tables, figures, graphs, photographs, and so on. But data included in a table should not be duplicated in a figure or graph.

All figures and tables should have descriptive titles and should include a legend explaining any symbols, abbreviations, or special methods used. Figures and tables should be numbered separately and should be referred to in the text by number, for example:

1. Figure 1 shows that the activity decreased after five minutes.
2. The activity decreased after five minutes (fig. 1).

Figures and tables should be self-explanatory; that is, the reader should be able to understand them without referring to the text. All columns and rows in tables and axes in figures should be labeled. See appendix B for graphing instructions.

This section of your report should concentrate on general trends and differences and not on trivial details. Many authors organize and write the results section before the rest of the report.

Discussion

Writing this section, you should explain the logic that allows you to accept or reject your original hypotheses. You should not just restate your results, but should emphasize interpretation of the data, relating them to existing theory and knowledge. Speculation is appropriate, if it is so identified. Suggestions for the improvement of techniques or experimental design may also be included here. You should also be able to suggest future experiments that might clarify areas of doubt in your results.

Literature Cited

This section lists all articles or books cited in your report. It is not the same as a bibliography, which simply lists references regardless of whether they were cited in the paper. The listing should be alphabetized by the last names of the authors. Different journals require different formats for citing literature. The format that includes the most information is given in the following examples:

For articles:

For books:

For chapters in books:

When citing references in the text, do not use footnotes; instead, refer to articles by the author's name and the date the paper was published. For example:

1. Fox in 2000 investigated the effects of hormones on the nest-building behavior of catbirds.
2. Hormones are known to influence the nest-building behavior of catbirds (Fox, 2000).

When citing papers that have two authors, both names must be listed. When three or more authors are involved, the Latin et al. (et alia) meaning "and others" may be used. A paper by Smith, Lynch, Merrill, and Beam published in 2004 would be cited in the text as:

Smith et al. (2004) have shown that...

This short form is for text use only. In the Literature Cited, all names would be listed, usually last name preceding initials.

There are a number of style manuals that provide detailed directions for writing scientific papers. Some are listed in further readings at the end of this section.

More and more students turn to the World Wide Web (WWW) and search engines to locate background information for reports. This is certainly acceptable but you should be aware that mere publication on the WWW does not assure that something is true. Because electronic sources may disappear overnight or a source may be changed (updated) in the time between a first and second access, such sources must be cited differently from printed materials. Citation of an electronic source should include:

Author’s last and first names with middle initial; Date of publication on the Internet, including revision dates; Title of the electronic document; The URL contained within angle brackets; and the date on which you accessed it. An example is:


General Comments on Style

1. All scientific names (genus and species) must be italicized. (Underlining indicates italics if fonts are not available.)

2. Use the metric system of measurements. Abbreviations of units are used without a following period.

3. Be aware that the word data is plural while datum is singular. This affects the choice of a correct verb. The
word *species* is used both as a singular and as a plural. Never use the word *specie*; it refers to a coin not an organism.

4. Numbers should be written as numerals when they are greater than ten or when they are associated with measurements; for example, 6 mm or 2 g but two explanations or six factors. When one list includes numbers over and under ten, all numbers in the list may be expressed as numerals; for example, 17 sunfish, 13 bass, and 2 trout. Never start a sentence with numerals. Spell all numbers beginning sentences.

5. Be sure to divide paragraphs correctly and to use starting and ending sentences that indicate the purpose of the paragraph. A report or a section of a report should not be one long paragraph.

6. Every sentence must have a subject and a verb.

7. Avoid using the first person, I or we, in writing. Keep your writing impersonal, in the third person. Instead of saying, "We weighed the frogs and put them in a glass jar," write, "The frogs were weighed and put in a glass jar."

8. Avoid the use of slang and the overuse of contractions.

9. Be consistent in the use of tense throughout a paragraph—do not switch between past and present. It is best to use past tense.

10. Be sure that pronouns refer to antecedents. For example, in the statement, "Sometimes cecropia caterpillars are in cherry trees but they can also be found," does "they" refer to caterpillars?

After writing a report, read it over, looking for lack of precision and for ambiguity. Each sentence should present a clear message. The following examples illustrate lack of precision:

1. "The sample was incubated in mixture A minus B. Yes, C." Does the mixture lack both B and C or lack contain C?

2. The title "Protection against Carcinogenesis by Antioxidants" leaves the reader wondering whether antioxidants protect from or cause cancer.

The only way to prevent such errors is to read and think about what you write. Learn to reread and edit your work.

**Further Readings**


BIOLOGY 613

HUMAN PHYSIOLOGY
LAB MANUAL

BY
CHRISTINE MANUGUID
SAMANTA SASSI
MEGUMI FUSE, PH.D.
How to Write a Lab Report
Modified from (Susan Cordova for the New Mexico Junior Academy of Science)

Laboratory reports are written by each student. The reports should be clear, concise, and consistent. Data and ideas may be shared by the students conducting the experiments together. Graphs may even be produced by the group; however, each student must use their own words in writing the report. Copying or paraphrasing another student’s work, direct copying or paraphrasing of text from published work, and from an online source (including charts, graphs, and pictures) without appropriate referencing is considered plagiarism (see Policy on Cheating in the University Bulletin). In the scientific method, direct copying, even with citations is not appropriate.

Style
In all sections of the paper, present tense should be used to report background that is already established. For example, “The heart is a four chambered vessel that circulates blood.” Use future tense for work that you will do. For example, “We will test the hypothesis that the chick embryo heart rate is modulated by adrenalin receptor agonists.” Always use past tense to describe results of a specific experiment, especially your own. For example, “Application of caffeine to the isolated chick embryo heart induced an increased rate of beating.” Number the pages of the body of the paper beginning with the Introduction as page 1. A Table of Contents is not necessary.

Captioning is a method of separating the body of a paper into sections. Headings show organization and identify the topic for a section or a block of information. For instance, it may offer a way to separate groups of results. Capital letters, underlining, point size, and position of the page help to differentiate rank or level. This is not necessary in a lab report, but is an option.

Lab Report Format

Title
Your name, date, and title of the paper should be the first item we see. It can be on a cover page, or as the header before the introduction. Your title should be specific in describing the experiment(s) you performed. For example, “Effects of endogenous agonists on heart rate in the isolated chick embryo” provides information on the experiment being described and is much more interesting than just “Chick Embryo Heart rate”

Introduction
Keep the introduction brief, but do present appropriate background information about the topic, the purpose of the experiments performed, as well as the experimental design followed by the hypothesis. Make sure that the reader knows enough to appreciate the relevance of the work and why it is appropriate to ask the question that you will address with your study. It should usually include research of others that supports the hypothesis presented or lead to your own experimental design. Always state the objective and the hypothesis in your introduction. Be sure to cite all “scientific facts” from texts and primary research articles, and break your introduction up into appropriate paragraphs.
METHODS

You must document all methods performed in your study. Do not, under any circumstances, report methods word-for-word from any of the written sources you used. You must cite the source. If you used Biopac or this supplement, you may cite it as your source instead of re-writing the methods. However, you must use full sentences. For example, “See supplement pg. 2-4 for methods.” is not adequate. It should be “The chick heart rate was isolated and monitored according to the methods provided in the supplement (Biol 613 Supplement, 2007).” Note that there will ALWAYS be some changes to the protocol, so you will need to identify these changes in full sentence form. Thus, you need to summarize, in your own words, what you did. For example, “The chick heart rate was isolated and monitored according to the methods provided in the supplement (Biol 613 Supplement, 2007). Saline controls, however, were only taken at the beginning of the lab period, and not prior to each experimental run”.

Do not give unneeded detail. For example, instead of “I took up 1 ml of adrenalin from a 5 ml tube with a 2 ml plastic pipette and added it to a chick embryo heart that I had dissected out, and I recorded the heart rate”, write “1 ml of adrenalin was added to the isolated chick embryo heart and heart rate was recorded”. We can also see that in this latter sentence, passive voice was used to report methods, a standard for most scientific publications. To give another example, one would write “Chick embryos were incubated at 37°C,” instead of “We kept the chick eggs at 37°C.”

Do not report information that would be irrelevant to an independent investigator. For example, not everyone uses the computer software you have in the lab. The programs you used to organize or plot data are not important. Most important, do not report any results of the experiment in the methods section. These, of course, go in the “Results” section.

RESULTS

Raw data include all observations or data that you get from your experiment. Raw data are never included in your lab report unless they are needed to give evidence for specific conclusions that cannot be obtained by looking at an analysis, or summation, of the data. Often this is appropriate as an appendix. Analyze your data, and then present it in the form of figures (graphs), tables, and/or descriptions of observations. Data in this form are called converted data. Figures are preferable to tables, and tables are preferable to straight text. By presenting converted data, you make your point succinctly and clearly. You must, however, decide very carefully what is the clearest way to present the data. Are histograms (bar graphs) or line graphs most appropriate? Is a table clearer than a graph? NEVER put the same data in both a table and a graph.

To give your results continuity, describe IN WRITING the relationship of each section of converted data to the overall study. For example, rather than just putting a graph on the paper and going into the discussion section, write, “In order to assess the role of drinks on urine flow rate, subjects were given coke and water to drink, and urine flow rate was monitored over time. Figure 1 shows the average urine flow rate for these groups. The urine flow rate for the coke group prior to drinking (T0) was lower than the water group. Both groups showed increases in urine production within the first 30 min but did not reach maximal flow rates until 90 minutes after drinking”. In other words, use a combination of spoken and written style to guide the reader through the graphs and to highlight what you think are the most important points on the graphs.
The table or figure should then be presented, complete with a detailed figure legend. The legend should explain what the table or figure is showing. For example, "Table 2. Drink composition and volume of water, Gatorade and Coke consumed in the lab". Table legends ALWAYS go above the table, figure legends ALWAYS go below the figure.

Insert all figures and tables into the body of the lab report instead of at the end. This is typically within the Results section, after the Methods and before the Discussion sections. If you are adding raw data, place it at the back of the report as an appendix. The appendix is also appropriate for any sample calculations that are needed, such as hand-worked statistical analyses or raw calculations that show how you arrived at reported values. A published research report will seldom have such an appendix, but it may be appropriate in the case of a lab report.

**Do not** draw conclusions in the results section. Reserve data interpretation for the Discussion section.

**DISCUSSION**

Interpret your data in the Discussion section. Explain all of your observations as much as possible, focusing on physiological mechanisms. When you refer to information, distinguish data generated by your own studies from published information or from information obtained from other students. Decide if each hypothesis is supported, rejected, or if you cannot make a decision with confidence. Do not simply dismiss a study or part of a study as "inconclusive." Make what conclusions you can, then suggest how the experiment must be modified in order to properly test the hypotheses. Refer to primary research articles and textbooks to back up your conclusions (and cite them appropriately!).

Most studies will require a critique of the experiment. Determine if you asked the right question in the first place. Decide if the experimental design adequately addressed the hypothesis, and whether or not it was properly controlled. You can then suggest future directions that you might take if you were to redo or continue with this research. The best studies open up new avenues of research. What questions remain? Did the study lead you to any new questions? Try to think up a new hypothesis and briefly suggest new experiments to further address the main question. Be creative, and don't be afraid to speculate.

**Citing Literature in the lab report**

Literature citations in the body of your paper should be in parentheses and contain only the authors’ last names and the year of publication. See examples below for more than two authors. If the author’s name is used in the text, then just the year of publication is given in parentheses. Information from sources (textbooks, journal articles) must be paraphrased (put in your own words) and cited within the body of the text. Do not quote entire sentences or paragraphs, even if you put quotes around them and cite them. This is not scientific form! Do not include the full reference within the text!

**Example citations:**

One to two authors: (Monod, 1949) / (Neidhardt and Monod, 1990)

Three or more author citations: (Neidhardt et al., 1990)

In the text: Heart rate variability is common in individuals (Smith and Wesson, 2005). This variability is due to autonomic system inputs (Widmaier et al, 2004). Rogers and Hammerstein (2000) found that other factors such as smoking may have an impact on these autonomic responses as well.
REFERENCES

Full details of the cited literature must be provided in the reference section. List all literature cited in your report in alphabetical order by the last name of the first author, or numerically (only if you use numerical citations in the body of your report). Use the proper form for citations.

For scientific papers:
Last name, First initials. Year. Title of the article. Journal Title (abbreviated). Volume (issue): page numbers.

Examples:


For a book:
Last name, First initial. Year. Title. Edition. Publisher, City. Pages referred.

Example:

For a website:

Examples:
HOW TO READ AND WRITE A SCIENTIFIC RESEARCH ARTICLE
Modified from <http://www.columbia.edu/cu/biology/ug/research/paper.html> *

FORMAT FOR A SCIENTIFIC PAPER
Scientific research articles provide a method for scientists to communicate with other scientists about the results of their research. A standard format is used for these articles, in which the author presents the research in an orderly, logical manner. This doesn't necessarily reflect the order in which you did or thought about the work, but is the order in which headers appear in the article itself. This format is:

Title
Authors
Abstract
Introduction
Materials and Methods
Results (with Tables and Figures)
Discussion
Acknowledgments
Literature Cited

READING A SCIENTIFIC PAPER
Because scientists are working off of hypotheses that they generally "believe" in, and because they typically have some of the best working knowledge in that particular area, it is very important to make sure you agree with their conclusions on your own. They may very well read more into their results than really exists, and while they may be right, it is important to differentiate what is "proven" (their results) and what is hypothetical (their educated guesses). Thus it is a good idea to read the paper in the following order:

Introduction
Results (with Tables and Figures)
Materials and Methods
Abstract
Discussion
Authors
Literature Cited

This order is significant since you want to make sure to come to your own conclusions before you read the authors' conclusions. Very often, the authors have so much information, that they read more into their results than they have shown. This is not to say that they are wrong, but they may be concluding far beyond what their results have shown, as "educated" guesses.

1. Use the Introduction to make sure you know a little about the topic. I usually read this in front of my computer so I can "Google" any words or topics I don't understand from the intro. This is merely for definitions or synonyms, not for quality scientific information necessarily. I may use Wikipedia to help me familiarize myself with a topic and to find words that mean something to me. I try to identify the objective so I know what the results will be based on. And very often, the last paragraph of the introduction gives a summary of what the authors found.
2. I follow this with an in depth look at the Results and I try to interpret those results myself, often pouring over the Materials and Methods at the same time. I usually identify the text paragraphs that discuss a particular figure or table and see what they say. I write many notes on the Tables or Figures, since they are often very sparse, and I make a note of what I think they showed.

3. I never read the Abstract or Discussion until I have made conclusions of my own from the data itself (I may read the Abstract early if I don’t have time to thoroughly read the paper). Once you have your own conclusions, you can then see what the authors have concluded. Their summary conclusions and results will be in the Abstract. In depth conclusions will be in the Discussion. I may then re-look at the Title as well since it is a good summary statement of what they found.

4. I use the Authors with a database search engine such as Pubmed to see what else they have published. The first author tells me who is doing the work. The last author, however, may often be the more highly published, since they are usually the primary investigators. They are worth checking up on Pubmed as well. Then I look over the Literature Cited to find other relevant papers. I may circle those I should find, or I just look at titles to see what other topics or conclusions have been covered. The titles are usually good indicators of the overall conclusions or results.

WRITING A SCIENTIFIC PAPER

Don’t write your paper in the order listed above. There is a very different order for writing it up. It is almost the same as the format for reading a paper. This format is:

Results (with Tables and Figures)
Materials and Methods
Discussion
Introduction
Literature Cited
Abstract
Title
Authors
Acknowledgments

RESULTS

1. This is where you present the results you’ve gotten. Use graphs and tables if appropriate, but also summarize your main findings in the text. Do NOT discuss the results or speculate as to why something happened; that goes in the Discussion.

2. You don’t necessarily have to include all the data you’ve gotten, and you won’t necessarily be putting it in the order that you conducted the experiments. This isn’t a chronological account. The reason you do Results first, is that your experiments tell a story, and you must not only fully understand your results, but you must order them in a way that logically takes the reader through a series of questions and conclusions. Once you have this order, you can write up Materials and Methods, Discussion etc. What you want to say about your results will also dictate what you need the reader to know in the introduction.
3. Use appropriate methods of showing data. Don't try to manipulate the data to make it look like you did more than you actually did. Choose whether you want to use tables or graphs so the data will be clearest.

E.g. "The drug cured 1/3 of the infected mice, another 1/3 were not affected, and the third group got away." This might be a nice histogram (bar graph) or a table, but not a line graph.

**TABLES AND FIGURES**

1. If you present your data in a table or graph, include a title describing what's in the table ("Enzyme activity at various temperatures", not "My results"). These are called legends and they go above Tables, or below Figures. For Figures, you should also label the x- and y-axes.

2. Using a legend, identify all items on the graph that are not clear. The reader should be able to look at a Figure/Table and its corresponding legend and understand the experiment without having to go through the entire Results section text.

3. Don't use a table or graph just to be "fancy". If you can summarize the information in one sentence, then a table or graph is not necessary.

**MATERIALS AND METHODS**

1. How did you conduct your experiment? There should be enough information here to allow another scientist to repeat your experiment. Look at other papers that have been published in your field to get some idea of what is included in this section.

2. If you had a complicated protocol, it may helpful to include a diagram, table or flowchart to explain the methods you used. But this is rare. Note that if you are repeating someone else's protocol you can also just cite them.

3. Do not put results in this section. You may, however, include preliminary results that were used to design the main experiment that you are reporting on. ("In a preliminary study, I observed the owls for one week, and found that 73% of their locomotor activity occurred during the night, and so I conducted all subsequent experiments between 11 pm and 6 am.")

4. Mention relevant ethical considerations. If you used human subjects, did they consent to participate. If you used animals, what measures did you take to minimize pain?

**DISCUSSION**

1. Highlight the most significant results, but don't just repeat what you've written in the Results section. How do these results relate to the original question? Do the data support your hypothesis? Are your results consistent with what other investigators have reported? If your results were unexpected, try to explain why. Is there another way to interpret your results? What further research would be necessary to answer the questions raised by your results? How do your results fit into the big picture?

2. End with a one-sentence summary of your conclusion, emphasizing why it is relevant.

**INTRODUCTION**

1. What question did you ask in your experiment? Why is it interesting? The introduction summarizes the relevant literature so that the reader will understand why you were interested in the question you asked. Two to four paragraphs may be enough. End with a sentence explaining the specific question you asked in this experiment. This part is done last since you have to decide what relevant information to put in partly based on what you conclude in your discussion.
TITLE
1. The title should be specific enough to describe the contents of the paper, but not so technical that only specialists will understand. The title should be appropriate for the intended audience.
2. The title usually describes the subject matter of the article:
   "Effect of Smoking on Academic Performance"
3. Sometimes a title that summarizes the results is more effective:
   "Students Who Smoke Get Lower Grades"

AUTHORS
1. The person who did the work and wrote the paper is generally listed as the first author of a research paper.
2. For published articles, other people who made substantial contributions to the work are also listed as authors. Ask permission before including a name as co-author.
3. Generally, the last author has supplied the resources (it is often their lab where the work was done, or their funds that allowed the work to be completed).

ABSTRACT
1. An abstract, or summary, is published together with a research article, giving the reader a "preview" of what's to come. Such abstracts may also be published separately in bibliographical sources, such as Biological Abstracts. They allow other scientists to quickly scan the large scientific literature, and decide which articles they want to read in depth. The abstract should be a little less technical than the article itself; you don't want to dissuade your potential audience from reading your paper.
2. Your abstract should be one paragraph, of 100-250 words, which summarizes the purpose, methods, results and conclusions of the paper (generally 2-3 sentences each).
3. It is not easy to include all this information in just a few words. Start by writing a summary that includes whatever you think is important, and then gradually prune it down to size by removing unnecessary words, while still retaining necessary concepts.
4. Don't use abbreviations or citations in the abstract. It should be able to stand alone without any footnotes.

ACKNOWLEDGMENTS
This section is optional. You can thank those who either helped with the experiments, or made other important contributions, such as discussing the protocol, commenting on the manuscript, or buying you pizza.

REFERENCES (LITERATURE CITED)
There are several possible ways to organize this section. Here is one commonly used way:

1. In the text, cite the literature in the appropriate places:

Scarlet (1990) thought that the gene was present only in yeast, but it has since been identified in the platypus (Indigo and Mauve, 1994) and wombat (Magenta, et al., 1995).

Note that the Magenta reference has more than two authors, and thus "et al." is used instead of listing all of the authors in the text.
2. In the References section list citations in alphabetical order.


Appendices for Standards:

Standard 5: Varied Teaching Strategies
13. Floral variation, an evolutionary key to success!

**Goals:**
1. Can you identify all the parts of a flower?
2. How is pollen dispersed in different plants?
3. Have certain pollinators coevolved with the plants they pollinate?

**Key Terms:**
- abiotic pollination
- anther
- biotic pollination
- carpel
- complete flower
- corolla
- filament
- gynoecium
- inferior ovary
- incomplete flower
- pistil
- pollination syndromes
- sepals
- stamen
- stigma
- style
- superior ovary

**Introduction**

Floral morphology, a look at generalities (Rust, figs. 45 & 46, V & C fig. 6.197)

The basic structure of a flower is diagrammed in the figure to the right. There are four series of floral parts, usually arranged in whorls, each with its own set of functions. Evolutionary botanists regard a flower as a highly modified stem axis around which are arranged several series of modified leaves. In some floral parts it is easy to visualize their leaf-like nature, but in others it takes some extra study to understand the origin of these organs from leaf-like ancestors.

Using what you know about flowers, what is the function of each of the whorls of a flower?

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>sepals</td>
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<td>petals</td>
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<tr>
<td>stigma</td>
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<td>anther</td>
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<td>style</td>
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<td>filament</td>
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<tr>
<td>ovary</td>
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</table>
Variations in Floral Morphology

With over 250,000 species of flowering plants, you wouldn’t expect each one to have identical flowers. Indeed, there are numerous variations on the general theme described above, yet it is still amazing that all flowers can be viewed as a modification of this typical pattern. Today you will learn many botanical terms to help you identify different ways that flowers can vary from each other.

- **Number of parts**: number of sepals, petals and reproductive parts can vary
- **Complete vs. incomplete**: a flower with all four series is called complete, if a series is missing the flower is incomplete
- **Unisexual vs. bisexual**: is the flower, male, female or bisexual
- **Fusion of sepals and petals**: results in flowers that are tubular and many other shapes
- **Fusion of stamens**: are the stamens fused to the petals, pistil or not fused
- **Corolla symmetry**: the shape of the corolla can be bilateral, radial or asymmetrical
- **Superior or inferior ovary**: If an ovary has all of the other three floral series fused to the base of the ovary, then the ovary is superior to the other series. What type of ovary is pictured on the flower below?

![Flower Image](http://www.pngplants.org/PNGtrees/DataDictionary/flofruFeat.html)

- **Monocot vs. dicot**: A good way to distinguish between a monocot and a dicot is by counting floral parts, if the floral parts come in groups of 3’s, the flower is most likely a monocot. If the flower has floral parts in multiples of 4’s and 5’s the flower is most likely a dicot.

---

Not all plants have flowers, but flowers did evolve from a homologous structure that all plants have. From what structure did each whorl of a flower evolve?

Your lab instructor will now hand each pair of students a flower. Draw a picture of the flower. Label all of the series of the flower. This flower can be the first entry on the floral morphology chart on page 13-3. After you finish the first flower, pick three more flowers in the back of the
room from the floral morphology section and fill in the rest of the chart.

<table>
<thead>
<tr>
<th>Flower picture</th>
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</thead>
<tbody>
<tr>
<td># of sepals</td>
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<tr>
<td># of petals</td>
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<tr>
<td># of stamens</td>
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<tr>
<td>Complete or Incomplete</td>
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<td>Fusion of sepals &amp;/or petals</td>
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<td>Fusion of stamen</td>
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<td>Corolla symmetry</td>
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<td>Superior or Inferior ovary</td>
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<tr>
<td>Monocot or dicot</td>
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</table>
Pollination

Stated simply, pollination in flowering plants is the process beginning with the departure of pollen from the anther and ending with its deposition on a stigma. Note that pollination is not the same as fertilization. Pollination must occur prior to fertilization. In non-flowering seed plants, pollination involves deposition of pollen at or near the micropyle of an ovule. Do you think that pollen from any flower can pollinate a flower from another species? Why or why not?

(A) Abiotic Pollination

When a non-animal vector is responsible for moving the pollen, the term abiotic pollination is used. There are two primary abiotic vectors: wind, and in aquatic environments, water. In wind-pollinated plants, pollen is released and carried airborne by the wind until it reaches a stigma of the same species. All grasses and many temperate tree species are wind-pollinated. Certain aspects of the floral system have evolved to enhance the likelihood of wind pollination. For example, wind-pollinated species generally produce relatively large amounts of pollen compared to the number of ovules (high pollen/ovule ratio). Another common adaptation seen in many wind-pollinated species is a very large stigma on the gynoecium. Many wind pollinated flowers also have reduced or absent corolla. Why would it be to their advantage not to have corolla?

How accurate do you think wind pollination is? Do you think it is very effective?

(B) Biotic Pollination

When pollen is delivered to stigmas by animal vectors the term biotic pollination is used. There are many species of animals that pollinate plants, and many adaptations of flowers to enhance pollination by various animals. The parts of flowers that function to enhance animal pollination can be thought of as performing one of two functions: signal or reward.

It is important to realize that most plant species are not pollinated by only one kind of pollinator. There are cases of species-specific pollination in some orchid species, but these are the exception. Despite the general nature of pollination in many species of plant, you can make some generalized statements about different animal groups that pollinate flowers. Certain insects, birds, and bats are known pollinators.

What are some examples of floral signals and rewards? Why do animals pollinate flowers, are they trying to help the plant?
Pollinators

1. **Coleoptera (beetles)** - Beetle pollination is generally regarded as among the least specialized of animal pollination. Beetles seem to favor large, strong-scented flowers, and it is common for beetles to chew the entire flower as a food source. Pollination by beetles, therefore, is regarded as a bit sloppy, but efficient enough to get the job done.

2. **Lepidoptera (butterflies and moths)** - Butterflies and moths constitute a diverse group, but many species of pollinating butterflies are diurnal (fly, hence pollinate by day) and rely on visual signals, while many species of pollinating moths are vespertine (evening-flying) and rely on olfactory signals. Lepidopterans also have long mouth parts that can probe deeply into structures containing food resources. Consequently, Lepidopteran-pollinated plants commonly have tubular corollas with nectar produced at the bottom of the tube.

3. **Diptera (flies and mosquitoes)** - Many species of flies are important pollinators of flowers (there are many different kinds of flies - not just house flies and horse flies). Many flies prefer flowers that have odors similar to sweat, feces, or decaying meat.

4. **Hymenoptera (bees and wasps)** - Many Hymenopterans are known for their elaborate vision capability (for example, they can see in the ultraviolet range), and this is reflected in the often elaborate visual signals that have evolved in species that are pollinated primarily by bees and wasps. The petals of bee-pollinated flowers are often adapted as a platform for the bee to land on and the bee is often led to the nectar via nectar guides which are markings on the flowers that direct the pollinator to the reward.

5. **Birds** - Birds are another group of animals that have evolved in parallel with flowering plants along lines of pollination syndromes. Most birds do not have the capability of olfaction, and this is true for pollinating birds. They are attracted to flowers with visual signals such as bright red coloration. While pollinating birds are not very large compared to most other bird species, they are generally much larger than insect pollinators. Therefore, expect bird-pollinated flowers to have large corollas often tubular in shape with and large volumes of nectar per flower.

6. **Mammals** - Mammals are not generally known for their pollinating activities, but one group stands out as an exception: the nectar feeding bats. When you think about it, bats, while much larger than insects and pollinating birds, have many of the same features that would make them excellent pollinators. The basic differences between bats and birds as pollinators are 1) bats are larger, and therefore require larger flowers with even more nectar, and 2) pollinating bats are active at night, so bat-pollinated flowers rely more heavily on non-visual signals. Indeed, bats have fine olfactory capability. Rodents and marsupials are also mammalian pollinators. To learn more about those pollinators, or other pollinators in general, you can take a course on Plant Taxonomy here at State.
In your table groups you will be assigned one of the pollinators below. You will create the perfect flower for your pollinator giving special thought to floral shape, color, and scent. Draw your flower on the dry erase board provided. You will then report your flower to the class. Fill out this chart as a study guide so that you have a quick reference for the types of flowers that each pollinator would choose as its ideal flower. If you believe that a certain trait is not applicable for that pollinator, simply state not applicable in the chart. The first one has been done for you as an example.

Table 13.2 Design the perfect flower to attract a certain pollinator.

<table>
<thead>
<tr>
<th>Pollinator</th>
<th>Pollinator Defining Characteristics</th>
<th>Flower Shape</th>
<th>Flower Color</th>
<th>Flower Scent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beetles</td>
<td>Eat entire flower, messy eaters.</td>
<td>Big flower</td>
<td>N/A</td>
<td>scented</td>
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<tr>
<td>Butterflies</td>
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<tr>
<td>Moths</td>
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<td>Flies</td>
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<tr>
<td>Bees</td>
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<tr>
<td>Birds</td>
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<td></td>
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<tr>
<td>Bats</td>
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<tr>
<td>No pollinator</td>
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</table>

It's time to play Name that Pollinator! Using the chart that you just created you will now visit the rest of the flowering plants in the lab. Fill in the chart on 13-8 and make the best determination of what you think the ideal pollinator for that flower would be. Let's see how far your ideal flower is from some of the flowers that these pollinators frequent in the wild.
Table 13.8 Name that Pollinator!

<table>
<thead>
<tr>
<th>Flower Number</th>
<th>Flower shape/size</th>
<th>Flower color / visual signals</th>
<th>Flower scent</th>
<th>Likely pollinator</th>
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Questions:

1. In terms of energy spent in reproduction, how do wind-pollinated species budget their energy? In terms of floral series, which series are they spending the most energy to produce? Where are they spending the least energy?

2. Sexual reproduction has proven to be advantageous for the survival of many species. Even so, not all plants undergo sexual reproduction. Dandelions produce seeds within an ovary without fertilization (the seed is diploid because it was not produced by meiosis). This is called agamospermy. Anyone that has ever tended a garden knows that dandelions are very successful. Can you discuss some advantages and disadvantages to this form of reproduction?

3. What is pollen?

4. Find a beautiful flower somewhere outside the lab. It can be from your garden, the grocery store or a field of wildflowers. Press it into the page of this manual and note the number of sepals, petals, and stamens. State whether it is complete or incomplete and if the ovary is superior or inferior. What is the symmetry? Is it a monocot or a dicot? Can you predict the type of pollinator that would visit this flower? Show your flower to your instructor during the next lab section for two points on your next quiz.
19 WHAT DOES IT MEAN TO BE AN ARTHROPOD?

Goals:
1. What are the basic features of arthropods and their subphyla?
2. What is the current understanding of the phylogenetic relationships among the arthropods?
3. What are the adaptations of arthropods and how are they advantageous for various natural histories?

Taxonomy: Phylum Arthropoda
   Subphylum Trilobita (extinct, but very important)
   Subphylum Cheliceriformes
      Class Merostomata - horseshoe crabs
      Class Arachnida - spiders and scorpions
   Subphylum Myriapoda
      Class Chilopoda - centipedes
      Class Diplopoda - millipedes
   Subphylum Crustacea
      Class Isopoda
      Class Copepoda
      Class Decapoda - lobster, crab, shrimp
   Subphylum Hexapoda
      Class Insecta - insects

There are many other classes of all these subphyla which will not be covered in this lab.

Key Terms
Abdomen                               Maxillae
Biramous                               Ovipositor
Calcium Carbonate                     Pedipalp
Cephalothorax                          Sclerotin
Chelicerae                             Tagmosis
Chitin                                 Thorax
Exoskeleton                            Uniramous
Mandible

Introduction

There are more species of arthropods than of any other group of living organisms. They have no rival in the complexity of their structural adaptations or in their ability to adapt to life in virtually all types of environments. Their wide geographical distribution has led to many interactions with our own species, especially in regards to human crops, clothing, and health. For example, the majority of our crops are pollinated by insects, particularly bees. Silk, which comes from the caterpillar of the silk moth, is an amazing fabric that cannot yet be produced synthetically. Some arthropod “pests” are carriers of diseases, such as ticks that spread Lyme disease and mosquitoes that carry malaria.
Predatory arthropods, such as spiders, are important for keeping insect populations from rapidly increasing to an outbreak. Many of the Crustacea are common seafood, and in many countries several members of the class Insecta are also eaten by humans. Other arthropods are major recyclers of the Earth’s nutrients.

**Arthropod Characteristics**

Arthropods are characterized by the following:

A. Segmented body plan

B. An outer exoskeleton of chitin, usually also hardened with the protein sclerotin (sclerotized) or with calcium carbonate.

C. Jointed appendages that have been modified for varied uses including legs, mouthparts, gills, ovipositor, antennae, etc.

D. An open circulatory system

E. Dorsal brain and a ventral nerve cord.

<table>
<thead>
<tr>
<th>Comparison of physical features of Arthropoda subphyla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trilobita</td>
</tr>
<tr>
<td><strong>Head Appendages</strong></td>
</tr>
<tr>
<td>1 pair of Antennae</td>
</tr>
<tr>
<td><strong>Tagmata</strong></td>
</tr>
<tr>
<td>Head, and segmented body parts with little differentiation</td>
</tr>
<tr>
<td><strong>Appendages</strong></td>
</tr>
<tr>
<td>Biramous</td>
</tr>
</tbody>
</table>

What unique feature do most of the Hexapods have?

Many crustaceans have a unique exoskeleton that is made of what material?
Evolutionary History of the Arthropods

Fossils of animals that can be identified as arthropods are abundant in deposits dating back at least to the Cambrian period. These fossils, and the most basal members of living arthropods groups show the ancestral condition of the body in arthropods: similar body segments and similar appendages. That condition can be illustrated by this cartoon:

However, two major evolutionary trends have occurred in the arthropods: tagmosis, or the fusion of segments into different body regions (or tagmata), and the specialization of appendages in the different body regions. Here is a cartoon illustrating a derived state within the arthropods:

This illustration shows an arthropod like an insect, with three tagmata: head, thorax, and abdomen. The appendages on the head are specialized for sensation (like the antennae) or for manipulation of food. The segments on the head are highly fused and compressed together. The segments in the thorax are enlarged, serving as a solid fulcrum for the action of the more elongated walking legs. The abdomen houses internal organs, and the appendages on the abdomen are often highly reduced.

The phylogenetic relationships among these groups is still subject to debate. The most current molecular studies have suggested that Hexapoda is a sister group to Crustacea. For now, the group consisting of the Hexapoda and Crustacea and the four other subphyla are considered sister groups with each other because of a lack of resolution placing any of the groups closer to one another than the others.
Draw the phylogenetic tree that would represent the current level of knowledge of Arthropod relatedness among subphyla:

Arthropod Subphyla Phylogenetic Tree based on Most Recent Molecular Studies

Using the characters in the chart of physical features, draw a different reasonable phylogenetic tree showing the relationships of the Arthropod subphyla. Mark your characters on the tree.

Arthropod Subphyla Phylogenetic Tree based on Morphology
What are the differences between the molecular tree and your tree based on morphology? Why are they different? Explain.

The phylum Arthropoda is closely linked with two other phyla, the velvet worms, or Onychophora, and the water bears, or Tardigrada. A nonliving cuticle covers members of both phyla, and they have appendages. However, the cuticle is not hard, and the appendages are not jointed. They resemble worms in some ways – they are elongate, and their body regions are not highly differentiated. Examine the specimens of velvet worms on display. Living velvet worms are terrestrial, found in moist environments in the tropics. They are carnivores, tangling up their prey in a kind of sticky goo they secrete.

Examine the velvet worm specimens.

What do you see?

Draw a picture below:

What physical characters do the velvet worms have in common with Arthropoda?

What physical characteristics distinguish them from the Arthropods?
Examine the water bear specimens.
What do you see?
Draw a picture below:

What physical characters do the water bears have in common with Arthropoda?

What physical characteristics distinguish them from the Arthropods?
Arthropod Examination

Examine the fossil of Trilobita:

The Subphylum Trilobita was abundant and widely distributed in Paleozoic seas. They are the most diverse group of extinct organisms and paleontologists have described about 4,000 species, although 15,000 to 17,000 species are estimated to have occurred worldwide. They probably lived exclusively in marine ecosystems because no freshwater forms have yet been discovered. Only a few example fossils are available in lab, but trilobites had a variety of physical morphologies that were adapted to different marine environments.

Draw your specimen below, and label the appendages

Describe the body regions:

Subphylum Trilobita

What is the function of each type of appendage?

Why aren't there any preserved specimens of Trilobita on display in the lab room?
Take a specimen of Cheliceriformes to examine

Most cheliceriformes are predators, a few such as ticks suck vertebrate blood, and some such as mites feed on plant tissue. Predators, such as spiders and scorpions, produce toxic venoms which are used to paralyze prey and for defense.

My specimen is in Class ________________ Prey ________________

Its common name is ________________ Habitat ________________

Draw your specimen below, and label the appendages

Subphylum Cheliceriformes

What is the function of each type of appendage?

Name two other examples of Cheliceriformes __________________________

________________________
Take a specimen of Crustacea to examine

Most species of crustaceans are aquatic. One of the few species of terrestrial crustaceans is the pillbug. Crustaceans are vital members of marine food chains, many serving as consumers of algae and other plants and in turn providing food for carnivores. If you have water samples available, observe the abundance of crustaceans in the zooplankton (the animal plankton of lakes and oceans). Other crustaceans are larger, and live in contact with the bottom. Many of these are characterized by well-developed walking legs and a high degree of tagmosis. Crabs, shrimp, lobsters, and crayfish are examples of this body plan.

My specimen is in Class _______________. Prey _______________________

Its common name is _______________. Habitat _______________________

Draw your specimen below, and label the appendages. Where are the gills?

Why are they located there?

Subphylum Crustacea

Name two other examples of Crustacea ____________________________

What is the function of each type of appendage?
Take a specimen of Myriapoda to examine

Centipedes are carnivores characterized by one pair of legs on each segment behind the head. Despite the difficulty of coordinating their walking legs, centipedes are able to move quite swiftly. The first pair of legs (maxillipeds) is modified into fangs which are used for injecting venom into prey. Most centipedes feed on other arthropods but some of the larger ones are known to eat mice, frogs, and snakes. Millipedes, on the other hand, are generally herbivores. They are not as agile as centipedes and most crawl fairly slowly. Many, however, are protected by poisonous secretions, and some even produce hydrogen cyanide. Thus, few animals eat millipedes.

My specimen is in Class ___________. Prey ________________

Its common name is _______________ Habitat ________________

Draw your specimen below, and label the appendages

Subphylum Myriapoda

Describe the body regions:

What is the function of each type of appendage?

Name two other examples of Myriapoda _____________________

__________________
Ecological Connections

The last subphylum of arthropods is the **Hexapoda**, which includes the insects and their more primitive relatives. Because of the enormous diversity and importance of insects in all facets of biology, we’ve reserved a separate lab for them. But to prepare, we’ll set up an experiment today, so that we can gather the data next session.

Pan Traps:

1. Take two small bowls and fill them halfway with slightly soapy water.

2. Set one of the bowls within one of the landscaped areas or planters on campus. (Try to put it somewhere inconspicuous so that it’s still there next time).

3. Set the other bowl somewhere behind the trailers that are at the back of Hensill Hall, and there is no landscaping.

When you check these bowls next meeting, which do you think will have more arthropods? Why?
Questions

1. Consider the differences in appendage modifications across the arthropod groups. How do the physical features of each group provide better adaptation for its habitat and allow for different life history strategies?

2. Each of the arthropod of subphyla are (or were) exceptionally diverse and abundant. The arthropod is well represented in every habitat. Speculate why the arthropod form has been so successful.
3. Case Study

A site manager in charge of a natural area wants to make sure the habitat at his site is as healthy as possible in order to be sure wildlife can thrive within it. To assess the health of a site, the manager can use a “bioindicator,” a group of organisms or type of organism that is studied within the site to determine abundances or what areas they are occupying.

Choose a type of habitat (desert, ocean, river, lake, tropical forest, arctic tundra, etc.)

What arthropod groups would be best suited as bioindicators for that habitat?

What aspects of those groups make them good indicators?

What are the advantages of using an arthropod as an indicator instead of traditional vertebrate groups such as birds, amphibians, fish, etc.?
Literature Review

Take a copy of Terry Erwin's article "Tropical forests: their richness in Coleoptera and other arthropod species" and answer the following questions. You will turn in these answers to your lab instructor at the beginning of the next laboratory period.

Answer the following questions based on the paper "Tropical forests: their richness in Coleoptera and other Arthropod species" by Terry Erwin.

1. What question was Erwin attempting to answer with the experiment described in this paper?

2. Which of the following beetle trophic groups had the highest species richness?
   a. Herbivores
   b. Predators
   c. Fungivores
   d. Scavengers

3. What are two characteristics of the study tree, *Luehea seemannii*?

4. Read over the mathematical methods of how Erwin extrapolated the estimate of the total number of tropical arthropod species. Give one reason his estimate could be inaccurate, based on his extrapolation.

5. If you were a Coleopterist and wanted to follow-up on Erwin's research with another experiment, how would you improve his methods, or how would you design your own experiment to gather additional or supporting data?
20 WHY ARE INSECTS IMPORTANT?

Goals: 1 What are the body parts of insects?
2 What are some of the larger insect orders and their characteristics?
3 How are the physical features of the different insect orders adapted to their various habitats and lifestyles?
4 What types of life cycles do insects have, and what are the advantages and disadvantages of the two types?

Taxonomy: Subphylum Hexapoda
Class Insecta
 Order Odonata – dragonflies and damselflies
 Order Orthoptera – grasshoppers, crickets and katydids
 Order Hemiptera – true bugs
 Order Coleoptera – beetles
 Order Lepidoptera – butterflies and moths
 Order Diptera – true flies
 Order Hymenoptera – bees, wasps and ants

Many other orders are part of Class Insecta, and the subphylum Hexapoda also includes some groups that are not insects.

Key Terms

<table>
<thead>
<tr>
<th>Term</th>
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<tbody>
<tr>
<td>Auditory Membrane</td>
<td>Holometabolous</td>
<td>Sclerotization</td>
</tr>
<tr>
<td>Cerci</td>
<td>Labrum</td>
<td>Spiracles</td>
</tr>
<tr>
<td>Elytra</td>
<td>Median Caudal Filament</td>
<td>Styli</td>
</tr>
<tr>
<td>Halteres</td>
<td>Proboscis</td>
<td>Tagma</td>
</tr>
<tr>
<td>Hemimetabolous</td>
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</tbody>
</table>

Introduction:

Insects are by any standard a successful group of organisms. Biologists estimate between six million to thirty million species worldwide, of which only a million have been named. Some authors estimate that about 1,000,000,000,000,000 individual insects are present on the earth. Consider that there are many species of insects that have not yet even been discovered.
Synapomorphies of Insects:

Insects are characterized by the following features:

A) Three pairs of walking legs,
B) Three body regions, or tagmata (head, thorax, and abdomen)
C) Mouth parts consisting of mandibles and 1st and 2nd maxillae, sometimes modified
D) Two pairs of well developed wings, except in the most primitive orders.

A) The grasshopper

The grasshopper provides an example of an adult insect. Study the external structure of the lubber grasshopper as shown in the overhead shown by your instructor and compare it to that of the spider and crayfish from the previous lab. You can also look at various grasshopper specimens.

What specializations are evident in the structure of the grasshopper?

How are the legs of grasshoppers adapted for terrestrial life?

Draw a very generalized picture of a grasshopper and identify the head, thorax, abdomen, the two sets of wings, and the antennae.
B) A living fossil

Insects probably evolved through a reduction of the number of walking legs. Evidence for this can best be seen in jumping bristletails (Order Microcoryphia). Examine the jumping bristletails on display. Note the leg-like structure of their maxilla. This supports the idea that arthropod mouthparts are modified legs. Note also the leg-like appendages (styli) present on the abdominal segments. These are thought to be remnants of a multi-legged body plan. The long multi-segmented appendages at the tip of the abdomen are the cerci plus a median caudal filament. Cerci are sensory structures that are also thought to be homologous to legs.

Why would scientists refer to the jumping bristle tail as a “living fossil”?

Draw a picture of a jumping bristle tail (your instructor may show you an overhead as well). Label the styli and the cerci.
Insect diversity - some important orders

* These are the orders of insects that you are required to be able to identify for Biology 240. Of course these are not all of the insect orders, this is not an entomology class, but these are orders that you are likely to have found around your homes and in your gardens and make up a nice representation of the class Insecta.

**Odonata. Dragonflies and damselflies.** These insects are active predators. Adults feed mostly on flying insects while the immature stages (Naiads) are aquatic and feed on aquatic invertebrates and small fish. Dragonflies hold their wings out to each side, like an airplane, whereas most damselflies hold them together above their abdomen.

**Orthoptera. Grasshoppers and crickets.** Members of this order feature enlarged hind legs for jumping and mandibulate mouthparts for chewing.

**Hemiptera. True Bugs, leafhoppers, aphids, spittlebugs, whiteflies, scale insects, mealybugs, cicada.** Mouthparts are modified into a piercing structure that can probe plant or animal tissue and suck nutrients out. This order contains a large number of plant pests familiar to gardeners.

**Coleoptera. Beetles.** This is the largest order of insects with over 250,000 described species. Accordingly, you can expect great diversity in structure and lifestyle. Members of this order are characterized by sclerotized forewings (elytra) that serve as a protective layer over the body of the adult animal. Most are terrestrial, but there are also many aquatic species. Most are herbivores but the order also includes many predatory and detritus-feeding species.

**Lepidoptera. Butterflies and moths.** Most adult lepidopterans lack mandibles and have mouthparts organized as a long collable "proboscis" through which food is ingested. These insects generally have enlarged wings that are covered with scales. Larvae have chewing mouthpart and are mostly herbivores.

**Diptera. Flies and mosquitoes.** This order is characterized by a transformation of hind wings into halteres, gyroscopic balancing organs that enhance rapid and efficient flight. Lifestyles of dipterans vary; most are saprophytic, living off of decaying material, while others are pollinators, parasites or blood-feeders

**Hymenoptera. Bees, wasps, and ants.** All members possess well-developed mandibles adapted to a wide array of tasks. This group contains many of the more agriculturally beneficial insects, including pollinators, and predators of plant-eating insects. To humans many Hymenoptera are familiar because of their stings.
Adaptation and Specialization

(A) Wings - Structure and Function

Development of wings was a key to the evolutionary event contributing to the success of insects, allowing them to elude predators and to colonize new habitats. Wings probably evolved from lobes of the dorsal plates of the thorax that helped absorb heat or from gills. Fossil insects show evidence of wings on all three thoracic segments. Modern insects, however, have wings restricted to the meso- and metathorax, the second and third segments. Primitive insects, such as dragonflies, have two pairs of equal-sized, membranous wings. The following two trends in wing structure are common among more advanced insects:

1. Toughening (sclerotizing) of the forewing has developed in some orders to provide more protection for the soft body parts of the abdomen. It is most pronounced in the beetles (Coleoptera).

2. An adaptation of some insect orders is the reduction in size of the hind wing along with the development of coupling devices to attach the wings together. This has resulted in faster more efficient flight and has frequently been associated with streamlining of the body as well. The most extreme case of this trend is in the flies (Diptera), where the hind wings have been reduced to a pair of gyroscopic balancing organs, the halteres.

<table>
<thead>
<tr>
<th>Hymenoptera</th>
<th>Toughness (membranous/sclerotized)</th>
<th># of wings</th>
<th>Position: roofflike, flat on back, stuck out on the sides, or pointing upright</th>
<th>Size relative to body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odonata</td>
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<tr>
<td>Orthoptera</td>
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<td>Hemiptera</td>
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<td>Coleoptera</td>
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<td>Lepidoptera</td>
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<tr>
<td>Diptera</td>
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</tbody>
</table>
Take the time to observe differences in size, structure, and number of wings present among the insects on display in lab. Fill out the chart on page to help
In your table groups, take an example specimen of each of the insect orders listed on page 20-4. Construct a simple dichotomous key for your specimens.

Key
Now use your key to determine insect orders from another lab member's group of insect specimens.

What order is the insect? _______________________

Check with the lab member. Did you key the insect correctly? _______

What order is the insect? _______________________

Check with the lab member. Did you key the insect correctly? _______

What order is the insect? _______________________

Check with the lab member. Did you key the insect correctly? _______

Considering the tremendous diversity of insects, what difficulties would an entomological taxonomist face when trying to describe insect groups and create dichotomous keys?
(B) Ecology - Radiation of Insects into different habitats

Examine the material on display to become familiar with examples of adaptation and radiation of insects into different habitats. Insects inhabit almost every imaginable habitat, including plants, wood, stored food products, and living animal tissue (parasitic insects).

Terrestrial Insects. The vast majority of insect species are adapted to a terrestrial life style. A rigid exoskeleton is often accompanied by a body surface that is resistant to water loss. The evolution of wings and the elaborate development of legs have created numerous options for locomotion on land.

Name a few examples of terrestrial insects: ____________________________________________

Aquatic Insects. Although only about 5% of the insect species are aquatic, those that are represent an array of taxonomic groups. Aquatic insects may be predators, herbivores, or scavengers. Insects that inhabit still water are also often physiologically adapted to an environment with reduced oxygen. Some insects have legs adapted for swimming.

Name a few examples of aquatic insects: ____________________________________________

Explain the possible benefit of the following structural adaptations of some aquatic insects:

- Boat-like Body Form

- "Oar-like" back-legs

- Two pairs of eyes – one on the dorsal side and one on the ventral side

- Reduced antennae

Soil Insects. There are numerous species of insects specialized to inhabit soil. Springtails, beetles, termites, ants, and fly larvae are some examples of groups with soil-inhabiting families. Insects may ingest organic material at the soil surface and defecate
organic remains deeper in the soil, thereby contributing to the process of vegetation decay. Excavation by soil insects also alters the soil, mixing layers and creating pores where oxygen can be present. Mating often occurs above the ground during brief periods.

Soil insects have a variety of unique structural features that make them better adapted for life in the ground. **Explain the possible benefit of the following structural adaptations:**

- Reduction of wings

- A body that is round in cross section

- Forelegs that are modified for digging

- Eyes and antennae may be reduced or absent

---

**Larval vs Adult stages: Advantages/constraints of each life style**

The process of going from a wingless immature stage to a winged adult is called metamorphosis. Most insects have either a hemimetabolous life cycle or a holometabolous life cycle. The young of hemimetabolous insects are called nymphs and closely resemble the adult. Wings form as external pads that grow larger on each molt and become functional wings after the final molt. The wings of holometabolous insects develop internally with the transition to adult taking place in a pupal stage. Their larvae look very different from the adult, and often have different feeding niches from adults. Larvae and adults often occupy very different habitats and ecological situations.

What are possible advantages to having a hemimetabolous life cycle compared to a holometabolous life cycle?

What are the possible disadvantages of a hemimetabolous life cycle compared to a holometabolous life cycle?
Ecological Connections

Remember the bowls of soapy water that you left in the ground during the previous lab? Now is the time to go and see what you caught. Working in groups of four, bring your bowls inside and examine what is in them. Be sure they are labeled so that you know which one came from the landscaped area and which one came from the area behind Hensill Hall. You can set your arthropods on paper towels to get a closer look.

Try to determine the orders of the Hexapoda and tally how many you have in each bowl.

Landscaped

Number of Odonata: 
Number of Orthoptera: 
Number of Coleoptera: 
Number of Hemiptera: 
Number of Hymenoptera: 
Number of Diptera: 
Number of Lepidoptera: 

Not landscaped

Number of Odonata: 
Number of Orthoptera: 
Number of Coleoptera: 
Number of Hemiptera: 
Number of Hymenoptera: 
Number of Diptera: 
Number of Lepidoptera: 

What is the most common order of the landscaped area? 

What is the most common order of the non-landscaped area? 
Which area has more total specimens? _______________. Why do you think that is the case?

What are the possible reasons for the differences you saw between the landscaped area and the non-landscaped area?

Did your results match the expectations you had when you were setting up the experiment?
Questions

1. What synapomorphics unite the insect orders you examined today?

2. Explain three adaptations that some insects developed that are not present in a primitive insect like the jumping bristletail.

3. Amongst the insect orders, wings have multiple functions. List some orders you learned and the functions of the wings in that order.
Take Home Assignment: Case Study

Insects are a big issue for farmers worldwide. A large plot of land with a crop monoculture is a feast for herbivorous insect species that feed on that particular plant. Unlimited food resources and high reproductive rates can lead to population outbreaks of some herbivorous insects causing significant damage to crops. Farmers respond with pesticides to kill the insect "pests." However, pesticides often have greatly reduced effect after a few years, causing farmers to use increasing amounts and biochemists to continue to create new formulations.

Why do pesticides become less effective over time?

What aspects of insect biology help the populations overcome pesticide treatments?

As an alternative to pesticides, sometimes predatory insects or other arthropods are released as a form of "biocontrol," to manage and prevent herbivorous insect outbreaks by eating the targeted insect pest. What does a biologist need to consider so that he/she recommends an appropriate and effective biocontrol agent?

What are some potential problems that might arise from using an insect as a form of biocontrol?

What alternative methods to pesticides and biocontrol can a farmer use to control insect pests?
GEOL/METR 310:  
Planetary Climate Change  
(Fall 2003)

Student-Led Discussions:  
Articles from the Literature

Dr. Dave Dempsey  
Dr. Karen Grove  
Dept. of Geosciences, SFSU

(Wednesday, Nov. 11)

Objectives:

- become better acquainted with aspects of climate change through critical reading of the literature, supported by student-led discussions

Assignment Outline

This assignment consists of three parts:

- Close reading of articles from the recent scientific literature about planetary climate change. For this part of the assignment, you will respond briefly in writing to sets of "reading questions" written to guide you through the articles. For one set of articles you will write your own reading questions, to guide other students through the articles.

- Participation in round-table, student-led discussion of the articles. For one set of articles you will lead the discussion yourself, along with a partner (assigned by the instructors).

- Researching and writing a paper on the aspect of planetary climate change covered by the articles on which you led a discussion. The paper should be based on those articles, plus others that complement them.

Topics to Be Covered

We will cover at least four of the following five topic areas (not necessarily in this order):

- Glacial Eras, Plate Tectonics, and the Carbon Cycle: "Snowball" earth, Himalayan uplift, and climate change on a grand scale.

- Glacial Cycles and Ocean/Atmospheric Circulations: Sudden climate shifts ("chaotic climate") and the role of atmosphere/ocean/glacial interactions.

- Arctic and Antarctic Climate Change: Ice caps, sea ice, sea level rise, climate instability


- Predicting Climate Change: Global warming and the roles of human vs. natural influences.

We request that you select your first, second, and third choices among these topics. We can't guarantee that you'll get any of your choices, though we'll do our best. The first student-led discussion will take place on Wednesday, Nov. 26, and the last one will be on either Friday, Dec. 12 or on Monday, Dec. 15 (finals week). Whoever leads a discussion will need to make available a set of "reading questions" for the other students as far in advance as possible (but at least two
days in advance), posted on Blackboard. All other students will turn in written responses to those reading questions on the day of the discussion.

The reading questions that you write for the benefit of the rest of the class will be worth 5% of the course grade. Your written responses to reading questions written by others will be worth 10%. Your co-leadership of a discussion will be worth 5%. Your written paper will be worth 20% and will be due at the end of finals week, regardless of when you co-led your discussion.
Excellence in teaching is the hallmark of San Francisco State University. We take deep pride in our well-deserved reputation for providing our students with an unequalled education and our faculty with opportunities to enhance their talents and contributions at all stages of their careers. The Center for Teaching and Faculty Development promotes and supports teaching excellence by responding to the needs of the San Francisco State faculty in their multiple roles of teaching, engaging in the activities of professional achievement and growth, and working in and for an urban community defined, in great part, by its diversity.

History and Mission

In 1992 a resolution of the Academic Senate (#RS-92-106) recommended the establishment of a center for the enhancement of teaching, recognizing that faculty professional development programs and activities encompass five broad areas:

1. Research, scholarly activities, and creative endeavors
2. Curriculum development
3. Instructional skills development and pedagogy
4. Community development
5. Institutional development

In 2005, responding to increased demand for training and support in academic technology on our campus, the former CET was reorganized into two units: one unit merged AV/ITV with technology training and support and is now operating under the name Academic Technology. The second unit, now operating under the name The Center for Teaching and Faculty Development, has a renewed
mission to support all faculty and continue the broad mission embraced by the original resolution of the Academic Senate. In early 2006, an associate dean was appointed to head the new department.

The Center is actively expanding its program of services offered to faculty to support classroom pedagogy and will continue to collaborate with other departments and units across campus to offer workshops, demonstrations, and forums related to supporting faculty in their teaching, scholarship and service. In addition, the threefold mission of the Center- supporting all faculty at all stages of their careers in their roles as teachers, as scholars and professionals, and as persons- recognizes the wide diversity of opportunities, challenges and responsibilities those general areas imply.

Faculty Consultations

The Center has faculty/staff available to consult with you on topics related to teaching and professional development. We are happy to make individual appointments or to help with department-wide or group concerns in any way we can.

The Associate Dean and the instructional design staff of the Center are available to conduct observations of teaching and provide formative evaluations for individual faculty. While we do not evaluate course content or provide formal written evaluations for personnel files, we can provide constructive comments on the organization and presentation of materials, classroom dynamics, use of technology, and other pedagogical issues.

To request a consultation, please call 338.6456 or email ctfd@sfsu.edu

Features and Highlights

New Faculty Orientation 2008 - 2009
Welcome New SF State Faculty!
Incoming faculty for the fall 2008 semester can register for New Faculty Orientation now. Additional details and resources are provided.

Read more about New Faculty Orientation

Accessibility Resources

http://ctfd.sfsu.edu/#History-Mission
Not sure how to create accessible Word or PDF documents?
The Center offers a number of guidelines for creating accessible instructional materials for your courses.

View the Accessibility Resources Available

The Garden
Monthly Newsletter for SF State Faculty
The Center publishes a monthly newsletter highlighting a number of topics of interest to faculty of SF State.

Read the Latest Issue of The Garden

Universal Design for Learning
Make your course concepts accessible for all your students
Find out how easy it is to implement UDL in all of your courses with these resources.

Learn More About Universal Design for Learning

Return to top of the Document

http://ctfd.sfsu.edu/#History-Mission
Course Design Resources

Great teaching requires taking risks. It comes from a willingness to try new methods and experiment with techniques which may be new at first. It comes out of being dissatisfied with what is merely adequate and aiming for that which could be truly amazing.

Top Ten Strategies for Designing Courses

1. Plan ahead! Excellence happens by design, and the more time invested in structuring the course and preparing for the lessons, the better. Before the course begins, it is wise to have an overview of each lesson and how the lessons address the overarching objectives of the course.

2. Understand your students- your target audience. Be aware of special needs, special interests, understand the culture they represent, get a sense of what they know already about the subject, and what they want to know.

3. Make early assessments of reading, writing and comprehension skills. This will help you to make potentially needed adjustments to the course or instructional strategies.

4. Identify the central and key concepts, information and skills the course will teach, and distinguish these from peripheral or tangential elements. Ensure that the central and key concepts, information and skills reflect the objectives for the course as emphasized by your department and/or program.

5. Avoid the "survey surge." Densely packed lectures and lessons often leave students with little to no time for meaningful reflection and class activities. Strive to achieve depth in the treatment of concepts, information and skills that are germane to the course.

6. Identify specific outcomes for each lesson and determine which instructional strategies will stimulate the greatest degree of student engagement and be the most effective way to convey or demonstrate the material.

7. Budget adequate time for the lesson, and include time for review, preview and student inquiries.
8. Build into each lesson small but significant assessments of students' comprehension and skills, and use the data to inform further instruction and assignments.

9. Ensure that all directions, guidelines, policies, grading criteria, readings, and resources are available to students in more than a single place and format.

10. Integrate into the lesson specific opportunities for students to explore and perhaps develop applications of their learning to the needs and concerns of their community; the relevancy of the material is a great motivator for learning!

References

Carlton College. "Designing Effective and Innovative Course." 
http://serc.carleton.edu/NAGTWorkshops/coursedesign


http://www.thenationalacademy.org/readings/designing.htm

Top Ten Suggestions for Constructing the Syllabus

1. Remember the syllabus serves many purposes: it is evidence of teacher preparedness and organization, it is a contract, it is a motivator, and it is a map that charts the scope and sequence of the course. Take care to chose a tone which avoids confrontative or combative tones; it is possible to set high expectations and boundaries without harshness. Have a peer review your syllabus before you distribute it if you have concerns.

2. Provide a rationale for the course and how it is linked to a particular program or social concern. This is a good place to insert your philosophy of teaching and philosophy of the subject. Statements made in this section provide an anchor or touchstone to everything that will happen in the course.

3. Identify the key concepts and principles of the subject, and link these to the overarching objectives of the department or program.

4. Identify specific outcomes for the course and be direct about what knowledge and skills students will master as a result of the course. Be sure to include outcomes that represent writing and oral skills if students will be required to present their learning in oral or written form.
5. Identify the assessments and the criteria that will be used to evaluate student work; be specific about due dates, progress reports, check lists, documentation styles, and expectations related to organization, depth and content.

6. Provide information about how to contact the instructor, when and where the class meets, and how to access information about the material in alternative ways, such as on-line or in library files.

7. Clearly articulate the behavioral expectations and consequences for failure to honor these. The behavior may be related to eating in class, cell phone use, tardiness, cheating, plagiarism, hostile or aggressive words or actions, etc.

8. Offer tips on how to be successful. This might include information about organizing the material, suggestions about writing, review strategies, etc. Include on-link resources that might offer in depth study strategies to students.

9. Identify where to go for support in the event that special needs arise and identify the emergency procedures for the classroom.

10. Provide an outline and identify key dates for exams, projects, and special events.

Resources

http://teaching.berkeley.edu/bdg/syllabus.html

Center for Excellence in Teaching. University of Southern California. 
http://www.usc.edu/programs/CET/resources

Rubrics and Effective Grading

Rubrics can be wonderful tools to help you and your students gain clarity around teaching and learning objectives. With a set of solid rubrics in place, grades can be tools to help students self-assess and evaluate their learning and the quality of their work, as well as motivate them. For both students and teachers, grades hold an important position in academic life.

Resources for Developing Successful Rubrics

Assessment, Assessment Rubrics and Evaluation Guidelines
This webpage contains information about and links to resources for Assessment, Assessment Rubrics and Evaluation Guidelines.

Examples of Scoring Rubrics
This compilation of websites created by the Chancellor's Office has a variety of sites including example rubrics used in different content areas, critical thinking rubrics, rubrics for online instruction, and more.
Why Use Rubrics?
Teach-ology's website offers information on why and how to use rubrics when assessing students.

Resources for Developing Effective Grading Practices

Tools for Teaching
Barbara Gross Davis, University of California, Berkeley identifies the functions of grading, strategies for grading, minimizing student complaints, making use of effective grading tactics and evaluating your grading policies.

Resources for Effective Grading
This site from the University of Illinois Teaching College Faculty Development Program has some suggestions and strategies for developing your grading policies and practices including a link to information on the Top 10 Grading Errors.

Evaluation Issues
This information from the Center for Teaching and Learning at UNC-Chapel Hill provides information on relative and absolute grading systems as well as some general information on grading issues.

Myths About Teaching at the University Level

<table>
<thead>
<tr>
<th>Myth</th>
<th>Reality and Resource</th>
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<tr>
<td>By the age students reach the university, their brains are fully developed.</td>
<td>Brain development actually occurs throughout a lifetime. Significant changes in the frontal lobe, where much organization, judgment and critical thinking is located, occur well into the mid-20s.¹</td>
</tr>
<tr>
<td>At this stage of their lives, students can easily spend most of their time learning and studying.</td>
<td>In 2005 the National Center for Educational Statistics revealed that 50% of full-time college students worked at least part-time, and that 10% of these individuals worked 35 hours or more.²</td>
</tr>
<tr>
<td>The higher the grades a teacher awards, the higher the student marks in teacher evaluations.</td>
<td>Students are more likely to give high marks to teachers that are rigorous and have clear and high standards of learning.³</td>
</tr>
<tr>
<td>Teachers who get high marks in student evaluations are not necessarily doing a good job teaching.</td>
<td>Students who rank teachers favorably are more likely to take advanced courses and major in the subject which the instructor taught.⁴</td>
</tr>
</tbody>
</table>

http://ctfd.sfsu.edu/course-design-resources.htm
At the college level, the individual learning preferences and styles do not matter; students will learn if the teachers know their stuff.

The ability to engage the students and to instruct and assess in multiple modalities stimulates student interest and motivation; student success is linked to teacher sensitivity to learning styles.\(^5\)


Effective Teaching Practices

Teaching effectively involves honing an intricate set of methods and approaches. Teachers consider a broad range of assessment options, both formative and summative, on their own effectiveness as well as on the learning effectiveness of their students. Find out more about how you can help your students assess themselves, methods you can use to determine the learning that is going on in the classroom and ways that you can use this information to improve your course.

Enhancing Classroom Participation

The benefits of student participation are widely recognized but getting students to participate can be a challenge. Here you'll find resources we have developed for our SF State faculty as well as information and resources for strategies and techniques you can use to increase participation in your class. Come to a workshop or sign up for a consultation for assistance with specific questions you may have.

For some general guidelines and information on encouraging and facilitating participation in your classroom, you may want to visit some of the following links.

Town Halls and Post-It Notes
This first person article focuses on the techniques of using post-it notes to go from 'seminars' to 'town hall meetings' in the classroom. Addressing the issue of required participation and creating structured cooperative learning opportunities, you may find some techniques and information here to work with.

Ideas for Increasing Class Participation
This seminar handout from Carnegie Mellon gives some tips for increasing class participation and encouraging active learning.

Suggestions for Instructors
The NYU Stern School of Business has put together a few more tips for what to say on your syllabus, techniques for increasing class participation and ones for managing over participants.

http://ctfd.sfsu.edu/effective-teaching-practices.htm
Top Ten Tips on Teaching Large Classes and Lectures

1. Recall, many strategies that represent best practice apply to classes of any size.

2. Personalize your class; get to know as many names as possible use seating charts and call upon students frequently.

3. Integrate active learning strategies that are well-focused on specific outcomes, for example: the fishbowl, in which students explore various points of view by way of listening to designated speakers surrounded by silent observers. Other strategies include clicker quizzes/inventories, pair and share, etc.

4. Provide feedback to students often; short quizzes, outlines, bibliographies, summaries, etc.

5. Integrate student critiques of work. Use samples of student work for class review and illustration of key points and skills.

6. Train and use teacher assistants for administrative duties, such as attendance, and instructional duties, such as grading and facilitating group work.

7. Encourage attendance by building things into the lesson that are generally not an experience one could get in other ways; fishbowl, debates, mock congress, mock publications, mock board meetings, mock trials, etc.

8. Relate material to current events and controversies in each session; relate material to student experience by asking them to illustrate examples in their own communities.

9. Encourage students to ask questions, and provide their insights; budget time in each session for this.

10. Ensure that course materials and resources are available to students by following the Universal Design for Learning model.

Resources

http://ccfd.sfsu.edu/effective-teaching-practices.htm
Problem Based Learning

Problem-based learning is an approach to teaching designed to help students develop essential skills required to find information, work with it and communicate it to others. Using problem-based learning, students often have higher long term retention of information and see more clearly the interconnection between disciplines.

Problem-based learning can be applied to classes of any size and require the instructor to consider a range of issues such as assessment, effective use of groups and more. A wealth of resources exists online and in print to help you learn more about it. These links can help you get started.

Problem-Based Learning
Instructors at the University of Delaware literally wrote the book about problem-based learning and have quite a bit of information on their website.

PBL Books and Resources
The University of Delaware provides a list of books and resources on problem-based learning to help you get started.

Top Ten Suggestions for Using Technology in Teaching

1. Use Universal Design for Learning standards in developing your website and lesson pages; this means offering options for scroll downs, closed captioning and other tools to ensure each student has maximum accessibility.

2. Avoid overstocking internet pages with too much information and design, so the learner can better focus on the essence of the material.

3. Ensure that directions are clear and stated on those pages where instructions on both using the site and completing an assignment are found.

4. Review the purpose and proper use of the technology with your classes at the beginning of the course, and monitor their success with the technology by frequently asking them about their experiences with the
5. When using links, be sure that they are current and germane to the course; it might be helpful to have a teacher's assistant conduct periodic searches for new items on the Web.

6. Clickers can provide teachers with the means of gathering student data relatively quickly. Clickers can enable teachers to quiz students on key items with immediate results that can be addressed in the subsequent lecture or activity. Clickers can also be used to survey students in order to get a sense of what is widely believed or how students might evaluate something related to the course itself.

7. Turnitin.com provides teachers with a quick and easy way to detect many forms of plagiarism. Using this tool can cut down on the hours it takes to check for plagiarism, and students can be encouraged to use this tool in order to check their own work for proper citations before submitting it for credit.

8. Using e-mail to communicate with students can be overwhelming, especially when one has hundreds of students at a time! If you are using this form of communication, it is essential to make clear the rules for such use and to be diligent about checking e-mail with tenacious regularity.

9. When using PowerPoint, avoid creating slides that are dense with narrativos. Outlines, quotations, bulleted main points and illustrations—such as graphs, charts or pictures can be used to stimulate conversation and demonstrate abstract ideas. Ensure that the PowerPoint is available on line and that students can retrieve a print out of the program in hard copy.

10. Showing films or listening to music are wonderful ways to stimulate the senses and provide illustrations of key concepts. Using these effectively requires teachers to identify for students the outcomes of such a presentation, and to align their assessments of student learning to these outcomes. Pausing during a film can be annoying for some, but it can also help students manage the meaning of what they are seeing by allowing for in-depth reflections and discussion.

Resources

Bothun, Gregory. Instructional Technology in the Classroom at the University of Oregon. University of Oregon. http://zebu.uoregon.edu/tech.html


Professional Development Workshops and Events

The Center for Teaching and Faculty Development works with faculty and units from all over SF State to design workshops that cover a broad range of faculty interests, from teaching enhancement to working with academic technology to research and grant opportunities.

We are always interested in broadening our offerings and meeting faculty requests. Check out the list of Upcoming CTFD Workshops to see what is currently being offered by The Center. If you have an idea for us to explore, we'd love to hear about it. Please send us an email or give us a call.

Upcoming CTFD Workshops

New Faculty Orientation Workshops

The following workshops are being offered primarily for new faculty at SF State and deal with issues and concepts important to incoming faculty. Existing faculty members are welcome to attend as well though.

Develop a Personalized Teaching-with-Technology Plan

Presented by Kevin Kelly, Academic Technology
Date and Time: Monday, August 18, 2008 9:00 AM - 11:00 AM
Location: Burk Hall 210

Curious about technology in the classroom? Wondering how and where to start? This workshop explores the advantages of digital learning, and will help you develop long and short range plans for effectively using various technologies in your teaching. Bring your syllabus with you and we will help you identify classroom and digital technologies to explore for your class.

Course Accessibility Overview I: Emphasis on Printed Materials

Presented by Christopher Read, Disability Programs and Resource Center

http://ctfd.sfsu.edu/workshops.htm
Date and Time: Monday, August 18, 2008 9:00 AM - 10:30 AM
Location: Student Services 4th Floor

What does accessibility really mean, and how can we, as faculty, implement it for our courses? Workshop participants will discuss the foundations of accessibility and arrive at a working definition for the classroom. You'll learn how to easily make instructional materials accessible, including handouts, syllabi and articles posted to iLearn. Beginning tutorials will demonstrate how to create accessible PDFs and MS Word documents, as well as discuss where to get further assistance. A handy accessibility checklist to help you prepare for your class is also included.

**What Makes Online Learning Different?**

Presented by Maggie Beers, Academic Technology
Date and Time: Monday, August 18, 2008 1:00 PM - 3:00 PM
Location: Burk Hall 210

Explore the unique challenges and benefits of online instruction! Participants will examine the differences between online and face-to-face instruction with particular attention to how variables in each environment affect learning, apply learner-centered pedagogies to online learning environments, and discuss how to overcome some typical obstacles.

**Facilitating Large Classes**

Presented by John Elia, Associate Chair, and Ivy Chen, Lecturer, Health Education Department
Date and Time: Monday, August 18, 2008 1:00 PM - 3:00 PM
Location: Burk Hall 229

Teaching large classes can be daunting, and demands not only careful preparation, but also a different way of thinking. Participants will explore the elements of meaningful pedagogy for large classes, including teacher-student relationships, collaboration with graduate assistants, time-management, clarity of expectations, and group participation. Effective strategies on sustaining equity for both students and teachers will also be discussed.

**Classroom Technology: the Workshop You Can't Afford to Miss**

Presented by Laurie Sosna, Academic Technology
Date and Time: Monday, August 18, 2008 3:00 PM - 4:30 PM
Location: Burk Hall 1 (Basement Level)

Managing day-to-day teaching technology can sometimes prove intimidating.
Participants will discover what kinds of audio-visual resources are available and learn how to comfortably use them. Faculty will also discover how to trouble-shoot, seek technological support if needed, and use electronically enhanced classrooms. If you plan on using a laptop, play back media or access the internet in your classes, this session is for you.

Creating/Selecting Instructional Materials

Presented by Pony Smith, Academic Technology
Date and Time: Tuesday, August 19, 2008 9:00 AM - 12:00 PM
Location: Burk Hall 210

Participants will explore the various modes of delivering instructional materials to students, and how to make materials universally accessible. You'll also explore multiple learning styles, and discover how designing your instructional materials for every learner is a hallmark of effective and excellent teaching.

Getting Started as a Faculty Researcher at SF State

Presented by Kendra Van Cleave, Library
Date and Time: Tuesday, August 19, 2008 9:00 AM - 10:30 AM
Location: Burk Hall 229

The university library is an integral partner in any research project. Faculty will be introduced to the collections and services available at the J. Paul Leonard Library, survey the electronic and print collections, and learn about inter-library loan and advanced research assistance. Accessibility concerns raised by the remodeling will also be addressed.

Classroom Administration: It's All On the Web (Just Add Students)

Presented by Julianne Tolson, Division of Information Technology
Date and Time: Tuesday, August 19, 2008 10:30 AM - 12:00 PM
Location: Administration 103

Smart management of your classes is essential to a productive semester. Discover how to access class rosters, administratively drop students, distribute permit numbers that allow students to add the class, enter grades and access data from previous terms, all in this hands-on workshop.

Getting Started With iLearn

Presented by Noelia Mendoza, Academic Technology
Date and Time: Tuesday, August 19, 2008 1:00 PM - 3:00 PM
Location: Burk Hall 210

iLearn is SF State's official online learning management system (LMS), and helps instructors create a centralized learning environment. Discover how to use iLearn to enhance student learning, while acquiring basic skills in course design, posting documents, and making materials universally accessible. Participants will set up a profile, learn how to post documents, and change course settings. Please bring the following to the workshop:

1. SF State ID and PAC numbers
2. An electronic copy of your syllabus and any electronic files you wish to post in your iLearn course
3. New faculty and staff should complete the SF State Employee/Student Information Privacy (ESIP) Training at https://www.sfsu.edu/online/esip.htm before attending

Using Rubrics to Assess Student Work

Presented by Barbara Holzman, Associate Professor, Geography and Human Environmental Studies
Date and Time: Tuesday, August 19, 2008 1:00 PM - 2:30 PM
Location: Health and Human Services 287

Assessment rubrics are an efficient way to evaluate student work. Barbara Holzman from Geography and Human Environment Studies will use the famous "cookie assessment" to explore the effectiveness of rubrics and provide several examples of how to apply the basic principles to rubric construction. Bring your course syllabi and an assignment example with you and leave with rubric examples. Cookies are provided!

Writing, the Graduate Writing Assessment Requirement, and You

Presented by Mary Soliday, Director, Writing Across the Curriculum/Writing in the Disciplines, and Betsy Blosser, Professor, Broadcast and Electronic Communication Arts Division
Date and Time: Wednesday, August 20, 2008 9:00 AM - 10:30 AM
Location: Administration 460

Learn about proficiency requirements at SF State before your class begins! Faculty will be introduced to the GWAR (Graduate Writing Assessment Requirement) as well as to the fundamentals of writing across the curriculum and within the disciplines. Instruction designed to enhance English proficiency will be emphasized.
Applied Stress Management in the Classroom

Presented by Rick Harvey, Assistant Professor, Health Department
Date and Time: Wednesday, August 20, 2008 11:00 AM - 1:00 PM
Location: Health and Human Services 306

"Stress" can be a cognitive or behavioral reaction to the demands of life and work, and our health and happiness can depend on how well we manage it. Rick Harvey will introduce some brief but valuable stress reduction and relaxation techniques for focusing attention, reducing body strain, and enhancing performance both personally as well as in classroom settings.

Engaging Students in Class

Presented by Erik Rosegard, Associate Professor, Recreation and Leisure Studies
Date and Time: Wednesday, August 20, 2008 2:00 PM - 4:00 PM
Location: Burk Hall 256

Every teacher needs to develop tools to keep a class focused and attuned, and this workshop provides an example on how to do so for a myriad of discipline-specific topics. Faculty will be introduced to the concepts of attention, arousal, motivation, and learning; a class scenario will be presented and participants will brainstorm a list of potential attention-grabbing techniques. The class will also converse about implementation and evaluation strategies.

Everything You Wanted to Know About Information Technology at SF State But Didn't Know How to Ask

Presented by Julianne Tolson, Division of Information Technology
Date and Time: Wednesday, August 20, 2008 2:00 PM - 3:30 PM
Location: Administration 103 (Limited to 20 Participants)

Discover the different information technology resources available at SF State! This interactive question and answer session will provide participants with information and insights on e-mail, web, software licensing, and technology resources available to you and your students.

Improving Student Research Skills

Presented by Kendra Van Cleave, Library
Date and Time: Thursday, August 21, 2008 9:00 AM - 10:30 AM
Location: Burk Hall 229

Explore skill competency in retrieving and analyzing information. Survey the
key elements of research assignments and discover the resources available to your students before scheduling their first project. Participants should bring their syllabi and assignments for personalized consultations. Accessibility concerns raised by the remodeling will also be addressed.

Course Accessibility Overview II: Emphasis on Use of Multimedia

Presented by Christopher Read, Disability Programs and Resource Center
Date and Time: Thursday, August 21, 2008 11:00 AM - 12:30 PM
Location: Student Services 4th Floor

Multimedia has long been an effective way to communicate your course materials, and with the range of options available through current technology, adding a multimedia component is easier than ever. Discover how to make these popular resources accessible for all of your students. Participants will learn how to prepare for the use of accessible multimedia in a classroom, and where to get guidance and resources for captioning videos, DVDs and Flash videos.

My Foibles and Modest Successes in Designing a Syllabus

Presented by Kitty Millet, Assistant Professor, Jewish Studies Program
Date and Time: Thursday, August 21, 2008 2:00 PM - 4:00 PM
Location: Burk Hall 229

The class syllabus is an extraordinarily important tool and can be a teacher's best friend. In this workshop, you'll discover strategies and insights on how to construct a syllabus for general education or upper division courses. University, college, and departmental guidelines will be highlighted. You'll also explore how an online syllabus differs from a traditional hard copy, and how its "embedded ancillaries" enhance university sponsored learning environments like iLearn and DIVA.

Workshop Calendar

To attend a workshop, view the Personal Online Workshop and Event Registration (POWER) system calendar and register for one that has already been planned. If you are interested in a particular topic that does not have a current workshop date available, please request that you be put on the list of interested faculty and we will get in touch with you about scheduling a future date.

http://ctfd.sfsu.edu/workshops.htm
Workshops Previously Offered by CTFD

Previous Workshops for Spring 2008

Design an Effective Syllabus
Assessment Rubrics
Faculty Associates Series: What Do "Frog Stories" Tell Us About Language and Learning of Bilingual Students?
iLearn Showcase: Translating Workbook Exercises into iLearn Quizzes
Faculty Associates Series: Practical Pedagogy - Teaching Complex Language to the 21st Century
Quality of Life Series: Learning to Manage Stress at Work and Play

Previous Workshops for Fall 2007

International and Globalization Series: Got Diversity? Pedagogy in a Global Context
Faculty Associate Series: Plato in Therapy - Integrating Philosophical Foundations of Social Justice and Multiculturalism into the Counseling Curriculum
New Faculty Series: Teaching Large Classes
The Teaching Professor Brown Bag Discussion: Course Design for Student Learning
The Teaching Professor Brown Bag Discussion: Brown Bag It with Teaching Professor
Conduct Training with Technology Series: iLearn Showcase - How to Teach 1,000 Students from a 150 Seat Classroom
Conduct Training with Technology Series: Turnitin Workshops

Previous Workshops for Spring 2007

Stress Reduction Techniques
Did My Students Actually Learn It?
MERLOT: The Integration of Digital Scholarship with Teaching
iLearn Faculty Showcase: iLearn for Homework Discussions and Multimedia Demonstration
Turnitin Workshops
Brownbag Discussion: Grant Writing - Asking Critical Questions
Avoiding the Crisis of Retirement
Student Assessment and Development Resources

Top Ten Tips for Assessing Student Performance

1. Clearly communicate your expectations in multiple venues well ahead of the due dates for exams and assignments.

2. Provide clear rubrics that illustrate how the work will be assessed. Provide clear examples of excellent, mediocre and unsatisfactory work, so standards are clear.

3. Assess often, even if such "dip-sticking" is merely for preview or review; this helps monitor student understanding and informs the instructor's course design and pacing.

4. Assess the process and not only the product. Certain skills related to research, media projects, writing, and scientific research are often overlooked in the assessment process as teachers focus on the final product. Assessing the process or benchmarks along the way to the final product also helps monitor the authenticity of student work.

5. Build into the course opportunities for students to assess student work and to experience the complexities of establishing standards and criteria for evaluations, and to appreciate the differences between outstanding, average and unsatisfactory work.

6. Use language in assessments that is specific and directed to precise elements of the student's work. Be clear, for example, about what in particular distinguishes unsatisfactory or poor performance from average or mediocre, or from outstanding or excellent work. Letter grades can easily correspond to alternative rubrics that describe in a narrative the grades' defining characteristics, for example: an essay that represents "masterful" work might contain a clear thesis, clear supports, in-depth commentary and analysis of supports with reference to authoritative sources, and recognition of and response to controversies and assumptions. In addition, the masterful work is well organized, properly documented, and uses proper grammar. Note: the elements of masterful essay can easily be formulated into a grading rubric.

7. Assert clear expectations regarding the authenticity of student work, be
clear about what distinguishes collaborative efforts and what is cheating; offer examples of each. Guide students to resources that will help them compose proper citations. Use Turnitin.com to help detect plagiarism.

8. Provide options for student expression of their knowledge and skills. It may be more appropriate for some students to recite rather than write their work; it might be more appropriate for some to bullet information and draw diagrams whereas others compose essays. Consider the purpose of the assessment and what is the targeted knowledge or skills; would the students express things more affectively in a lab or with open notes? Is the point of the assessment to evaluate their writing skills or ability to represent abstract ideas in any way possible?

9. Emphasize the importance of readings and preparations for lessons by administering small quizzes or inquires at the onset of class, and highlight the relevance of that reading or preparation throughout the lesson.

10. As part of a class discussion, ask students to develop their own test questions, or projects based on a specific unit of study. Engage them in conversation about what might make an appropriate instrument to measure what they want to measure, and what might be inadequate. Such conversations may help students distinguish between various types of competencies, such as their ability to identify or describe a certain subject, as opposed to their ability to synthesize it or create an original thesis about it.

Resources

Association of American Colleges and Universities


Return to top of the Document

Student Advising

Advising is an important part of being a professor. Help your students make the right decisions by utilizing these resources available through the university.

SF State Policy on Undergraduate Academic Advising

Drafted in 1995 by the Academic Senate, the policy was revised and approved in 2006.

http://ctfd.sfsu.edu/student-resources.htm
Download accessible PDF file for SF State Policy on Undergraduate
Academic Advising

Academic Advising Resources
This website is for all academic advisors at SF State. Its sole purpose is to
provide universal information and training for all academic advisors - both to
support graduation and to promote good advising practices across campus.

SF State Undergraduate Advising Center
This website is full of information for any faculty who will be teaching or
working with undergraduates.

Graduate Studies at SF State
Links to Graduate Advising are available off of the SF State Graduate
Studies Webpage.

Student Learning Styles *

Help your students assess their own learning and increase their learning
effectiveness by finding out more about their own learning styles. Visit these
resources to find out more.

Index of Learning Styles
This site has some interesting information on learning styles although the
results page from the questionnaire is tough to read.

Abiator's Online Learning Styles Inventory
This website has several tests and tips for students on Learning Styles,
Analytical/Global Thinker, and Multiple Intelligences.

Best Educational E-Practices (BEEP)
Project Eagle at St. Petersburg College is focused on the relationship of
learning styles and online learning.

Learning Styles
The Center for Teaching Effectiveness at the University of Delaware has
several tools for teachers and student self-assessment site links as well.

Teaching Styles
The Teaching and Learning Center at Eastern Kentucky University also
offers links about teaching styles.
NSF award to researcher also aids students

July 10, 2008 -- Diana Chu, assistant professor of biology, was awarded the National Science Foundation’s CAREER grant, the agency’s most prestigious award for junior faculty who have demonstrated a commitment to excellence in both research and teaching.

The five-year grant of $655,000 will support both Chu’s research on the role of proteins in sperm production and an SF State program to improve the writing skills of her graduate students.

The funding supports collaboration with SF State’s Learning Assistance Center, which provides skills-based tutoring to students. Graduate students in English tutor graduate students in biology on how to write effective scientific papers and grant proposals, an important skill for their future careers as scientists.

“We already know that this is a great help to our students,” said Chu. “Last year, the College of Science and Engineering funded the work of the tutors. The biology students became more confident in their ability to write about their science, and the English students were excited about the challenge of describing cellular biology that everyone can understand.” Jonathan Knight, biology lecturer and a former editor at the journal “Nature,” is an advisor to the project.

“This is what’s cool about San Francisco State,” said Chu. “You can always find people to help and everyone is always thinking about what’s best for the students.”

The grant money will also fund laboratory supplies and post-doctoral and graduate student assistants for Chu’s research. Chu’s research, which involves collaboration with colleagues at Scripps Research Institute, Yale University and the University of North Carolina at Chapel Hill, focuses on the biology of sperm and the causes of male infertility. Earlier research by Chu, published in the journal “Nature,” identified evolutionarily conserved proteins critical to the production of healthy sperm.

“The NSF funding will allow us to concentrate on one particular protein variant that is expressed exclusively in sperm,” Chu said. “Whenever we remove this protein, the
results are a decrease in fertility. We want to find out why."

Chu's work uses Caenorhabditis elegans, a one-millimeter-long worm, as a model since its genome is completely sequenced. "The complex process of making sperm is much simpler in worms than it is in other species," said Chu.

The National Science Foundation's Faculty Early Career Development Grant Program identifies scientists who are early in their careers and who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research.

"Diana Chu exemplifies the purpose of the National Science Foundation CAREER awards and SF State," said Sheldon Axler, dean of the College of Science and Engineering. "We are dedicated to providing students with opportunities to conduct sophisticated science."

Chu is the eighth SF State faculty member to be honored with a CAREER grant in the past eight years. Axler said that this recognition positions SF State among elite research universities, which are the typical recipients of CAREER grants. Only eight other universities in the California State University 23-campus system have received NSF CAREER grants.

SF State's biology department is the largest in the California State University system. It ranks second among all U.S. comprehensive universities whose graduates successfully enroll in Ph.D. programs. Graduates from SF State go on to successful careers as researchers and faculty at internationally recognized biotechnology companies and institutions.

-- Denize Springer
First Monday

Grants & Contracts: February 2003

Grants and Contracts is published in FirstMonday for the faculty and staff at SFSU on the first Monday of the month in September, October, November, December, February, March, April and May by the Public Affairs office. 415/338-1665. pubcom@sfsu.edu

SFSU was awarded an additional $572,669 in grants and contracts in August, $201,610 in October, $3,590,266 in November. SFSU received $4,109,095 in December, and $85,000 in the first part of January.

August

John Stubbs, Biology, "SFSU GK-12 Fellows Project, Yr. 03," National Science Foundation, $542,000.

Carol Langbort, Elementary Education, "Bay Area Teacher Training Institute," Bay Area Teacher Training Institute, $30,669.

October


James Wiley, Public Research Institute, "Alcohol Problems and Service Dynamics," Public Health Institute, $26,768.

Richard Dugdale, Romberg Tiburon Center, "North Bay Nutrient and Pathogen TMDL Study," San Francisco Estuary Institute, $8,000.

November


Jean Van Keulen, Urban Institute, "Head Start Program PA-22 Basic Yr. 04/Supplemental," Dept. of Education, $300,000.


Philip Prinz, Special Education, "Ed Roberts Fellow in Disability and Rehabilitation," The Regents of the University of California, $19,548.


Charlotte Ferretti, Edelman Institute, "Basic Nurse Education and Practice Program," Dept. of Health and Human Services, $32,091.

Brian Murphy, Urban Institute, "Service Learning For Family Health - 02," Chancellor's Office/CILTS, $25,976.

Wilfred Denetclaw, Research and Sponsored Programs/Chemistry and Biochemistry, "RIMI - Cell Molecular," National Institutes of Health, $266,836.


Richard Dugdale, Romberg Tiburon Center, "Role of Wind-Driven Transport: Phytoplankton, - 03," National Science Foundation, $195,444.


Violetta Cavalli Sforza, Computer Science, "Women's International Science Collaboration Program," American Association for the Advancement of Science, $4,990.

Wim Kimmerer, Romberg Tiburon Center, "Modeling the Impact of Predators in the Delta," State Dept. of
Water Resources, $189,905.

December


Elaine Ikeda, Urban Institute, "Western Region Campus Compact Consortium - 03," Western Washington University, $67,000.


Richard Dugdale, Romberg Tiburon Center, "Farallones Nutrients," Naval Postgraduate School, $5,000.

Paul Sherwin, Poetry Center, "California Arts Council Project 02-03," California Arts Council, $4,000.

Gail Whitaker, Academic Program Development, "Mental Health Symposium," The Zellerbach Family Funds, $15,000.


Jian Lockey, English, "Conquest and English Legal Identity in the Early Modern Romance," Erasmus Institute at the University of Notre Dame, $22,944.


January

Grants and Contracts is published in FirstMonday for the faculty and staff at SFSU on the first Monday of the month in October, November, December, February, March, April and May by the Public Affairs office. 415/338-1665. pubcom@sfsu.edu

SFSU was awarded $4,868,061 in grants and contracts for the month of September and $4,637,741 for the first part of October. The following list of faculty members and their projects was provided by the Office of Research and Sponsored Programs.

September


Nancy Carnal, Biology, "The San Francisco Bay Area Collaborative," San Jose State Foundation, $287,310.


Teresa Carrillo, La Raza Studies, "UC Links Project," University of California-Berkeley, $32,000.

Brian Murphy, Urban Institute, "Living Wage Analysis Project," Dept. of Human Services-City and County of San Francisco, $48,956; "SFPC Urban Curriculum: CBO Capacity Bldg." Rockefeller Foundation, $49,050.


Anita Leal-Idrogo/Robert Chope, Counseling, "Job Development and Placement"
Training," U.S. Dept of Education, $100,000.

Diane Resek, Mathematics, "Educating Teachers in Mathematics," National Science Foundation, $194,336.


Paul Longmore/Alice Nemon, Institute on Disability, "Empowering the Disabled Community," U.S. Dept. of Education, $100,000.

Martha Roditti, Social Work, "SF South East Community Connection - 02," U.S. Dept. of Health and Human Services, $100,000.


Frances Wilkerson, Romberg Tiburon Center, "The Fate of Upwelled Nitrate in Monterey Bay - 03," Department of Energy, $346,713.


Peggy Fielder, Biology, "Regional Geographic Initiative," Environmental Protection Agency, $10,000.


Thomas Parker, Biology, "Structure of Mycorrhizal Fungal Communities," U.S. Dept. of Agriculture, $237,000.


Marvin Feit, Social Work, "Mental Health Foster Care Training," City and County of San Francisco, $80,703.


Bruce Macher, Chemistry & Biochemistry, "RIMI - Research Associate Activity - 04," National Institute of Health/National Center for Research Resources, $226,748; "RIMI -


**Brian Murphy**, Urban Institute, "Risk Oversight within Brownfields Communities," Environmental Protection Agency, $125,500.


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**October**

**Barbara Neuhauser**, Physics & Astronomy, "High Sensitivity Detectors for Particle Physics," National Science Foundation, $90,000.


**Paul Fonteyn**, Office of Research & Sponsored Programs, "Graduate Research Fellowship Program," National Science Foundation, $26,500.


**Jacob Perea**, Adult Education, "UCS - Administration - 05," U.S. Dept. of Education,
$91,970.


Steve Dickison, Poetry Center, "GFA '99-00'," City and County of San Francisco, $11,000; "National Endowment for the Arts," National Endowment for the Arts, $15,000; "Grant for the Arts," Grant for the Arts/San Francisco Hotel Tax Fund, $11,000.

Richard Dugdale, Romberg Tiburon Center, "EPA Star Grant - MASTER," Environmental Protection Agency, $881,062.

Richard Dugdale/ Frances Wilkerson, Romberg Tiburon Center, "EPA Star Grant - Sub-Account #1," Environmental Protection Agency, $372,091.


Stephen Bollens, Romberg Tiburon Center, "EPA Star Grant - Sub-Account #3," Environmental Protection Agency, $157,156.

Wim Kimmerer, Romberg Tiburon Center, "EPA Star Grant - Sub-Account #4," Environmental Protection Agency, $155,644.

Wim Kimmerer/ Jan Thompson, Romberg Tiburon Center, "EPA Star Grant - Sub-Account #5," Environmental Protection Agency, $90,007.


Adrienne Cool, Physics & Astronomy, "White Dwarfs Distances to Globular Clusters," Space Telescope Science Institute, AURA, $14,778.

Patricia Foschi, Romberg Tiburon Center, "GIS Classification Analyses of Urban Oasis," California Urban Environmental Research & Education Center, $25,046.


Lori Goetz, Special Education, "Low-Incidence Disabilities," U.S. Dept. of
Education/CSU - Hayward, $139,500.


**Gilbert Robinson**, Urban Institute, "SFDHS/SFUI Collaborative - 03," City and County of San Francisco, $77,608.
Center for Science and Mathematics Education

Projects Directed by Faculty Associated with SFSU's Center For Science And Mathematics Education

Numerous faculty in the College of Education and in the College of Science & Engineering are involved in science or mathematics education projects. Some projects are focused on research into science and mathematics education; some involve the development of new curriculum materials; some support in-service or pre-service K-12 teachers, others are fostering the development of in-person or on-line communities of science or mathematics educators...

Each project listed below provides opportunities for people to help alleviate the problem of insufficient number of high quality scientific, technological, engineering, and mathematics professionals. Only brief descriptions are provided below; please read the full description of projects that you find interesting by navigating to the project's home page.

<table>
<thead>
<tr>
<th>Title</th>
<th>Project Website</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPAL</td>
<td><a href="http://www.sfsu.edu/~sepal/">http://www.sfsu.edu/~sepal/</a></td>
<td>The Science Education Partnership and Assessment Laboratory, funded by the National Science Foundation, partners SFSU science graduate students with K-12 teachers in the SFUSD to improve science teaching and learning for students in grades K through 16.</td>
</tr>
<tr>
<td>SF-ROCKS</td>
<td><a href="http://sf-rocks.sfsu.edu/">http://sf-rocks.sfsu.edu/</a></td>
<td>The SFSU Reaching Out to Communities and Kids with Science in San Francisco project, funded by the National Science Foundation, partners SFSU science graduate students with K-12 teachers in the SFUSD to improve science teaching and learning for students in grades K through 16.</td>
</tr>
<tr>
<td>REvitalizing ALgebra</td>
<td><a href="http://math.sfsu.edu/hsu/msp/">http://math.sfsu.edu/hsu/msp/</a></td>
<td>The REAL partnership, funded by the National Science Foundation, is a model for a professional development system that brings together three groups: algebra teachers in grades 8-10, university mathematics majors, and mathematics graduate students who are teaching remedial courses at the</td>
</tr>
</tbody>
</table>
The Online and Live Communities of Teachers project, funded by a National Science Foundation CAREER award to Prof. Eric Hsu, is searching for appropriate ways to use the Internet for teacher professional development. A combined online and live course and support structure is being developed for graduate algebra instructors at SFSU, and will then be adapted for graduate instructors of the PDP Treisman workshops at UC Berkeley.

The first CSME mini-grant program RFP was held in Spring 2007. The projects funded for Summer and Fall 2007 are:

<table>
<thead>
<tr>
<th>Investigators</th>
<th>Department</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamie Chan, Amber Johnson,</td>
<td>Department of Biology</td>
<td>Moving Towards Inquiry in a Biology Laboratory</td>
</tr>
<tr>
<td>Robert Patterson, and Kimberly Tanner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deborah Curtis</td>
<td>Department of Administration and Interdisciplinary Studies</td>
<td>A Hierarchical Linear Model Analysis of the Mathematics Pathways and Pitfalls Lessons</td>
</tr>
<tr>
<td>Eric Hsu</td>
<td>Department of Mathematics</td>
<td>Early Field Experiences for Math Majors</td>
</tr>
<tr>
<td>Kimberly Tanner</td>
<td>Department of Biology</td>
<td>Exploring Undergraduate Student Conceptions of Environmental Science: What Role Does Biological Knowledge Play in Environmental Literacy?</td>
</tr>
<tr>
<td>Maika Watanabe</td>
<td>Department of Secondary Education</td>
<td>DVDs of Successful Teaching Practices in Detracked Math and Science Classrooms</td>
</tr>
</tbody>
</table>

http://csme.sfsu.edu/projects/index.html
The CSME is a collaboration of the COE and the COSE.

College of Education
College of Science & Engineering
Notes for Nan on Bio 355
10/12/2004

Nan,

You can abstract from these notes as needed.

We consider ethics at frequent intervals throughout the course. The textbook offers short segments on bioethics in most chapters. We integrate discussion extensives. Most examples we stress are bioethical issues, like genetic testing, the consequences of knowing one's genetic future, and the possiblity of gene therapy. In discussing recombinant DNA technology, we also consider whether or not scientists should do work just because they can. In the area of ethical issues in the practice of science, we talk about the idea Mendel may have fudged some of his data. I encourage students to present their opinions of current issues in the press. One example of textbook coverage is the "Genetics and Society" section on page 142. In addition, there are thought questions about ethical and social issues at the end of many chapters.

I stress the multicultural nature of human genetics, paying attention to gender and ethnic differences as well as the broad representation of ethnic groups and genders among practicing geneticists. E. E. Just and Barbara McClintock are two good examples. I also explain how mutations can be used as a means of tracing population histories, and how certain genetic conditions are more common in some populations (ethnic groups) than in others, partly as an adaptation to environmental challenges these groups have faced in the past. Prominent examples include the high frequency of sickle cell anemia in African Black populations, and of hereditary breast cancer in Eastern European Jews. Response to drugs also differs because of genetic polymorphisms influencing drug metabolism; one example is the response of Black as compared with Asian children to the asthma medication, albuterol. We thus cover not only the diversity of scientists, but health disparities related to genetics as well.

Although some facts of genetics are presented in a purely didactic manner, most are presented in the context of experimental findings. I stop in class and ask students to help with the interpretation of experiments, although the opportunities to do this in a class of 60-120 students is often limited. Exams involve the interpretation and analysis of experimental data.

Some sample exam questions:

Qn. 20 Points.
Experiments by Griffith using virulent (S) and nonvirulent (R) strains of bacteria showed that there was a "transforming principle." Subsequent work by Avery, McCleod and McCarty showed that this transforming material was DNA. Explain these experiments.

Q7. 20 Points
S. Benzer crossed two rII mutant strains that had mutations within the same cistron. He obtained 10,000,000 plaques on E. coli B, but only 500 on E. coli K. What is the map distance, in cM, between these two mutations?

Q8. 20 points
Mutations isolated in two separate laboratories and named clueless and dunce lead to a similar phenotype of abnormally small brains in Drosophila. When a homozygous clueless mutant is mated to a homozygous dunce mutant, the F1 offspring aren't too bright either, having small brains.

Are the two mutations in cis or in trans in the F1 progeny? Explain or illustrate your answer.

Are clueless and dunce in the same or in different cistrons? Explain.

Give a biochemical interpretation to the statement that mutations are in the same or in different cistrons.

Question 19. 15 pts.
A 24-year-old woman has had two children; both had the typical phenotypic characteristics of Down syndrome. She is considering a third pregnancy, and she wants your advice concerning her chances of having a third child with Down syndrome. (A) What would you tell her? (B) Would you suggest further medical testing? (C) If so, what test would you suggest and what could you expect to learn from it? (D) What is your best guess at the chances that her next child will have Down syndrome?
Project Assignment for Poster Presentation 50 points
Plant Physiology Lab - Spring 2004

Genetic, molecular and biochemical tools can be used to untangle the intricacies of physiological processes, answer our many questions, and bring us closer to understanding how various essential processes occur in plants.

Throughout the semester we have learned about and used a number of molecular, and genetic approaches that could be applied to investigate questions of interest in plant physiology. These methods include: 1) tissue culture methods to generate plant callus and induce the formation of plants or plant organs; 2) plant transformation (introducing a gene of interest); 3) mutant screening; 4) use of hormone regulated promoters (for example, dex or IAA regulated promoters) in engineered gene constructs to allow control of gene expression or monitor hormone concentrations 5) use of a reporter gene (in our case, β-glucuronidase, i.e. GUS or GFP), 6) Western blotting and 7) confocal microscopy.

Likewise, you have become familiar with several biochemical/analytical procedures this semester that can be brought to bear on questions of interest. These procedures include: 1) spectrophotometry (use of standard curves and absorption spectra and in enzyme assays to monitoring changes in substrates or products of reactions over time); 2) chromatographic methods to separate molecules of interest, 3) enzyme assays to investigate enzyme properties (had to cancel this one, but in principle understand how to monitor progress of a reaction by monitoring concentrations of substrates or products over time, then determining from these data the “rates of reaction” under different conditions, for example pH, temperature, different initial substrate concentrations); 4) use of artificial dyes as electron acceptors to investigate rates of electron transport; 5) titration analysis to quantitate acid or base content in tissues; 6) polyacrylamide gel electrophoresis to separate proteins (in native and SDS gels), 7) determining protein molecular weights for proteins separated by SDS-gel electrophoresis, 8) immunodetection methods (ELISA) and immunoblotting (Western blotting); 9) CO₂ and O₂ monitors to examine rates of respiration and photosynthesis, 10) pressure bomb to determine leaf water potential 11) others (see syllabus for other methods).

The project you are being assigned today will allow you to be creative and design a set of experiments to gather data on a question of interest. We expect that you will draw exclusively, or at least heavily, on methods/procedures used in class this semester, but you are not restricted to these if a member of your team has other expertise.

For this assignment:
1) Work in groups as assigned.
2) Choose one of the following projects.
3) Develop a set of hypotheses.
4) Design an approach to test a hypothesis or hypotheses the team selects

5) Prepare and present a poster that outlines your hypotheses, approaches to testing these (your experimental procedures), the rationale for your experimental approach and the techniques you have selected, your expected results and an explanation for these results.

Project requirements:

1) Projects must involve three techniques used in class this semester. Substitution of techniques not used in class is possible, but MUST be approved by the instructor.

2) Projects must include at least one molecular/genetics technique and at least one biochemical/analytical procedure.

3) Verbal presentation of your Poster to the class must involve all team members as presenters and should take about 15-20 minutes.

Possible Project 1. Gravitropism in stems
In the first “experiment” we did this semester, you observed that shoots exhibit negative gravitropism. If shoots are oriented horizontally, the stems soon grow/“bend” upward and the shoot regains a vertical orientation. This growth response is suggested to be promoted by IAA since it is known that IAA in the appropriate concentration range for stem or root tissue can promote cell elongation. Data also suggests that for a sustained IAA effect on cell elongation, protein synthesis is required. Design an experiment or experiments to determine whether IAA might be involved in the gravitropic response of plant stems and which proteins, if any, are involved in stem gravitropism.

Project 2. Is *Mesembryanthemum nudiflorum* an inducible CAM plant?
Some CAM plants are obligate CAM plants, but others can shift from C₃ to CAM in response to environmental changes. These plants are called “facultative” or “inducible” CAM plants. It is known that *M. crystallinum* can be induced to shift its photosynthesis mode to CAM when salt concentrations increase in the solution around its roots. The bay area salt flat plant, *M. nudiflorum* has properties that suggest it might also be an inducible CAM plant. Propose a study to determine whether CAM can be induced in *M. nudiflorum* and to investigate gene expression and/or biochemical/physiological mechanisms that underlie this shift in metabolism.

Project 3. “Big Fruit”
In a search for genes that control the size of fruits, a gene named BIF (for big fruit) was identified in *Arabidopsis*. It has been suggested that the BIF gene product (the BIF protein) might be directly involved in fruit formation. Utilize at least two of the molecular techniques listed on page 1 and propose a study to analyze whether BIF is indeed involved in controlling fruit size. (Recall projects must use 3 techniques total.)
Project teams:  Madeleine*, Scott, Natalia
Jess*, Kana, Long Yan
Andrew*, Cynthia
Lia*, Triny, Laura

Assignments and due dates:

DUE MAY 11, before you leave class:
Team name (members), Project selected and hypotheses that will be tested.
(details not required, we just want to know what you are doing!)

DUE May 19th, last day of class
Poster and Oral presentation

DUE May 19th, last day of class
Keep a participation log, to be turned in on the final day along with your poster project.

The log is not meant to be cumbersome or a burden; it is simply a record that outlines what each person on your team contributed to the project.

Here is a suggested format and examples of possible entries

<table>
<thead>
<tr>
<th>Date</th>
<th>Record of team activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/6 (in class)</td>
<td>Team assembled, all members present, all contributed to determining which project we would develop and in deciding the experimental approach we would take; submitted project intent sheet to Nan</td>
</tr>
<tr>
<td>whenever</td>
<td>Met at the student union for ~1 hour. x,y,z brought materials they obtained via researching the topic and discussed these. Aaa couldn’t make the meeting but sent comments. We decided to do..... And ask Aaa to put this together</td>
</tr>
<tr>
<td>whenever</td>
<td>All met, x led discussion on how to present .... Y prepared graphs And figures for ..... and we approved two of these, but suggested Changes that Y will make in the third. Z gave progress report on Her part. A needed help with question and we addressed this.</td>
</tr>
</tbody>
</table>

Etc. enough to show what each person contributed
The following project evaluation scheme is provided for your information and to provide perspective that may be useful as you plan your project presentation.

1. Introduction- (5 points):
   Clear presentation of the “problem” or “question”.
   Determined whether background information was needed – clear presentation of any relevant background information
   Reasonable hypothesis or hypotheses posed to address problem or question
   Clear presentation of hypothesis or hypotheses

2. Proper Methods and Rationale for choice of methods (8 pts)
   At least one analytical/biochemical method; at least one molecular/genetic method
   Three methods total
   Appropriate methods to address hypotheses posed
   Appropriate rationale presented for choosing these methods
   Presentation of the experimental design is organized and logical
   Appropriate controls for experiments presented in the experimental design

3. Expected Results and Explanation (i.e. Discussion) (7 pts)
   Expected results are logical and could be obtained with experimental design
   Good visual representations of data expected
   Clear presentation of expected results
   Clear presentation of rationale or explanation for expected results

4. Presentation and Interaction with Audience (5 pts)
   All members of the team participate in the presentation
   Planning for presentation evident – clear connections between parts of presentation and clear that each person knows what his/her responsibility is and how it fits in the overall presentation
   Team members are able to interact with audience and address questions

5. Participation log; individual effort to team project (5 points)
Appendices for Standards:

Standard 6: Early Field Experiences
Engaging scientists and teachers in partnership, research and coursework to transform science teaching kindergarten through college.

<table>
<thead>
<tr>
<th>SEPAL Programs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum Program</td>
<td>SEPAL's newest program aims to bring together K-12 teachers and their students with individuals from multiple stages on the biomedical research career pathway. Together, a community composed of biomedical scientists who are women of color— including SFSU undergraduate students, SFSU Masters students, SFSU alumni in local docoral and biotechnology positions, and SFSU Faculty—and middle and high school students and teachers will collaborate to learn about the biology behind women's health issues and current research being conducted by women biomedical researchers of color. <a href="#">visit site</a></td>
</tr>
<tr>
<td>GK-12 Partnership Program</td>
<td>Year-long partnerships in classrooms between Bay Area middle and high school teacher and SFSU science graduate student to co-plan and co-teach weekly hands-on, inquiry-based science lessons. <a href="#">visit site</a></td>
</tr>
<tr>
<td>SEPAL Teaching Assistantships In K-12 Schools</td>
<td>SFSU College of Science &amp; Engineering graduate teaching assistantship in a Bay Area middle or high school. Graduate student scientists collaborate with teachers to co-plan and co-teach hands-on, inquiry-based science lessons. <a href="#">visit site</a></td>
</tr>
<tr>
<td>Science Education Partners In Biology</td>
<td>Semester-long partnership between Bay Area elementary or middle school teacher and SFSU biology undergraduate students to explore a variety of potential projects including co-creation of inquiry-based science lessons, co-sponsoring after-school science clubs or science fairs, and other innovative ideas. <a href="#">visit site</a></td>
</tr>
<tr>
<td>Action Research Projects</td>
<td>SFSU graduate/undergraduate students collaborate with a science teacher and/or SEPAL staff member to conduct a science education research project that uncovers students' preconceptions, misconceptions, or attitudes about science. <a href="#">visit site</a></td>
</tr>
</tbody>
</table>

SEPAL is made possible through funds from the National Science Foundation GK-12 Grant and PFSMETE Start-Up Grant, and through in-kind support from SFSU's Department of Biology and College of Science and Engineering.
SEPAL offers a variety of programs that provide partnership opportunities for K-12 teachers and SFSU undergrad and graduate scientific trainees. Specifically, the Science Education Partners in Biology Program:

- Supports teachers in addressing life science standards
- Supports the teaching of hands-on science activities (either during the school-day or in an after-school setting)
- Provides college role models for K-12 students
- Allows SFSU science students to revisit and apply their biology content knowledge by sharing it with K-12 teachers and their students in the classroom

For SFSU science students, the Science Education Partners in Biology Program is a course offered through the Department of Biology (Biology 652). Students will learn how to develop biology lessons and get practice teaching them.

Who are the partnership teams?

Partnership Teams consists of one or two 3rd, 4th, 5th, or 7th grade science teachers from a single school-site, their students, and two science students from SFSU.

2007 Partnership Teams and Participating Schools

When does this happen?

The semester-long Science Education Partners in Biology Program repeats each Fall. For Fall 2007 – partner teams will co-plan & co-teach 6 science lessons together over the course of the semester.

How do I get involved?

If you are interested in participating in the Science Education Partners in Biology Program, contact Allison Busch at aibusch@sfsu.edu or (415) 405-3756.
SEPAL offers a variety of research opportunities in which Bay Area K-12 teachers and SFSU research students collaborate to understand K-12 student conceptions in science. Through these classroom-based action research projects, Bay Area teachers and SFSU research student partners will have the opportunity to: 1) develop novel assessment tools and questions, 2) collect data from K-12 students through student writings, drawings, and interviews, 3) analyze these data to reveal students' conceptual understandings and misunderstandings in science, and 4) share their findings with others.

To these ends, Bay Area teachers and SFSU research students are expected to...

- Collaborate regularly in the teacher's classroom to pilot assessment tools and/or collect data from K-12 students in a manner that is integrated with the teacher's existing curriculum and assessment plans.
- Co-develop assessment tools, co-plan the collection of data in the classroom, and co-analyze student work together.
- Co-present a poster on the assessment tools they develop and analysis of student data at the annual SFSU College of Science and Engineering Poster session.
- Support the overall project by contributing to evaluation through written reflections once a semester and providing formative feedback to the project director.
- Participate in these partnership efforts throughout the school year, from September to May.
- Meet as a partnership team periodically at the school site with the project director to share successes and troubleshoot challenges.

To find out more, contact SEPAL coordinator Allison Busch at akbusch@sfsu.edu.
### Science Education Partners in Biology

<table>
<thead>
<tr>
<th>TEACHER</th>
<th>SCHOOL</th>
<th>GRADE</th>
<th>SCIENCE PARTNERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laura Spiering</td>
<td>El Dorado Elementary</td>
<td>3rd</td>
<td>Savanna Baker-Leyva</td>
</tr>
<tr>
<td>Nathan Fahey &amp; Aerielle Spusta</td>
<td>JFK Elementary (Daly City)</td>
<td>3rd / 4th</td>
<td>Rocio Diaz &amp; Crystal Zhang</td>
</tr>
<tr>
<td>Kathleen Rose &amp; Patricia Arian &amp; Jane Jones</td>
<td>Lakeshore Elementary</td>
<td>3rd</td>
<td>Kimberly Lowe &amp; Flip McDaniels</td>
</tr>
<tr>
<td>Tom Ehnle</td>
<td>Marina Middle School</td>
<td>7th</td>
<td>Brian Salisbury &amp; David Frischer</td>
</tr>
<tr>
<td>Irene Hirota</td>
<td>Presidio Middle School</td>
<td>7th</td>
<td>Masae Ahmann &amp; Tiffany Maroh</td>
</tr>
<tr>
<td>Bridget Slevin &amp; Nora Youna</td>
<td>Redding Elementary</td>
<td>3rd</td>
<td>Melissa Milam &amp; Amy Ngo</td>
</tr>
<tr>
<td>Dieter Rogers &amp; Cindy Mar</td>
<td>Rosa Parks Elementary</td>
<td>4th</td>
<td>Juan Centano &amp; Chia Teoh</td>
</tr>
<tr>
<td>Lulu Monti &amp; Luann Daniel</td>
<td>Spruce Elementary (South SF)</td>
<td>2nd</td>
<td>Trenisha Oakley &amp; Lena Rudolph</td>
</tr>
<tr>
<td>Beverlie Leano &amp; Philip Burnett</td>
<td>Webster Elementary (Daly City)</td>
<td>4th / 5th</td>
<td>Cecile Awayan &amp; Melo Encinas</td>
</tr>
<tr>
<td>Cheryl McCue &amp; Johnny Hansell</td>
<td>West Portal Elementary</td>
<td>5th</td>
<td>Stefana Borovska &amp; Erika Schenk</td>
</tr>
</tbody>
</table>

**How do I get involved?**

To express interest in participating, contact SEPAL Program Coordinator, Allison Busch at (415) 405-3756 or akbusch@sfsu.edu

[http://www.sfsu.edu/~sepal/sepbioprogram/sepbio_teams.html](http://www.sfsu.edu/~sepal/sepbioprogram/sepbio_teams.html)
For more information about SEPAL opportunities, visit www.sfsu.edu/~sepal

<< back to SEP-Bio home page

back to SEPAL

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http://www.sfsu.edu/~sepal/seploprogram/seplo_oteams.html
BIOL 652 Course Description

Title: SFSU Science Partners in K-12 Schools

GE Status: Standard 6 Intro (2)

U.S. History and Government:

Prerequisites: Completion of at least one upper division course in your major field of study, and instructor consent.

Term(s)
Offered:

Units: (4)

Description: Introduction to science teaching and learning. Students engage in K-12 classroom teaching, examine their own understanding of science, discuss science education literature, and analyze science lessons and student learning. Class work, 2 units; field work, 2 units. (Also offered as SCI 652. May not be repeated under an alternate prefix.) [CSL may be available; consult index for page reference.]

Effective: Summer 2008

Latest Offering:

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SAN FRANCISCO STATE UNIVERSITY

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1600 Holloway Avenue, San Francisco, CA 94132 (415) 338-1111

Last modified April 02, 2008 by bulletin@sfsu.edu
# Forms and Links for Prospective Students

## Applications / Information

<table>
<thead>
<tr>
<th>Program</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Subject Credential Program</td>
<td>Multiple Subject Credential Program General Information / Application Packet</td>
</tr>
<tr>
<td>Special Education Programs</td>
<td>Education Specialist Credential Program General Information / Application Packet</td>
</tr>
<tr>
<td>Communicative Disorders Program</td>
<td>Communicative Disorders Program Information / Application Packet</td>
</tr>
<tr>
<td>Single Subject Credential Program</td>
<td>Single Subject Credential Program General Information / Application Packet</td>
</tr>
</tbody>
</table>

## Miscellaneous

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Constitution Requirement</td>
<td>Information on completing this requirement including a list of local test site centers.</td>
</tr>
<tr>
<td>Credential Application Fee Document</td>
<td>Fee slip for the Department Application Fee</td>
</tr>
<tr>
<td>Test Preparation Sources for: CBEST, Praxis, SSAT, RICA, CLAD/BCLAD</td>
<td>Registration Bulletins and Test Preparation Sources</td>
</tr>
<tr>
<td>Certificate of Clearance Instructions</td>
<td>General Information</td>
</tr>
<tr>
<td>Subject Matter Competency Advisors</td>
<td>Complete list of all Subject Matter Competency advisors on the SFSU campus</td>
</tr>
<tr>
<td>Subject Matter Competency Form</td>
<td>This form must be filled out by the Subject Matter Competency advisor.</td>
</tr>
<tr>
<td>List of Agencies Serving School Volunteers</td>
<td>These agencies will help place you in the appropriate classroom for Early Field Experience. Click here to download list</td>
</tr>
<tr>
<td>Credential Course Substitution Form</td>
<td>To substitute a course in the credential program please take this form to your department. Click here to download form.</td>
</tr>
</tbody>
</table>

[http://www.sfsu.edu/~cstpc/formsprospective.html](http://www.sfsu.edu/~cstpc/formsprospective.html)
Request to Add Credential or Master's Degree
For Credential or Master's students who need to change programs, add a credential or add a Master's program. Special Education students need the signature of the department head. Single/Multiple Subject credential students need the signature of the Admissions Specialist BH 244.
Click here to download form.

Things You Can Do to Prepare For Applying to the SFSU Credential Program
List of things you can do to prepare you for applying to one of the credential programs.
Click here to download form.

Useful Links
California Commission on Teacher Credentialing
http://www.ctc.ca.gov/

CALIFORNIA DEPARTMENT OF EDUCATION
Content Standards
http://www.cde.ca.gov/be/st/ss

CALIFORNIA DEPARTMENT OF EDUCATION - Curriculum Frameworks & Instructional Materials
Content standards were designed to encourage the highest achievement of every student, by defining the knowledge, concepts, and skills that students should acquire at each grade level.
http://www.cde.ca.gov/ci/cr/cf/

CBEST
Use this web site to find complete CBEST program information, including testing requirements, up-to-date registration information, how to prepare for the test, and how to obtain your unofficial test results online.
http://www.cbest.acesinc.com/

CSET
California teaching credential candidates are required by law to verify their subject matter knowledge and competencies and are provided two alternative paths for fulfilling this requirement. One way is to complete a program of subject matter preparation approved by the California Commission on Teacher Credentialing (CCTC). The second way is to pass one or more subject matter examinations. The CSET and Single Subject Assessments for Teaching are two testing programs used by the CCTC for this purpose.
http://www.cset.acesinc.com/

RICA
Here you'll find up-to-date registration information, test preparation materials, and services that enable you to register and obtain your unofficial test results online.
http://www.rica.acesinc.com/
**The Teacher Prep Center at City College of San Francisco**
The Teacher Prep Center at City College of San Francisco offers related coursework, fieldwork opportunities and CBEST and CSET Prep courses and support for SFSU students interested in becoming teachers.

http://www.ccsf.edu/Departments/Child_Development/Teacher_Preparation/index.html

**The Professional Development Project at City College of San Francisco**
The Professional Development Project at City College of San Francisco is available to help all early childhood education students and professionals in San Francisco secure Child Development Permits from the Commission on Teacher Credentialing. SFSU students interested in obtaining a permit, can call or visit PDP. Financial assistance is available and informational workshops are held at SFSU.

http://www.ccsf.edu/Departments/Child_Development/ChildNet

**Child Development Training Consortium’s Financial Reimbursement Program**
SFSU students currently working in child development programs and attending school may be interested in applying for the Child Development Training Consortium’s Financial Reimbursement Program entitled the, "Career Incentive Grant". Up to $800/year may be available.

http://www.childdevelopment.org/sqgrants.htm

**Teach California**
TEACH California provides information and answers questions about teaching in California.

http://www.teachcalifornia.org/

**CTC Elementary (Multiple Subject) Teaching Credential Information**

http://www.ccsf.edu/Departments/Child_Development/Teacher_Preparation/index.html

**CTC Secondary (Single Subject) Teaching Credential Information**

http://www.ctc.ca.gov/credentials/CREDS/secondary-teaching.html

**CTC Special Education (Education Specialist Instruction) Credential Information**

http://www.ctc.ca.gov/credentials/CREDS/special-ed.html

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**COE  CSTPC**

[San Francisco State University logo]

updated 04/16/2008

http://www.sfsu.edu/~cstpc/formsprospective.html
AGENCIES SERVING SCHOOL VOLUNTEERS

The Teaching Credential Program at San Francisco State University requires all Multiple, Single Subject, and Special Education Teaching Credential candidates fulfill 45 hours of Early Field Experience in a public classroom setting. The experience should be within the last 5 years in a classroom similar to the one you wish to teach. The classroom should be culturally and linguistically diverse, meaning that 1/3 of the student population are English language learners. This includes Ebonics speakers. The experience includes substitute teaching, volunteering, classroom observation, teaching assistant and teaching. The resources below can assist you in finding and placing you in a field experience location.

San Francisco

SFSU Community Involvement Center
CIC Building
(415) 338-1486

City College of San Francisco
Teacher Prep Center – Bungalow 213
50 Phelan Avenue, L207
San Francisco, CA 94112
(415) 239-3890
www.ccsf.edu/Departments/Child_Development/Teacher_Prep_Center

San Francisco School Volunteers
601 McAllister Street, 1st Floor
San Francisco, CA 94102
(415) 749-3700 x 3014 (Phone)
www.sfsv.org
Email: sfsvmail@sfsv.org

North Bay

Marin County School Volunteers
1111 Las Gallinas Avenue
P.O. Box 4925
San Rafael, CA 94913
(415) 499-5986 (Phone)
(415) 491-7471 (FAX)
www.marincountyschoolvolunteers.org
Email: mcsvmcoe@marin.k12.ca.us

East Bay

Oakland Heroes
121 East 11th Street, Port 13-A
Oakland, CA 94606
(510) 879-2908 or (510) 879-3160 (Phone)
(510) 879-2909 (FAX)
www.oaklandheroes.org
Email: heroes@ousd.k12.ca.us

Berkeley School Volunteers
1335 Allston Way
Berkeley, CA 94703
(510) 644-8832 (Phone)
www.bpef-online.org
Email: bs bfs@berkeley.k12.ca.us

South Bay

Pacifica School Volunteers
375 Reina del Mar  (Mailing Address)
830 Rosita Road  (Physical Address)
Pacifica, CA 94044
(650) 355-9432 (Phone)
(650) 359-7471 (FAX)
www.pacificasd.org/curriculum/pacificavolunteers/
Email: psv@pacificasd.org

Redwood City School District
Human Resources, RSCD
750 Bradford Street
Redwood City, CA 94063
(650) 423-2251 (Phone)
www.rscd.k12.ca.us
Center for Science and Mathematics Education

San Francisco State University's Center for Science and Mathematics Education has been established to address the nation's lack of high quality scientific, technological, engineering and mathematics professionals. The Center's intent is to:

- recruit, prepare, and support good science and mathematics teachers;
- foster research into science and mathematics education and promote its application; and
- establish a community of science and mathematics education scholars, practitioners, and students.

The Center has been established on the premise that communication and interaction among science and mathematics educational researchers, teachers who train and support in-service and future science and mathematics teachers, and those who teach science and mathematics at all education levels will generate greater advances in science and mathematics than individual efforts in any one of these areas. To this end, the Center facilitates collaboration among faculty in the Colleges of Education and Science and Engineering, supports the development of innovative science and math curricula and pedagogy, and sponsors programs to disseminate developments in science and mathematics education. The Center provides a lending library of equipment and supplies for local K-12 science and math teachers, and provides a focus for the growing community of science and mathematics educators, including students, teachers and other interested parties. The Center also facilitates the integration of partnership and outreach activities into courses offered by the University, with the intention of inspiring more undergraduates to become committed science and mathematics teachers, and to improve the proficiency of current science and mathematics instructors and faculty, increasing the educational opportunities available to science and mathematics students at every level.

 Funds and plans to establish the Center were approved by President Corrigan and Provost and Vice President Gemello in August 2006 in response to a request from faculty in, and the Deans of, the Colleges of Education and Science & Engineering. We invite you to explore our site to learn more about the activities of the Center, and to join our efforts, or to contribute to our work in any way you can.

- CSME's Mission Statement

http://csme.sfsu.edu/
Jamie Chan  jmchan@sfsu.edu
Jan Mokros  jmokros@sfsu.edu
Ray Trautman  trautman@sfsu.edu

The CSME is a collaboration of the CoE and the CoSE.
College of Education

College of Science & Engineering
Center for 
Science and Mathematics Education

Fellowships and other Support for Prospective Science and Mathematics Teachers

The CSME helps undergraduate science, math, and engineering students who are thinking about a career as a teacher...

- Plan their course selection
- Obtain early field experience
- Apply to a credential program
- Interact with other students with similar career goals
- Obtain financial support

Current Fellowship Opportunities

- **Spaceward Bound**
  Sponsored by the NASA Exploration System Mission Directorate, the Spaceward Bound program will be held in the Mojave Desert, CA from April 6-9th 2008, and everyone who is selected will have all expenses paid (including travel, program fees, room and board).

Active Fellowships
This year's application period is over, but we anticipate offering similar fellowships next year. Send us a note, if you'd like us to notify you when the next application period is opened.

- **Math and Science Teacher Initiative (MSTI) Fellowships**
  Up to $4,000 per year, supported by the California State University System.

- **Robert Noyce Scholarships**
  Up to $10,000 per year, supported by the National Science Foundation.

http://csme.sfsu.edu/students/fellowships.html
News Flash! Spaceward Bound Takes SFSU Students to Lassen National Park

Spaceward Bound Lassen 2008

Aspiring high school science and mathematics teachers from San Francisco State University and CSU-Chico have a unique opportunity to work alongside scientists performing Moon/Mars analog exploration research. The opportunity is part of the Spaceward Bound program, co-sponsored by the California State University (CSU) and the National Aeronautics and Space Administration's Ames Research Laboratory in Moffett Field, CA.

The program will be held in Lassen Volcanic National Park from August 17-22, 2008. Participants will have their expenses paid (including travel, program fees, room and board).

The innovative Spaceward Bound program will implement "expeditionary science learning", in which participants work with NASA and CSU scientists and engineers to perform science and technology research in the field and learn and apply planetary exploration concepts, theories and ideas. They will also work with the Centers for Science and Mathematics Education (CSME) at both SFSU and CSU-Chico campuses to address the question: How does scientific fieldwork inform and connect with the work of a 6-12th grade teacher?

You are invited to apply!

A turquoise green shallow cool water pool above the Bumpass Hell hydrothermal area.

Applications are available as:

Center for Science and Math Education (SCI 211)
SRO Office (SCI 209)
Secondary Ed Office (BH 40)
Teacher Preparation Center (BH 244)

Alternatively, you can download an application form here:

- Spaceward Bound Lassen Application Form (Microsoft Word document: editable)
- Spaceward Bound Lassen Application Form (PDF format: not editable)

Questions?
Come by CSME office in Science 211, or E-mail Jan Mokros (jmokros@sfsu.edu), Director of CSME.
Bio 652: Science Education Partners In Biology

SEP BIO Lesson Plan Format

Title of Lesson: What Do Living Things Eat?
Lesson #: 2
Date of Lesson: 10/10, 10/24, 10/26

School Name: Bryant Elementary
SFUSD Teacher Names: Edward Klaus, Sandra Camp, Gil Guillermo
SFSU Student Names: Jessica Quan and Siobhan Poling
Number of Students: 22 per class (66 total)

1. Learning Goals: What did you want the students to learn from the lesson?
   Our goal for this lesson was to get the students thinking about where the food that they eat gets its food. (Food chain) We also wanted them to be able to make a prediction based on evidence for what an animal might eat.

2. Activity/Teaching Strategies: What did students do to learn these things?
   We had the students look at a variety of animal skulls—specifically the teeth. We had both carnivore and herbivore skulls so that the students could compare the teeth.

3. Time Management: What was the timeline for the different pieces of the lesson?
   Prior to this lesson students record everything that they eat for one day in a food diary

   Before Skull Activity
   1. Introduce lesson, “What do living things eat?” Make bridge to last lesson with a reminder that nutrition is a requirement for life.
   2. Students write down their ideas on where milk comes from.
   3. Class discussion. Whole class traces the origin of milk back to cows.
   4. Students pick one item of food from their food diary and trace it back to animals/plants.
   5. Introduce the terms Carnivore, Herbivore, and Omnivore.

   5 min: Jessica
   Tie in with food diary- some animals eat only plants, some eat only meat, and some eat both. Brainstorm ways they could figure out what an animal eats. From looking at skulls what would be one way to figure out what an animal eats?

   5 min: Bryant Teacher
   Go over guidelines and instructions for looking at skulls. Go over vocabulary “Prediction” and “Evidence”. Model worksheet.

   30 min: Everyone
   1. Hand out pre-assigned skulls to pairs. (1 skull each- alternate between carnivore and herbivore)
   2. Students observe skulls in order to determine what they eat. They are asked to make this prediction based on evidence.
3. Each person in the group records predictions and evidence on their answer sheet. The sheet includes space for them to make a prediction for each skull: I think my animal eats _______. It also includes space for them to draw pictures. Students may arrive at decisions as a group, but each person records on their own answer sheet.

4. Optional: Have students look at their own teeth in a mirror.

15 min:
1. Bryant Teacher
2. Jessica
3. Siobhan

1. One person from each group shares their table’s thoughts.
2. As groups share, we tell them what their animal is. Record their predictions and list a few things that the animal eats.
3. Make food chain.

5 min:
Bryant Teacher

In preparation for the next lesson, students write down their thoughts on what plants eat. (Handout)

4. Materials Management: What materials were needed to do this lesson?
We had 6 carnivore skulls and 6 herbivore skulls so that each group of 4 would have one of each. We also had small hand mirrors so that students who finished early could look at their own teeth. In Gil’s class he brought out some small magnifying glasses that seemed to help (At least with the gopher skull).

5. Classroom & Student Management: How were students organized during the lesson and how did you ensure that ALL students were engaged in the lesson?
We had students working in pairs with each pair having one skull. They were then paired with another group that had a skull of a different type of animal. For example, if the first pair had an herbivore skull, their partner pair would have a carnivore skull. We made sure that all students were engaged in the lesson by filling out a worksheet and floating around the room, keeping students on track. For those that finished early we had them compare their own teeth with the teeth of the animal skull so that they would not distract other groups.

6. Assessment of Student Learning: What questions did you ask to find out what students knew before the lesson? After the lesson?
Before the lesson we asked students what they learned from the food diary and for a brief reminder of what carnivores, herbivores, and omnivores are. We also asked them what they (as a scientist) would do to figure out what an animal eats. After the lesson we came together as a class and each pair shared their prediction for what kind of food they thought that their animal ate and evidence for that prediction.

7. Reflection on the Lesson

A. What were you most proud of about how you taught this lesson?
I was really proud of being able to start the lesson. In the previous lesson our partner teacher or Siobhan started off the lesson and I kind of had little parts afterwards. This time, not only was I responsible for the lesson itself (handouts, lesson timeline, communication), I was also in charge of engaging the students and making them excited to do the activity. I’m also proud that none of the skulls broke and that while some of kids didn’t quite get what we were
trying to teach them, there was a large group that did. I was also really proud that the students were so interested in the skulls. They really wanted to know what animal it belonged to and how we got them.

B. What was most challenging about this lesson?

What was most challenging about this lesson was the timing. When Siobhan and I taught the lesson for the first time we tried to cram too much material into too short a time. We ended up not being able to get through half of what we had planned. So, when we taught the lesson again in Sandra and Gil’s classes, we asked them to do the food diary activity before we came to do the skull activity. Another factor that could have impacted Edward’s class was the fact that it was first day back after a holiday (so they would be a little wired anyway) and there was a mouse in the room.

Another thing that was challenging was getting to kids to focus on evidence. Most of them were concerned with figuring out what kind of animal their skull was and the specific things that it ate. (Like flies, bees, caterpillars) Even when we were sharing out as a class and we asked for evidence we would get answers like “It eats meat because the teeth are big (as in size, not length)”. That was one frustrating thing we had with Gil’s class. Before we passed out the skulls he made some comment about big animals eating big things and small animals eating small things, which really stuck in the students minds.

There was also one boy in Gil’s class that was just having a really difficult time focusing on the lesson. Both Siobhan and I worked with him, but his brain just seemed turned off to what we were saying.

C. Given your answers above, if you were to teach this activity again, what would you do differently?

If we had to teach this lesson again, I would correct the statement that big animals eat big things before they students get set in that mode. I’m not sure how much it would deviate from the actual learning goals, but bringing up the idea of snakes and their ability to unhang their jaws in order to eat large prey might prevent them from taking Gil’s statement too religiously. Another thing I would do differently would be to have some kind of handout about the placement of teeth. Some of the carnivore skulls had flat teeth in the back where the molars would be, which led many students to think that the skull was an omnivore because it had both kinds of teeth. Gil’s class had a pretty nice handout with the names and locations of the different teeth in humans, which might have been beneficial in both Sandra and Edward’s classes.

8. Please attach (electronically or physically): any handouts, worksheets, or lesson planning tools your team used to develop this activity
Title of Lesson: How can Air Make a plant?
Lesson #: 3
Date of Lesson: 11/7 and 11/28

School Name: Bryant Elementary
SFUSD Teacher Names: Sandra Camp, Gil Guillermo, and Edward Klaus
SFSU Student Names: Siobhan Poling and Jessica Quan
Number of Students: 22 per class

1. Learning Goals: What did you want the students to learn from the lesson?
Plants create new tissues in their bodies out of mostly CO₂ molecules they get from the air.
The majority of the dry weight of plants is made up of carbon that they got from CO₂ in the air.
Plants bring gasses into their bodies through tiny holes in their leaves.
CO₂ has weight, even when it’s floating around in the air; plants don’t create their body masses out of nothing, they use the weight of the carbon in the CO₂ to add to their weight.

2. Activity/Teaching Strategies: What did students do to learn these things?
Students were shown an acorn and a log and asked to think about when the acorn grows into a tree (which the log is a part of) what materials does it use to build up such a large and heavy body? Students then wrote on the question ‘where do plants get the materials to build their bodies when they grow?’ Students were then told the answer this question and we did some activities to try to prove to them that carbon from CO₂ was the main ingredient in plant tissues.
We did a short demo to try to show that plants bring gasses into their bodies: a beaker partially full of water with a leaf stem sticking into the water and a straw above the water line is sealed air tight. When the teacher sucks on the straw a vacuum is created and air is sucked through the leaf into the stem, and into the water. The student observes bubbles forming where the cut stem meets the water. Each teacher did this demo for a third of the class so each student would have a chance to observe the bubbles. We also made a diagram of the process showing the path of air into the stomata through the stem as a handout.
We weighed dry ice (solid CO₂) at the beginning and the end of the class period. This activity helped to show that CO₂ has a weight (the solid form can be weighed on a scale). We also tried to show that CO₂ gas must have a weight too, the weight at the end of the class period was significantly less than at the beginning of the period, we extrapolated that this ‘missing’ weight must be floating around in the air.
3. Time Management: *What was the timeline for the different pieces of the lesson?*
See attached timeline.

4. Materials Management: *What materials were needed to do this lesson?*
   Scales
   Dry ice in a cooler
   Plastic bags for weighing the dry ice
   Towels for handling the dry ice
   3 demo setups each consisting of:
     - Long stemmed leaf
     - Beaker with two holed stopper and glass straw
     - Water
     - Earthquake wax to seal the beaker
   Acorn
   Log
   Top Secret Envelope with answer to per-assessment question inside
   Recording sheet for weighing dry ice
   Pre-assessment question handout
   Demo diagram handout
   Overhead showing the relationship between solid liquid and gas

5. Classroom & Student Management: *How were students organized during the lesson and how did you ensure that ALL students were engaged in the lesson?*
This lesson involved a lot of discussion with the whole group. We could have done a better job of ensuring that all students had a chance to talk.
Students weighed dry ice groups of 4. I think that all students had a chance to handle the materials and the scales.
The last time we taught the lesson we asked some of the groups to weigh their ice in sealed plastic bags. The idea was that the sealed bags would not lose weight because the CO₂ gas would stay in the bag, this didn’t really work, the bags were either not fully sealed or somewhat permeable. We also hope that this made the activity more engaging because the groups were not all doing the same thing.
Students wrote individually on the pre-assessment question which gave them a chance to reflect what would be the discussion for the rest of the class.
We added an element of performance to our lesson by telling them the answer to the pre-assessment question was a top secret piece of information that most adults don’t even know. We put a large piece of paper with ‘carbon dioxide’ written on it in a manila envelope labeled ‘top secret’. This was engaging, they really liked it!
The demo was done in smaller groups so that everyone had a chance to see the bubbles.
We spent a good bit of time discussing the core concepts as a whole group. When we were doing this we practiced wait time to ensure that we heard from some of the students who needed more time to think.
6. Assessment of Student Learning: What questions did you ask to find out what students knew before the lesson? After the lesson?
See attached pre-assessment sheet (both the original and revised versions).
After the lesson we did not do a formal assessment. This may have been a good idea because our partner teachers were all going to continue to teach the concept. But we could have done a quick post-assessment.

7. Reflection on the Lesson

A. What were you most proud of about how you taught this lesson?
I am proud of how ambitious this lesson plan was. I think that the concepts are very difficult to grasp and thus difficult to teach. Our partner teachers were not totally convinced that this lesson wasn’t conceptually too difficult for their students when we first brought it to the table, but we (and the students) really pulled it off! This lesson really honored these students intellectual abilities. They were really engaged because their brains were really working. Although I don’t think that everyone came away from this one hour lesson with a clear and solid understanding that carbon is the building block for plant tissues I think that this concept will come more easily to them when they learn photosynthesis in depth, and most importantly everyone exercised their minds and expanded their thinking about science and plants.

B. What was most challenging about this lesson?
It was very difficult to think of activities that taught the concepts that we wanted to teach. In the end the activities that we did were pretty good but I wonder if something else could have been better. The dry ice worked well but the demo could have been more dramatic (although the kids in my group really liked it today). Also I wish we could have done some kind of experiment showing that plants breathe in CO₂.

C. Given your answers above, if you were to teach this activity again, what would you do differently?
One of our partner teachers suggested that we could improve the demo by having another beaker which was set up the same way as the first but instead of a leaf it could have two straws: one submerged in the water and one above the water. When we suck on the above water straw, bubbles would come out the submerged straw, this would clearly show the path of air in the beaker.
I also would just keep my eyes and ears open for some other hands-on way to teach this concept.

8. Please attach (electronically or physically): any handouts, worksheets, or lesson planning tools your team used to develop this activity
Cellular Respiration in a Terrarium
A Case Study Discussion
Presenters: Nacha Chavez and Rachel Hipps
Alvarado Elementary School Team
October, 20, 2005

Introduction:
We would like to design one or two lessons that teach cellular respiration in an accessible, memorable way. One of our partner teachers has been suggesting all semester that we build terrariums with the kids. This would be an exciting project, and so, if possible, we would like to teach a cellular respiration lesson or two that incorporates terrariums.

Background:
• The kids will have been exposed to the idea of respiration. We plan to do the BTB experiment with them. We may also design and play a game with them that teaches cellular respiration.
• The teachers are enthusiastic about the project and will prepare the kids with whatever preliminary lessons are necessary.
• The kids are quite bright, and would love making terrariums.
• We plan to teach the lesson no sooner than two weeks from now.
• We are still not sure what organisms would be best suited to the terrariums, but we could procure plants, tadpoles, slugs, snails, roly pollies, hermit crabs, etc.

Dilemma Questions:
1. How could a terrarium be used to demonstrate cellular respiration? What would the components of that terrarium be?
2. What should our learning goals be? How extensively should we expect our 5th graders to understand cellular respiration? What terms should we use in our lesson?
<table>
<thead>
<tr>
<th></th>
<th>Skull #1</th>
<th>Skull #2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prediction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Name:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Draw or Write Description of Skull</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. I think Skull #1 eats meat/plants/both because

2. I think Skull #2 eats meat/plants/both because
The Radish Experiment

1. Predict the relative biomass of the plant material in each of the three treatments.
2. Write an explanation of your predictions about the results using your knowledge of biology.
The Radish Experiment

Experimental Setup:
- Weighed out 3 batches of radish seeds each weighing 1.5 g.

Experimental Treatments:
- A. Seeds not moistened (left DRY) placed in LIGHT
- B. Seeds placed on moistened paper towels in LIGHT
- C. Seeds placed on moistened paper towels in DARK

- After 1 week, all plant material was dried in an oven overnight (no water was left) and the plant biomass was measured in grams on a scale.
Exploring Our Own Ideas in Science

The majority of actual weight (dry biomass) gained by plants as they progress from seed to adult plant comes from which one of the following substances?

a. Particle substances in the soil that are taken up by plant roots.

b. Molecules in the air that enter through holes in the plant leaves.

c. Substances dissolved in water taken up directly by plant roots.

d. Energy from the sun.

1. My initial ideas...

Circle One: A B C D

I chose this answer because...

____________________________________________________

____________________________________________________

____________________________________________________

2. My revised ideas...

Circle One: A B C D

I chose this answer because...

____________________________________________________

____________________________________________________

____________________________________________________

3. My final ideas...

Circle One: A B C D

I chose this answer because...

____________________________________________________

____________________________________________________

____________________________________________________
Bio 652: Science Education Partners in Biology

Guidelines for Electronic Reflective Journals

The primary purpose of the SEP BIO Reflective Journal is to provide an opportunity for each student to reflect regularly on her/his fieldwork experiences. These journals are confidential and are intended to be a forum for frank and honest reflection.

What should I write about in my journal?
Although you will submit your journal for me to read, please try to use it primarily as a tool for yourself. It is a place to celebrate successes, revisit frustrations, and reflect on things you’re learning from your experiences in the course. In general, please consider the following question while you are writing:

What did you learn this week through your course and fieldwork experiences?

From time to time, we’ll also ask you to reflect on an additional question, perhaps about a reading or about activities from class. Most weeks, I will also assign a question in class to be addressed in your journal entry for that week. Questions may be related to field experiences, course readings, or reflections on class discussions.

How much time should I spend writing?
In our busy lives, time for reflection can be elusive, yet it is essential in processing new experiences and ideas. I ask that you spend approximately 45 minutes on your reflective journal entry each week. If you find this writing time particularly useful, please feel free to spend more time.

To whom do I send my journal entries?
Please send your weekly reflection electronically to kdtanner@sfsu.edu. I will be the primary reader of your reflections, and I very much appreciate your candor and willingness to share your thoughts with me. In some instances, I may share journal entries with the class for discussion. If for any reason you’d prefer I not share your reflective journal entry during a given week, just note that at the beginning of your entry. If journal entries are shared more widely (e.g. sharing quotes from everyone’s response to a reading; in a publication) comments will be presented anonymously.

What happens to them when I turn them in?
I read them! In addition, I will be analyzing them for common themes among the group and using your experiences to help us chart our course through the semester.

When are they due?
Please submit your journal entry each week no later than 5 pm on the Tuesday before our class meets. The first reflective journal entry should be emailed to me by Tuesday evening, September 5, 2006.
Bio 652: Science Education Partners in Biology
Electronic Reflective Journal Assignment
Due Tuesday, October 3, 2006

For your journal entry this week, please address the following two questions. Please spend approximately half of your 45 minutes of writing time on each one. You may always spend longer on your reflective journal if you would like...

1. How are you using questions in your teaching? When during a lesson do you use them? For what purposes do you use them? *

2. To the best of your ability, record all of the questions — both written and verbal — that you, your SFSU partner, and your teacher partners ask(ed) during your first lesson. *
For your journal entry this week, please address the following two questions. Please answer them separately, in separate paragraphs and spend approximately half of your 45 minutes of writing time on each one. You may always spend longer on your reflective journal if you would like…

1. At this point in time, what are you most struggling with in your teaching?  ★

2. Write a revised explanation for the results of The Radish Experiment. Follow the directions given on the handout. Be prepared to share your explanation and defend your ideas in class next week.

For your journal entry this week, please address the following two questions. Please answer them separately, in separate paragraphs and spend approximately half of your 45 minutes of writing time on each one. You may always spend longer on your reflective journal if you would like…

1. At this point in time, what are you most struggling with in your teaching?

2. Write a revised explanation for the results of The Radish Experiment. Follow the directions given on the handout. Be prepared to share your explanation and defend your ideas in class next week.
Bio 652: Science Education Partners in Biology

Electronic Reflective Journal Assignment
Due Wednesday, November 1, 2006

For your journal entry this week, please address the following two questions. Please answer them separately, in separate paragraphs and spend approximately half of your 45 minutes of writing time on each one. You may always spend longer on your reflective journal if you would like...

1. What did you learn this week through your SEP BIO partnership experiences?

2. Go to: http://www.ncsu.edu/felder-public/ILSpage.html. At this site complete the Index of Learning Styles questionnaire. After reading the Felder and Silverman article entitled Learning and Teaching Styles in Engineering Education, reflect on the reading and your questionnaire results. As you write, consider the following questions and be prepared to discuss them in class:

   - To what extent have you been aware of your own learning style as a student?
   - How has your learning style affected your experiences in college courses?
   - What strategies, if any, have/do you use to learn ideas in classes that are not a good fit for your learning style?
For your journal entry this week, please address the following question. As always, spend approximately 45 minutes writing. You may always spend longer on your reflective journal if you would like...

1. What were the three most valuable experiences for you during the course – both seminar and fieldwork components – this semester?

2. Would you (very honestly) take this class again? Would you (very honestly) recommend it to other SFSU students? Why or Why not?
Bio 652: Science Education Partners In Biology

Introduction to Case Study Discussions: Grappling with Science Teaching Dilemmas

What is a Case Study Discussion?
Case Study Discussions provide a structured opportunity for colleagues to share dilemmas they are struggling with in their teaching and to benefit from the ideas and experiences of the group. Case Study Discussions provide a venue to bring ideas in progress, unanticipated problems, and unexpected outcomes. As much as possible, Case Study Discussions are grounded in artifacts and evidence, such as lesson plans and sample student work. The goals of colleagues engaging in a series of Case Study discussions are to:

- participate in thoughtful and supportive discussions of actual teaching situations and dilemmas
- hone our skills as educational problem solvers who pose questions, explore multiple perspectives, and examine alternative solutions
- share knowledge, experiences and expertise with one another that enables us to all get smarter about science teaching and learning
- develop a reflective community of science educators

What are potential topics for a Case Study Discussion?
Topics for case studies should be actual, substantive dilemmas in science teaching and learning. Cases should be neither trivial nor insoluble, but rather complex enough to provide multiple avenues for discussion and the possibility of multiple solutions. The content of the case must be explainable in about 10 minutes and intellectually accessible to all members of the group. Following the overview of the Case Study, the presenting team puts forward 3-5 questions for the group specifically to address. Potential categories of Case Studies that might be appropriate for SEP Biology teams are:

Retrospective Cases (about a lesson already taught)
- Unanticipated outcomes of a lesson plan previously taught—where did it go wrong? How could we teach it differently next time?
- Disconnects between the goal of a lesson and actual student understanding—what did students understand? Not understand? How do we know?

Prospective Cases (about a lesson that you will be teaching)
- Sticking points or conundrums that have arisen in planning a science lesson
- Strategies for transforming a traditional lesson plan into a more hands-on, inquiry-based lesson

These categories are merely starting points. Please do not let categories hinder your ambitions for presenting a Case Study. All presenters will have a thought partner in deciding on the Case Study topic and questions that they bring to the group.
Please prepare your own personal Statement of Teaching Philosophy. I encourage you to examine the set of sample teaching statements handed out in class, but also to be creative in constructing a teaching statement that reflects your own personal philosophy of science teaching at this point in your career. For some of you this may be a piece of writing that you are able to use in your professional lives in the future. If so, please write to the audience (community college faculty, teaching credential program, medical/dental school admission committee) that is most relevant to your future goals.

Your Teaching Statement must be at least 650 words (~1 page single spaced).
What is good science teaching?

Please share as much detail as possible about your ideas and write using complete sentences.
Final Individual Reflection

What did you learn from your experiences in the Science Education Partners in Biology program?

How did you learn these things?

Please share your thoughts in complete sentences. Please be as specific as you can and provide examples whenever possible to support the statements you make. Thank you in advance for your time and effort in putting your thoughts down on paper!
Appendices for Standards:

Standard 7: Assessment of Subject Matter Competence
**SAN FRANCISCO STATE UNIVERSITY**

**SUBJECT MATTER COMPETENCY REVIEW**

This form is to be completed by subject matter competency advisor.

Applicant Name _____________________________  UIN ____________-

Subject Area ________________________________

<table>
<thead>
<tr>
<th>SFSU COURSE</th>
<th>DEPT. &amp; COURSE #</th>
<th>COURSE TITLE</th>
<th>UNITS</th>
<th>GRADE</th>
<th>TERM</th>
<th>INSTITUTION (other than SFSU)</th>
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<table>
<thead>
<tr>
<th>COURSEWORK IN PROGRESS (SHOW PROOF OF ENROLLMENT)</th>
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☐ Has completed 100% of Commission-approved subject-matter program requirements

☐ Will meet 100% of Commission-approved subject matter program requirements upon satisfactory completion of coursework currently in progress. (proof of enrollment must be attached)

☐ Has not yet completed subject matter program requirements.

TOTAL UNITS _____ GPA (Of subject matter courses. Must be at least 2.75): ______

Signature of Subject Area Advisor ___________________________  Print Name ___________________________  Date ____________

**Students who will not be attending SFSU's credential program need to get an accompanying letter from the SFSU Credential Services office (BH 238, 338-1758) to submit to their chosen credential program. The Credential Services office charges a $25.00 fee for the letter.**
Fall 2007 Graduating Biology Major Survey

Introduction
Congratulations on your intent to file your SFSU Graduation Application as a Graduating Biology Major!

The SFSU Department of Biology is committed to the continual improvement of its programs and courses. The professors and lecturers in the SFSU Department of Biology are very interested in hearing your opinions on your learning experiences in SFSU biology courses.

Thank you in advance for your honest and complete answers to the following questions. All responses will be kept strictly anonymous.

Your Learning Experiences in SFSU Biology Courses
The biology faculty invest substantial time and effort in developing and teaching biology courses that:
1) inspire students' interest in biology,
2) promote learning of biological concepts, and
3) support students' career goals.

Please reflect on all of your learning experiences in SFSU biology courses. Think about which of your learning experiences in your biology courses were MOST VALUABLE to you and which were LEAST VALUABLE to you. In the pages that follow, you will be prompted to briefly describe these experiences.

There are NO right or wrong answers. We want to know what you think! Please share your ideas in as much detail as possible, and please write in complete sentences. Your ideas are very valuable to us, and we appreciate your time and energy in answering these questions honestly.

MOST Valuable Learning Experiences in SFSU Biology Courses
What were the THREE MOST VALUABLE learning experiences you had in your SFSU biology courses?
Please describe these learning experiences briefly in the three boxes below...

1. MOST Valuable Learning Experience
2. MOST Valuable Learning Experience

Page 2

Fall 2007 Graduating Biology Major Survey

LEAST Valuable Learning Experiences in SFSU Biology Courses

What were the THREE LEAST VALUABLE learning experiences you had in your SFSU Biology courses?

Please describe these learning experiences briefly in the three boxes below...

3. MOST Valuable Learning Experience
1. LEAST Valuable Learning Experience
2. LEAST Valuable Learning Experience
3. LEAST Valuable Learning Experience

Page 3

Fall 2007 Graduating Biology Major Survey

A Few Final Questions...

Please answer the following questions, based on your experiences as an SFSU biology major.

1. I am more enthusiastic about biology now than when I started my biology major at SFSU.

   * nmlkJDisagree nmlkJSomewhat
   * Disagree
   * nmlkJNeutral nmlkJSomewhat Agree nmlkJAgree

2. My undergraduate biology education at SFSU has prepared me well for my future career plans.

   * nmlkJDisagree nmlkJSomewhat
   * Disagree
   * nmlkJNeutral nmlkJSomewhat Agree nmlkJAgree

3. The biology LECTURE course that contributed MOST significantly to my learning was:

4. The biology LECTURE course that contributed
LEAST significantly to my learning was:
5. The biology LABORATORY/FIELD course that contributed MOST significantly to my learning was:
6. The biology LABORATORY/FIELD course that contributed LEAST significantly to my learning was:
7. I consider myself a biologist.

8. I felt supported and encouraged during my experiences as an SFSU Biology major.

9. I came to SFSU specifically for one of the specialized biology majors (e.g. botany, physiology, ecology, marine biology, microbiology, cell and molecular biology, zoology).

10. I would have attended SFSU to get my biology degree even if specialized biology majors were not offered.

11. I would recommend the SFSU undergraduate biology program to potential students.
12. In one sentence, what will you remember most about your learning experiences as an SFSU biology major 10 years from now?
13. Upon completion of my biology degree, I plan to pursue a career in...
14. What else, if anything, would you like to share with us about your learning

Page 5
Fall 2007 Graduating Biology Major Survey

More About You...
Please answer the following questions to help us better understand the similarities and differences in the experiences of different populations of SFSU biology students.

Experiences as an SFSU Biology major?

1. What is your specific biology major?
- General Biology
- Botany
- Cell and Molecular Biology
- Clinical Science
- Ecology
- Marine Biology/Limnology
- Microbiology
- Physiology
- Zoology

2. Did you major or minor in another field at SFSU?
- No
- Yes
If Yes, what was your other major or minor?

3. I am...
- Female
- Male

4. I most closely identify as...
- Asian
- African-American
- Caucasian
- Filipino
- Latino
- Decline to State
- Other (please specify)
Transfer Student Follow-Up Question
To Verify Your Participation in This Survey
The questions below will allow us 1) to notify the SFSU Biology Department that you completed this survey and 2) to keep in touch with you as an SFSU Biology Department Alumnus.

This personal information will in NO WAY be affiliated with your responses to the previous questions on this survey.

5. Are you a transfer student?
   nmlkjNo
   nmlkjYes

1. My experiences in SFSU biology courses were superior to my experiences in biology courses at other institutions.
   nmlkjDisagree nmlkjSomewhat
   Disagree
   nmlkjNeutral nmlkjSomewhat Agree nmlkjAgree

2. Your Name
   First Name
   Middle Name
   Last Name
   Other Name/Nick Name

2. Your Permanent Address
   Street Address
   City
   State
   Zip Code

3. Your Current Email Address(es)
   Preferred email address
   Other email address

4. Your Current Phone Numbers
   Page 7

Fall 2007 Graduating Biology Major Survey

Thank You!
Thank you for your time and thoughtfulness in responding to this survey of SFSU Graduating Biology Majors.

If you have any concerns about this survey or suggestions for its improvement, please contact:

Kimberly Tanner, Assistant Professor
5. Your SFSU information
First Year Attended SFSU
SFSU ID Number

6. What is your birth date?
MM DD YYYY
My birth date is... //

7. What is today's date?
MM DD YYYY
Today is... //
**Spring 2008 Grad Survey Summary**
*Learning Experiences in SFSU Biology Courses*

1. **Most Valuable Learning Experience**
   Response
   Count
   184
   *answered question 184*
   *skipped question 0*

2. **MOST Valuable Learning Experience**
   Response
   Count
   184
   *answered question 184*
   *skipped question 0*

3. **MOST Valuable Learning Experience**
   Response
   Count
   184
   *answered question 184*
   *skipped question 0*

4. **LEAST Valuable Learning Experience**
   Response
   Count
   182
   *answered question 182*
   *skipped question 2*

5. **LEAST Valuable Learning Experience**
   Response
   Count
   182
   *answered question 182*
   *skipped question 2*

6. "Plants get their food from the soil." Please choose an answer below that reflects how much you agree with this statement.
   Response
   Percent Response
   Count
   Strongly agree 16.6% 29
   Agree 49.1% 86
   Disagree 25.7% 45
   Strongly disagree 8.6% 15

   Briefly explain your answer choice in complete sentences. 169
9. The majority of actual weight (dry biomass) gained by plants as they progress from seed to adult plant comes from which one of the following?
Response
Percent Response
Count
Substances in the soil that are taken up by plant roots. 36.0% 63
Molecules in the air that enter through holes in the plant leaves. 20.6% 36
Water taken up directly by plant roots. 23.4% 41
Energy from the sun. 20.0% 35
Briefly explain your answer choice in complete sentences. 157

11. What is photosynthesis? Briefly explain your ideas about photosynthesis in complete sentences.
Response
Count
175

12. I am more enthusiastic about biology now than when I started my biology major at SFSU.
Response
Percent Response
Count
Disagree 4.6% 8
Somewhat Disagree 5.2% 9
Neutral 16.8% 29
Somewhat Agree 24.3% 42
Agree 49.1% 85
answered question 173
skipped question 11
Page 4
Somewhat Agree 45.1% 78
Agree 31.8% 55
answered question 173
skipped question 11
14. The biology LECTURE course that contributed MOST significantly to
my learning was:
Response
Count
173
answered question 173
skipped question 11
15. The biology LECTURE course that contributed LEAST significantly to
my learning was:
Response
Count
173
answered question 173
skipped question 11
Page 5
17. The biology LABORATORY/FIELD course that contributed LEAST
significantly to my learning was:
Response
Count
173
answered question 173
skipped question 11
18. I consider myself a biologist.
Response
Percent
Response
Count
Disagree 2.9% 5
Somewhat Disagree 7.5% 13
Neutral 19.1% 33
Somewhat Agree 34.1% 59
Agree 36.4% 63
answered question 173
skipped question 11
Page 6
Somewhat Agree 36.4% 63
Agree 26.0% 45
answered question 173
skipped question 11
20. I came to SFSU specifically for one of the specialized biology majors (e.g. botany, physiology, ecology, marine biology, microbiology, cell and molecular biology, zoology).
   Response
   Percent Response
   Count
   Disagree 16.8%  29
   Somewhat Disagree 8.1%  14
   Neutral 18.5%  32
   Somewhat Agree 17.9%  31
   Agree 38.7%  67
   answered question 173
   skipped question 11

22. I would recommend the SFSU undergraduate biology program to potential students.
   Response
   Percent Response
   Count
   Disagree 5.8%  10
   Somewhat Disagree 3.5%  6
   Neutral 20.2%  35
   Somewhat Agree 33.5%  58
   Agree 37.0%  64
   answered question 173
   skipped question 11

23. In one sentence, what will you remember most about your learning experiences as an SFSU biology major 10 years from now?
   Response
   Count
   173
   answered question 173
   skipped question 11

25. What else, if anything, would you like to share with us about your learning experiences as an SFSU Biology major?
   Response
   Count
   173
   answered question 173
skipped question 11
26. What is your specific biology major?
   Response
   Percent Response
   Count
   General Biology 17.3% 30
   Botany 1.7% 3
   Cell and Molecular Biology 17.3% 30
   Clinical Science 2.9% 5
   Ecology 4.6% 8
   Marine Biology/Limnology 1.7% 3
   Microbiology 21.4% 37
   Physiology 31.8% 55
   Zoology 1.2% 2
   answered question 173
skipped question 11
Page 9
   answered question 173
   skipped question 11
28. I am...
   Response
   Percent Response
   Count
   Female 71.7% 124
   Male 28.3% 49
   answered question 173
   skipped question 11
29. I most closely identify as...
   Response
   Percent Response
   Count
   Asian 32.9% 57
   African-American 5.2% 9
   Caucasian 19.1% 33
   Filipino 11.6% 20
   Latino 9.8% 17
   Decline to State 3.5% 6
   Other (please specify) 17.9% 31
   answered question 173
   skipped question 11
Page 10
   skipped question 11
31. My experiences in SFSU biology courses were superior to my
   experiences in biology courses at other institutions.
   Response
Percent Response
Count
Disagree 4.0% 7
Somewhat Disagree 5.8% 10
Neutral 38.2% 66
Somewhat Agree 27.7% 48
Agree 24.3% 42
answered question 173
skipped question 11
32. Your Name
Response
Percent Response
Count
First Name 100.0% 172
Middle Name 69.8% 120
Last Name 99.4% 171
Other Name/Nick Name 12.8% 22
answered question 172
skipped question 12
Page 11
Zip Code 98.8% 170
answered question 172
skipped question 12
34. Your Current Email Address(es)
Response
Percent Response
Count
Preferred email address 100.0% 172
Other email address 45.3% 78
answered question 172
skipped question 12
35. Your Current Phone Numbers
Response
Percent Response
Count
Home 62.2% 107
Cell 73.3% 126
Work 7.6% 13
Other 1.7% 3
answered question 172
skipped question 12
Page 12
skipped question 12
37. What is your birth date?
Response
Percent Response
Count
My birth date is... 100.0% 172
answered question 172
skipped question 12
38. What is today's date?
Response
Percent Response
Count
Today is... 100.0% 172
answered question 172
skipped question 12
To assist students understand University regulations and policies, and to guide them in the submission of petitions and paperwork. If appropriate, we provide advice on study skills improvement and suggest potentially helpful University resources such as counseling, financial aid, tutoring, etc.

**Pre-major Support**

To advise students interested in careers in engineering, mathematics, or science, but who have not determined the best area for themselves. For these students we help clarify academic and career goals and help them select a major compatible with those goals. We refer students to major field advisors in the departments for more detailed information about specific degree programs and career opportunities.

**Change-of-major Support**

To support students considering changing their major with information on College programs and referrals to program advisors.

**Career Advising**

To support the departments and the Career Center in their efforts to provide career advising.

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E-mail: cosesrc@sfsu.edu -- Phone: (415) 405-3955 -- Science Building, Room 247

*This page was last modified on October 27, 2003*
General Biology Advising

The following students should consult General Biology Advisors:

- Students who are obtaining a B.A. in General Biology
- Students who are obtaining a Minor in Biology
- Students who are interested in demonstrating Subject Matter Competency or obtaining Single Subject Credential in Biological Sciences

As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

Undeclared students who wish to change their major to a Biology degree: NEW INFO

Please be certain that the Biology major is the appropriate major for YOU. If you are considering applying for the B.S. Nursing degree, you should select your major based on the course requirements that overlap with the Nursing major. Please consider the fact that the Nursing major is an impacted major (more students apply than can be accepted). A better strategy to obtain your degree in a reasonable time may be to select a major that will accept the Nursing-related courses for credit towards the major, so that you will not have to start from scratch with a new major. This is particularly important if you have already taken Biol 210/211 and Biol 610/611—these courses are NOT accepted for Biology major credit. The following majors do accept these courses for the major:

- Dietetics
- Health Education
- Kinesiology

General Biology Students

[return to top of page]

described in the SFSU Bulletin, the Bachelor of Arts in General Biology degree provides breadth, but not depth, in biology. The major is designed to support
the students who are interested in obtaining a teaching credential in the Biological Sciences for K-12. While it is true that the major can be structured to give the student the required depth for many career and educational goals, in many cases the Bachelor of Science degree may serve the student’s goals better.

Students seeking General Biology Advising should consult the Biology Advising Web Page for information on the following issues:
1. Learn more about a specific biology major
2. Develop a course plan (Recommended 4 year course plans for General Biology major)
3. Obtain approval for transfer courses or substitution courses
4. Improve your performance in your courses
5. Change your major
6. Obtain approval on an academic advising petition
7. Obtain approval for Financial Aid Graduation Plan
8. Obtain approval on your baccalaureate graduation application (Instructions to fill out the Graduation Checklist)

Other Frequently Asked Questions from General Biology Majors:

- Can Chem 333 be used to substitute for Chem 130?
  - Yes, and an equivalency form must be filed to indicate this change.

- How many units can be double-counted to fulfill the major and GE requirements?
  - 12 units, but at least one Segment III must be outside the major.

Recommended 4 year course plans for the General Biology major:
It is essential for a General Biology student to meet with an advisor to develop a course plan tailored to his/her career and educational goals. The recommended course plans below are suggestions and should be modified upon consultation with a General Biology Advisor. They are listed to demonstrate that:

- All lower division courses need not be completed prior to taking the upper division course work
It is critical to pay attention to the prerequisites when developing the course plan. In general, the student should try to limit the science course load to two courses per semester and balance the semester units with General Education courses and electives of interest. The upper division electives should be selected in consultation with the Biology Advisor.

**Description of General Biology major requirements**

**Version 1: "lower division first"**

<table>
<thead>
<tr>
<th>Year 1 Fall</th>
<th>Year 1 Spring</th>
<th>Year 2 Fall</th>
<th>Year 2 Spring</th>
<th>Year 3 Fall</th>
<th>Year 3 Spring</th>
<th>Year 4 Fall</th>
<th>Year 4 Spring</th>
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</thead>
<tbody>
<tr>
<td>Chem 115</td>
<td>Biol 230</td>
<td>Biol 240</td>
<td>Ecol course</td>
<td>Physio w/lab*</td>
<td>Cell Biol w/lab*</td>
<td>Upper Div elective</td>
<td>Upper Div elective</td>
</tr>
<tr>
<td>Phys 111/112</td>
<td>Phys 121/122</td>
<td>Chem 215**</td>
<td>Chem 130</td>
<td>Biol 355</td>
<td>Evol or Org course</td>
<td>Upper Div elective</td>
<td>Upper Div elective</td>
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<tr>
<td>Math 124 or 226</td>
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**Version 2: "physics later, no Biol 612 (Human Physiology)"**

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<tr>
<th>Year 1 Fall</th>
<th>Year 1 Spring</th>
<th>Year 2 Fall</th>
<th>Year 2 Spring</th>
<th>Year 3 Fall</th>
<th>Year 3 Spring</th>
<th>Year 4 Fall</th>
<th>Year 4 Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 115</td>
<td>Biol 230</td>
<td>Biol 240</td>
<td>Evol or Org course</td>
<td>Physio w/lab*</td>
<td>Cell Biol w/lab*</td>
<td>Upper Div elective</td>
<td>Upper Div elective</td>
</tr>
<tr>
<td>Math 226</td>
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*consult the Description of General Biology major requirements for the appropriate Cell or Physiology laboratory (only one lab required)*

**Chem 215 prerequisites**: C- or better in CHEM 115 and in 2 of the following courses: PHYS 111, PHYS 121; PHYS 220, PHYS 230, or PHYS 240; MATH 226, MATH 227; or consent of instructor
<table>
<thead>
<tr>
<th>Physiology courses:</th>
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<tbody>
<tr>
<td>BIOL 525 Plant Physiology</td>
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<tr>
<td>BIOL 612 Human Physiology</td>
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<tr>
<td>BIOL 630 Animal Physiology</td>
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<tr>
<td>Cell Biology courses:</td>
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<tr>
<td>BIOL 343 Cellular and Molecular Immunology</td>
</tr>
<tr>
<td>BIOL 350 Cell Biology</td>
</tr>
<tr>
<td>BIOL 401 General Microbiology</td>
</tr>
<tr>
<td>BIOL 450 Biology of the Protozoa</td>
</tr>
<tr>
<td>BIOL 524 Plant Molecular Biology</td>
</tr>
<tr>
<td>CHEM 349 General Biochemistry</td>
</tr>
<tr>
<td>Evolution or Organismal courses:</td>
</tr>
<tr>
<td>BIOL 328 Human Anatomy (4)</td>
</tr>
<tr>
<td>BIOL 337 Evolution</td>
</tr>
<tr>
<td>BIOL 380 Comparative Embryology</td>
</tr>
<tr>
<td>BIOL 453/454 General Parasitology/Laboratory (3/1)</td>
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<tr>
<td>BIOL 459 Arthropod Biology (4)</td>
</tr>
<tr>
<td>BIOL 460 General Entomology (4)</td>
</tr>
<tr>
<td>BIOL 461 Insect Taxonomy (4)</td>
</tr>
<tr>
<td>BIOL 475 Herpetology</td>
</tr>
<tr>
<td>BIOL 478 Ornithology</td>
</tr>
<tr>
<td>BIOL 480 Mammalogy (4)</td>
</tr>
<tr>
<td>BIOL 500 Evolution and Diversity of Plants (4)</td>
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<td>BIOL 502 Biology of the Algae (4)</td>
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<tr>
<td>BIOL 504 Biology of the Fungi (4)</td>
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<tr>
<td>BIOL 505 Comparative Anatomy of Vascular Plants (4)</td>
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<tr>
<td>BIOL 514 Plant Taxonomy (5)</td>
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<tr>
<td>BIOL 555 Marine Invertebrate Zoology (4)</td>
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<tr>
<td>BIOL 570 Biology of Fishes (4)</td>
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</tbody>
</table>

*As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

**Note:**
The following courses are generally taught both Fall and Spring semesters (check Class Schedule)
- Chem 115, Chem 215, Chem 130
Math 124, Math 226
Phys 111/112, Phys 121/122

The following courses are generally taught during the Summer semester (check Class Schedule, required courses are in bold)
BIOL 328, BIOL 355
CHEM 115, CHEM 215
MATH 124 or MATH 226
PHYS 111/112, PHYS 121/122

Minor in Biology

In order to obtain a Minor in Biology, the student must meet with a General Biology Advisor and develop a course plan to fulfill the following requirements (as indicated in the SFSU Bulletin description of the Minor in Biology).

Requirements:

- 23 units total
  - All courses for a letter grade (CR/NCR is not acceptable)

Introductory Biology courses or the equivalent (as a prerequisite for other courses)
* Biol 230 and Biol 240 (10 units)

Physiology course (the lab is not an official requirement)
Note that 610/611 may also be used depending upon the background or goals of the individual (3 units, +2 units if lab is taken)
* BIOL 525 Plant Physiology
* BIOL 526 Plant Physiology Lab
* BIOL 612 Human Physiology
* BIOL 613 Human Physiology Lab
* BIOL 630 Animal Physiology
* BIOL 631 Animal Physiology Lab

Ecology, one of the following (3 or 4 units, including field work)
- BIOL 313 Principles of Ecology (3)
* BIOL 482 Ecology (4)
*BIOL 529 Plant Ecology (4)
*BIOL 580 Limnology (3)
*BIOL 585 Marine Ecology (4)

As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

Genetics/Evolution (3 units), one of the following
* Biol 355 Genetics
* Biol 337 Evolution (note that Biol 355 Genetics is a prerequisite)

In the remaining 23 units, which is basically one more class, the student should try to get some depth in one of the fields above. The requirements above are actually pretty flexible so depending on the background or goals of the student, he/she may be able to substitute one of the "requirements" for a course that will give them more depth in a given area. Consult the description for the General Biology B.A. major for suggested upper division courses.

The student should refer to the SFSU Bulletin description of Minor Programs for additional policies for an approved minor degree. These policies include:

- Double Counting Courses Between Major and Minor. Courses may count for both a major and a minor where there is a clearly stated overlap in the Bulletin requirements.
- Double Counting Between Minor and GE. No limitations.
- Upper Division/Residence Units. At least half of the units making up the minor must be taken in residence and at least half must be upper division.
- No Minor in Major. Students cannot complete a minor in the same field as the major.
- Grade Point Average. A minimum 2.0 grade point average is required in the minor.

> return to top of page
Candidates for teaching credential programs who wish to meet the SFSU requirements for subject matter competency for the single subject credential in Science (Concentration in Biological Sciences) must meet both depth in biology requirements and breadth requirements in chemistry, geosciences, and physics.

Candidates for the teaching credential program who wish to have their transcripts evaluated for subject matter competency must contact a General Biology Advisor to arrange a meeting. The candidate must supply transcripts and additional supporting documentation to confirm completion of the required coursework. This documentation may include course catalogs and course syllabi if the courses were not taken at SFSU. Prior to meeting with the General Biology Advisor, the candidate should download and fill out the Biology Single Subject Credential Worksheet to assist the Advisor in determining subject matter competency.

For the student matriculating at SFSU, the coursework for the B.A. in General Biology with minor modifications, and additional coursework in the geosciences combined meet both the depth and breadth requirements:

The coursework (modified SFSU Bachelor of Arts Requirements in General Biology with additional classes):

- BIOL 230/240, General Biology I and II
- CHEM 115*, CHEM 215/216* General Chemistry I and II (with lab)
- CHEM 130, Organic Chemistry
- PHYS 111/112, PHYS 211/212, General Physics I/II
- MATH/STAT 124, Statistics, OR MATH 226, Calculus I
- BIOL 355, Genetics
- BIOL 525, 612, OR 630, a Physiology course
- BIOL 343, 350, 401, OR 450, a Cell Biology course
- Physiology or Cell Biology lab
- BIOL 3134, 482, 529, 580, 585, an Ecology course
- BIOL 337, Evolution
- BIOL (upper division, see General Biology B.A. major) and organismal biology course
- GIS 110, Search for Solutions (substitute for geology, astronomy, meteorology, if appropriate)
- Additional upper division biology electives to total 57 units for the major (SFSU)
• Electives selected when combined with other upper-division biology courses should clearly demonstrate a foundation in human, microbial, animal, and microbial biology. For example, the student may take the human physiology lecture, general microbiology, plant ecology, and marine invertebrate zoology. It would be inappropriate for the student to take courses that focus only on plant biology or only organismal biology.

• Geosciences: 2-5 courses

• The Geosciences breadth requirement covers astronomy, geology, meteorology, and oceanography, but the material need not be covered in four separate courses. These are the SJSU course options:

  - Current Requirements (as approved by CTE): Student takes 5 courses

  1. Astr 1 15/116: Introduction to Astronomy, 3 units, and Lab, 1 unit

  2. Geol 1 10: Physical Geology, 4 units (includes lab)

  3. Our Violent Planet: a CTE Segment II cluster that includes
     a. Geog 402: The Climatic Challenge, 4 units
     b. Geol 302: The Violent Earth, 3 units
     c. Metr 302: The Violent Atmosphere and Ocean, 3 units

  - Alternative: Student takes 3 courses

  1. Astr 1 15/116: Introduction to Astronomy, 3 units, and Lab, 1 unit

  2. Geol 1 10: Physical Geology, 4 units (includes lab)

  3. Metr 302: The Violent Atmosphere and Ocean, 3 units OR CIS 510: Search for Solutions (to Global Climate Change)

  - Alternative: Student takes 2 courses

  1. Astr 1 15/116: Introduction to Astronomy, 3 units, and Lab, 1 unit

  2. Geol/Metr 310: Planetary Climate Change, 4 units (includes lab), covers geology, meteorology, and oceanography

• Required for single subject science competence, although not for the BA. Counts as an upper division elective; see also Geosciences Breadth

000023
requirement

Students with degrees from other institutions:
If the course work was done at a different institution, the biology course work must include a year of general biology and classes in general physiology, ecology, evolution, and organismal biology. For breadth requirements, the course work in chemistry, physics, astronomy, geology, meteorology, and oceanography must total at least 24 semester or 36 quarter units.

The California Commission on Teacher Credentialing now has a new, specialized, and limited credential in Science-Biological Sciences (Specialized). To be eligible for the subject-matter competency in this Biological Sciences (Specialized) credential, a candidate needs either a post baccalaureate degree or 30 semester units of postgraduate course work in the major field or a closely related subject. Teacher certification would be only for biological sciences. A teacher with this limited credential would not be able to teach general science, integrated science, or introductory science.

Additional links of interest:
- single subject teaching credential information
- download the subject matter competency form (Single Subject Program)
- SF State Bulletin for the specific courses for the BA in General Biology
- Biology course descriptions
- Course descriptions for courses in other departments

return to top of page

San Francisco State University

Dated 9/21/2004

Questions on web page?
Advising for Pre-Service Teachers

To help you decide which education degree, if any, is required for your field of interest, review the list of the College of Education's Degrees and Programs. The College of Education is organized into five departments, and offers a variety of degree programs.

To help you decide which credential program, if any, is required for your career goals, review the list of the Credential Services Teacher Preparation Center. To teach science or mathematics at the high school level, a single subject credential is required. There are three pathways to the credential: the two-semester regular program; the Canada College pathways program; and the employed teacher intern program.

There are several prerequisites that must be completed before you can apply to the single subject credential program:

- Applicants must have earned a bachelor's degree or higher from a regionally accredited college or university.
- Applicants must demonstrate that they have fulfilled a minimum requirement of 45 hours of Early Field Experience.

The Credential program does not provide further preparation in a subject area. Knowledge of the subject should be mastered before beginning a credential program. There are two ways applicants can prove their competency:

1. Passing the required exams.
2. Completing an Approved Subject Matter Competency Program.

The science subject matter competency advisors are:

- Chemistry: Prof. Palmer.
- Geosciences: Prof. Caskey.
- Physics: Prof. Lockhart.

- The Single Subject Credential Program General Information Packet identifies requirements to enter the program.
The CSME is a collaboration of the COE and the COSE.
College of Education
College of Science & Engineering
February 15: Start in FALL semester

Deadlines: Both the Credential Program Application and the University Graduate Admission Application are due on the above deadline. This deadline is the same date from year to year. If the deadline falls on a weekend, department applications will be accepted until 5:00 p.m. the next working day following the deadline. Please note that Graduate Division applications must be submitted online on or before the deadline regardless of what day the deadline falls.

ATTEND AN INFORMATION MEETING: Meetings are held regularly by the Credential Services Office. Check the bulletin board outside Burk Hall 244 or visit our website, http://www.sfsu.edu/~cstpc/informet.html. Meetings are designed to inform students of the best possible way to meet the requirements for admission to a Credential Program. Explanation of the requirements, a description of the program, and timelines are discussed. All applicants are strongly encouraged to attend an information meeting.

CHECKLIST: The following list is a quick overview of program requirements. A brief description of each requirement follows.

REQUIRED TO ENTER THE SINGLE SUBJECT CREDENTIAL PROGRAM:

- A. CSU Graduate/Post-baccalaureate application (completed online at csumentor.edu)
- B. Single Subject Credential Program Application
  1. Program application pages 1 and 2
  2. Processing Fee $25.00
  3. Official transcripts from all colleges or universities attended
  4. Bachelor’s Degree must be posted before starting the program
  5. GPA (2.67 overall or 2.75 in last 60 semester units)
  6. Statement of Purpose
  7. Early Field Experience in a public classroom setting
  8. Letters of recommendation (minimum of three)
  9. Subject Matter Competency Requirement
  10. Basic Skills Requirement
  11. Second Language Requirement
  12. Certificate of Clearance
  13. Negative TB test completed within 12 months of program start

ADMISSION PROCEDURES: Faculty will only interview applicants with complete applications who meet minimum qualifications and program expectations. If selected for an interview, applicants will be notified by mail 2 to 3 weeks after the application deadline. Applicants will be notified by mail of the admission decision 2 to 3 weeks after the interview. There will be a mandatory orientation meeting for applicants who are offered admission. After attending the orientation, new students will be assigned a faculty advisor and register for classes.
1. **UNIVERSITY APPLICATION:** Apply to San Francisco State University's Graduate Division (415/338-2234, ADM 250), using the Graduate/Post-baccalaureate application to The California State University. Application information can be found on the Graduate Studies webpage https://www.sfsu.edu/~gradsdy. The application can be filled out online at http://www.csumentor.edu. You can also check the status of your application at https://www.sfsu.edu/online/appstat.htm. When filling out the online application, indicate your Major/Program Objective as "Education (Single Subject/Second Ed.) [Cred/MA]"; indicate your Degree Objective as "MA"; indicate your Credential Objective as "Single Subject (your subject)". The application must be submitted online by department deadlines.

2. **FEE:** There is a $55 fee for this application. You can pay online at the time of the application submission or you can pay Graduate Admissions after you have submitted your application.

3. **TRANSCRIPTS:** Submit one official set of sealed transcripts from every college or university attended to the SFSU Graduate Admissions, ADM 250, 1600 Holloway Avenue, San Francisco, CA 94132. (Transcripts should be sent to the student and submitted either in person or by mail as one packet or they may be sent directly from colleges/universities to SFSU Graduate Admissions.) If you have previously attended SFSU, you may not need to send transcripts. Please check with Graduate Admissions regarding their policies.

4. **TOEFL:** If you are an international student or if you have a bachelor's degree from outside the United States, please contact the Graduate Admissions directly. There may be additional admission requirements for admission, such as the Test of English as a Foreign Language (TOEFL).

B. **CREDENTIAL PROGRAM REQUIREMENTS FOR ADMISSION**

1. **CREDENTIAL PROGRAM APPLICATION:** Applicants must also complete the Single Subject Credential Program Application. The application must include the items listed below:

2. **PROCESSING FEE:** Applicants should pay at the Bursar's office prior to submitting the program application. The Bursar will print a receipt on the payment slip included in the program application. If applicant cannot pay in person at the Bursar's office, a check or money order payable to SFSU can be included with the program application.

3. **TRANSCRIPTS:** Official transcripts must be included with the Credential Program application or sent by the school directly to the Credential Services Office. This is in addition to transcripts for the CSU Graduate/Post-baccalaureate application. Transcripts from outside the United States must be evaluated by an approved agency. Contact the Credentials Services Office for a list of agencies. We recommend that applicants collect all official transcripts and turn in with the application, if at all possible. Transcripts of SFSU work can be unofficial copies from MySFSU. You must submit official transcripts of any coursework that does not appear on your SFSU transcript.

4. **DEGREE:** Applicants must have earned a bachelor's degree or higher, except in professional education (i.e. secondary education), from a regionally accredited college or university. Applicants with degrees from outside the United States must have the equivalent of a bachelor's degree from a United States regionally accredited institution. The degree must be awarded before enrolling in the credential program. If the degree is not awarded at the time of the application deadline, applicants must provide transcripts at the time of application and updated transcripts once the degree has been awarded.

5. **GPA:** Applicants for admission should have attained a grade point average of at least 2.67 in all baccalaureate and post baccalaureate coursework or a grade point average of at least 2.75 in the last 60 semester units or 90 quarter units.

6. **STATEMENT OF PURPOSE:** Applicants must submit a typed essay (1-3 pages). Some questions to consider when formulating your essay: Why do you want to be a teacher? What experiences have prepared you to teach in a linguistically diverse, urban setting? What personal qualities do you possess and what experiences have you had that have prepared you to work in a collaborative environment such as a high school or a cohort in the Single Subject Program?

7. **EARLY FIELD EXPERIENCE:** Applicants must demonstrate that they have fulfilled a minimum requirement of 45 hours of Early Field Experience prior to applying to the Single Subject Credential Program. This Early Field Experience requirement can be met by volunteering, substitute teaching, or working in a Single Subject, regular education classroom in a California public school, in an appropriate subject area. The classroom should be culturally and linguistically diverse, meaning that at least one third of the students are English Language Learners. This includes Ebonics speakers. The intention is for applicants to gain some exposure to and familiarity with the role of the teacher, the student age group, the current curriculum standards, and the public school environment. The experience should be within the last 3 years. Experiences in pre-schools, special education, higher education, religious education, or outside the U.S. will not meet this requirement.

A letter of recommendation from the teacher or supervising site administrator must verify this experience. The letter should briefly describe the classroom composition, including the cultural background of the students, and the classroom environment, including grade level and subjects taught. The letter should also state how the applicant was involved in the classroom, including qualitative comments about the applicant's performance in the classroom, especially noting the applicant's effectiveness in a linguistically and culturally diverse classroom. The letter should be on letterhead and have an original signature. A sample letter is attached. This letter also counts as one of the three required letters of recommendation.
Resources that can assist you in finding field experience locations are The San Francisco School Volunteers (415/749-3700), Pacifica School Volunteers (650/355-9432), or the SF State Community Involvement Center (CIC 415/338-1486). You may also call your local school district for more options. The Teacher Preparation Center has a more complete list of volunteer placement programs.

8. **LETTERS OF RECOMMENDATION**: A minimum of three letters is required. The Early Field Experience letter can count as one of the three letters. Letter(s) should address the applicant's character, aptitude for teaching, work ethic, academic ability, and so on. Additional letters beyond the required three will also be accepted to augment the application. Letters should be on letterhead and have original signatures. Letters from relatives and letters more than five years old will not be accepted. Applicants should collect all letters and include them with the rest of the application.

9. **SUBJECT MATTER COMPETENCY**: The Credential program does not provide further preparation in a subject area. Knowledge of the subject should be mastered before beginning a credential program. There are two ways applicants can prove their competency:
   - **Passing the required exams.** All parts of the exam for your subject must be taken before the application deadline. Those with only partial passing scores will not be admitted. Photocopies of all exam scores should be included with the Credential Program Application, even if you have requested the scores sent to SFSU by the testing company. Exams vary by subject. See the CSET exam information and registration guide, [http://www.cset.nesinc.com](http://www.cset.nesinc.com). All subject matter competency exam scores are valid for five years.
   - **Completing an Approved Subject Matter Competency Program.** To have your coursework assessed, please consult the list of advisors on page 12 and make an appointment. The form the advisor needs to complete is on page 13 of this document. Applicants must complete 100% of subject matter competency coursework to be admitted and begin the credential program.

   If you have completed a subject matter competency program at another university, we must have an official, original form or letter with a Commission on Teacher Credentialing-approved signature verifying that you have met all subject matter program requirements in a program approved by the Commission on Teacher Credentialing.

   If your subject area is not listed on the advisor list provided, then SFSU does not have an approved subject matter competency program for that area. Subject Matter Program evaluations can only be done by SFSU or the institutions from which you earned a BA. If neither institution has an approved program, consult the CCTC for an alternate institution.

10. **BASIC SKILLS REQUIREMENT**: Choose one of the following options to fulfill this requirement:
   - **A. CBEST (California Basic Skills Examination)** Submit a photocopy of the results. For registration booklets, contact the SFSU Testing Center, ADM 152, 415.338-2271 or the Teacher Preparation Center, Burk Hall 244, 415/405-3594. It is also possible to register on-line: [www.cbest.nesinc.com](http://www.cbest.nesinc.com).
   - **B. Out-of-State Basic Skills Exam.** Submit a photocopy of the results. Not all states' Basic Skills Exams have been approved by the CTC. Contact the Teacher Preparation Center to find out if the test you took is approved. For more information on specific tests, contact the appropriate Department of Education for the state in which you want to take the test.
   - **C. CSET: Multiple Subjects Plus Writing Skills.** Available July 1, 2007. Submit a photocopy of the results. Registration can be done on-line at [http://www.cset.nesinc.com/](http://www.cset.nesinc.com/). Registration bulletins are available in the Teacher Preparation Center (Burk Hall 244.) Not recommended for Single Subject Applicants.

11. **SECOND LANGUAGE REQUIREMENT**: Applicants must show verification of experience learning a single second language obtained through one of the options described on page 8.

12. **CERTIFICATE OF CLEARANCE**: In accordance with California state law and Education code, all teaching credential applicants must go through a background check. All applicants must apply for a Certificate of Clearance with the Commission on Teacher Credentialing (CCTC) OR submit proof of prior completion of the clearance. **Acceptable documentation in lieu of a Certificate of Clearance**: Valid credentials or permits issued by the California Commission on Teacher Credentialing, including emergency 30-day, pre-interim, emergency long-term, clear or preliminary, or Child Development permits. District or other job related clearance is not acceptable. Submit a photocopy of the document or a print-out from the Commission on Teacher Credentialing website [https://teacherred.ctc.ca.gov/teachers/index.jsp](https://teacherred.ctc.ca.gov/teachers/index.jsp). For instructions on applying for the Certificate of Clearance see page 10.

13. **TB TEST**: TB test verification should be a photocopy of a note or card from a Doctor. A negative skin test or a letter from a doctor verifying a clear chest x-ray is acceptable. Test or x-ray evaluation should be within 12 months of program start date.

**TUITION RATE**
As of Fall 2008 the Credential Only status is no longer an option for incoming credential students. All credential students will be considered Secondary Education Master/Credential students. This designation is for university status purposes only. Credential students cannot work on a Secondary Education MA. Due to this status change, please be aware that ALL credential students will be paying tuition at the Graduate rate.

REQUIRED BEFORE A CREDENTIAL CAN BE GRANTED, IN ADDITION TO CREDENTIAL PROGRAM COURSEWORK:
These can be completed after admission, before completing the program.

- Completion of U.S. Constitution course or exam: Applicants must meet the U.S. Constitution requirement either by course work or examination. Those who earned a B.A. from a California State University campus have already met this requirement. Check with the Teacher Preparation Center to see if you have met this requirement. They can provide a list of testing options that meet this requirement.

- CPR: Must have current training in administering CPR to adults, children and infants at the time of application to the Commission on Teacher Credentialing

MA IN SECONDARY EDUCATION
The Department of Secondary Education also offers an MA Program in Secondary Education. To be eligible for this program you must have the following:

- A Preliminary or Clear Single Subject Credential
- A minimum of two years experience teaching in a single subject classroom
- For a list of other requirements please contact the Department of Secondary Ed.
SINGLE-SUBJECT CREDENTIAL COURSE WORK OPTIONS

The Single Subject Teaching Credential Program is designed to prepare qualified candidates with the course work and field experiences needed to enable them to effectively teach their subject in California public schools, particularly middle and high schools. The Department of Secondary Education prepares candidates to teach in the following subject areas: Art, English, Foreign Language, Mathematics, Music, Physical Education, Science, and Social Science. The SFSU Single Subject Credential Program is a one-year, full-time program when starting the program in the fall semester.

For course descriptions, consult the SFSU Bulletin, which can be found online or purchased in the bookstore. For class times and locations, consult the class schedule, available online.

SINGLE SUBJECT CREDENTIAL PROGRAM OUTLINE – FALL START
TWO SEMESTER PROGRAM FOR FULL-TIME STUDENTS

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<thead>
<tr>
<th>FIRST SEMESTER FALL</th>
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<tr>
<td>Curriculum &amp; Instruction 1—discipline-based; see course number below</td>
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<tr>
<td>Subject Area-Course Number: English-ENG 713; Mathematics-S ED 759.01; Science-S ED 759.02; and Social Science-SED 759.03; Art-ART 650; Foreign Languages-FL 750; Music-MUS 760; and P.E.-KIN 750</td>
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<tr>
<td>Student Teaching 1 – Observation &amp; Participation</td>
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<tr>
<td>Social, Cultural and Historical Foundations of Education</td>
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<td>Literacy Across Content Areas</td>
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<td>Classroom Environment</td>
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<td>Adolescent Development</td>
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<td>Computer Fundamentals for Teachers</td>
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17 total units

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<th>SECOND SEMESTER SPRING</th>
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<td>Curriculum &amp; Instruction 1—discipline-based; see course number below</td>
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<td>Subject Area-Course Number: English-ENG 714; Mathematics-S ED 769.01; Science-S ED 769.02; and Social Science-SED 769.03; Art-ART 655; Foreign Languages-FL 751; Music-MUS 761; and P.E.-KIN 751</td>
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<tr>
<td>Student Teaching 2</td>
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<tr>
<td>Professional Perspectives &amp; Practices (cohort class must be taken concurrently with SED 660)</td>
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<td>Second Language Development</td>
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16 total units
GRADING POLICY AND SYSTEMS

GRADING POLICY

Policies concerning evaluation of student work ("grading") are under continuous review and subject to change. Department chairs are responsible for informing department members of basic faculty grading policy and procedures and for ensuring adherence to these policies and procedures.

It is the responsibility of the instructor to describe to each class the methods of evaluation. Students should feel free to ask for an explanation of the grading practices in any course.

Additional definitions which are applicable to special circumstances for graduate programs can be found in the Graduate Studies section, Registration and Grading Procedures for Culminating Experience Courses.

Basic Definitions

The following symbols shall be used in evaluating student performance. Performance will be interpreted to reflect the quality of the student's accomplishment relative to the standards set for each course.

A = Performance of the student has been of the highest level, showing sustained excellence in meeting course responsibilities.
B = Performance of the student has been good, though not of the highest level.
C = Performance of the student has been adequate, satisfactorily meeting the course requirements.
D = Performance of the student has been less than adequate.
F = Performance of the student has been such that course requirements have not been met.
CR = (Credit) Performance of the student in undergraduate level course has been equivalent to grades A through C-; performance of the student in graduate level courses has been equivalent to grades A through B-.
NC = (No Credit) Performance of the student has been less than that of CR level.
I = (Incomplete Authorized) Indicates that a portion of required course work has not been completed and evaluated in the prescribed time period due to unforeseen, but fully justified, reasons and that there is still a possibility of earning credit. It is the responsibility of the student to bring pertinent information to the attention of the instructor and to determine from the instructor the remaining course requirements which must be satisfied to remove the Incomplete. A final grade is assigned when the work agreed upon has been completed and evaluated. An I must normally be made up within one calendar year immediately following the end of the term during which it was assigned. This limitation prevails whether or not the student maintains continuous enrollment. Failure to complete the assigned work will result in an I being converted to a F.

http://www.sfsu.edu/~bulletin/current/grading.htm
to an IC symbol, unless the faculty member assigns a specific letter grade at the time the Incomplete Authorized is assigned, which would replace the I in the student's record at the end of the calendar year deadline.

**C** = (Incomplete Charged) Indicates that a student who received an authorized incomplete (I) has not completed the required course work within the allowed time limit. The IC replaces the I and is counted as a failing grade for grade point average and progress point computation.

**W** = (Withdrawal) Indicates that the student was permitted to withdraw from the course after the 4th week of instruction with the approval of the instructor and appropriate campus officials. It carries no connotation of quality of student performance and is not used in calculating grade point average or progress points.

**WU** = (Withdrawal Unauthorized) Indicates that an enrolled student did not withdraw from the course and also failed to complete course requirements. It is used when, in the opinion of the instructor, completed assignments or course activities or both were insufficient to make normal evaluation of academic performance possible. For purposes of grade point average and progress point computation, this symbol is equivalent to an F.

**AU** = (Audit) Indicates that the student was enrolled on a non-credit basis. Enrollment as an auditor is subject to the permission of the instructor and shall be permitted only after students otherwise eligible to enroll in the course on a credit basis have had an opportunity to do so. Auditors are subject to the same fees structure as credit students and regular class attendance is expected. Once enrolled as an auditor, a student may not change to credit status unless such a change is requested prior to the last day to add classes. A student who is enrolled for credit may not change to audit after the second week of instruction.

**R** = (Report in Progress) Used in connection with courses that extend beyond one academic term. It indicates that work is in progress but that assignment of a final grade must await completion of additional work. Work is to be completed within one year except for graduate culminating experience courses.

**RD** = (Report Delayed) Indicates no grade was turned in by the professor. It is used where a delay in the reporting of a grade is due to circumstances beyond the control of the student. The symbol may be assigned by the registrar only and, if assigned, shall be replaced by a substantive grading symbol as soon as possible.

**GRADING SYSTEMS**

The basic grading system to be used at San Francisco State University is the A-F system (see definitions above).

An alternative Credit/No Credit (CR/NC) system may be used under the following conditions:

- A list of courses in which CR/NC grading is mandatory is maintained in each departmental office.
- In courses where the CR/NC option is permitted, but not mandatory, students must notify the instructor, by the end of the sixth week of instruction, of their decision to be evaluated on the CR/NC basis. Students may change their grading option on the web at www.sfsu.edu/student. No change in this decision is permitted after the eighth week of instruction.
- No more than 30% of the units earned at this university, and applied toward an undergraduate degree,
may be taken for CR grades.

For students working toward a master's degree, no more than 30% of the units used on the Graduate Approved Program, including transfer work, may be taken for CR grades.

- All students in a given class, whether being evaluated on the A-F or CR/NC basis, are to be treated in the same manner with respect to assignments, methods of evaluation, and standards of performance. The only difference is in the symbol entered on the student's official grade record.
- Students who select CR/NC grading should be informed that CR grades may be interpreted as a C and NC grades may be changed to an F when considered by other institutions.

Use of Incomplete Authorized (I) Grade

The symbol "I" (Incomplete Authorized) indicates that a portion of required course work has not been completed and evaluated in the prescribed time period due to unforeseen, but fully justified, reasons and that there is still a possibility of earning credit. It is the responsibility of the student to bring pertinent information to the attention of the instructor and to determine from the instructor the remaining course requirements that must be satisfied to remove the incomplete. A final grade is assigned when the work agreed upon has been completed and evaluated.

An incomplete must normally be made up within one calendar year immediately following the end of the term during which it was assigned. This limitation prevails whether or not the student maintains continuous enrollment. Failure to complete the assigned work will result in an I being converted to an IC symbol.

If a student has extenuating circumstances and an extension of the one year is necessary, the student should contact the instructor involved and obtain a designated extension of time to make up the incomplete. The form to be used for this extension is the Petition for Waiver of College Regulations. The petition must be approved by the instructor and the department chair and forwarded to the Registrar's Office.

A grade of Incomplete (I) will not be changed after a degree or credential has been awarded even though it is made up within the time period.

Use of Report in Progress (RP) Grade

The RP symbol is used in connection with theses, projects, and similar courses in which assigned work frequently extends beyond a single academic term. It indicates that work is in progress and has been evaluated and found to be satisfactory to date, but that assignment of a precise grade must await completion of additional work. Cumulative enrollment in units attempted may not exceed the total number applicable to the student's educational objective. The RP symbol shall be replaced with the appropriate final grade within one year of its assignment except for graduate culminating experience courses.

Use of Withdrawal Unauthorized (WU) Grade

The symbol WU shall be used where a student, who is enrolled on the census date, does not officially withdraw from a course but fails to complete it. Its most common use is in those instances where a student has not completed sufficient course assignments or participated in sufficient course activity to make it possible, in the opinion of the instructor, to report satisfactory or unsatisfactory completion of the class by
use of the letter grade (A-F). The instructor shall report the last known date of attendance by the student. The WU symbol shall be identified as a failing grade in the transcript legend, and shall be counted as units attempted but not passed in computing the grade point average. In courses that are graded NC or in cases where the student has elected CR/NC evaluation, use of the WU symbol is inappropriate and NC shall be used instead.

GRADE POINT AVERAGE

Grade point averages are determined by dividing the total number of grade points earned by the total number of units attempted in courses in which A-F grades are assigned.

Grade Points

The following grade points are assigned per unit of course work:

- A = 4.0
- A- = 3.7
- B+ = 3.3
- B = 3.0
- B- = 2.7
- C+ = 2.3
- C = 2.0
- C- = 1.7
- D+ = 1.3
- D = 1.0
- WU = 0.0
- IC = 0.0
- 0.7

Other grading symbol, including W, I, AU, RP, RD, CR, NC, carries grade point credit.

DEFINITION OF SEMESTER UNIT

One semester unit corresponds to one hour per week for every unit in a fall or spring semester (fifteen (15) weeks of class meeting). (At least two hours of study is expected in preparation for each hour of class.)

or

Three hours of laboratory work per week for fifteen (15) weeks,

or

Two hours of class work in activity-type courses in art, music, and speech per week for fifteen (15) weeks. (At least one hour of outside preparation is expected for each hour of laboratory or activity class work.)

Summer session and extension units are evaluated on a basis of hours to units equal to those above, but adapted to the special schedules of these programs.

DEFINITION OF CONTINUING EDUCATION UNIT (CEU)

CEUs are nationally recognized units of measurement for participation in professional development programs for which academic credit is not awarded. CEUs may neither be applied to nor substituted for graduation requirements. One CEU is earned for 10 hours of instruction.
policy requires an evaluation of student learning for all courses which award CEUs.

**GRADE CHANGES**

- Letter grades are not convertible to other letter grades and NC grades are not convertible to CR grades except in cases of instructor or administrative error. All grade changes are by petitions, with a recommendation of a grade change by the instructor and the approval of the department chair and/or college dean.
- Except in cases of instructor or administrative error, CR/NC grades are not convertible to letter grades or vice versa. All grade change requests involving the CR/NC option are by petition, with a recommendation by the instructor and the approval of the department chair and/or college dean. Requests for reasons other than clerical error are subject to review by the Board of Appeals and Review.
- A student wishing to request a retroactive grade change, withdrawal, or addition of a course must initiate the request during the semester in attendance immediately following the semester when the original grade was assigned or the course in question was offered.
- Retroactive change of grades and withdrawals are subject to review by the Registrar.
- Grade changes are not permitted after the award of a degree or credential, unless the change is for a course not used for the degree (in the case of a graduate student continuing after the award of a degree or readmitted second baccalaureate student) or in the case of a formal school grade appeal process when the request has been initiated by the student in the semester immediately following the award of the grade.
- Request for W is not a grade change, rather it is a request for retroactive withdrawal.

**Student Appeal for Grade Change**

San Francisco State University policy, consistent with California State University policy, guarantees the student a right to appeal a final course grade when the student believes that the assigned grade does not reflect what the student has earned according to the criteria for grading as outlined by the instructor of the course. SFSU policy states that: (1) It is the responsibility of the instructor of each course to define his/her grading policy and criteria as early in the semester and as explicitly as possible while conforming to accepted university practices. If there is any deviation from this original statement of course policy, all affected students should be informed. (2) It shall be assumed that the grade assigned is correct and that the student appealing the grade must justify the need for a change of the grade assigned. (3) Normally, grade appeals should be resolved informally between the student and faculty involved. (4) A student who believes s/he has been assigned an improper grade should meet with the instructor of record and together review the grading procedures used to determine the grade assigned on the student's transcript. If, after careful review of the grading procedures, the student is still dissatisfied, or if the instructor of record refuses to take part in the informal process, the student may initiate the formal grade appeal procedure.

**REPEAT OF COURSES**

Unless otherwise stated in the course descriptions in the current SFSU Bulletin, courses may not be repeated additional units of credit.
When undergraduate students choose to repeat a course in which the grade was F, U, WU, or IC, all units attempted and all grade points will be included in the student's cumulative totals. (Units earned toward graduation include courses receiving passing grades only.) When undergraduate students choose to repeat a course in which the grade was passing, all units attempted and all grade points earned will be used in the calculation of the student's grade point average, but the units earned will be applied to the calculation of total units earned only once.

Once a bachelor's degree has been granted, repeating courses for any reason (as a visitor, post-baccalaureate, or Open University student) will not affect the GPA or content of the degree already granted.
February 15: Start in FALL semester

**Deadlines:** Both the Credential Program Application and the University Graduate Admission Application are due on the above deadline. This deadline is the same date from year to year. If the deadline falls on a weekend, department applications will be accepted until 5:00 p.m. the next working day following the deadline. Please note that Graduate Division applications must be submitted online on or before the deadline regardless of what day the deadline falls.

**ATTEND AN INFORMATION MEETING:** Meetings are held regularly by the Credential Services Office. Check the bulletin board outside Burk Hall 244 or visit our web site, http://www.sfsu.edu/~cspc/infomeet.html. Meetings are designed to inform students of the best possible way to meet the requirements for admission to a Credential Program. Explanation of the requirements, a description of the program, and timelines are discussed. All applicants are strongly encouraged to attend an information meeting.

**CHECKLIST:** The following list is a quick overview of program requirements. A brief description of each requirement follows.

**REQUIRED TO ENTER THE SINGLE SUBJECT CREDENTIAL PROGRAM:**

A. CSU Graduate/Post-baccalaureate application (completed online at csumentor.edu)
B. Single Subject Credential Program Application
   1. Program application pages 1 and 2
   2. Processing Fee $25.00
   3. Official transcripts from all colleges or universities attended
   4. Bachelor’s Degree must be posted before starting the program
   5. GPA (2.67 overall or 2.75 in last 60 semester units)
   6. Statement of Purpose
   7. Early Field Experience in a public classroom setting
   8. Letters of recommendation (minimum of three)
   9. Subject Matter Competency Requirement
   10. Basic Skills Requirement
   11. Second Language Requirement
   12. Certificate of Clearance
   13. Negative TB test completed within 12 months of program start

**ADMISSION PROCEDURES:** Faculty will only interview applicants with complete applications who meet minimum qualifications and program expectations. If selected for an interview, applicants will be notified by mail 2 to 3 weeks after the application deadline. Applicants will be notified by mail of the admission decision 2 to 3 weeks after the interview. There will be a mandatory orientation meeting for applicants who are offered admission. After attending the orientation, new students will be assigned a faculty advisor and register for classes.

**A. CSU GRADUATE APPLICATION REQUIREMENTS FOR ADMISSION**
1. **UNIVERSITY APPLICATION:** Apply to San Francisco State University’s Graduate Division (415/338-2234, ADM 250), using the Graduate/Post-baccalaureate application to The California State University. Application information can be found on the Graduate Studies webpage https://www.sfsu.edu/~gradstdy. The application can be filled out online at http://www.csumentor.edu. You can also check the status of the application at https://www.sfsu.edu/online/appstat.htm. When filling out the online application, indicate your Major/Program Objective as “Education (Single Subject/Second Ed.) [Cred/MA]”, indicate your Degree Objective as “MA”; indicate your Credential Objective as “Single Subject (your subject)”. The application must be submitted online by department deadlines.

2. **FEE:** There is a $55 fee for this application. You can pay online at the time of the application submission or you can pay Graduate Admissions after you have submitted your application.

3. **TRANSCRIPTS:** Submit one official set of sealed transcripts from every college or university attended to the SFSU Graduate Admissions, ADM 250, 1600 Holloway Avenue, San Francisco, CA 94132. (Transcripts should be sent to the student and submitted either in person or by mail as one packet or they may be sent directly from colleges/universities to SFSU Graduate Admissions.) If you have already attended SFSU, you may not need to send transcripts. Please check with Graduate Admissions regarding their policies.

4. **TOEFL:** If you are an international student or if you have a bachelor’s degree from outside the United States, please contact the Graduate Admissions directly. There may be additional admission requirements for admission, such as the Test of English as a Foreign Language (TOEFL).

**B. CREDENTIAL PROGRAM REQUIREMENTS FOR ADMISSION**

1. **CREDENTIAL PROGRAM APPLICATION:** Applicants must also complete the Single Subject Credential Program Application. The application must include the items listed below:

2. **PROCESSING FEE:** Applicants should pay at the Bursar’s office prior to submitting the program application. The Bursar will print a receipt on the payment slip included in the program application. If applicant cannot pay in person at the Bursar’s office, a check or money order payable to SFSU can be included with the program application.

3. **TRANSCRIPTS:** Official transcripts must be included with the Credential Program application or sent by the school directly to the Credential Services Office. This is in addition to transcripts for the CSU Graduate/Post-baccalaureate application. Transcripts from outside the United States must be evaluated by an approved agency. Contact the Credentials Services Office for a list of agencies. We recommend that applicants collect all official transcripts and turn them in with the application, if at all possible. Transcripts of SFSU work can be unofficial copies from MySFSU. You must submit official transcripts of any coursework that does not appear on your SFSU transcript.

4. **DEGREE:** Applicants must have earned a bachelor’s degree or higher, except in professional education (i.e. secondary education), from a regionally accredited college or university. Applicants with degrees from outside the United States must have the equivalent of a bachelor’s degree from a United States regionally accredited institution. The degree must be awarded before enrolling in the credential program. If the degree is not awarded at the time of the application deadline, applicants must provide transcripts at the time of application and updated transcripts once the degree has been awarded.

5. **GPA:** Applicants for admission should have attained a grade point average of at least 2.67 in all baccalaureate and post baccalaureate coursework or a grade point average of at least 2.75 in the last 60 semester units or 90 quarter units.

6. **STATEMENT OF PURPOSE:** Applicants must submit a typed essay (1-3 pages). Some questions to consider when formulating your essay: Why do you want to be a teacher? What experiences have prepared you to teach in a linguistically diverse, urban setting? What personal qualities do you possess and what experiences have you had that have prepared you to work in a collaborative environment such as a high school or a cohort in the Single Subject Program?

7. **EARLY FIELD EXPERIENCE:** Applicants must demonstrate that they have fulfilled a minimum requirement of 45 hours of Early Field Experience prior to applying to the Single Subject Credential Program. This Early Field Experience requirement can be met by volunteering, substitute teaching, or working in a Single Subject, regular education classroom in a California public school, in an appropriate subject area. The classroom should be culturally and linguistically diverse, meaning that at least one third of the students are English Language Learners. This includes Ebonics speakers. The intention is for applicants to gain some exposure to and familiarity with the role of the teacher, the student age group, the current curriculum standards, and the public school environment. The experience should be within the last 5 years. Experiences in pre-schools, special education, higher education, religious education, or outside the U.S. will not meet this requirement.

A letter of recommendation from the teacher or supervising site administrator must verify this experience. The letter should briefly describe the classroom composition, including the cultural background of the students, and the classroom environment, including grade level and subjects taught. The letter should also state how the applicant was involved in the classroom, including qualitative comments about the applicant’s performance in the classroom, especially noting the applicant’s effectiveness in a linguistically and culturally diverse classroom. The letter should be on letterhead and have an original signature. A sample letter is attached. This letter also counts as one of the three required letters of recommendation.
8. LETTERS OF RECOMMENDATION: A minimum of three letters is required. The Early Field Experience letter can count as one of the three letters. Letter(s) should address the applicant's character, aptitude for teaching, work ethic, academic ability, etc. Additional letters beyond the required three will also be accepted to augment the application. Letters should be on letterhead and have original signatures. Letters from relatives and letters more than five years old will not be accepted. Applicants should collect all letters and include them with the rest of the application.

9. SUBJECT MATTER COMPETENCY: The Credential program does not provide further preparation in a subject area. Knowledge of the subject should be mastered before beginning a credential program. There are two ways applicants can prove their competency:

- Passing the required exams. All parts of the exam for your subject must be taken before the application deadline. Those with only partial passing scores will not be admitted. Photocopies of all exam scores should be included with the Credential Program Application, even if you have requested the scores sent to SFSU by the testing company. Exams vary by subject. See the CSET exam information and registration guide, http://www.cset.nesinc.com. All subject matter competency exam scores are valid for five years.

OR

- Completing an Approved Subject Matter Competency Program. To have your coursework assessed, please consult the list of advisors on page 12 and make an appointment. The form the advisor needs to complete is on page 13 of this document. Applicants must complete 100% of subject matter competency coursework to be admitted and begin the credential program.

If you have completed a subject matter competency program at another university, we must have an official, original form or letter with a Commission on Teacher Credentialing-approved signature verifying that you have met all subject matter program requirements in a program approved by the Commission on Teacher Credentialing.

If your subject area is not listed on the advisor list provided, then SFSU does not have an approved subject matter competency program for that area. Subject Matter Program evaluations can only be done by SFSU or the institutions from which you earned a BA. If neither institution has an approved program, consult the CTC for an alternate institution.

10. BASIC SKILLS REQUIREMENT: Choose one of the following options to fulfill this requirement:

A. CBEST (California Basic Skills Examination) Submit a photocopy of the results. For registration booklets, contact the SFSU Testing Center, ADM 152, 415.338-2271 or the Teacher Preparation Center, Burk Hall 244, 415/405-3594. It is also possible to register on-line: www.cbest.nesinc.com.

B. Out-of-State Basic Skills Exam. Submit a photocopy of the results. Not all states' Basic Skills Exams have been approved by the CTC. Contact the Teacher Preparation Center to find out if the test you took is approved. For more information on specific tests, contact the appropriate Department of Education for the state in which you want to take the test.


11. SECOND LANGUAGE REQUIREMENT: Applicants must show verification of experience learning a single second language obtained through one of the options described on page 8.

12. CERTIFICATE OF CLEARANCE: In accordance with California state law and Education code, all teaching credential applicants must go through a background check. All applicants must apply for a Certificate of Clearance with the Commission on Teacher Credentialing (CTC) OR submit proof of prior completion of the clearance. Acceptable documentation in lieu of a Certificate of Clearance: Valid credentials or permits issued by the California Commission on Teacher Credentialing, including emergency 30-day, pre-intern, emergency long-term, clear or preliminary, or Child Development permits. District or other job related clearance is not acceptable. Submit a photocopy of the document or a print-out from the Commission on Teacher Credentialing website https://teachercrd.ctc.ca.gov/teachers/index.jsp. For instructions on applying for the Certificate of Clearance see page 10.

13. TB TEST: TB test verification should be a photocopy of a note or card from a Doctor. A negative skin test or a letter from a doctor verifying a clean chest x-ray is acceptable. Test or x-ray evaluation should be within 12 months of program start date.

TUITION RATE
As of Fall 2008 the Credential Only status is no longer an option for incoming credential students. All credential students will be considered Secondary Education Master/Credential students. This designation is for university status purposes only. Credential students cannot work on a Secondary Education MA. Due to this status change, please be aware that ALL credential students will be paying tuition at the Graduate rate.

REQUIRED BEFORE A CREDENTIAL CAN BE GRANTED, IN ADDITION TO CREDENTIAL PROGRAM COURSEWORK:
These can be completed after admission, before completing the program.

- Completion of U.S. Constitution course or exam: Applicants must meet the U.S. Constitution requirement either by course work or examination. Those who earned a B.A. from a California State University campus have already met this requirement. Check with the Teacher Preparation Center to see if you have met this requirement. They can provide a list of testing options that meet this requirement.

- CPR: Must have current training in administering CPR to adults, children and infants at the time of application to the Commission on Teacher Credentialing

MA IN SECONDARY EDUCATION
The Department of Secondary Education also offers an MA Program in Secondary Education. To be eligible for this program you must have the following:

- A Preliminary or Clear Single Subject Credential
- A minimum of two years experience teaching in a single subject classroom
- For a list of other requirements please contact the Department of Secondary Ed.
**SINGLE-SUBJECT CREDENTIAL COURSE WORK OPTIONS**

The Single Subject Teaching Credential Program is designed to prepare qualified candidates with the course work and field experiences needed to enable them to effectively teach their subject in California public schools, particularly middle and high schools. The Department of Secondary Education prepares candidates to teach in the following subject areas: Art, English, **Foreign Language**, Mathematics, Music, Physical Education, Science, and Social Science. The SFSU Single Subject Credential Program is a one-year, full-time program when starting the program in the fall semester.

For course descriptions, consult the SFSU Bulletin, which can be found online or purchased in the bookstore. For class times and locations, consult the class schedule, available online.

**SINGLE SUBJECT CREDENTIAL PROGRAM OUTLINE – FALL START**
**TWO SEMESTER PROGRAM FOR FULL-TIME STUDENTS**

<table>
<thead>
<tr>
<th>FIRST SEMESTER FALL</th>
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<tbody>
<tr>
<td>Curriculum &amp; Instruction 1—discipline-based; see course number below</td>
<td>3 units</td>
</tr>
<tr>
<td>Subject Area-Course Number: English-ENG 713; Mathematics-S ED 759.01; Science-S ED 759.02; and Social Science-SED 759.03; Art-ART 650; Foreign Languages-FL 750; Music-MUS 760; and P.E.-KIN 750</td>
<td></td>
</tr>
<tr>
<td>Student Teaching 1 — Observation &amp; Participation</td>
<td>S ED 640 1 unit</td>
</tr>
<tr>
<td>Social, Cultural and Historical Foundations of Education</td>
<td>S ED 701 3 units</td>
</tr>
<tr>
<td>Literacy Across Content Areas</td>
<td>S ED 720 3 units</td>
</tr>
<tr>
<td>Classroom Environment</td>
<td>S ED 751 3 units</td>
</tr>
<tr>
<td>Adolescent Development</td>
<td>S ED 800 3 units</td>
</tr>
<tr>
<td>Computer Fundamentals for Teachers</td>
<td>ITEC 601 1 unit</td>
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<tr>
<th>SECOND SEMESTER SPRING</th>
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<tr>
<td>Curriculum &amp; Instruction — discipline-based; see course number below</td>
<td>3 units</td>
</tr>
<tr>
<td>Subject Area-Course Number: English-ENG 714; Mathematics-S ED 769.01; Science-S ED 769.02; and Social Science-SED 769.03; Art-ART 655; Foreign Languages-FL 751; Music-MUS 761; and P.E.-KIN 751</td>
<td></td>
</tr>
<tr>
<td>Student Teaching 2</td>
<td>S ED 660 7 units</td>
</tr>
<tr>
<td>Professional Perspectives &amp; Practices (cohort class must be taken concurrently with SED 660)</td>
<td>S ED 752 3 units</td>
</tr>
<tr>
<td>Second Language Development</td>
<td>S ED 790 3 units</td>
</tr>
<tr>
<td></td>
<td>16 total units</td>
</tr>
</tbody>
</table>
EMPLOYED TEACHER INTERN PROGRAM

The Intern program is a four-semester program held at the SFSU campus. All participants must be employed at least part-time as the teacher of record in their subject area and meet all internship credential requirements. All classes for the Employed Teacher Intern Program will be held after 4 p.m.

**FIRST YEAR — two courses per semester**

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social, Cultural and Historical Foundations of Education</td>
<td>S ED 701</td>
<td>3 units</td>
</tr>
<tr>
<td>Curriculum &amp; Instruction 1—subject specific; see course number below</td>
<td></td>
<td>3 units</td>
</tr>
<tr>
<td>Subject Area-Course Number: Art-Art 650; English-Eng 713; Foreign Languages-FL 750; Mathematics-S ED 759.01; Music-MUS 760; P.E.-KIN 750; Science-S ED 759.02; and Social Science-SED 759.03. Offered fall semester only for Art, Foreign Languages, Music, and Physical Education.</td>
<td></td>
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</tbody>
</table>

| Curriculum & Instruction 2—subject specific; see course number below |       | 3 units |
| Subject Area-Course Number: Art-Art 655; English-Eng 714; Foreign Languages-FL 751; Mathematics-S ED 769.01; Music-MUS 761; P.E.-KIN 751; Science-S ED 769.02; and Social Science-SED 769.03. Offered spring semester only for Art, Foreign Languages, Music, and Physical Education |       |       |
| Literacy Across Content Areas | S ED 720 | 3 units |

**SECOND YEAR — two courses per semester (plus Student Teaching)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second Language Development</td>
<td>S ED 790</td>
<td>3 units</td>
</tr>
<tr>
<td>Adolescent Development</td>
<td>S ED 800</td>
<td>3 units</td>
</tr>
<tr>
<td>Student Teaching 1/Observation &amp; Participation (concurrently with S ED 751)</td>
<td>S ED 640</td>
<td>1 unit</td>
</tr>
<tr>
<td>Classroom Environment</td>
<td>S ED 751</td>
<td>3 units</td>
</tr>
<tr>
<td>Student Teaching</td>
<td>S ED 660</td>
<td>7 units</td>
</tr>
<tr>
<td>Professional Perspectives &amp; Practices (cohort class must be taken concurrently with SED 660)</td>
<td>S ED 752</td>
<td>3 units</td>
</tr>
</tbody>
</table>

**EXTRA REQUIREMENTS FOR INTERN APPLICANTS:**

- **Proof of Employment:** Applicants must submit approved proof of employment as teacher of record in their own classroom.

- **Completion of U. S. Constitution course or exam:** Applicants must meet the U.S. Constitution requirement either by course work or examination. Graduates from a California State University campus have already met the requirement. Check with the Teacher Preparation Center to see if you have met this requirement. They can provide a list of testing options that meet this requirement.
Second Language Requirement Candidates must show verification of experience learning a single second language obtained through one of the options described below:

A. Completion of 1-6 semester units (or 1-9 quarter units) in course work that emphasizes the learning of a language other than English (including American Sign Language). A grade of "C" or better, "Pass," or "Credit," must be earned in each course, verified by an official transcript from a regionally accredited college or university, or comparable institution outside the United States. Professional Development and Continuing Education units from such institutions are acceptable.

B. Successful completion of two years of course work in a language other than English in grades seven (7) through twelve (12) in a public or private secondary school with an average grade of C or better, verified by an official transcript or a letter from the school.

C. Successful completion of the training in a language other than English given by the Peace Corps to volunteers preparing to serve in a non-English speaking country, verified by official Peace Corps documentation.

D. Immigrating to the United States from a non-English speaking country at any age, verified by a birth certificate, passport, entry visas, or other documents.

E. Passage of any nationally administered, standardized examination in a language other than English, verified by an official score report.

F. A proficiency level of "novice-high" or above on the American Council on the Teaching of Foreign Languages, Inc. (ACTFL) Proficiency Guidelines or "0+" (zero plus) or above on the Interagency Language Roundtable (ILR) Proficiency Descriptions, verified by an official score report.

G. A score on a College-Level Examination Program (CLEP) examination in a language other than English administered by the College Board equal to or higher than the minimum score recommended by the American Council on Education for awarding credit for two semesters, verified by an official score report.

H. Residence in a non-English speaking country or countries for twelve consecutive months at age 18 or older, verified by passports, work visas, letters from employers, or other documents.

I. Successful completion of one academic year (over a single period) at age 14 or above at a school in which all instruction, except in the subject area of English, was delivered in a language other than English, verified by an official transcript or a letter from the school.

J. Successful completion of two academic years in a non-English language development school program. Must be verified by letter or transcript. (e.g. Chinese language after-school or Saturday language program)

K. Achievement of a score on the Advanced Placement Examination in a language other than English offered by Educational Testing Service for which college credit or advanced standing is awarded, verified by either an official transcript or a letter from the registrar's or admission's office from a regionally accredited institution of higher education.

L. Completion of 90 hours of language training, with a grade of "C" or better or the equivalent, in a language other than English offered under the auspices of the California Department of Education's Bilingual Teacher Training Program (BTTP) or by a county office or school district whose program, prior to its implementation, has been deemed equivalent to the BTTP by the California Department of Education. This training is to be verified by a letter signed by an authorized representative of the BTTP or county or district program.
MISSION High School
3750 18th Street
San Francisco, CA 94114
Phone: (415) 241-6240

March 3, 2007

To whom it may concern:

I am writing to verify that ____ (applicant name) ____ has volunteered for at least 45 hours in my ___ grade classroom since ____ (date) ____. My classroom is comprised of diverse students, primarily Hispanic/Latino, but also including Asian American, African American and Filipino-American students. My students also have diverse needs, such as ____________________.

I am also writing to evaluate (applicant’s) performance. There are several ways in which s/he has helped in my classroom: ____________________, ____________________, and ____________________. I observed (applicant) interacting with students and noticed that _______. Based on his/her performance in my class, I believe that (applicant) has the potential to be an effective teacher because of the following qualities: ____________________, ____________________, and ____________________. One area that (applicant) might focus on for improvement is ____________________. Finally, I would like to note that (applicant) demonstrated a (fair/good/excellent) work ethic. For example, ____________________.

If you have further questions, please do not hesitate to contact me at (415) 123-4567 or teacher@yahoo.com.

Sincerely,

A. Teacher

SAMPLE   SAMPLE   SAMPLE
CERTIFICATE OF CLEARANCE ONLINE APPLICATION INSTRUCTIONS

HAVE YOUR FINGERPRINTS TAKEN VIA LIVESCAN

- Print three (3) copies of the LiveScan form: http://www.ctc.ca.gov/credentials/leaflets/41-LS.pdf
  You must use the CCTC LiveScan form. If you had your fingerprints taken at a district or for another type of job, these will
  NOT be electronically submitted to the CCTC.

- Visit a LiveScan Operator — usually a $60-$80 charge.
  o SFSU Department of Public Safety – call 415.338.7200 for an appointment.
  OR
  o See the State Attorney General’s website for a list of LiveScan operators by county:
    http://www.ag.ca.gov/fingerprints/publications/contact.htm

COMPLETE THE ONLINE APPLICATION AT THE CCTC WEBSITE

- Go to: http://www.ctc.ca.gov

- Click the link Look up a Credential.

- On the next page, click on Direct Application.

- Fill in the required fields and click the Continue button until the application is completed.

- Pay the fee — $29.50

- Print out verification that you completed the application for your personal records.

- Once your COC is processed it can be printed from the internet. After two weeks, log in to the Credential Look-up on the
  CCTC website: https://teachercred.ctc.ca.gov/teachers/PersonalSearchProxy. If yours does not appear keep checking this
  site.

- Submit a copy of the Certificate of Clearance to the Credential Admissions Office. Please do NOT submit the
  “Printer Friendly” copy. The document needs to list: your name, the document number and the issuance date.
<table>
<thead>
<tr>
<th>Office Name</th>
<th>Students can:</th>
<th>Location/hours</th>
<th>Phone, fax, web, email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Preparation Center</td>
<td>• ask general questions about teacher credentialing</td>
<td>Burk Hall 244</td>
<td>P: 415-405-3594</td>
</tr>
<tr>
<td>Credential Services</td>
<td>• view job/volunteer opportunity postings</td>
<td>M-Th 10-12 and 1-4:30</td>
<td>F: 415-338-940</td>
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<tr>
<td>Admissions &amp; Analysts</td>
<td>• pick up or drop off an application for admission to the credential program</td>
<td>F 1-3</td>
<td><a href="mailto:credinfo@sfsu.edu">credinfo@sfsu.edu</a></td>
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<tr>
<td></td>
<td>• view their credential program file</td>
<td></td>
<td><a href="http://www.sfsu.edu/~estpc">www.sfsu.edu/~estpc</a></td>
</tr>
<tr>
<td></td>
<td>• apply to the CCTC for a credential</td>
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<tr>
<td>Cahill Learning Resource</td>
<td>• view and check out books and videos, including curriculum and lesson plan</td>
<td>Burk Hall 319</td>
<td>P: 415-338-3423</td>
</tr>
<tr>
<td>and Media Lab</td>
<td>guides, children's literature, education theory books and professional</td>
<td>M, T 1-7 p.m. W, Th 1-6 p.m. F 1-5 p.m.</td>
<td>coe.sfsu.edu/cahill/index.htm</td>
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<td>• use media equipment</td>
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<td>• use space to study work on group projects</td>
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<tr>
<td>College of Education</td>
<td>• get scholarship information</td>
<td>Burk Hall 240</td>
<td>P: 415-338-2051</td>
</tr>
<tr>
<td>Graduate Office</td>
<td>• turn in GAP forms</td>
<td>M-F 1-5</td>
<td><a href="mailto:retta@sfsu.edu">retta@sfsu.edu</a></td>
</tr>
<tr>
<td></td>
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<td><a href="http://www.sfsu.edu/~coe/coe/gradoffice.html">www.sfsu.edu/~coe/coe/gradoffice.html</a></td>
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<td><a href="http://www.sfsu.edu/~coe/coe/scholarships.html">http://www.sfsu.edu/~coe/coe/scholarships.html</a></td>
</tr>
<tr>
<td>Department of Secondary</td>
<td>• make an appt. with the Department Chair</td>
<td>Burk Hall 41</td>
<td>P: 415-338-1201</td>
</tr>
<tr>
<td>Education</td>
<td>• drop off something for faculty mail boxes</td>
<td>M W Th F</td>
<td>F: 415-338-914</td>
</tr>
<tr>
<td></td>
<td>• get SED course information</td>
<td>9-1 p.m.</td>
<td><a href="mailto:seconded@sfsu.edu">seconded@sfsu.edu</a></td>
</tr>
<tr>
<td>Graduate Division</td>
<td>• check the status of their student standing</td>
<td>GradStop in Admin Bldg 250</td>
<td>P: 415-338-2234</td>
</tr>
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<td></td>
<td></td>
<td>M-F 9-5</td>
<td>F: 415-405-0340</td>
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<td></td>
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<td></td>
<td><a href="mailto:gradstdy@sfsu.edu">gradstdy@sfsu.edu</a></td>
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<td><a href="http://www.sfsu.edu/~gradstdy">www.sfsu.edu/~gradstdy</a></td>
</tr>
<tr>
<td>Financial Aid</td>
<td>• get help with state and federal financial aid programs</td>
<td>One Stop in Student Service Bldg.</td>
<td>P: 415-338-7000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M-Th 8:30-7:00 F 8:30-5:00</td>
<td>F: 415-405-0340</td>
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<td><a href="http://www.sfsu.edu/~finaid">www.sfsu.edu/~finaid</a></td>
</tr>
<tr>
<td>Bursar's Office</td>
<td>• pay registration and other fees</td>
<td>Administration Building 155 or One</td>
<td>P: 415-338-1281</td>
</tr>
<tr>
<td></td>
<td>find out deadlines and directions for payment</td>
<td>Stop, Student Services (check web for</td>
<td><a href="http://www.sfsu.edu/~bursar/welcome.htm">www.sfsu.edu/~bursar/welcome.htm</a></td>
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<td></td>
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<td>hours)</td>
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<tr>
<td>Career Center</td>
<td>• view job postings</td>
<td>Student Services Bldg. 206</td>
<td>P: 415-338-1761</td>
</tr>
<tr>
<td></td>
<td>• get resume help</td>
<td>M-F 8:30-4:30 Alan Fisk has office</td>
<td><a href="http://www.sfsu.edu/~career">www.sfsu.edu/~career</a></td>
</tr>
<tr>
<td></td>
<td>• get career fair information</td>
<td>hours Tues 3:30-5 p.m. in BH 238</td>
<td>also <a href="http://www.edjoin.org">www.edjoin.org</a> has job listings for most districts and</td>
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<td></td>
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<td>charter schools in California</td>
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## SUBJECT MATTER COMPETENCY ADVISORS

<table>
<thead>
<tr>
<th>Subject Area</th>
<th>Dept. Office</th>
<th>Dept. Phone</th>
<th>Advisor</th>
<th>Phone</th>
<th>Office</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>ART</td>
<td>FA 265</td>
<td>338-2176</td>
<td>Julia Marshall</td>
<td>338-1785</td>
<td>FA 282</td>
<td><a href="mailto:jmarshall@sfu.edu">jmarshall@sfu.edu</a></td>
</tr>
<tr>
<td>BIOLOGY</td>
<td>HH 534</td>
<td>338-1548</td>
<td>S. Pasion (sabbatical Sp 09)</td>
<td>405-0756</td>
<td>HH668</td>
<td><a href="mailto:pasion@sfu.edu">pasion@sfu.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S. Williams</td>
<td>338-1655</td>
<td>HH216</td>
<td><a href="mailto:williams@sfu.edu">williams@sfu.edu</a></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C. Domingo</td>
<td>338-6955</td>
<td>HH 705</td>
<td><a href="mailto:cdomingo@sfu.edu">cdomingo@sfu.edu</a></td>
</tr>
<tr>
<td></td>
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<td></td>
<td>G. LeBuhn (sabbatical 07-08)</td>
<td>405-0729</td>
<td>HH 741</td>
<td><a href="mailto:lebuhn@sfu.edu">lebuhn@sfu.edu</a></td>
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<tr>
<td></td>
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<td><a href="http://online.sfu.edu/~pasion/AdvisingWeb/generalbiology.htm#subject">http://online.sfu.edu/~pasion/AdvisingWeb/generalbiology.htm#subject</a></td>
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<tr>
<td>ENGLISH</td>
<td>HUM-285</td>
<td>338-2264</td>
<td>English Teacher Resource</td>
<td>405-2454</td>
<td>HUM 289</td>
<td><a href="mailto:etrac@sfu.edu">etrac@sfu.edu</a></td>
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<td>Advising Center</td>
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<td></td>
<td>Nelson Graff</td>
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<tr>
<td>LANGUAGE OTHER THAN ENGLISH</td>
<td>Classics</td>
<td>338-2068</td>
<td>David Leitao</td>
<td>338-7444</td>
<td>HUM 376</td>
<td><a href="mailto:dleitao@sfu.edu">dleitao@sfu.edu</a></td>
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<tr>
<td>LATIN</td>
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<tr>
<td>FRENCH</td>
<td>Foreign</td>
<td>338-1421</td>
<td>Delphine Perret</td>
<td>338-6061</td>
<td>HUM 535</td>
<td><a href="mailto:dperret@sfu.edu">dperret@sfu.edu</a></td>
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<td>Languages</td>
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<tr>
<td>GERMAN</td>
<td>Foreign</td>
<td>338-1106</td>
<td>Ilona Vandergriff</td>
<td>338-1106</td>
<td></td>
<td><a href="mailto:vgriff@sfu.edu">vgriff@sfu.edu</a></td>
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<td>ITALIAN</td>
<td>Foreign</td>
<td>338-3161</td>
<td>Christopher Concolino</td>
<td>338-3161</td>
<td>HUM 459</td>
<td><a href="mailto:concoco@sfu.edu">concoco@sfu.edu</a></td>
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<td>JAPANESE</td>
<td>Foreign</td>
<td>338-7451</td>
<td>Mashiko Minami</td>
<td>338-7451</td>
<td>HUM 339</td>
<td><a href="mailto:mmminami@sfu.edu">mmminami@sfu.edu</a></td>
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<tr>
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<td>Languages</td>
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<tr>
<td>CHEMISTRY</td>
<td>TH-806</td>
<td>338-1288</td>
<td>Peter Palmer</td>
<td>338-7717</td>
<td>TH 730</td>
<td><a href="mailto:palmer@sfu.edu">palmer@sfu.edu</a></td>
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<tr>
<td>GEOSCIENCES</td>
<td>TH 509</td>
<td>338-2061</td>
<td>John Caskey</td>
<td>405-0533</td>
<td>TH 616</td>
<td><a href="mailto:caskey@sfu.edu">caskey@sfu.edu</a></td>
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<tr>
<td>MATHEMATICS</td>
<td>TH-937</td>
<td>338-2251</td>
<td>Robert Marcucci</td>
<td>338-2661</td>
<td>TH 945</td>
<td><a href="mailto:marcucci@math.sfu.edu">marcucci@math.sfu.edu</a></td>
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<tr>
<td>MUSIC</td>
<td>CA-214</td>
<td>338-1431</td>
<td>Wendell Hanna</td>
<td>405-0487</td>
<td>CA 262</td>
<td><a href="mailto:whanna@sfu.edu">whanna@sfu.edu</a></td>
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<td>PHYSICAL</td>
<td>GYM-101</td>
<td>338-1258</td>
<td>Christine Summerford</td>
<td>338-1599</td>
<td>GYM 128</td>
<td><a href="mailto:summer@sfu.edu">summer@sfu.edu</a></td>
</tr>
<tr>
<td>EDUCATION</td>
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<tr>
<td></td>
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<td></td>
<td>Claudia Guedes</td>
<td>338-2160</td>
<td>GYM 134</td>
<td><a href="mailto:cguedes@sfu.edu">cguedes@sfu.edu</a></td>
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<tr>
<td>PHYSICAL</td>
<td>338-1258</td>
<td></td>
<td>Christine Summmerford</td>
<td>338-1599</td>
<td>GYM 128</td>
<td><a href="mailto:summer@sfu.edu">summer@sfu.edu</a></td>
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<td>P.E: Concentration:</td>
<td>CA 140</td>
<td>338-1431</td>
<td>Albirda Rose</td>
<td>338-2100</td>
<td>FA 435</td>
<td><a href="mailto:birdrose@sfu.edu">birdrose@sfu.edu</a></td>
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<tr>
<td>DANCE</td>
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<td></td>
<td></td>
<td></td>
<td>Susan Whipp</td>
<td>338-6374</td>
<td>CA 162</td>
<td><a href="mailto:swwhipp@sfu.edu">swwhipp@sfu.edu</a></td>
</tr>
<tr>
<td>PHYSICS</td>
<td>TH-334</td>
<td>338-1659</td>
<td>James Lockhart</td>
<td>338-2451</td>
<td>TH 520</td>
<td><a href="mailto:lockhart@stars.sfu.edu">lockhart@stars.sfu.edu</a></td>
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<td>SOCIAL SCIENCE</td>
<td>SCI-276</td>
<td>338-1604</td>
<td>obtain a Social Sciences work sheet in SCI 276 or online:</td>
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<td></td>
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<td>Richard Hoffman</td>
<td>338-1604</td>
<td>SCI 276</td>
<td><a href="mailto:rhoffman@sfu.edu">rhoffman@sfu.edu</a></td>
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<tr>
<td></td>
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<td>Abdol Oñate</td>
<td>338-6177</td>
<td>SCI 220</td>
<td><a href="mailto:onate@sfu.edu">onate@sfu.edu</a></td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Sherry Keith (sabbatical Fall 08)</td>
<td>338-1317</td>
<td>SCI 267B</td>
<td><a href="mailto:skeithe@sfu.edu">skeithe@sfu.edu</a></td>
</tr>
</tbody>
</table>

*If a subject is not listed, SFSU does not have an approved program at this time. Subject Matter Program evaluations can be done only by the institution at which the student earned the BA or the institution at which the credential program is being completed. If neither institution has an approved subject matter program consult the CCTC for an appropriate institution.*
SUBJECT MATTER COMPETENCY REVIEW

This form is to be completed by subject matter competency advisor.

Applicant Name ____________________________  UIN ___________-

Subject Area ________________________________

COURSEWORK COMPLETED

<table>
<thead>
<tr>
<th>SFSU COURSE</th>
<th>DEPT. &amp; COURSE #</th>
<th>COURSE TITLE</th>
<th>UNITS</th>
<th>GRADE</th>
<th>TERM</th>
<th>INSTITUTION (other than SFSU)</th>
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COURSEWORK IN PROGRESS (SHOW PROOF OF ENROLLMENT)

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</table>

☐ Has completed 100% of Commission-approved subject-matter program requirements

☐ Will meet 100% of Commission-approved subject matter program requirements upon satisfactory completion of coursework currently in progress. (proof of enrollment must be attached)

☐ Has not yet completed subject matter program requirements.

TOTAL UNITS _______ GPA (Of subject matter courses. Must be at least 2.75): _________

Signature of Subject Area Advisor _______________  Print Name ______________________  Date __________

**Students who will not be attending SFSU’s credential program need to get an accompanying letter from the SFSU Credential Services office (BH 238, 338-1758) to submit to their chosen credential program. The Credential Services office charges a $25.00 fee for the letter.**
DEADLINES

February 15: Start in FALL semester*

For an explanation of requirements, see the "General Information" document.

A complete application consists of the following:

A. CSU Graduate/Post-baccalaureate application (completed online at www.csumentor.com)

B. Single Subject Credential program Application
   1. Single Subject Credential Program Application pages 1 and 2
   2. Processing Fee $25.00
   3. Official transcripts from all colleges or universities attended
   4. Bachelor's Degree must be posted before starting the program
   5. GPA (2.67 overall or 2.75 in last 60 semester units)
   6. Statement of Purpose
   7. Early Field Experience in classroom setting
   8. Letters of recommendation (minimum of three)
   9. Subject Matter Competency Requirement
   10. Basic Skills Requirement
   11. Second Language Requirement
   12. Certificate of Clearance
   13. Negative TB test completed within 12 months of program start

Turn in ALL application materials together in one packet by the deadline.

Make certain your full name appears clearly on every document.

SUBMIT ALL APPLICATION MATERIALS TO:

Credential Services Office ATTN: Credential Admissions
College of Education - Burk Hall 244
San Francisco State University
1600 Holloway Avenue
San Francisco, CA 94132-4158

*This deadline is the same date from year to year. If the deadline falls on a weekend, department applications will be accepted until 5:00 p.m. the next working day following the deadline. Please note that Graduate Division applications must be submitted online on or before the deadline regardless of what day the deadline falls.
Start semester: Fall ☐☐☐☐

General Information
SSN #: ☐☐☐☐-☐☐☐☐-☐☐☐☐☐☐ Date of birth: ☐☐/☐☐/☐☐☐☐
SFSU ID #: ☐☐☐☐☐☐☐☐☐☐

Name first middle last

Current Address number and street city/state zip

Permanent Address number and street city/state zip

Email
Home Phone ☐☐☐☐-☐☐☐☐☐☐ Work Phone ☐☐☐☐-☐☐☐☐☐☐☐☐☐☐

Ethnic identity code*: ☐☐ Male ☐☐ Female ☐☐

*Your response is voluntary and will not affect your admission

Academic Information
Status at SFSU at time of admission to the selected program (CHECK ONE ONLY!):
☐ New graduate student (CSU Graduate/Postbaccalaureate Application submitted to SFSU Graduate Admissions Office (ADM 254).

Date submitted: ☐☐/☐☐/☐☐☐☐ (mm/dd/yyyy)

☐ Already enrolled graduate student - enrolled as __________________________ major

Degrees earned or in progress:
Bachelor's Degree: Date (to be) granted ☐☐/☐☐/☐☐☐☐ Institution __________________________
Academic Major __________________________

Master's Degree: Date (to be) granted ☐☐/☐☐/☐☐☐☐ Institution __________________________
Academic Major __________________________

Applicant Signature
I have read and understood the instructions and information given to me in this document. All information I am submitting is true and correct.
Name: __________________________ Date: __________________________

Rev. 9/12/2008
Macintosh HD:Users:laura:Desktop:SSPapp.doc

000051
Single Subject Program Options

Please indicate your choice below: (Check ONE ONLY!)

Programs will be offered dependent on Commission on Teacher Credentialing approval.

☐ Regular Day Program, High School Emphasis  ☐ Regular Day Program, Middle School Emphasis (Fall start only)
☐ Intern Program  (must include contract of employment)

Within our Single Subject Credential Program, which one of the following authorized subject fields do you intend to qualify? Please indicate your choice below: Check ONE ONLY!

☐ Art
☐ English
☐ Foreign Language _______________ (specify)
☐ Mathematics
☐ Mathematics-Foundation level
☐ Music
☐ Physical Education

Subject Matter Competency met through ☐ course work OR ☐ examination

Statement of Purpose

Type a personal narrative (no more than 3 pages, double-spaced) in which you explain why you want to be a teacher. What experiences have prepared you for this? What experiences have prepared you to teach in an urban setting with culturally and linguistically diverse students in under-achieving schools?

Second Language Requirement

_____ Option (A – L) (Refer to page 6 of General Information for full description of options)

Type of Documentation submitted as verification of above listed option: ________________________________

SFSU College of Education Credential Program File Use and Storage Policy

All materials submitted to San Francisco State University (SFSU) become the property of SFSU and will not be returned. SFSU will not make photocopies or otherwise duplicate materials for applicants' personal use. Applicants should make copies for personal use before submitting materials to SFSU. Applicants may access their credential file for viewing or to make copies at their own expense during the Teacher Preparation Center's office hours in Burk Hall 244. Applicants must show photo ID to access their file.

Files of applicants who were denied entrance to a program or who chose not to enroll in the program the semester for which they were admitted will be kept for one year. Requests to reapply and have previous applications reconsidered for future semesters must be made in writing and submitted according to published application deadlines.

Upon being recommended by SFSU to the California Commission on Teacher Credentialing for award of a Preliminary or Professional Clear credential, all materials not directly related to the application for the credential or SFSU accreditation will be destroyed.

A record of the application and recommendation for the Preliminary or Clear credential and supporting documents will be stored for 7 years.

Consult the San Francisco State University Registrar for information about San Francisco State University transcript policies.
Early Field Experience

Title 5 Regulations from the California State University Chancellor's Office requires each credential candidate to have participated in a supervised Early Field Experience in a school setting prior to application to a credential program. The Early Field Experience is designed to simulate the credential you are seeking so we may gain a preliminary assessment of your potential as a classroom teacher. Thus, the classroom must be in any single subject in single subject, general education classroom setting. However, the subject area need not be the same as your subject area. Completion of your field experience must be documented by submitting this signed form. In addition, the quality of your work must be evaluated in letter of recommendation from a teacher or administrator.

DOCUMENTATION OF EARLY FIELD EXPERIENCE: SFSU permits a variety of options in meeting this requirement. Below, please indicate which option you have met. The bottom of this page must be signed and submitted with your application to verify completion of the Early Field Experience.

1. Completion of 45 hours paid experience as a teacher aide or teacher assistant the majority of which time has been direct or indirect contact with students. The classroom teacher, a site administrator or a district administrator may verify this.

2. Completion of 45 hours as a classroom teacher either in a public school with an emergency permit, as a substitute teacher, or in a private school as verified by an administrator.

3. Completion of 45 hours working with students as a volunteer in a regular education classroom with a credentialled teacher. The classroom teacher would verify this experience.

4. Successful completion of any course or courses which have a field experience in which you worked with children or young adults. Please note course(s) and include a copy of transcript and/or course description for verification, as well as a letter from a teacher or site administrator.

Applicant Name____________________________________ SFSU ID ___________________________

School Name________________________ (School) __________________________ (City)

Grade Level(s)________________________ Inclusive Dates: __________________________

Environment:  □ Bilingual  □ Limited English Proficient (at least 35% of class)

□ Public school  □ Private school  □ All fluent English speakers

□ Urban □ Suburban □ Rural

Teacher or administrator signature __________________________ Print name and position __________________________
SFSU College of Education
ADMISSIONS APPLICATION FEE

LAST NAME

FIRST

TELEPHONE NUMBER

SFSU I.D. NUMBER

SEMESTER

PAY AT CASHIER
Student Services Building, 1st floor.
SFSU Bursar’s Office
SAN FRANCISCO STATE UNIVERSITY
1600 Holloway Avenue
San Francisco, CA 94132-4158
415-338-1281

ACTION
Fee
ACCOUNT
Application for Admission $25 73480

Please return PAID receipt with completed application to:

Credential Admissions, BH 244
College of Education
San Francisco State University
1600 Holloway Avenue
San Francisco, CA 94132-4158

THIS AREA IS FOR SFSU BURSAR OFFICE USE ONLY
Appendices for Standards:

Standard 8: Advisement and Support
Biology Advising Information

This web page provides general information and links to additional web pages of interest to SFSU Biology majors. An SFSU Biology Major should meet with his/her major-specific Biology Advisor on a regular basis to ensure timely progress to the baccalaureate degree. **ALWAYS BRING YOUR UNOFFICIAL SFSU TRANSSCRIPTS, DARS/ASE, AND FORMS WHEN YOU MEET WITH YOUR MAJOR-SPECIFIC ADVISOR.**

**Biology Advising for Summer 2008:**
If you wish to meet with a Biology Advisor during the summer, please make sure that you
- **STOP** at the Department of Biology Office HH534
- **PICK UP** the BIOLOGY ADVISING CHECKLIST or DOWNLOAD the Biology Advising Checklist (click here to download) BEFORE you visit the Summer Biology Advisor.
- **READ** the BIOLOGY ADVISING CHECKLIST
- **BRING** all the required paperwork indicated in the Checklist for your meeting with your Advisor.

<table>
<thead>
<tr>
<th>Summer Biology Advisors (as of 7/11/08)</th>
<th>PLEASE CHECK SCHEDULE REGULARLY FOR UPDATED OFFICE HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter Ingmire</td>
<td>Sally Pasion</td>
</tr>
<tr>
<td><a href="mailto:ping@sfsu.edu">ping@sfsu.edu</a></td>
<td><a href="mailto:pasion@sfsu.edu">pasion@sfsu.edu</a></td>
</tr>
<tr>
<td>HSS351</td>
<td>HH668C</td>
</tr>
<tr>
<td><strong>Office Hours</strong></td>
<td><strong>Office Hours</strong></td>
</tr>
<tr>
<td>7/14 – 7/28:</td>
<td>DROP-IN OFFICE</td>
</tr>
<tr>
<td>Mondays and Thursdays</td>
<td>HOURS...FIRST COME, FIRST SERVED</td>
</tr>
<tr>
<td>10:30am-12:30pm</td>
<td>7/14 to 7/31:</td>
</tr>
<tr>
<td>Thursday, 8/14, 10:30am-12:30pm</td>
<td>Mondays and Thursdays, 12noon - 2pm</td>
</tr>
<tr>
<td>Tues, 8/19, and Wed, 8/20, 2-4pm</td>
<td>Mon 8/18, and Wed 8/20, 12noon - 2pm</td>
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</table>

**Additional Advising Information**

NEW! **Recommended Chemistry Sequence for Biology Majors** (pdf)
Download a flow chart of the recommended order to complete the required Chemistry courses for all Biology Majors.

**Graduation Checklists for Biology Majors**

**Summer 2008** Graduating students must fill out an ONLINE SURVEY—see the Graduation Checklist web page!

**Information for TRANSFER STUDENTS**

SFSU Bulletin description of Biology Degree Programs

**Biology Major Advisors**

**Department of Biology**

Search SFSU

http://online.sfsu.edu/~pasion/AdvisingWeb/biologyadvising.htm
### Department of Biology Equivalency form
*(pdf, Adobe Acrobat reader required)*

| Beginning Fall 2004, Biol 313 Principles of Ecology not accepted for Biology degree |
| Interested in Teaching K-12 Biology? Single Subject Credential in Biological Sciences |
| Class Schedule |

**Department of Biology Majors Requirements**

**Health Professions at SFSU home page**

**Biology Course descriptions**

*NSF Noyce Scholarship Opportunity for Spring and Fall 2007 for students preparing to become K-12 science or mathematics teachers!! Click here for more information*

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**Typical reasons to see your Biology Advisor:**

1. Learn more about a specific biology major
2. Develop a course plan. **NEW 4-year Course Plans AVAILABLE**
3. Obtain approval for transfer courses or substitution courses **Lower Division Articulation chart**
4. Improve your performance in your courses
5. Change your major **ATTENTION UNDECLARED MAJORS**
6. Obtain approval on an academic advising petition **ATTENTION PROBATION STUDENTS**
7. Obtain approval for Financial Aid Graduation Plan
8. Obtain approval on your baccalaureate graduation application
9. Obtain Advanced Placement credit towards your major
10. Organic Chemistry requirement: Chem 130 or Chem 333?
11. Obtain approval to take a course at SFSU Consortium campuses (including UCSF and UC Berkeley) for major credit

---

Please click on the following links if you are interested in:

- B.A., General Biology
- Minor in Biology
- Subject Matter Competency/Single Subject Credential in Biological Sciences

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As of Fall 2004, Biol 313 Principles of Ecology has restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Biol 482 Ecology has revised course content and serves as a broad Ecology course intended for Biology majors. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree **(PLEASE CHECK WITH YOUR BIOLOGY ADVISOR).**
# ADVISORS Fall 2007 Dept. of Biology

## Botany

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone No</th>
<th>Office</th>
<th>Email Address</th>
<th>Office Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. Desjardins</td>
<td>338-6995</td>
<td>HH 705</td>
<td><a href="mailto:cdonel@fasu.edu">cdonel@fasu.edu</a></td>
<td>Mon 10-11, Wed 9-10</td>
</tr>
<tr>
<td>W. Desclaux</td>
<td>338-6995</td>
<td>HH 705</td>
<td><a href="mailto:cdonel@fasu.edu">cdonel@fasu.edu</a></td>
<td>Mon 10-11, Wed 9-10</td>
</tr>
<tr>
<td>Z. He</td>
<td>338-6995</td>
<td>HH 705</td>
<td><a href="mailto:cdonel@fasu.edu">cdonel@fasu.edu</a></td>
<td>Mon 10-11, Wed 9-10</td>
</tr>
<tr>
<td>C. Smith</td>
<td>338-6995</td>
<td>HH 705</td>
<td><a href="mailto:cdonel@fasu.edu">cdonel@fasu.edu</a></td>
<td>Mon 10-11, Wed 9-10</td>
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## Clinical Science

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<tbody>
<tr>
<td>D. Smith-Beckman</td>
<td>338-3467</td>
<td>SCI 277</td>
<td><a href="mailto:dmphilip@fasu.edu">dmphilip@fasu.edu</a></td>
<td>Tues 11-12, Thurs 11-12</td>
</tr>
<tr>
<td>S. Weinstein</td>
<td>338-1843</td>
<td>SCI 277</td>
<td><a href="mailto:steinwt@fasu.edu">steinwt@fasu.edu</a></td>
<td>Tues 11-12, Thurs 11-12</td>
</tr>
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## Ecology

<table>
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</thead>
<tbody>
<tr>
<td>E. Conner</td>
<td>338-6995</td>
<td>HH 705</td>
<td><a href="mailto:eec@fasu.edu">eec@fasu.edu</a></td>
<td>Mon 1:30-2:30, Tues 3:30-5:30, Thurs 3:30-5:30</td>
</tr>
</tbody>
</table>

## Marine & Limnology

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<tr>
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<td>338-6995</td>
<td>HH 705</td>
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<tr>
<td>Z. He</td>
<td>338-6995</td>
<td>HH 705</td>
<td><a href="mailto:cdonel@fasu.edu">cdonel@fasu.edu</a></td>
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<tr>
<td>C. Smith</td>
<td>338-6995</td>
<td>HH 705</td>
<td><a href="mailto:cdonel@fasu.edu">cdonel@fasu.edu</a></td>
<td>Mon 10-11, Wed 9-10</td>
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</table>

## Microbiology

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<tbody>
<tr>
<td>J. Chen</td>
<td>338-3719</td>
<td>HH 668B</td>
<td><a href="mailto:jchen@fasu.edu">jchen@fasu.edu</a></td>
<td>Wed 4-6pm By Appt.</td>
</tr>
<tr>
<td>S. Smith-Beckman</td>
<td>338-3467</td>
<td>SCI 277</td>
<td><a href="mailto:dmphilip@fasu.edu">dmphilip@fasu.edu</a></td>
<td>Tues 11-12, Thurs 11-12</td>
</tr>
<tr>
<td>S. Weinstein</td>
<td>338-1843</td>
<td>SCI 277</td>
<td><a href="mailto:steinwt@fasu.edu">steinwt@fasu.edu</a></td>
<td>Tues 11-12, Thurs 11-12</td>
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## Physiology

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<tbody>
<tr>
<td>J. Bressler</td>
<td>338-3340</td>
<td>HH 426</td>
<td><a href="mailto:jbressler@fasu.edu">jbressler@fasu.edu</a></td>
<td>Tues 3-4pm By Appt.</td>
</tr>
<tr>
<td>C. Moffatt</td>
<td>338-1831</td>
<td>HH 420</td>
<td><a href="mailto:cmooffatt@fasu.edu">cmooffatt@fasu.edu</a></td>
<td>Wed 4-6pm By Appt.</td>
</tr>
<tr>
<td>B. Rothman</td>
<td>338-2948</td>
<td>HH 221</td>
<td><a href="mailto:broothman@fasu.edu">broothman@fasu.edu</a></td>
<td>Wed 4:30</td>
</tr>
<tr>
<td>J. Stillman</td>
<td>338-7144</td>
<td>HH 425</td>
<td><a href="mailto:jstillman@fasu.edu">jstillman@fasu.edu</a></td>
<td>Wed 4-6pm By Appt.</td>
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## Zoology

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<tbody>
<tr>
<td>J. Hafenik</td>
<td>338-3740</td>
<td>HH 426</td>
<td><a href="mailto:jhafenik@fasu.edu">jhafenik@fasu.edu</a></td>
<td>Wed 9-10, Thurs 9-10</td>
</tr>
<tr>
<td>E. Rostman</td>
<td>338-1196</td>
<td>HH 761</td>
<td><a href="mailto:erostman@fasu.edu">erostman@fasu.edu</a></td>
<td>Mon 12-2pm By Appt.</td>
</tr>
<tr>
<td>G. Spicker</td>
<td>338-6756</td>
<td>HH 755</td>
<td><a href="mailto:gspicker@fasu.edu">gspicker@fasu.edu</a></td>
<td>Mon 12-2pm By Appt.</td>
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## Other Subjects/Advising

<table>
<thead>
<tr>
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<tr>
<td>K. Turner</td>
<td>405-3438</td>
<td>HH 433</td>
<td><a href="mailto:kturner@fasu.edu">kturner@fasu.edu</a></td>
<td>Wed &amp; Fri 9-10</td>
</tr>
<tr>
<td>L. Chen</td>
<td>338-6763</td>
<td>HH 346</td>
<td><a href="mailto:lchen@fasu.edu">lchen@fasu.edu</a></td>
<td>Mon 11-11</td>
</tr>
<tr>
<td>B. Rothman</td>
<td>338-2418</td>
<td>HH 221</td>
<td><a href="mailto:broothman@fasu.edu">broothman@fasu.edu</a></td>
<td>Wed 4-6pm By Appt.</td>
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</tbody>
</table>

## Graduate Advisor

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone No</th>
<th>Office</th>
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<th>Office Hours</th>
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<tbody>
<tr>
<td>R. Patterson</td>
<td>338-1237</td>
<td>HH 451</td>
<td><a href="mailto:rpaterson@fasu.edu">rpaterson@fasu.edu</a></td>
<td>Mon, Wed 8-10</td>
</tr>
<tr>
<td>D. Chu</td>
<td>405-3487</td>
<td>HH 764</td>
<td><a href="mailto:dchu@fasu.edu">dchu@fasu.edu</a></td>
<td>Mon 11-11</td>
</tr>
<tr>
<td>L. Chen</td>
<td>338-6763</td>
<td>HH 346</td>
<td><a href="mailto:lchen@fasu.edu">lchen@fasu.edu</a></td>
<td>Mon 11-11</td>
</tr>
<tr>
<td>R. Patterson</td>
<td>338-1237</td>
<td>HH 451</td>
<td><a href="mailto:rpaterson@fasu.edu">rpaterson@fasu.edu</a></td>
<td>Mon, Wed 8-10</td>
</tr>
<tr>
<td>R. Patterson</td>
<td>338-1237</td>
<td>HH 451</td>
<td><a href="mailto:rpaterson@fasu.edu">rpaterson@fasu.edu</a></td>
<td>Mon, Wed 8-10</td>
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<tr>
<td>R. Patterson</td>
<td>338-1237</td>
<td>HH 451</td>
<td><a href="mailto:rpaterson@fasu.edu">rpaterson@fasu.edu</a></td>
<td>Mon, Wed 8-10</td>
</tr>
<tr>
<td>P. Willerson</td>
<td>338-3519</td>
<td>HH 346</td>
<td><a href="mailto:pwillerson@fasu.edu">pwillerson@fasu.edu</a></td>
<td>Mon 11-11</td>
</tr>
<tr>
<td>J. Romeo</td>
<td>338-5008</td>
<td>HH 346</td>
<td><a href="mailto:jromeo@fasu.edu">jromeo@fasu.edu</a></td>
<td>Mon 11-11</td>
</tr>
<tr>
<td>M. Fouse</td>
<td>405-9728</td>
<td>HH 422</td>
<td><a href="mailto:mfouse@fasu.edu">mfouse@fasu.edu</a></td>
<td>Mon 11-11</td>
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## Certificate/Program Advising

<table>
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<td>L. Chen</td>
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<td>HH 346</td>
<td><a href="mailto:lchen@fasu.edu">lchen@fasu.edu</a></td>
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## Genomic Engineering

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<tr>
<td>J. Rome</td>
<td>338-5008</td>
<td>HH 346</td>
<td><a href="mailto:jromeo@fasu.edu">jromeo@fasu.edu</a></td>
<td>Mon 11-11</td>
</tr>
</tbody>
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*Note: Office hours and availability may vary. Please contact advisors directly for updates.*
The following students should consult General Biology Advisors:

- Students who are obtaining a B.A. in General Biology
- Students who are obtaining a Minor in Biology
- Students who are interested in demonstrating Subject Matter Competency or obtaining Single Subject Credential in Biological Sciences
  - NSF Noyce Scholarship Opportunity for Spring and Fall 2008 for students preparing to become K-12 science or mathematics teachers!!
    - Scholarship amount: up to $10,000 per year for two years maximum
    - Eligibility (see application for more details or check online at http://www.mastep.sjsu.edu):
      1) Seniors (majoring in any Science, Technology, Engineering, or Mathematics (STEM) discipline) who intend to enter SFSU or SJSU's credential program,
      2) students entering/enrolled in SFSU/SJSU Credential programs*, preparing to become math or science teachers or
      3) senior or credential students* preparing to become middle school science specialists (*BA/BS in math/science discipline required) are eligible to apply.
    - Application deadline:
      Spring 2008 awards: Nov 15, 2007
      Fall 2008 awards: May 1, 2008
    - Click here to download a pdf of the Noyce Scholarship Flyer (pdf)
    - Click here to download the Noyce Application (pdf)
  - Noyce Applicants are AUTOMATICALLY eligible for an additional $4,000 yearly scholarship (Math & Science Teaching Initiative Fellowship, MSTI). Call or e-mail Dr. Jan Mokros, Director, Center for Science and Mathematics Education, SCI 211, 415-405-4092, jmokros@sfsu.edu for more information on the MSTI Fellowship.

As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

Undeclared students who wish to change their major to a Biology degree: NEW INFO
Please be certain that the Biology major is the appropriate major for YOU. If you are considering applying for the B.S. Nursing degree, you should select your new major based on the course requirements that overlap with the Nursing major. Please consider the fact that the Nursing major is an impacted major (more students apply than can be accepted). A better strategy to obtain your degree in a reasonable time may be to select a major that will accept the Nursing-related courses for credit towards the major, so that you will not have to start from scratch with a new major. This is particularly important if you have already taken Biol.
210/211 and Biol 610/611--these courses are NOT accepted for Biology major credit. The following majors do accept these courses for the major:

- B.S. Dietetics
- B.S. Health Education
- B.S. Kinesiology

General Biology Students

As described in the SFSU Bulletin, the Bachelor of Arts in General Biology degree provides breadth, but not depth, in biology. The major is designed to support the students who are interested in obtaining a teaching credential in the Biological Sciences for K-12. While it is true that the major can be structured to give the student the required depth for many career and educational goals, in many cases the Bachelor of Science degree may serve the student’s goals better.

Students seeking General Biology Advising should consult the Biology Advising Web Page for information on the following issues:

1. Learn more about a specific biology major
2. Develop a course plan (Recommended 4 year course plans for General Biology major)
   - Obtain approval for transfer courses or substitution courses
3. Improve your performance in your courses
4. Change your major
5. Obtain approval on an academic advising petition
6. Obtain approval for Financial Aid Graduation Plan
7. Obtain approval on your baccalaureate graduation application (Instructions to fill out the Graduation Checklist)
8. Obtain Advanced Placement credit towards your major
9. Organic Chemistry requirement: Chem 130 or Chem 333?

Other Frequently Asked Questions from General Biology Majors:

- Can Chem 333 be used to substitute for Chem 130?
  - Yes, and an equivalency form must be filed to indicate this change.
- How many units can be double-counted to fulfill the major and GE requirements?
  - 12 units, but at least one Segment III must be outside the major.

Recommended 4 year course plans for the General Biology major:

It is essential for a General Biology student to meet with an advisor to develop a course plan tailored to his/her career and educational goals. The recommended course plans below are
suggestions and should be modified upon consultation with a General Biology Advisor. They listed to demonstrate that:

- All lower division courses need not be completed prior to taking the upper division course work
- It is critical to pay attention to the prerequisites when developing the course plan
- In general, the student should try to limit the science course load to two courses per semester and balance the semester units with General Education courses and electives of interest
- the upper division electives should be selected in consultation with the Biology Advisor
- Description of General Biology major requirements

Version 1: "lower division first"

<table>
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<th>Year 1 Spring</th>
<th>Year 2 Fall</th>
<th>Year 2 Spring</th>
<th>Year 3 Fall</th>
<th>Year 3 Spring</th>
<th>Year 4 Fall</th>
<th>Year 4 Spring</th>
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<td>Chem 115</td>
<td>Biol 230</td>
<td>Biol 240</td>
<td>Ecol course</td>
<td>Physio w/lab*</td>
<td>Cell Biol w/lab*</td>
<td>Upper Div elective</td>
<td>Upper Div elective</td>
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<td>Phys 111/112</td>
<td>Phys 121/122</td>
<td>Chem 215**</td>
<td>Chem 130</td>
<td>Biol 355</td>
<td>Evol or Org course</td>
<td>Upper Div elective</td>
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Version 2: "physics later, no Biol 612 (Human Physiology)"

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<td>Biol 230</td>
<td>Biol 240</td>
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*consult the Description of General Biology major requirements for the appropriate Cell or Physiology laboratory (only one lab required)
**Chem 215 prerequisites: C- or better in CHEM 115 and in 2 of the following courses: PHYS 111, PHYS 121; PHYS 220, PHYS 230, or PHYS 240; MATH 226, MATH 227; or consent of instructor

<p>| Physiology courses: | Evolution or Organismal courses: |</p>
<table>
<thead>
<tr>
<th>BIOL 525 Plant Physiology</th>
<th>BIOL 328 Human Anatomy (4)</th>
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<tr>
<td>BIOL 612 Human Physiology</td>
<td>BIOL 337 Evolution</td>
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<td>BIOL 630 Animal Physiology</td>
<td>BIOL 380 Comparative Embryology</td>
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<td>BIOL 453/454 General Parasitology/Laboratory (3/1)</td>
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<tr>
<td>Cell Biology courses:</td>
<td>BIOL 459 Arthropod Biology (4)</td>
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<tr>
<td>BIOL 350 Cell Biology</td>
<td>BIOL 460 General Entomology (4)</td>
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<tr>
<td>BIOL 401 General Microbiology</td>
<td>BIOL 461 Insect Taxonomy (4)</td>
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<td>BIOL 435 Immunology</td>
<td>BIOL 475 Herpetology</td>
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<td>BIOL 450 Biology of the Protozoa</td>
<td>BIOL 478 Ornithology</td>
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<td>BIOL 524 Plant Molecular Biology</td>
<td>BIOL 480 Mammalogy (4)</td>
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<td>CHEM 349 General Biochemistry</td>
<td>BIOL 500 Evolution and Diversity of Plants (4)</td>
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<td>BIOL 502 Biology of the Algae (4)</td>
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<td>BIOL 504 Biology of the Fungi (4)</td>
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<td>BIOL 505 Comparative Anatomy of Vascular Plants (4)</td>
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<td>BIOL 514 Plant Taxonomy (5)</td>
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<td>BIOL 555 Marine Invertebrate</td>
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<td>Zoology (4)</td>
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<td>BIOL 570 Biology of Fishes (4)</td>
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*As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

**Note:**
The following courses are generally taught both Fall and Spring semesters (check Class Schedule)
Chem 115, Chem 215, Chem 130
Math 124, Math 226
Phys 111/112, Phys 121/122

The following courses are generally taught during the Summer semester (check Class Schedule, required courses are in **bold**)
**Biol 328, BIOL 355**
**CHEM 115, CHEM 215**
MATH 124 or MATH 226

HYS 111/112, PHYS 121/122

Minor in Biology

In order to obtain a Minor in Biology, the student must meet with a General Biology Advisor and develop a course plan to fulfill the following requirements (as indicated in the SFSU Bulletin description of the Minor in Biology).

Requirements:

- 23 units total
- All courses for a letter grade (CR/NCR is not acceptable)

Introductory Biology courses or the equivalent (as a prerequisite for other courses)
* Biol 230 and Biol 240 (10 units)

Physiology course (the lab is not an official requirement)
* BIOL 525 Plant Physiology
* BIOL 526 Plant Physiology Lab
* BIOL 612 Human Physiology
* BIOL 613 Human Physiology Lab
* BIOL 630 Animal Physiology
* BIOL 631 Animal Physiology Lab

Ecology, one of the following (3 or 4 units, including field work)
* #BIOL 313 Principles of Ecology (3)
* BIOL 482 Ecology (4)
* BIOL 529 Plant Ecology (4)
* BIOL 534 Wetlands Ecology (4)
* BIOL 580 Limnology (3)
* BIOL 582 Biological Oceanography (4)
* BIOL 585 Marine Ecology (4) (If 3 unit Biol 585 taken, then 2 unit Biol 586 lab must be taken)

As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and cannot be taken for credit towards any Biology undergraduate degree. Students who have taken
Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

- Genetics/Evolution (3 units), one of the following
  * Biol 355 Genetics
  * Biol 337 Evolution (note that Biol 355 Genetics is a prerequisite)

In the remaining 23 units, which is basically one more class, the student should try to get some depth in one of the fields above. The requirements above are actually pretty flexible so depending on the background or goals of the student, he/she may be able to substitute one of the "requirements" for a course that will give them more depth in a given area. Consult the description for the General Biology B.A. major for suggested upper division courses.

The student should refer to the SFSU Bulletin description of Minor Programs for additional policies for an approved minor degree. These policies include:

- Double Counting Courses Between Major and Minor. Courses may count for both a major and a minor where there is a clearly stated overlap in the Bulletin requirements.
- Double Counting Between Minor and GE. No limitations.
- Upper Division/Residence Units. At least half of the units making up the minor must be taken in residence and at least half must be upper division.
- No Minor in Major. Students cannot complete a minor in the same field as the major.
- Grade Point Average. A minimum 2.0 grade point average is required in the minor.

Subject Matter Competency/Single Subject Credential in Biological Sciences

Candidates for teaching credential programs who wish to meet the SFSU requirements for subject matter competency for the single subject credential in Science: (Concentration in Biological Sciences) must meet both depth in biology requirements and breadth requirements in chemistry, geosciences, and physics.

Candidates for the teaching credential program who wish to have their transcripts evaluated for subject matter competency must contact a General Biology Advisor to arrange a meeting. The candidate must supply transcripts and additional supporting documentation to confirm completion of the required course work. This documentation may include course catalogs and course syllabi if the courses were not taken at SFSU. Prior to meeting with the General
Biology Advisor, the candidate should download and fill out the Biology Single Subject Credential Worksheet to assist the Advisor in determining subject matter competency.

For the student matriculating at SFSU, the course work for the BA in General Biology, with minor modifications, and additional course work in the geosciences combined meet both the depth and breadth requirements.

The course work (modified SFSU Bachelor of Arts Requirements in General Biology with additional classes):

- BIOL 230/240, General Biology I and II
- CHEM 115*, CHEM 215/216* General Chemistry I and II (with lab)
- CHEM 130, Organic Chemistry
- PHYS 111/112, PHYS 121/122, General Physics I/II
- MATH/STAT 124, Statistics, OR MATH 226, Calculus I
- BIOL 355, Genetics
- BIOL 525, 612, OR 630, a Physiology course
- BIOL 343, 350, 401, OR 450, a Cell Biology course
- Physiology or Cell Biology lab
- BIOL 313#, 482, 529, 534, 580, 582, 585, an Ecology course
- BIOL 337, Evolution*
- BIOL (upper division, see General Biology B.A. major), an organismal biology course
- CIS 510, Search for Solutions** (substitute for geology, astronomy, meteorology, if appropriate)
- Additional upper division biology electives to total 57 units for the major (at SFSU)
  - Electives selected when combined with other upper division biology courses should clearly demonstrate coverage of human, plant, animal, and microbial biology. For example, the student may take the human physiology lecture, general microbiology, plant ecology, and marine invertebrate zoology. It would be inappropriate for the student to take courses that focus on only plant biology or only organismal biology.
- Geosciences, 2-5 courses
  - The Geosciences breadth requirement covers astronomy, geology, meteorology, and oceanography, but the material need not be covered in four separate courses. These are the SFSU course options:
    - Current Requirements (as approved by CTC): Student takes 5 courses
    1. Astr 115/116: Introduction to Astronomy, 3 units, and Lab, 1 unit
    2. Geol 110: Physical Geology, 4 units (includes lab)
    3. Our Violent Planet, a GE Segment III cluster that includes:
a. Geog 402: The Climatic Challenge, 3 units
b. Geol 302: The Violent Earth, 3 units
c. Metr 302: The Violent Atmosphere and Ocean, 3 units

- Alternative: Student takes 3 courses
  1. Astr 115/116: Introduction to Astronomy, 3 units, and Lab, 1 unit
  2. Geol 110: Physical Geology, 4 units (includes lab)
  3. Metr 302: The Violent Atmosphere and Ocean, 3 units OR CIS 510: Search for Solutions (if Global Climate Change)

- Alternative: Student takes 2 courses
  1. Astr 115/116: Introduction to Astronomy, 3 units, and Lab, 1 unit
  2. Geol 405 (formerly Geol 310) [also offered as METR/OCN 405]: Planetary Climate Change, 4 units (includes lab), covers geology, meteorology, and oceanography

*Required for single subject science competence, although not for the BA
**Counts as an upper division elective; see also geosciences breadth requirement
***Needed to meet the breadth requirements

As of Fall 2004, Biol 313 Principles of Ecology will have restructured course content and not be taken for credit towards any Biology undergraduate degree. Students who have taken Biol 313 Principles of Ecology prior to Fall 2004, may use the completed course for credit towards their degree (Please check with your advisor).

Students with degrees from other institutions:
If the course work was done at a different institution, the biology course work must include a year of general biology, and classes in genetics, physiology, ecology, evolution, and organismal biology. For breadth requirements, the course work in chemistry, physics, astronomy, geology, meteorology, and oceanography must total at least 24 semester (or 36 quarter) units.

The California Commission on Teacher Credentialing now has a new, specialized, and limited credential in science: Biological Sciences (Specialized). To be eligible for the subject matter competency in this Biological Sciences (Specialized) credential, a candidate needs either a post baccalaureate degree or 30 semester units of postgraduate course work in the subject (or a closely related subject). Teaching certification would be only for Biological Sciences. A teacher with this limited credential would not be able to teach general science, integrated science, or introductory science.

Additional links of interest:
- SFSU College of Education Credential Services Teacher Preparation Center
- single subject teaching credential information
  - single subject credential program application (pdf)
  - single subject credential program information/application packet (pdf)
  - single subject credential program information/meetings
- SFSU bulletin for the specific courses for the BA in General Biology
- Biology course descriptions
- Course descriptions for courses in other departments

> return to top of page

Updated 1/09/08 SFSU home
Questions on web page?

搐
1 To learn more about the specific biology major that interests you

An SFSU Biology student should consult his/her Biology Advisor and take advantage of various College resources to develop his/her career goals, to discuss employment options after obtaining the degree, or to obtain information on pre-health professional or graduate schools.

- SFSU Bulletin description of Department of Biology degree programs
- SFSU Career Center
- College of Science and Engineering Student Resource Center
- What can I do with a major in...?
- Health Professions at SFSU home page
- Pre-Health Professions program
- SFSU Pre-Health Professions Undergraduate Program

Students interested in a career as a Forensics Criminalist:
It is REQUIRED that your college transcripts contain the following courses: Genetics, Molecular Biology, Biochemistry, Statistics, and Analytical Chemistry.

- So you want to be a Forensic Scientist
- Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students
- CSU Fresno Professional Science Master's Degree in Forensic Science
- San Jose State University Criminal Justice Administration-Biological Emphasis (this downloads a pdf)
- Council on Forensic Science Education home page

>return to top of page

2 To develop a course plan for your major course work

It is essential for each student to develop a course plan for his/her majors course work. In developing a good course plan:

- it is important to check the prerequisites for each course. The prerequisites listed for a given course are classes required to be completed prior to taking the course. In some cases, the class may be taken concurrently if indicated in the course description. Click here to check the Biology Course Descriptions.
- it is important to check whether a course is taught both fall and spring semesters, only fall or spring semester, or taught during the summer semester. This will allow the student flexibility in developing the course plan. Click here to check the Biology Course Descriptions.
- an SFSU Biology student should consult with his/her Biology Advisor for approval of the course plan for the majors course work. This way the student can balance the majors course work with the General Education requirements, and better gauge the time to degree.
- the student should also meet with a GE Advisor at the Undergraduate Advising Center to determine an equivalent GE course plan. The DARS/ASE reports also track progress toward completion of the GE requirements.
Suggested 4-year course plans

NOTE: All Biology majors are required to take Biol230/240 (General Biology I/II). It is generally recommended that students take Chem115 (General Chemistry I) BEFORE taking Biol230/Biol240 (General Biology I/II).

Four-year course plans are available for the following Biology majors.

These are SUGGESTED course plans—students should meet with their Biology Advisors to develop an optimal course plan for meeting their degree requirements.

- B.A. in Biology, General
- B.S. in Biology: Concentration in Botany (pdf)
- B.S. in Biology: Concentration in Cell and Molecular Biology (pdf)
- B.S. in Biology: Concentration in Ecology (pdf)
- B.S. in Biology: Concentration in Marine Biology and Limnology (pdf)
- B.S. in Biology: Concentration in Microbiology (pdf)
- B.S. in Biology: Concentration in Physiology (pdf)
- B.S. in Biology: Concentration in Zoology (pdf)

Click here for a worksheet for planning majors course work.

>return to top of page

3. To transfer courses into your specific major

If an SFSU Biology student plans to use a course taken at another university to satisfy a Biology majors requirement, the student must have this approved by a Biology Advisor and the Chair of the Department of Biology. This transfer to the major is a TWO STEP process. First, the University must approve the transfer. Second, the Department must approve the transfer.

STEP ONE: UNIVERSITY APPROVAL. Before the Department can consider accepting the course for major credit, the University must approve the transfer of the course, designated on the Advanced Standing Evaluation (see "How to read your ASE") or the Degree Audit Report (DARS). Transfer students submit their transcripts prior to entering the University. Approved courses are transferred for specified units as indicated on the ASE (or DARS, "About Your Degree Audit Report"). The student cannot receive more units than the University has awarded on the ASE (or DARS) and cannot receive more units than the equivalent SFSU course.

Courses taken at a junior college (two-year college) can ONLY FULFILL LOWER DIVISION REQUIREMENTS. However, such course work may be given "content only" credit if the course work is deemed equivalent to an SFSU upper division course. The upper division units must be made up by taking another upper division elective.

To determine equivalency of a transfer course, the following resources may be of use:

--Articulation website (www.assist.org)
--Click here to download a Lower Division Articulation chart. This chart shows which courses at Bay Area colleges transfer for lower division courses required for the SFSU Biology degrees. The information in the chart was obtained using the Assist.org articulation website.

STEP TWO: DEPARTMENT APPROVAL. The student must meet with the Biology Advisor to confirm that a specific transfer course is equivalent to a majors requirement. Once a course has been deemed equivalent, the student must fill out the Department of Biology Equivalency Form (download here, or...
pick up at Department Office), obtain the approval of the Biology Advisor, and submit the form to the Department of Biology for approval by the Chair of the Department. **If the course equivalency is shown on the www. assist.org articulation website, the student must print out this articulation reeement and attach the agreement to the Equivalency Form.** If the course equivalency is based on the analysis of course materials by faculty, the course syllabus or course catalog description must be attached to the Equivalency Form. It is recommended that the Equivalency Forms be filled out sooner than later--do not wait until graduation to get the equivalency forms approved.

In addition, if the student plans to take a course as an upper division elective for the major, but that course is not listed in the official list of electives for the major, then the student must fill out the Department of Biology Substitution Form (download here, or pick up at the Department Office), obtain the approval of the Biology Advisor, and submit the form to the Department of Biology for approval by the Chair of the Department. **If the substitution is replacing an upper division course required for the Major, the required course being must replaced must be listed and an explanation provided on the Substitution Form.** In general, the student should consult with a Biology Advisor for approval of the substitution PRIOR to taking the course. It is recommended that the Substitution Forms be filled out sooner than later--do not wait until graduation to get the substitution forms approved.

*Note that it is the responsibility of the student to keep all signed Equivalency and Substitution Forms to submit with the graduation application.*

>return to top of page

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4 To develop strategies to improve performance in your Biology courses

Biology Faculty maintain regular office hours during the semester to meet with students in their classes in order to provide assistance with course work and preparation for exams and assignments. Students are encouraged to meet with their professors during these office hours. In addition, the following resources are available:

- Overview of SFSU tutoring resources
- Learning Assistance Center--Biology tutoring
- Community Access and Retention Program tutoring
- SFSU Testing Center
  - Academic Skills online workshops
  - Academic Skills Workshops on Videotapes
  - Academic Skills Internet Links

>return to top of page

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5 To change your major

In order to change one's major, one must have a minimum 2.0 GPA in the current major. The student must make an appointment with the appropriate Biology Advisor for the major you are changing to, and bring to this meeting the following paperwork:

- current unofficial SFSU transcripts
- a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
• current course enrollment
• prospective course plan
• change of major form (available on internet as downloadable pdf here, or at the Department of Biology Office)

After the advisor approves the change of major, the student must take the form to the Department of Biology for the signature of the Chair of the Department.

**ATTENTION UNDECLARED STUDENTS** who wish to change their major to a Biology degree: NEW INFO
Please be certain that the Biology major is the appropriate major for YOU. If you are considering applying for the B.S. Nursing degree, you should select your new major based on the course requirements that overlap with the Nursing major. Please consider the fact that the Nursing major is an impacted major (more students apply than can be accepted). A better strategy to obtain your degree in a reasonable time may be to select a major that will accept the Nursing-related courses for credit towards the major, so that you will not have to start from scratch with a new major if you are not accepted into the Nursing degree program. This is particularly important if you have already taken Biol. 210/211 and Biol 610/611--these courses are NOT accepted for Biology major credit. The following majors do accept some of these courses for the major:

- B.S. Dietetics
- B.S. Health Education
- B.S. Kinesiology

>return to top of page

6 To get academic advising petitions signed

Students who are on academic probation, mandatory advising, or subject to disqualification are required to meet with their advisors for approval of the academic advising petition prior to registration. Additional information is available at the Advising Center web page on Mandatory Academic Probation. In addition, the College of Science and Engineering Student Resource Center provides useful Probation Help information as well as a Grade Point Deficiency Calculator.

The student should bring to the meeting with the Biology Advisor:

- copies of PREVIOUS ACADEMIC STANDING PETITIONS/PROBATION CONTRACTS (available at the Department of Biology Office, Franciscan Building). **This is a NEW REQUIREMENT.**
- the current Academic Standing Petition (mailed to the student, available from Student Services Center, available on internet as downloadable pdf here, or at the Department of Biology Office)
- a copy of his/her unofficial SFSU transcripts
- a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
- current course enrollment
- a list of courses the student wishes to take the next semester
- any documents to support serious and compelling reasons which may have contributed to his/her poor academic performance

After the student meets with the advisor, the student brings the signed petition to the Department of
Biology for the approval by the Chair of the Department, then takes the form to the Dean's office for approval.

7 To get a financial aid graduation plan signed

Students on financial aid are sometimes asked by the Financial Aid office to prepare a Financial Aid Graduation Plan. The student should make an appointment with his/her advisor and come to the meeting with the following items:

- unofficial SFSU transcripts
- a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
- a copy of the Financial Aid Graduation Plan, filled out by the student prior to the meeting
- the original Financial Aid Graduation Plan to be filled out by the student in consultation with the advisor

Once the advisor approves the plan, the student takes the form to the Department of Biology office for department approval and then to the Financial Aid office.

8 To get approval for your graduate application

All Biology Major graduation applicants for Spring 2008 MUST complete an ONLINE SURVEY before the Department will approve the graduation application. Your input will help the Department improve its programs and courses for all Biology students. Go to the Graduation Checklist web page to find out more about the survey.

Click here to fill out the online Baccalaureate Degree Application for Graduation. This downloadable graduation application form also has useful graduation FAQs. Please note that students should apply for graduation only if they believe they will have satisfied all degree requirements by the end of the term in which they have applied. In addition, students must have completed at minimum of 100 units in order to apply for graduation and walk during the commencement ceremony.

Note: SFSU Registrar policy allows students to apply for graduation, indicating the Spring or Summer Graduation dates on the graduation application, by Feb 15, 2008, in order to walk during the May 2008 commencement. The student must complete the "in progress" courses during the semesters indicated. You cannot submit your graduation application for approval (to walk in the May Commencement) if you have units remaining in the Fall Semester. If the student does apply for graduation, and does not complete the required units, the graduation application will be denied until the completion of the remaining courses for the degree. The student will be required to re-apply for graduation when the units are completed (SFSU Registrar deadlines). The student must meet with the Biology Advisor and bring the following:

http://online.sfsu.edu/~pasion/AdvisingWeb/biologyadvising.htm
• a Department of Biology Graduation Checklist filled out prior to meeting with the advisor
• the Graduation Application, with the majors course work listed in the same order the classes appear in the Biology Major descriptions listed in the Graduation Checklist
• a copy of his/her unofficial SFSU transcripts
• a copy of his/her Advanced Standing Evaluation (ASE), and Degree Audit Report (if a transfer student)
• current course enrollment
• signed Department of Biology Equivalency and Substitution forms for necessary course work
  ○ Blank Department of Biology Equivalency and Substitution forms may be obtained from the Department of Biology Office (Franciscan Building) or may be downloaded from the links below.
  ○ The Equivalency forms are used to obtain permission from your major advisor to use an off-campus course as part of your major program. You must consult with a major advisor well in advance to discuss every single class in the major that you take at another college, including courses in math, chemistry, biology, and physics. The transfer course must first be accepted by the University for credit (ASE/DARS). Once a course has been deemed equivalent, the student must fill out the Department of Biology Equivalency Form (download here, or pick up at Department Office), obtain the approval of the Biology Advisor, and submit the form to the Department of Biology for approval by the Chair of the Department. This process is necessary because the University approved-transfer of the course to SFSU does not guarantee that the course will be accepted for the major. It is recommended that the EQUIVALENCY FORMS be filled out sooner than later—do not wait until graduation to get the equivalency forms approved.
  ○ The Substitution forms are used to obtain permission from your major advisor to use an SFSU upper division Biology course as an approved upper division elective if the course is not specifically listed in the official elective list for the major. The student must fill out the Department of Biology Substitution Form (download here, or pick up at the Department Office), obtain the approval of the Biology Advisor, and submit the form to the Department of Biology for approval by the Chair of the Department. In general, the student should consult with a Biology Advisor for approval of the substitution PRIOR to taking the course. It is recommended that the SUBSTITUTION FORMS be filled out sooner than later—do not wait until graduation to get the substitution forms approved.

Note:

• Courses transferred into the major must be listed as they appear on the transcript from the transfer institution.
• Upper division GE courses are not generally allowed as upper division electives. In some cases, one course can be used if it is appropriate to the student’s career/educational goals.
• The graduation petition must be signed by the Biology Advisor and by the Chair of the Department of Biology. After obtaining the Advisor’s signature, the student drops off the petition at the Department of Biology Office where it will be reviewed (the student does not need to meet with the Chair of the Department). Note that the transcripts and Department forms must accompany the application.
• After the petition has been reviewed and approved, the student is responsible for picking up the petition from the Department Office and taking it to the Administration Building to pay the graduation application fee or to the One Stop Student Services Center.
To obtain Advanced Placement Exam Credit in the Department of Biology

Students may receive credit towards the lower division requirements for the major with the appropriate scores on Advanced Placement Exams. It is up to the discretion of the Chair of the Department whether the AP exam credit will be accepted for the major (this applies to all lower division requirements for the major).

For the Department of Biology, a Biology AP exam score of 4 or 5 in general will be accepted towards the Biol 230 requirement. Advanced Placement Exam Credit appears on the ASE. Note that the restrictions for double counting also apply towards the AP exam credit: a maximum of 12 units may be double counted between the GE requirements and the major requirements. If a student wishes to apply AP exam credit for the degree, the student must consult the Biology Advisor and the Chair of the Department.

10 Organic Chemistry requirement: Chem 130 or Chem 333?

All Biology degrees require completion of at least one semester of Organic Chemistry. Most of them require the lower division Organic Chemistry I lecture, Chem 130. However, the Microbiology B.S. and the Cell & Molecular Biology B.S. degrees require the upper division Organic Chemistry I lecture, Chem 333 (as well as the second semester Organic Chemistry II lecture, Chem 335). If a biology course lists Chem 130 as a prerequisite, Chem 333 is acceptable in lieu of Chem 130. Students may elect to take the upper division Chem 333 instead of Chem 130. The student must file a Department of Biology Equivalency Form (pdf) to indicate this change.

Pre-health profession students should note that the upper division Organic Chemistry I and II with labs (Chem 333/334/335/336) are considered part of the minimal science requirements for applying to the health profession programs (including medical school, veterinary medicine, dental school, pharmacy school).

11 Obtain approval to take a course at SFSU Consortium campuses (including UCSF and UC Berkeley) for major credit

SFSU students may wish to take advantage of the SFSU cooperative programs with UCSF, UC Berkeley, or other institutions that participate in the San Francisco Consortium.

In general, during the regular sessions (summer and winter sessions and extension classes excluded) a matriculated, full-time SFSU student may take up to one course per semester at an SFSU consortium campus on a space available basis if they are unable to take the equivalent course at SFSU. The instructor of this non-SFSU course must be willing to accept the SFSU student. The SFSU student must have SFSU Biology Department approval (Faculty Advisor and Department Chair) and SFSU registrar approval. The specific requirements are outlined in the SFSU Bulletin and the appropriate enrollment forms below.
Detailed information is available in the SFSU Bulletin:
Special Enrollment Programs information (http://www.sfsu.edu/~bulletin/current/spenroll.htm)
Forms for enrollment in special programs (consortium enrollment, cross enrollment at California
Community Colleges or CSU campuses or cross registration at UC Berkeley) are available at:
Special Enrollment Programs Forms (http://www.sfsu.edu/~admisrec/forms/formstoc.htm#special)

> return to top of page

Updated 7/11/08
Questions on web page?
INFORMATION MEETINGS DATES FOR PROSPECTIVE APPLICANTS

It is highly recommended that all prospective candidates attend Information Meetings. These information meetings cover admissions requirements and procedures.

To attend a meeting, please reserve a seat by emailing infomtg@sfsu.edu. Space is limited so make your reservation at least 48 hours in advance. Please include the date you wish to attend, your name, email and phone number.

All application materials will be available at the information meeting.
All information meetings are held in Burk Hall – 230

Multiple Subject Credential Program
Single Subject Credential Program
Special Education Credential and Masters Programs
Communicative Disorders Credential and Masters Programs
Child Development Permit Information Meeting

Multiple Subject Credential Program
(For those interested in teaching at the Elementary School level)

It is highly recommended that all prospective candidates attend Information Meetings. These information meetings cover admissions requirements and procedures.

To attend a meeting, please reserve a seat by emailing infomtg@sfsu.edu. Include the date you wish to attend and your contact information.

Fall Admission Only - Deadline is February 15, 2009

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Single Subject Credential Program
(For those interested in teaching at the Middle School or High School level)

It is highly recommended that all prospective candidates attend Information Meetings. These information meetings cover admissions requirements and procedures.

To attend a meeting, please reserve a seat by emailing infomtg@sfsu.edu. Include the date you wish to attend and your contact information.

Deadline to apply for Fall 2009 - February 15, 2009

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<td>2:00 - 4:00 pm</td>
<td>BH 230</td>
</tr>
<tr>
<td>Monday</td>
<td>December 1, 2008</td>
<td>2:00 - 4:00 pm</td>
<td>BH 230</td>
</tr>
</tbody>
</table>
Special Education Credential and Masters Programs
(for those who want to work in Special Education environments)

It is highly recommended that all prospective candidates attend Information Meetings. These information meetings cover admissions requirements and procedures.

To attend a meeting, please reserve a seat by emailing informtc@sfsu.edu. Include the date you wish to attend and your contact information.

Deadline to apply for Fall 2009 – March 15, 2009
Deadline to apply for Spring 2009– October 15, 2008

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>December, 15, 2008</td>
<td>2:00 - 4:00 pm</td>
<td>BH 230</td>
</tr>
</tbody>
</table>

Communicative Disorders Masters of Science/Speech Language & Hearing Credential
(Speech and Language Pathology and Audiology)

To attend a meeting, please reserve a seat by emailing informtc@sfsu.edu. Include the date you wish to attend and your contact information.

Deadline to apply for Fall 2009 Admission– February 1, 2009

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>October 20, 2008</td>
<td>2:00 - 4:00 pm</td>
<td>BH 230</td>
</tr>
<tr>
<td>Friday</td>
<td>December 5, 2008</td>
<td>2:00 - 4:00 pm</td>
<td>BH 230</td>
</tr>
</tbody>
</table>

Child Development Permit
(Informational meeting for those interested in working in pre-schools)

For those interested in working in pre-school settings presented by City College of San Francisco.

To attend a meeting, please reserve a seat by emailing informtc@sfsu.edu. Include the date you wish to attend and your contact information.

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
</table>

COE         CSTPC

SAN FRANCISCO STATE UNIVERSITY
updated 10/21/2008
Must meet depth in biology and breadth in chemistry, geoscience, and physics
See details at http://online.sfsu.edu/~pasion/AdvisingWeb/generalbiology.htm#subject

<table>
<thead>
<tr>
<th>Lower Division Requirements (modified Gen Biol B.A.)</th>
<th>Grade</th>
<th>Other/Units</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 115 (General Chem I, 5 units)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology 230 (General Biol I, 5 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology 240 (General Biol II, 5 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chem 215/216 (Gen Chem II and lab, 3/2 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chem 130 (Gen Org Chem, 3 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phys 111/112 (Gen Phys I/Lab, 3/1 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phys 121/122 (Gen Phys II/Lab, 3/1 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math 124/Stat 124 (3 units) OR Math 226 (Calc I, 4 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL Lower Division UNITS (34 - 35 units)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*units listed are semester units

Comments:

<table>
<thead>
<tr>
<th>Upper Division Requirements (modified Gen Biol B.A.)</th>
<th>Grade</th>
<th>Other/Units</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biol 355 (Genetics, 3 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Physiology Course, 3 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Cell Biology Course, 3 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Physiology or Cell Biology Lab, 2 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Ecology course, 3 - 4 units)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol 337 (Evolution, 3 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Organismal course, 3 - 5 units)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Elective)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Elective)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biol (Elective)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL Upper Division UNITS (24 - 25 units)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Biol 313 accepted only if completed PRIOR to FALL 2004
chemistry, physics, geosciences must total at least 24 semester or 36 quarter units

Total Units (58 - 60 units) GPA

Comments:

<table>
<thead>
<tr>
<th>Geosciences Breadth Requirement (2-5 courses)</th>
<th>Grade</th>
<th>Other/Units</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>astronomy, geology, meteorology, and oceanography</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 24 semester units = 36 quarter units
SCIENCE SUBJECT MATTER COMPETENCY 000023
Department of Biology
Advising Checklist for Undergraduate Majors

NAME ____________________________ MAJOR ____________________________

ADVISOR ____________________________ assigned by Department of Biology Office Receptionist

BIOLOGY ADVISING: http://online.sfsu.edu/~pasion/AdvisingWeb/biologyadvising.htm
Use your full name on all correspondence. Keep copies of ALL your forms until you graduate.

EACH STUDENT SHOULD MEET WITH HIS/HER ADVISOR TO ESTABLISH A COURSE PLAN.

ALWAYS BRING THE FOLLOWING ITEMS TO YOUR MEETING WITH YOUR ADVISOR:

☐ Your current unofficial SFSU transcripts*

☐ Your Degree Audit Report*
   for transfer credit from DARS schools

☐ Your Advanced Standing Evaluation**
   for transfer credit from non-DARS schools or AP exam credit

☐ A print out of your current course enrollment

☐ Copies of supporting transcripts from other campus(es)

Additional forms or supporting documents for your visit

❖ To obtain approval for the transfer of course credit for courses taken at non-SFSU campus
   Download the EQUIVALENCY FORM from:
   http://www.sfsu.edu/~biology/pages/BiologyEquivalencyForm.pdf

❖ To obtain approval for the substitution of a course for your major degree requirement
   Download the SUBSTITUTION FORM from:
   http://www.sfsu.edu/~biology/pages/BiologySubstitutionForm.pdf

❖ To change your major
   Fill out and download the CHANGE OF MAJOR form
   http://www.sfsu.edu/~admisrec/forms/cm.htm

❖ To obtain approval for your academic standing petition (mandatory advising, probation)
   Academic standing petition
   http://www.sfsu.edu/~admisrec/forms/formstoc.htm

☐ Copies of your PREVIOUS ACADEMIC STANDING PETITION AGREEMENTS
   If you do not have copies, you may obtain them from the Department of Biology Office, but you should keep copies of all petitions

❖ To obtain approval for your Financial Aid Graduation Plan
   Obtain Financial Aid Graduation Plan form from Financial Aid Advisor

❖ To obtain approval for your baccalaureate graduation application
   Graduation Checklist
   http://online.sfsu.edu/~pasion/AdvisingWeb/GradChecklists.htm

☐ All approved Equivalency and Substitution forms

☐ Baccalaureate Graduation Application
   https://www.sfsu.edu/~admisrec/gradapp/ga.htm

*download online from MySFSU (https://www.sfsu.edu/online/login.htm)
**available from One Stop Student Services Center in the Student Services Building.

Revised 1/24/06
Department of Biology Graduation Checklist

**BACHELOR OF ARTS IN GENERAL BIOLOGY**

### Lower Division Requirements (32-33 units)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
<th>Equiv. Form if any (✓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 230</td>
<td>Introductory Biology I</td>
<td>5</td>
<td>✓</td>
</tr>
<tr>
<td>BIOL 240</td>
<td>Introductory Biology II</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>CHEM 115</td>
<td>General Chemistry I: Essential Concepts of Chemistry</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>CHEM 130</td>
<td>General Organic Chem. (CHEM 333 also acceptable)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CHEM 215</td>
<td>General Chemistry II (CHEM 216 is recommended)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PHYS 111/112</td>
<td>General Physics I/Laboratory (3/1)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PHYS 121/122</td>
<td>General Physics II/Laboratory (3/1)</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

One course from the following (3-4):

- MATH 124 Elementary Statistics (3)
- MATH 226 Calculus I (4)

**Total lower division requirements:** 32-33

### Upper Division Requirements (24-25 units)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 355</td>
<td>Genetics</td>
<td>3</td>
</tr>
</tbody>
</table>

One physiology course from the following (3):

- BIOL 525 Plant Physiology (3)
- BIOL 612 Human Physiology (3)
- BIOL 630 Animal Physiology (3)

One cell biology course from the following (3):

- BIOL 350 Cell Biology (3)
- BIOL 401 General Microbiology (3)
- BIOL 435 Immunology (3)
- BIOL 450 Biology of the Protozoa (3)
- BIOL 524 Plant Molecular Biology (3)
- CHEM 349 General Biochemistry (3)

One physiology or cell biology laboratory course from the following (2-4):

- BIOL 526 Plant Physiology Laboratory (2)
- BIOL 613 Human Physiology Laboratory (2)
- BIOL 631 Animal Physiology Laboratory (2)
- BIOL 436 Immunology Laboratory (2)
- BIOL 351 Experiments in Cell and Molecular Biology (4)
- BIOL 402 General Microbiology Laboratory (2)
- BIOL 451 Protozoology Laboratory (2)
- CHEM 343 Biochemistry I Laboratory (3)
# Department of Biology Graduation Checklist

**One ecology course from the following (3-5):**

<table>
<thead>
<tr>
<th>Course Num.</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 482</td>
<td>Ecology (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 529</td>
<td>Plant Ecology (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 534</td>
<td>Wetland Ecology (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 580</td>
<td>Limnology (3)</td>
<td></td>
</tr>
<tr>
<td>BIOL 582</td>
<td>Biological Oceanography (3)</td>
<td></td>
</tr>
<tr>
<td>BIOL 585/586</td>
<td>Marine Ecology (3/2)</td>
<td></td>
</tr>
</tbody>
</table>

**One evolution or organismal biology course from the following (3-5):**

<table>
<thead>
<tr>
<th>Course Num.</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 328</td>
<td>Human Anatomy (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 337</td>
<td>Evolution (3)</td>
<td></td>
</tr>
<tr>
<td>BIOL 380</td>
<td>Embryology (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 453/454</td>
<td>General Parasitology/Laboratory (3/1)</td>
<td></td>
</tr>
<tr>
<td>BIOL 459</td>
<td>Arthropod Biology (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 460</td>
<td>General Entomology (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 461</td>
<td>Insect Taxonomy (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 475</td>
<td>Herpetology (3)</td>
<td></td>
</tr>
<tr>
<td>BIOL 478</td>
<td>Ornithology (3)</td>
<td></td>
</tr>
<tr>
<td>BIOL 480</td>
<td>Mammalogy (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 500</td>
<td>Evolution and Diversity of Plants (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 502</td>
<td>Biology of the Algae (3)</td>
<td></td>
</tr>
<tr>
<td>BIOL 504</td>
<td>Biology of the Fungi (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 505</td>
<td>Comparative Anatomy of Vascular Plants (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 514</td>
<td>Plant Taxonomy (5)</td>
<td></td>
</tr>
<tr>
<td>BIOL 555</td>
<td>Marine Invertebrate Zoology (4)</td>
<td></td>
</tr>
<tr>
<td>BIOL 570</td>
<td>Biology of Fishes (4)</td>
<td></td>
</tr>
</tbody>
</table>

**Upper division electives selected in consultation with an advisor:**...........4-8

<table>
<thead>
<tr>
<th>Course Num.</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Required** | **Completed**

| Total upper division requirements | 24-25 | |
| Total for major                   | 57    | |
SFSU Department of Biology
Graduation Checklists for Undergraduate Degrees

Graduation Application Submission Process (for SUMMER 2008)
All Biology Major graduation applicants for SUMMER 2008 MUST complete an ONLINE SURVEY before the Department will approve the graduation application. Your input will help the Department improve its programs and courses for all Biology students.

• This requirement does not apply to Minor in Biology degree candidates.

If you do not have a Biology Major Advisor, please obtain your Biology Advisor assignment at the Department of Biology Office.

Download the Biology Advising Checklist (click here to download) BEFORE you visit your Biology Major Advisor.

Make sure that you bring all the required paperwork indicated in the Advising Checklist for your meeting with your Advisor.

Important deadlines:
Deadline to submit your graduation application to the Department of Biology Office (HH534): Monday, July 7, 4pm
Deadline to submit your Department-approved graduation application (with application fee receipt) to the Registrar’s Office: Friday, July 11, 5pm.

Step One: Access to Online Survey

1. Please click on the following link to access the SUMMER 2008 Graduating Biology Major Survey:
   https://www.surveymonkey.com/s.aspx?sm=P51jDqTWB02xmTK1zq0YVw_3d_3d
2. Please complete the online survey. Your responses will remain strictly anonymous.

Step Two: Fill out your Major Specific Graduation Checklist
Click on the following links to download the Graduation Checklist for the indicated major. Note, clicking on the link will open the checklist as a pdf in your browser. You can download the pdf by either "right-clicking" from a PC or holding down the mouse-click on a Mac and selecting the download or save the link option. Adobe Acrobat Reader is required to view these pdfs.

2007 - 2008 Graduation Checklists:
B.A. in Biology, General
B.S. in Biology: Concentration in Botany
B.S. in Biology: Concentration in Cell and Molecular Biology
B.S. in Biology: Concentration in Ecology
B.S. in Biology: Concentration in Marine Biology and Limnology
B.S. in Biology: Concentration in Microbiology
B.S. in Biology: Concentration in Physiology
B.S. in Biology: Concentration in Zoology
B.S. in Clinical Science
Minor in Biology

You can find Graduation Checklists for previous years at this link:

http://online.sfsu.edu/~pasion/AdvisingWeb/GradChecklists.htm
Alternatively, you can pick up the appropriate checklist for your Bulletin Year at the Department of Biology Office (HHS34). You are following requirements for your major from a previous bulletin, please come by the Biology Department Office (Hensill Hall 534) to obtain a copy of the major requirements from the bulletin year that you are following.

When you fill out the Graduation Checklist:

- Make sure you check off each course completed and list the correct number of units.
- If you are using a transfer course, check off that you have the approved Department Equivalency Form with your Checklist.

An Equivalency form must be attached to your application for any/all non-SFSU classes used in your major and taken at another institution. Download Equivalency Form here.

Directions for approval of the Equivalency Form are here: Approval of Transfer Courses.
- All upper division electives should be listed in the table available at the end of the Checklist.

All elective courses should be listed on the approved Department Substitution Form with your Checklist.

Use a Department Substitution form or memo (from an advisor) identifying classes used to meet Lower Division or Upper Division electives required that are not listed in your major concentration. Download Substitution Form here.

**Step Three: Fill out the Graduation Application**

Click here to fill out the online Baccalaureate Degree Application for Graduation. This downloadable graduation application form also has useful graduation FAQs.

Please note that students should apply for graduation only if they believe they will have satisfied all degree requirements by the end of the term in which they have applied (SFSU Registrar deadlines).

When you fill out the Graduation Application:

- Make sure you list the courses in the same order they appear on the Graduation Checklist.
- If the course is a transfer course, make sure you write the course name and number from the transfer campus.

**Step Four: Meet with your Advisor for approval of your Graduation Application (please see info about Summer 2008 Advisors on Biology Advising Web page)**

Details for obtaining approval of your Graduation Application, along with a list of all forms to bring to your meeting with your Advisor are listed here: To get approval of your graduation application

Briefly, bring:

- a Department of Biology Graduation Checklist filled out prior to meeting with the advisor
- the Graduation Application, with the majors course work listed in the same order the classes appear in the Biology Major descriptions listed in the Graduation Checklist
- a copy of your unofficial SFSU transcripts
- a copy of your Advanced Standing Evaluation (ASE) and Degree Audit Report (if a transfer student)
- print out of your current course enrollment

...Department of Biology Equivalency and Substitution forms for necessary course work
Step Five: Submit your Graduation Application (and additional forms) to the Department of Biology for approval

- Deadline for submitting your Graduation Application to the Biology Department to meet the Summer semester graduation deadline is Monday, July 7, 4pm.
- This application must be approved by your Major Advisor BEFORE you submit it to the Department Office.
- You must complete the Online Survey BEFORE you submit your application to the Department Office (see Step One above).
- Applications submitted after this deadline may not be approved in time to meet the University deadline (Friday, July 11).

After your application has been reviewed and signed by your Major Advisor, please bring your application to our Biology Department Office and leave the application for the Chair to review. You do not need to meet with the Chair of the Department.

Typically, it is best to allow one week for review of your application before picking it up from the Biology Department Office.

Step Six: Pay the graduation application fee and submit your Graduation Application to the University (One Stop Center)

The deadline for submitting your Graduation Application to the University to meet the Summer semester graduation deadline is FRIDAY, JULY 11.

After your application has been approved by the Department, you may pick up the application and pay the graduation application fee at the Bursar’s Office in the Administration Building.

- NOTE: It would be best to have your application approved BEFORE you pay the fee. However, if you are submitting your graduation application for approval close to this deadline (July 11), you should PAY for the graduation application BEFORE you submit the application to the Department Office (after your Advisor has approved the application).
- After you pay the fee, you may submit your graduation application (and the accompanying forms) to the One Stop Student Services Center.

Below is a list of course numbers that were changed for the current bulletin year. Please note these changes as appropriate.

<table>
<thead>
<tr>
<th>Previous Course Number</th>
<th>Current Course Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 111</td>
<td>CHEM 115</td>
</tr>
<tr>
<td>CHEM 113</td>
<td>CHEM 215</td>
</tr>
<tr>
<td>CHEM 114</td>
<td>CHEM 216</td>
</tr>
<tr>
<td>MATH 220</td>
<td>MATH 226</td>
</tr>
<tr>
<td>MATH 221</td>
<td>MATH 227</td>
</tr>
</tbody>
</table>

- Please note that CHEM 333 can be used in place of CHEM 130 (requires a Biology Department equivalency form).
Congratulations to all graduating seniors!! We wish you good luck in your future career.
ACADEMIC SENATE POLICY #S06-191

Policy on Undergraduate Academic Advising
(formerly Academic Senate Policy #S95-191)

Overview

The need for high quality academic advising is acknowledged by students, faculty, staff, and administrators alike to be a key component to student success and progress to degree. Recent reports by the CSU Chancellors Office and CSU Academic Senate identify advising as fundamental to the mission of the CSU. This revision to Academic Senate Policy #S95-191 serves to reaffirm the commitment of the San Francisco State University academic community to high quality academic advising, and in a newly added Section V specifies five implementation activities and strategies that correspond to each of the five key pivotal points of advising enumerated in Section III.

I. Philosophy

Academic advising is inextricably linked with student learning. In partnership, classroom instruction and academic advising assist students in weaving together the strands of personal and intellectual learning which are the marks of a true higher education. Through skillful academic advising students are guided toward the timely completion of their studies as well as the identification and fulfillment of academic and career goals.

II. Advising Program Objectives

The purpose of advising at San Francisco State University is to facilitate the intellectual and personal development of our students, to enhance their academic performance, and to ensure students' progress toward graduation by assisting them in achieving the following objectives:

A. Facilitating Intellectual and Personal Development

1. Choosing, clarifying, planning and achieving educational and career goals;

2. Understanding the relationship between academic experience and career opportunities/objectives;

3. Identifying academic skills that need to be acquired or enhanced to achieve educational goals.

B. Enhancing Academic Performance

1. Developing a strategy to monitor progress and development at the University;
2. Selecting courses to integrate educational and personal goals with the objectives of the University (to educate a skillful, ethical, principled, and liberally-educated citizenry);

3. Exploring academic options to make meaningful short and long-term decisions (e.g. course substitutions, Segment III clusters, options within a major, electives);

4. Increasing awareness of the full range of campus programs and services (e.g. Career Day, EOP, pre-professional advising).

C. Ensuring Progress Toward Graduation

1. Understanding and following the University's policies and procedures leading to graduation (e.g. requirements for completion of general education, majors and programs, and other University requirements);

2. Completing and processing appropriate forms and petitions necessary to maintain ongoing academic progress (e.g. graduation applications, petitions for withdrawal, waiver of college regulations, academic probation, independent study, grade changes, incompletes, etc.);

3. Accessing information and guidance regarding post-baccalaureate studies (e.g. graduate, law, or medical school).

III. Pivotal Points for Advising

Academic advising does not take place in a vacuum; rather, it occurs within a framework of a student's academic progress. Ideally, students would seek and obtain academic advising on a regular basis throughout their academic careers. Minimally, advising revolves around the following five key pivotal points: (1) when the student enters the university, either as a first-year or transfer student, (2) when the student enters the major, minor, or program, (3) if and when the student experiences academic difficulty, including probation and possibility of disqualification, (4) when the student moves into upper division standing and closer to graduation and (5) as the student prepares to graduate and move beyond his or her studies at San Francisco State University.

It is within the scope of these five pivotal points that the SFSU Policy on Advising is founded. What follows are specific responsibilities of students, faculty, departments and administrators to ensure that students and the university community alike maximize the benefits of the SFSU academic advising programs.

IV. Responsibilities

A. Students are responsible for the following:

1. Knowing and completing all degree requirements.

2. Consulting a SFSU Bulletin once upon entering the University and a Class Schedule every semester. Obtaining department or major brochures, handbooks, and information as necessary.

3. Attending a new student orientation program prior to the first semester of attendance.
4. Declaring a major in a timely manner. It is recommended that students who enter SFSU as freshmen declare a major by no later than the end of the sophomore year and those students who enter as junior transfers declare a major by the end of the second semester in attendance.

5. Maintaining a personal academic advising folder and taking it to every advising appointment. It is recommended that this folder include:

   a. Grade reports or unofficial copies of prior college/university transcripts;
   b. Evaluations of transfer credit (Advanced Standing Evaluations/ASE);
   c. DARS, G.E. and Graduation check lists;
   d. Semester grade reports; and
   e. Tentative schedules and other forms and notes from formal advising sessions (e.g. Incomplete Grade Form, Probation Release, Course Withdrawal Form, etc.).

6. Seeking academic advising at the appropriate time. Minimally, to include:

   a. When entering the university, either as a first-year or transfer student;
   b. When entering the major, minor, or program;
   c. If and when experiencing academic difficulty, including probation and possibility of disqualification;
   d. When moving into upper division standing and closer to graduation, and;
   e. When preparing to graduate and move beyond studies at San Francisco State University.

7. Seeking academic advising from the appropriate sources:

   a. Declared majors will receive their primary academic advising from their major department;
   b. Undeclared students will receive their primary academic advising from the Advising Center or a specifically assigned Academic Support Program (e.g. Educational Opportunity Program);
   c. Students with declared majors who are also in special academic support programs (e.g. EOP) will maintain regular contact with (1) the advisor in the appropriate support program and (2) the faculty advisor in their major.

8. Evaluating academic advising programs and individual academic advisors through established procedures or by speaking or writing directly to faculty advisors, chairs of departments, Deans of Colleges, or supervisors of campus advising units.
B. Faculty Advisors are responsible for the following:

1. Being prepared after the first semester of employment to advise students:
   a. Attend an advising orientation or in-service training as provided by department/program or university services;
   b. Obtain and become familiar with the SFSU Bulletin, "Gator Aid" Student Handbook and current Department advising materials;
   c. Become skilled in using electronic advising tools (e.g. DARS, Roadmaps, Graduation Planners, the Advising Center website);
   d. Become familiar with University advising materials and procedures (e.g. ASE, Class Schedule);
   e. Be familiar with campus advising resources as listed in the Bulletin under "University Resources and Support Services".

2. Providing accessible advising services to students by scheduling and maintaining regular office hours.

3. Providing supportive academic advising assistance by responding to the differing needs of SFSU's diverse student population. Advisors should be trained to 1) recognize problems that affect the academic performance of students, either personal, social or economic, and 2) to refer students to appropriate campus support services (e.g. Counseling and Psychological Services, Advising Center, EOP, Financial Aid, Testing Center, etc.).

C. Each Department or Program is responsible for the following:

1. Preparing and implementing a written plan for advising students in their majors. The plan should include the following elements:
   a. A clear delineation of who in the department is responsible for academic advising (e.g. Department Chair, Advising Coordinator, GE Advising Coordinator, Probation Advising Coordinator, etc.), including the designation of liaisons with important Campus Advising Resources (e.g. Advising Center, EOP, Disability Programs and Resource Center, Financial Aid, etc.);
   b. Identification of mechanisms which ensure the accessibility of advising (e.g. faculty office hours which accommodate a variety of student schedules; periodic department orientations, peer advising program, written advising materials, etc.);
   c. A method by which faculty advisors will be selected (including lecturer faculty, per College procedures), assigned, and trained to provide academic advising;
   d. Materials which will be used in the advising process, including an orientation-to-the major brochure or handbook, a prerequisite-to-the major flow chart, a semester-by-semester graduation plan for native and transfer students (including GE and major requirements) and a graduation progress checklist;
e. An information program for the major/minor (e.g. Advising Day major/minor overview; new majors/orientation meeting);

f. A written plan requiring students on academic probation/subject to disqualification to meet with a major advisor as a requisite for ongoing registration;

g. A procedure to evaluate the effectiveness of departmental advising, including recognition of advisors.

2. Making specific requirements of their academic program readily available to students by having a designated area on department bulletin board for public display of advising procedures and information. Departments are encouraged to develop electronic means for disseminating advising information to students and faculty.

3. Providing a list of faculty advisors, their office hours, where they are located and the type of advising provided.

D. The Advising Center is responsible for the following:

1. Providing direct advising services to students in the following ways:

   a. Be the primary advising department for Undeclared, Special Major, and Re-entry students;

   b. Provide services to the above student populations who experience academic difficulty or are subject to disqualification;

   c. Coordinate orientation programs for new students and SFSU all-university advising programs and events;

   d. Provide general advising information workshops, drop-in quick questions, and advising appointments by referral (GE and general graduation requirements) for the general student population;

   e. Coordinate special advising programs as necessary (e.g. CEEL, Special Major, GE petition process).

2. Providing the following advising support services to University staff, faculty and departments:

   a. Gather and disseminate appropriate academic advising materials to assist college, department, and program advising coordinators; once a semester, call a meeting of all advising coordinators;

   b. Act as a referral service and respond to questions from the college, department, and program advising coordinators, as well as from faculty and students;

   c. Be familiar with campus-wide advising problems and formulate and make suggestions for the improvement of the advising program;

   d. Play an integral role in preparing, reviewing and updating advising related all-university publications (e.g. SFSU Bulletin, Student Handbook, Class Schedule, etc.)
Hola Karen, Dave,

Saludos desde Playa del Carmen!

I got this from Helen Goldsmith and thought you might be able to look at it and decide whether the transfer pattern is ok?

Thanks,

Oz

Begin forwarded message:

From: Helen Goldsmith <hgold@sfsu.edu>
Date: July 11, 2008 2:40:28 PM PDT
To: Oswaldo Garcia <ogarcia@sfsu.edu>
Subject: [Fwd: final review of Geology LDTP 15-unit local agreements]

Hi Oswaldo,
I know that sometimes you have trouble with e-mail - did you receive this when I sent it a few weeks ago?
Helen

-------- Original Message --------
Subject: final review of Geology LDTP 15-unit local agreements
Date: Wed, 25 Jun 2008 10:30:53 -0700
From: Helen Goldsmith <hgold@sfsu.edu>
To: Oswaldo Garcia <ogarcia@sfsu.edu>
CC: Sung Hu <suh@sfsu.edu>, Lisa White <lwhite@sfsu.edu>
References: <442860D2.9000498@sfsu.edu> <46535CF3-E129-4AFE-A2CF-BEC8481DE741@sfsu.edu>

Hi Oswaldo,
I hope you're having a good summer so far.

The CSU Lower Division Transfer Pattern (LDTP) project is finally going live this fall with the 2009-2010 application period that begins October 1. As you know, LDTP includes a systemwide pattern of at least 45-units that was agreed upon by department representatives throughout the CSU. In addition, each campus was asked to create its own campus-specific agreement with the remaining units to make up 60 units in transfer. As you may recall, we agreed to include ENG 114 & 214 in the campus-specific agreements in the hopes that more students will transfer with these courses completed.

Campuses are being asked to review their campus-specific patterns one last time to make sure they are accurate before they are posted on ASSIST and CSU Mentor.

One change since the agreements were made is that the CAN numbering system is being eliminated. Therefore, we must replace CAN numbers with SFSU-specific numbers, whenever possible. You'll notice that I highlighted several places where I think changes need to be made (for example, including the new title for the BA - I'm not sure whether you want it in parentheses as I've done so that students understand that...
we're still talking about what's being called Geology in the rest of the state?).

The attachments include both the campus-specific agreements (word document) and the CSU agreements (PDF file with the statewide agreement at the beginning and the original campus-specific agreements in alphabetical order by campus).

Please let me know if the attached campus-specific agreement still accurately reflects your department's preferences in terms of facilitating transfer. Ideally, if you (or someone from the department) could let me know no later than mid-July that would be really helpful.

Feel free to call me if you have any questions.

Thanks!

Helen
x81999
The Lower-Division Transfer Pattern (LDTP) consists of the CSU statewide pattern of coursework outlined below, plus campus-specific coursework, bringing the total pattern to at least 60 but no more than 70 transferable semester units for students to complete at a California Community College (CCC).

The CSU statewide pattern of coursework for CCC students who plan to major in Geology at any CSU campus offering the major includes:
- Completion of lower-division general education requirements, following either the CSU General Education Breadth (GE-Breadth) or the Intersegmental General Education Transfer Curriculum (IGETC) pattern;
- Completion of the CSU graduation requirements in United States History, Constitution and American Ideals; and
- Completion of additional semester units as specified below in (3).

Please note that the information here is an academic and curricular advising tool: a roadmap that enables transfer students to efficiently and effectively progress towards the CSU baccalaureate degree in a specified discipline. California Community College students should work closely with their advisers when planning their academic program in preparation for transfer to the CSU.

This information does not represent any guarantee with regard to admission nor does it include or replace CSU campus admissions impaction criteria (see [http://www.calstate.edu/AR/impactioninfo.shtml](http://www.calstate.edu/AR/impactioninfo.shtml)). These curricular guidelines are subject to change.

<table>
<thead>
<tr>
<th>CSU Statewide Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Complete lower-division general education requirements.</td>
<td>39 units for GE-Breadth</td>
</tr>
<tr>
<td>Obtain a certification of completion of GE-Breadth or IGETC by the California Community College before transferring to a CSU campus.</td>
<td>Minimum grades of C are required in courses used to meet GE-Breadth Areas A and B4. or 37 units for IGETC Minimum grade of C is required in each course used for IGETC.</td>
</tr>
<tr>
<td>While completing general education, follow the course pattern stated below.</td>
<td></td>
</tr>
<tr>
<td>(2) Complete the graduation requirements in United States History, Constitution and American Ideals.¹</td>
<td>0 units required for GE-Breadth</td>
</tr>
<tr>
<td>These are typically completed with one course each in American government and American history, or a sequence of courses that integrate the history and government topics.</td>
<td>6 units for IGETC IGETC does not permit double counting of courses to meet IGETC and U.S. History, Constitution and American Ideals requirements.</td>
</tr>
<tr>
<td>Students completing GE-Breadth should ordinarily use these courses to satisfy 6 units of Area D.</td>
<td></td>
</tr>
<tr>
<td>(3) Complete a Physical Geology/Introductory Geology course [CAN GEOL 2] with a corresponding geology laboratory.</td>
<td>1 Unit if GE-Breadth completed 0 units if IGETC completed</td>
</tr>
<tr>
<td>This should ordinarily be used to satisfy GE-Breadth Areas B1 and B3. Together, the course and the laboratory also meet IGETC Area 5A and the laboratory requirement of Area 5.</td>
<td></td>
</tr>
</tbody>
</table>

¹ CCC courses that fulfill general education and graduation requirements in United States History, Constitution and American Ideals are listed at [www.assist.org](http://www.assist.org).
<table>
<thead>
<tr>
<th>Course Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4) Complete Calculus, 1st semester [CAN MATH 18]. This course should be used</td>
<td>1 unit</td>
</tr>
<tr>
<td>to satisfy GE-Breath Area 4 or IGETC Area 2.</td>
<td></td>
</tr>
<tr>
<td>(5) Complete General Chemistry for Science Majors, 1st semester, with</td>
<td>5 units</td>
</tr>
<tr>
<td>corresponding laboratory [CAN CHEM 2].</td>
<td></td>
</tr>
<tr>
<td><strong>Total Semester Units Required for Statewide LDTP Pattern</strong></td>
<td>46-49 units</td>
</tr>
</tbody>
</table>
Geology

LOWER-DIVISION TRANSFER PATTERN
CSU Bakersfield Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Bakersfield campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>- A course that articulates with [CAN MATH 20], Calculus II and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- A course that articulates with [CAN CHEM 4], Chemistry II and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- Courses that articulate with [CAN PHYS SEQ A], Physics I or</td>
<td>0-7 units</td>
</tr>
<tr>
<td>Courses that articulate with [CAN PHYS SEQ B], Physics II</td>
<td></td>
</tr>
<tr>
<td>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</td>
<td>0-15 units</td>
</tr>
<tr>
<td>Total Semester Units Required for CSU Bakersfield</td>
<td>15 units</td>
</tr>
</tbody>
</table>

Geology

LOWER-DIVISION TRANSFER PATTERN
CSU Channel Islands Campus-Specific Pattern

This campus does not have a major, concentration, or option in Geology.

Geology

LOWER-DIVISION TRANSFER PATTERN
CSU Chico Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Chico campus-specific pattern for the Major in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>- A course that articulates with [CAN GEOL 4], Historical Geology with Lab and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>- A course that articulates with [CAN MATH 20], 2nd Semester Calculus and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- A course that articulates with [CAN PHYS 8], Physics: Mechanics and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- A course that articulates with [CAN GOVT 2], American Government</td>
<td>0-3 units</td>
</tr>
<tr>
<td>The following courses are recommended:</td>
<td></td>
</tr>
<tr>
<td>- A course that articulates with [CAN PHYS 12], Physics: Electricity and Magnetism</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- A course that articulates with [CAN CHEM 4], 2nd Semester</td>
<td>0-5 units</td>
</tr>
<tr>
<td>General Chemistry with Lab</td>
<td>0-3 units</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>14 units</td>
</tr>
</tbody>
</table>

**Geology**

**LOWER-DIVISION TRANSFER PATTERN**

**CSU Dominguez Hills Campus-Specific Pattern**

In addition to the statewide pattern, the following is the CSU Dominguez Hills campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course(s) that articulates with General Chemistry II and Laboratory and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 20], Calculus II and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN GEOL 4], Historical Geology and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 2], General Physics with Algebra and Trigonometry</td>
<td>0-17 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>17 units</td>
</tr>
</tbody>
</table>

**Geology**

**LOWER-DIVISION TRANSFER PATTERN**

**CSU East Bay Campus-Specific Pattern**

In addition to the statewide pattern, the following is the CSU East Bay campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with a Second semester of Introductory Chemistry and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with a Second semester of Introductory Physics</td>
<td>0-8 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>14 units</td>
</tr>
</tbody>
</table>
Geology
LOWER-DIVISION TRANSFER PATTERN
CSU Fresno Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Fresno campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CSUF GEOL 2], Historical Geology - A course in the origin and evolution of solid earth, life, oceans, and atmosphere as revealed by the rock record’s fossil remains with emphasis on the evolution of life and the physical environment. and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>• A course that articulates with [CSUF PHYS 2A], General Physics - A course that covers topics and concepts in Newtonian mechanics of point particles and rigid bodies, energy, properties of fluids, heat and thermodynamics, waves and sound. and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CSUF PHYS 2B], General Physics - A course that covers topics and concepts in light, electricity, magnetism, atomic structure, relativity, quantum nature of light and matter, nuclear structure and radiation. and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CSUF CHEM 1B], General Chemistry - A course that covers acid-base theory; chemical kinetics; equilibrium (acid-base, hydrolysis, and solubility); thermodynamics, electrochemistry; selected topics in nuclear chemistry, coordination chemistry, and/or chemistry of selected groups.</td>
<td>0-5 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</td>
<td>0-16 units</td>
</tr>
<tr>
<td>Total Semester Units Required for CSU Fresno</td>
<td>16 units</td>
</tr>
</tbody>
</table>

Geology
LOWER-DIVISION TRANSFER PATTERN
CSU Fullerton Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Fullerton campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN GEOL 4], Historical Geology with Lab and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 20], 2nd Semester Calculus II and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], 2nd Semester General Chemistry with Lab and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 8], 1st Semester Physics</td>
<td>0-4 units</td>
</tr>
</tbody>
</table>
Geology
LOWER-DIVISION TRANSFER PATTERN
Humboldt State University Campus-Specific Pattern

In addition to the statewide pattern, the following is the Humboldt State University campus-specific pattern for the B.A. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 20], Calculus, 2nd semester and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], General Chemistry for Science Majors, 2nd semester, with corresponding laboratory and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 22], Calculus, 3rd semester or</td>
<td>0-4 units</td>
</tr>
<tr>
<td>A course that articulates with [CAN STAT 2], Introductory Statistics such as Biometrics or Statistics and</td>
<td></td>
</tr>
<tr>
<td>• Physics, 1st semester, either College Physics [CAN PHYS 2] or General Physics [CAN PHYS 4]*</td>
<td>0-4-units</td>
</tr>
</tbody>
</table>

*Strongly recommended for students interested in pursuing graduate degrees.

<table>
<thead>
<tr>
<th>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</th>
<th>0-16 units</th>
</tr>
</thead>
</table>

Total Semester Units Required for Humboldt State University 16 units

In addition to the statewide pattern, the following is the Humboldt State University campus-specific pattern for the B.S. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 20], Calculus, 2nd semester and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], General Chemistry for Science Majors, 2nd semester, with corresponding laboratory and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 22], Calculus, 3rd semester or</td>
<td>0-4 units</td>
</tr>
<tr>
<td>A course that articulates with [CAN STAT 2], Introductory Statistics such as Biometrics or Statistics and</td>
<td></td>
</tr>
<tr>
<td>• Physics, 1st semester, either College Physics [CAN PHYS 2] or General Physics [CAN PHYS 4]*</td>
<td>0-4-units</td>
</tr>
</tbody>
</table>

000043
In addition to the statewide pattern, the following is the Humboldt State University campus-specific pattern for the B.A. in Geosciences.

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN BIOL 2], Principles of Biology. If possible this course should be used to satisfy GE-Breadth Area B2. Together, the course and the laboratory also meet IGETC Area 5B. and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], General Chemistry for Science Majors, 2nd semester, with corresponding laboratory and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 2], College Physics, 1st semester and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 4], College Physics, 2nd semester and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN BIOL 6], General Botany or General Zoology</td>
<td>0-4 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</td>
<td>0-17 units</td>
</tr>
</tbody>
</table>

Total Semester Units Required for Humboldt State University | 17 units

Geology

LOWER-DIVISION TRANSFER PATTERN
CSU Long Beach Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Long Beach campus-specific pattern for the B.S. in Earth Science:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 20], 2nd Semester Calculus II and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], 2nd Semester General Chemistry and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 8], Physics: Mechanics and Heat and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN GEOL 4], Historical Geology with Lab</td>
<td>0-4 units</td>
</tr>
<tr>
<td>The following course is recommended:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 12], Physics: Electricity and Magnetism</td>
<td>0-4 units</td>
</tr>
</tbody>
</table>
(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units.  

| Total Semester Units Required for Earth Science at CSU Long Beach | 17 units |

In addition to the statewide pattern, the following is the CSU Long Beach campus-specific pattern for the B.S. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
</table>
| (1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:  
  - A course that articulates with [CAN MATH 20], 2nd Semester Calculus II and  
  - A course that articulates with [CAN CHEM 4], 2nd Semester General Chemistry and  
  - A course that articulates with [CAN PHYS 8], Physics: Mechanics and Heat and  
  - A course that articulates with [CAN GEOL 4], Historical Geology with Lab  
  The following course is recommended:  
  - A course that articulates with [CAN PHYS 12], Physics: Electricity and Magnetism  |
| 0-4 units | 0-5 units | 0-4 units | 0-4 units | 0-4 units |

(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units.  

| Total Semester Units Required for Geology at CSU Long Beach | 17 units |

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Geology

LOWER-DIVISION TRANSFER PATTERN  
CSU Los Angeles Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Los Angeles campus-specific pattern for the B.S. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
</table>
| (1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:  
  - A course that articulates with [CAN CHEM 4], General Chemistry II and Lab and  
  - A course that articulates with a second semester of expository writing that emphasizes exposition, research, and critical thinking, typically called “Writing and Critical Thinking” (as opposed to “Literature and Composition”) and  
  - A course that articulates with [CAN GEOL 4], Historical Geology and  
  - A course that articulates with Mineralogy or  
  If Mineralogy is not available complete either:  
  - A course that articulates with [CAN PHYS 2], General Physics with Algebra and Trigonometry or  
  - A course that articulates with [CAN PHYS 8], General Physics with Calculus I and Lab |
| 0-5 units | 0-3 units | 0-4 units | 0-4 units | 0-4 units | 0-4 units | 0-4 units | 0-4 units |
Geology
LOWER-DIVISION TRANSFER PATTERN
California Maritime Academy Campus-Specific Pattern

This campus does not have a major, concentration, or option in Geology.

Geology
LOWER-DIVISION TRANSFER PATTERN
CSU Monterey Bay Campus-Specific Pattern

This campus does not have a major, concentration, or option in Geology.

Geology
LOWER-DIVISION TRANSFER PATTERN
CSU Northridge Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Northridge campus-specific pattern for the B.S. in Geological Sciences:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], 2nd semester General Chemistry with Lab and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 8], Physics: Mechanics &amp; Heat and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN GEOL 4], Historical Geology with Lab</td>
<td>0-4 units</td>
</tr>
<tr>
<td>Recommended:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 12], Physics: Electricity &amp; Magnetism</td>
<td>0-4 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>0-1 units</td>
</tr>
<tr>
<td>Total Semester Units Required for Geological Sciences at CSU Northridge</td>
<td>14 units</td>
</tr>
</tbody>
</table>

In addition to the statewide pattern, the following is the CSU Northridge campus-specific pattern for the B.S. in Secondary Teaching:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
</tbody>
</table>
- A course that articulates with [CAN CHEM 4], 2nd semester General Chemistry with Lab and
- A course that articulates with [CAN PHYS 8], Physics: Mechanics & Heat and
- A course that articulates with [CAN GEOL 4], Historical Geology with Lab

Recommended:
- A course that articulates with [CAN PHYS 12], Physics: Electricity & Magnetism

(2) Complete additional coursework to bring total to 60 transferable semester units

| Total Semester Units Required for Secondary Teaching CSU Northridge | 14 units |

In addition to the statewide pattern, the following is the CSU Northridge campus-specific pattern for the B.S. in Environmental Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], 2nd semester General Chemistry with Lab and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 8], Physics: Mechanics &amp; Heat and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN GEOL 4], Historical Geology with Lab</td>
<td>0-4 units</td>
</tr>
<tr>
<td>Recommended:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 12], Physics: Electricity &amp; Magnetism</td>
<td>0-4 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>0-1 units</td>
</tr>
<tr>
<td>Total Semester Units Required for Environmental Geology at CSU Northridge</td>
<td>14 units</td>
</tr>
</tbody>
</table>

Geology
LOWER-DIVISION TRANSFER PATTERN
Cal Poly Pomona Campus-Specific Pattern

In addition to the statewide pattern, the following is the Cal Poly Pomona campus-specific pattern for the B.S. in Integrated Earth Studies:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN GEOL 4], Historical Geology with Lab and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CPP GSC 116], Introduction to Astronomy - A course that focuses on the composition, history, and dynamics of the solar system (the sun, planets, moons, comets, asteroids, and meteors) and theories of its origin and evolution. Also examines the nature of stars, galaxies, and the</td>
<td>0-3 units</td>
</tr>
</tbody>
</table>
universe as interpreted from analysis of starlight. and
- A course that articulates with [CPP GSC 215/215L], Mineralogy with Lab - A course in the identification, occurrence, origin and uses of the common minerals; quantitative x-ray diffraction microanalysis, physical and chemical properties of minerals and introductory morphologic crystallography. and
- A course that articulates with [CAN CHEM 4], Chemistry or A course that articulates with [CAN PHYS 2], Algebra-based Physics

(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units

| Total Semester Units Required for Integrated Earth Studies at Cal Poly Pomona | 14 units |

In addition to the statewide pattern, the following is the Cal Poly Pomona campus-specific pattern for the B.S. in Geology.

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>- A course that articulates with [CAN GEOL 4], Historical Geology with Lab and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- A course that articulates with [CPP GSC 215/215L], Mineralogy with Lab - A course in the identification, occurrence, origin and uses of the common minerals; quantitative x-ray diffraction microanalysis, physical and chemical properties of minerals and introductory morphologic crystallography. and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- A course that articulates with 2[CAN MATH 20], &quot;nd Semester Calculus and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>- A course that articulates with [CAN CHEM 4], Chemistry or A course that articulates with [CAN PHYS 8], Calculus-based Physics</td>
<td>0-3 units</td>
</tr>
</tbody>
</table>

(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units

| Total Semester Units Required for Geology at Cal Poly Pomona | 15 units |

**Geology**

**LOWER-DIVISION TRANSFER PATTERN**

**CSU Sacramento Campus-Specific Pattern**

In addition to the statewide pattern, the following is the CSU Sacramento campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>- A course that articulates with [CAN GEOL 4], Historical Geology with Lab</td>
<td>0-4 units</td>
</tr>
</tbody>
</table>

(2) Complete additional coursework to bring total to 60 transferable semester units

| 0-10 units |
## Geology

**LOWER-DIVISION TRANSFER PATTERN**

**CSU San Bernardino Campus-Specific Pattern**

In addition to the statewide pattern, the following is the CSU San Bernardino campus-specific pattern for the B.A. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• Courses that articulate with [CAN PHYS SEQ B], One year sequence of Physics</td>
<td></td>
</tr>
<tr>
<td>(2) Complete additional coursework from General Education categories C, D, and/or E, if necessary, to bring total to 60 transferable semester units.</td>
<td>0-14 units</td>
</tr>
</tbody>
</table>

**Total Semester Units Required for the B.A. at CSU San Bernardino**

14 units

In addition to the statewide pattern, the following is the CSU San Bernardino campus-specific pattern for the B.S. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS SEQ B], One year sequence of Physics</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CSUSB CHEM 216], General Chemistry II with Lab - A course that covers chemical kinetics and equilibrium, thermodynamics, redox reactions and electrochemistry, and topics in inorganic, organic, biological and environmental chemistry. and</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CSUSB MATH 122], Calculus for the Life Sciences II - A course that covers topics from integral calculus and an introduction to elementary differential equations.</td>
<td></td>
</tr>
<tr>
<td>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</td>
<td>0-14 units</td>
</tr>
</tbody>
</table>

**Total Semester Units Required for CSU San Bernardino**

14 units
Geology
LOWER-DIVISION TRANSFER PATTERN
San Diego State University Campus-Specific Pattern

In addition to the statewide pattern, the following is the San Diego State University campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [SDSU BIOL 100], General Biology</td>
<td>0-3 units</td>
</tr>
<tr>
<td>- A beginning course in biology stressing processes common to living organisms. and</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [SDSU CHEM 200], General Chemistry - General principles of chemistry with emphasis on inorganic materials. and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [SDSU MATH 151], Calculus II - A course that covers techniques and applications of integration; improper integrals; differential equations; infinite series; conic sections; curves in parametric form; polar coordinates.</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4, SDSU CHEM 201], General Chemistry - General principles of chemistry with emphasis on inorganic materials and qualitative analysis.</td>
<td>0-5 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>0-6 units</td>
</tr>
<tr>
<td>Total Semester Units Required for San Diego State University</td>
<td>17 units</td>
</tr>
</tbody>
</table>

Geology
LOWER-DIVISION TRANSFER PATTERN
San Francisco State University Campus-Specific Pattern

In addition to the statewide pattern, the following is the San Francisco State University campus-specific pattern for the B.A. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN GEOL 8], Historical Geology</td>
<td>0-3 units</td>
</tr>
<tr>
<td>and</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with Paleontology and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 2], General Physics I and Lab and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 4], General Physics II and Lab</td>
<td>0-4 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</td>
<td>0-14 units</td>
</tr>
<tr>
<td>Total Semester Units Required for the B.A. in Geology at San Francisco State University</td>
<td>14 units</td>
</tr>
</tbody>
</table>
In addition to the statewide pattern, the following is the San Francisco State University campus-specific pattern for the B.S. in Geology.

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN CHEM 4], General Chemistry II and Lab and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN MATH 20], Calculus II and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 8], General Physics with Calculus I and Lab</td>
<td>0-4 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>0-1 unit</td>
</tr>
<tr>
<td>Total Semester Units Required for the B.S. in Geology at San Francisco State University</td>
<td>14 units</td>
</tr>
</tbody>
</table>
Geology
LOWER-DIVISION TRANSFER PATTERN
San Jose State University Campus-Specific Pattern

In addition to the statewide pattern, the following is the San Jose State University campus-specific pattern for the B.S. in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [SJSU ENGL 001B], Composition II - A course in expository writing, supplemented by critical reading and analysis of expository prose or literature. and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>• A course that articulates with [SJSU CHEM 001B], General Chemistry - A course that covers topics including stoichiometry, colligative properties, kinetics, equilibria, thermodynamics and electrochemistry. and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [SJSU PHYS 050], General Physics/Mechanics - A course that covers particle Kinematics and dynamics, work and energy, linear momentum, rotational motion, fluids, vibrations, and sound. and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>Either:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [SJSU PHYS 051], General Physics/Electricity and Magnetism - A course that covers electric and magnetic fields, dc and ac circuits, electromagnetic waves. or</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [SJSU PHYS 052], General Physics/Heat and Light - A course that covers temperature, heat, thermodynamics, kinetic theory, geometric and physical optics, and an introduction to quantum physics.</td>
<td></td>
</tr>
<tr>
<td>(2) Complete additional coursework to bring total to 60 transferable semester units</td>
<td>0-1 units</td>
</tr>
<tr>
<td>Total Semester Units Required for Geology at San Jose State University</td>
<td>14-16 units</td>
</tr>
</tbody>
</table>

In addition to the statewide pattern, the following is the San Jose State University campus-specific pattern for the B.A. in Earth Science:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [SJSU CHEM 001B], General Chemistry - A course that covers topics including stoichiometry, colligative properties, kinetics, equilibria, thermodynamics and electrochemistry. and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [SJSU PHYS 002A], Fundamentals of Physics - A first semester of a two-semester sequence that is non-calculus based and covers the topics of mechanisms, heat, and sound. and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [SJSU PHYS 002B], Fundamentals of Physics - A second semester of a two-semester sequence that covers electricity and magnetism, optics and atomic structure. and</td>
<td>0-4 units</td>
</tr>
</tbody>
</table>
• A course that articulates with [SJSU ASTR 101], Modern Astronomy - A principally non-mathematical discussion of current scientific observational and theoretical understanding of the origin and evolution of stars, galaxies and the cosmos.  

<table>
<thead>
<tr>
<th>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</th>
<th>0-16 units</th>
</tr>
</thead>
</table>

| Total Semester Units Required for Earth Science at San Jose State University | 16 units |

Geology
LOWER-DIVISION TRANSFER PATTERN
Cal Poly San Luis Obispo Campus-Specific Pattern

In addition to the statewide pattern, the following is the Cal Poly San Luis Obispo campus-specific pattern for Earth Sciences:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete: A course that articulates with General Botany and A course that articulates with Physical Geography and A course that articulates with College Physics and A course that articulates with Statistics and A course that articulates with Astronomy - Introduction to the Solar System</td>
<td>0-3 units 0-3 units 0-3 units 0-3 units 0-3 units</td>
</tr>
</tbody>
</table>

| (2) Complete additional coursework to bring total to 60 transferable semester units | 0-2 units |

| Total Semester Units Required for Cal Poly San Luis Obispo | 15 units |

Geology
LOWER-DIVISION TRANSFER PATTERN
CSU San Marcos Campus-Specific Pattern

This campus does not have a major, concentration, or option in Geology.
Geology
LOWER-DIVISION TRANSFER PATTERN
Sonoma State University Campus-Specific Pattern

In addition to the statewide pattern, the following is the Sonoma State University campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [SSU MATH 211S], Calculus II - A course that includes the calculus of exponential and logarithmic functions; trigonometric and inverse trigonometric functions; numerical integration; techniques of integration; introduction to applications of integration; differential equations; Taylor polynomials; improper integrals; series; and introduction to partial derivatives. and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [SSU CHEM 115A and 115B], Chemistry II - An introduction to science and scientific thought by using problem-solving strategies in both a conceptual and mathematical manner, with topics that include atomic and molecular structure, states of matter, chemical reactions, stoichiometry and thermodynamics. and</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with [SSU PHYS 114 and 116], Physics I with Lab - An introduction to vectors; classical mechanics, including particle dynamics and fluid mechanics; simple harmonic motion; thermodynamics and kinetics. and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [SSU PHYS 214 and 216], Physics II with Lab - A course that covers electrostatics, quasistatic fields and currents, magnetostatics; electromagnetic induction; waves; physical and geometric optics.</td>
<td>0-4 units</td>
</tr>
<tr>
<td>(2) Complete additional coursework, if necessary, to bring total to 60 transferable semester units</td>
<td>0-17 units</td>
</tr>
<tr>
<td>Total Semester Units Required for Sonoma State University</td>
<td>15-17 units</td>
</tr>
</tbody>
</table>

Geology
LOWER-DIVISION TRANSFER PATTERN
CSU Stanislaus Campus-Specific Pattern

In addition to the statewide pattern, the following is the CSU Stanislaus campus-specific pattern:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation requirements), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [CAN PHYS 2], College Physics for Science Majors, 1st semester, with corresponding laboratory.</td>
<td>0-5 units</td>
</tr>
<tr>
<td>• A course that articulates with College Algebra and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>• A course that articulates with College Trigonometry and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>• A course that articulates with a Historical Geology course with laboratory</td>
<td>0-4 units</td>
</tr>
</tbody>
</table>

...000054...
If Calculus has not been completed as part of the statewide pattern, College Algebra and College trig will be accepted in its place. If Calculus I has been completed as part of the statewide agreement, then complete one additional college mathematics course.

| (2) Complete additional coursework to bring total to 60 transferable semester units | 0-14 units |
| Total Semester Units Required for CSU Stanislaus | 14 units |
**Geology (Earth Sciences)**

**LOWER-DIVISION TRANSFER PATTERN**

San Francisco State University Campus-Specific Pattern

In addition to the statewide pattern, the following is the San Francisco State University campus-specific pattern for the BA in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation), complete:</td>
<td></td>
</tr>
<tr>
<td>• A course that articulates with [SFSU GEOL 115], Earth and Life through Time, a course in historical geology and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>• A course that covers topics in Paleontology and</td>
<td>0-3 units</td>
</tr>
<tr>
<td>• A course that articulates with [SFSU PHYS 111 and 112], General Physics I and Laboratory and</td>
<td>0-4 units</td>
</tr>
<tr>
<td>• A course that articulates with [SFSU PHYS 121 and 122], General Physics II and Laboratory</td>
<td>0-4 units</td>
</tr>
</tbody>
</table>

If possible, complete a course that articulates with [SFSU ENG 114], College Composition, 1st semester - Training in expository-argumentative composition, emphasizing work on clear and effective sentences and the organization and development of paragraph and essay and a course that articulates with [SFSU ENG 214], College Composition and Literature, 2nd semester - Expository-argumentative composition and critical reading skills through the study of literature; special attention to logic, style, and rhetoric as part of the units for general education in the Statewide pattern.

| (2) Complete additional coursework to bring total to 60 transferable semester units. | 0-14 units |
| Total Semester Units Required for B.A. in Earth Sciences at San Francisco State University | 14 units |

Question to department: It looks like SF State has no lower division course to articulate with paleontology – since CAN is gone, is there more description you would like for this course? Also, would you want to include the full course descriptions for the SFSU courses (GEOL 115, PHYS 111/112 and 121/122)?

In addition to the statewide pattern, the following is the San Francisco State University campus-specific pattern for the BS in Geology:

<table>
<thead>
<tr>
<th>Campus-Specific Pattern</th>
<th>Semester Unit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) If not taken as part of the statewide pattern (including general education and/or major preparation), complete:</td>
<td></td>
</tr>
</tbody>
</table>

000056
- A course that articulates with [SFSU CHEM 215 and 216], General Chemistry II and Laboratory and
- A course that articulates with [SFSU MATH 227], Calculus II and
- A course that articulates with [SFSU PHYS 111 and 112], General Physics with Calculus I and Laboratory and

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 units</td>
</tr>
<tr>
<td>0-4 units</td>
</tr>
<tr>
<td>0-4 units</td>
</tr>
</tbody>
</table>

If possible, complete a course that articulates with [SFSU ENG 114], College Composition, 1st semester - Training in expository-argumentative composition, emphasizing work on clear and effective sentences and the organization and development of paragraph and essay and a course that articulates with [SFSU ENG 214], College Composition and Literature, 2nd semester - Expository-argumentative composition and critical reading skills through the study of literature; special attention to logic, style, and rhetoric as part of the units for general education in the Statewide pattern.

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-14 units</td>
</tr>
</tbody>
</table>

(2) Complete additional coursework to bring total to 60 transferable semester units.

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 units</td>
</tr>
</tbody>
</table>

Total Semester Units Required for B.S. in Geology for San Francisco State University

Question to department: with CAN gone, would you want to include the full course descriptions for the SFSU courses (CHEM 215/216, MATH 227, and PHYS 111/112)?
The agreement you selected was not available for 08-09. The agreement for 07-08 is shown instead.

Articulation Agreement by Major
Effective during the 07-08 Academic Year

Biology: General, BA

--- Lower division requirements ---

BIOL 230 Introductory Biology I (5) No course articulated
($ CAN BIOL SEQ A)

BIOL 240 Introductory Biology II (5) BIO 101B General Biology
($ CAN BIOL SEQ A)

BIOL 230 & Introductory Biology I (5) BIO 101A & General Biology
($ CAN BIOL SEQ A)

BIOL 240 Introductory Biology II (5) BIO 101B General Biology
($ CAN BIOL SEQ A)

CHEM 115 Gen Chem I: Essential (5) CHEM 101A General College
Concepts of Chemistry Chemistry
(CAN CHEM 2)
($ CAN CHEM SEQ A)

OR

CHEM 103A General Chemistry Engineering

CHEM 130 General Organic Chemistry (3) CHEM 208A Organic Chemistry

--- Req. El. 8.3 (2) ---

--- Req. El. 10.5 (2) ---

http://www.assist.org/web-assist/report.do?agreement=aa&reportPat...FCITY&ria=SFSU&ia=SFSU&ola=SFCITY&ay=07-08&au=08-09&dora=BIO,GEN
<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 130</td>
<td>General Organic Chemistry (3)</td>
<td></td>
<td>No transfer</td>
</tr>
<tr>
<td>CHEM 215</td>
<td>Gen Chem II: Quant Appl (3)</td>
<td></td>
<td>No course articulated</td>
</tr>
<tr>
<td>PHYS 111</td>
<td>General Physics I</td>
<td>3</td>
<td>PHYC 2A &amp; Introductory Phys (S CAN PHYS 2)</td>
</tr>
<tr>
<td></td>
<td>(S CAN PHYS 2)</td>
<td></td>
<td>(S CAN PHYS SEQ 4)</td>
</tr>
<tr>
<td>PHYS 112</td>
<td>General Physics I Lab</td>
<td>1</td>
<td>PHYC 2AL &amp; Introductory Phys (S CAN PHYS 4)</td>
</tr>
<tr>
<td></td>
<td>(S CAN PHYS 2)</td>
<td></td>
<td>(S CAN PHYS SEQ 4)</td>
</tr>
<tr>
<td>PHYS 121</td>
<td>General Physics II</td>
<td>3</td>
<td>PHYC 2B &amp; Introductory Phys (S CAN PHYS 4)</td>
</tr>
<tr>
<td></td>
<td>(S CAN PHYS 4)</td>
<td></td>
<td>(S CAN PHYS SEQ 4)</td>
</tr>
<tr>
<td>PHYS 122</td>
<td>General Physics II Lab</td>
<td>1</td>
<td>PHYC 2BL &amp; Introductory Phys (S CAN PHYS 4)</td>
</tr>
<tr>
<td></td>
<td>(S CAN PHYS 4)</td>
<td></td>
<td>(S CAN PHYS SEQ 4)</td>
</tr>
</tbody>
</table>
Articulation Agreement by Major
Effective During the 07-08 Academic Year
To: San Francisco State
07-08 General Catalog
From: City College of San Francisco
Semester

| PHYS 112 & General Physics I | 1 | PHYC 2AL & Introductory Physics Laboratory |
| ($ CAN PHYS 2) | ($ CAN PHYS 2) | ($ CAN PHYS 2) |
| ($ CAN PHYS SEQ A) | ($ CAN PHYS SEQ A) | ($ CAN PHYS SEQ A) |
| PHYS 121 & General Physics II | 3 | PHYC 2B & Introductory Physics |
| ($ CAN PHYS 4) | ($ CAN PHYS 4) | ($ CAN PHYS 4) |
| ($ CAN PHYS SEQ A) | ($ CAN PHYS SEQ A) | ($ CAN PHYS SEQ A) |
| PHYS 122 General Physics II Lab | 1 | PHYC 2BL Introductory Physics Laboratory |
| ($ CAN PHYS 4) | ($ CAN PHYS 4) | ($ CAN PHYS 4) |
| ($ CAN PHYS SEQ A) | ($ CAN PHYS SEQ A) | ($ CAN PHYS SEQ A) |

One course from the following:
MATH 124 Elementary Statistics (CAN STAT 2)

| 3 | MATH 80 Probability and Statistics (CAN STAT 2) |
| OR | ECON 5 Introductory Statistics |
| OR | PSYC 5 Statistics for Behavioral Science (CAN PSY 6) |

OR

MATH 226 Calculus I (CAN MATH 19)

| 4 | MATH 110A Calculus I (CAN MATH 18) |
| ($ CAN MATH SEQ B) | ($ CAN MATH SEQ B) |
| ($ CAN MATH SEQ C) | ($ CAN MATH SEQ C) |

Please see the San Francisco State University Bulletin for additional information.
Center for
Science and Mathematics Education

Advisory Board of the Center for Science and Mathematics Education.

The Advisory Committee’s role includes the following:

- Advice on setting research and project agendas;
- Review and advice on mathematics and science subject-matter preparation program;
- Help in setting budgetary policies and priorities for spending and investment; and
- Help in establishing collaboration and funding from external sources.

The Advisory Committee membership includes eleven SFSU faculty and additional members from external organizations and industry:

- Advisory Committee Chair: Prof. and Assoc. Dean Sung Hu;
- Chairs or designee of the Departments of
  - Biology
  - Chemistry and Biochemistry
  - Computer Science
  - Geosciences
  - Mathematics
  - Physics and Astronomy
- Department of Secondary Education (one from math, one from science)
- Department of Elementary Education (one from math, one from science)
- K-12 Representatives; Teachers and/or Administrators
- Science Education Organizations
- Industrial Representatives
The CSME is a collaboration of the COE and the COSE.

College of Education
College of Science & Engineering

http://csme.sfsu.edu/people/advisory_board.html
EQUIVALENCY AUTHORIZATION
for Biology Major Course Requirements

Student Name: ___________________________ Soc. Sec. No.: ___________________________

*It is the student's responsibility to keep this form and submit it with his/her graduation petition.

I request the following course:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Course No.</th>
<th>Title</th>
<th>Units</th>
<th>Term (Sem or Qtr?)</th>
</tr>
</thead>
</table>

to be used as an equivalent for the following SFSU course requirement:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Course No.</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
</table>

This course equivalency was determined by:

☐ A formal articulation agreement
☐ evaluation by faculty advisor from course materials

I have determined this course to be:

☐ Lower Division
☐ Course Content only/ No Unit Credit
☐ Upper Division

I request the following course:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Course No.</th>
<th>Title</th>
<th>Units</th>
<th>Term (Sem or Qtr?)</th>
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to be used as an equivalent for the following SFSU course requirement:

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<th>Title</th>
<th>Units</th>
</tr>
</thead>
</table>

This course equivalency was determined by:

☐ A formal articulation agreement
☐ evaluation by faculty advisor from course materials

I have determined this course to be:

☐ Lower Division
☐ Course Content only/ No Unit Credit
☐ Upper Division

Signature of Advisor ___________________________ Date __________

Signature of Department Chair ___________________________ Date __________
Appendices for Standards:

Standard 9: Program Review and Evaluation
GUIDELINES FOR THE FIFTH CYCLE OF ACADEMIC PROGRAM REVIEW

Academic Senate Policy #S99-161
(Formerly Academic Senate Policy #S99-161)

At its meeting of February 23, 1999, the Academic Senate approved the following policy for guidelines for the fifth cycle of Academic Program Review:

The purpose of academic program review at San Francisco State University is to assess the University's academic degree programs in order to assure that they are of the highest possible quality. Its goals include identifying and articulating the values, competencies, and learning outcomes expected for each program, assessing the currency of learning objectives, and describing how those learning objectives have been revised in response to changing needs and new knowledge. Additionally, its purpose includes assessing how well the articulated values, competencies, and learning outcomes have been achieved and describing methods being employed to increase their achievement. The review should provide information, analysis, and evaluation that will help all elements of the University plan and make decisions about the maintenance, enhancement, reduction, consolidation, or discontinuance of baccalaureate, master's, and joint-doctoral degree programs.

Academic program review in the fifth cycle will include the following three components:

1. Instructional Unit Self-Study and Recommendation
2. External Review and Recommendation
3. University Review and Decision-Making

1. Instructional Unit Self-Study and Recommendation

At the start of the process for a given College, representatives from the instructional units, the College, the Office of Academic Affairs, and the Academic Program Review Committee (APRC) will meet to discuss substantive and procedural questions. Those attending should indicate any specific areas or issues needing to be addressed, so that these may be given special attention in the review process.

Every instructional unit which offers academic programs leading to baccalaureate, master's, or joint doctoral degrees (other than those subject to periodic accreditation review) shall prepare a self-study that will serve as a basis for all subsequent reviews and recommendations. In this self-study, the unit should describe and assess each degree program it offers, following the guidelines that appear in the Handbook for the Fifth Cycle of Academic Program Review. Department chairs and program heads should assure that there is widespread faculty participation in the self-studies and that the faculty are made aware of all findings and recommendations.

The unit shall forward its completed self-study to the Office of Academic Affairs and to the College Dean for their respective review and signatures indicating that the self-study is complete and ready for external review.

2. External Review and Recommendation

The purpose of external review is to help each instructional unit improve the quality of its degree programs and to add an additional perspective to the recommendations made in the self-study. It is anticipated that the external reviewers will provide evaluative assistance and support for program goals.

Typically, the review will be conducted by a team of two members, representing both a CSU and a non-CSU perspective.

The unit faculty and the College Dean, working together, shall choose the potential reviewers. The College Dean shall forward their names and addresses to the Vice President for Academic Affairs for his/her concurrence. Reviewers will receive a copy of the unit's self-study and supporting documents and are expected to spend two days on the campus interviewing students, faculty, and administrators and to prepare a report of findings and recommendations. Copies of this report shall be sent to the program head and to the College Dean, both of whom will be invited to respond in

of 4

3/31/05 11:40 AM
writing, commenting on recommendations made and adding recommendations as needed. The report and responses will become part of the unit's program review file evaluated by the Academic Program Review Committee and the Office of Academic Affairs. Upon receipt of the report, the University will pay the reviewers an honorarium (in addition to travel costs and other expenses).

3. University Review and Decision-Making

In order to provide a University-wide faculty perspective and assist in University-wide planning, the Academic Program Review Committee will carefully review each unit's self-study, external review report, and responses to the external review. APRC will meet with the College Dean and program faculty to ensure that APRC fully understands all recommendations made. APRC will accept additional data and recommendations from the units at this time. It will then proceed to evaluate all recommendations and send its report to the Chair of the Academic Senate and the Vice President for Academic Affairs for transmission to all interested parties. APRC should review all recommendations in a timely fashion and submit its findings to appropriate units as expeditiously as possible. APRC will also send any policy recommendations and its annual report to the Academic Senate.

After the faculty of the instructional unit, the College Dean, and the Office of Academic Affairs have had an opportunity to study all reports and recommendations, representatives of these three areas will meet to discuss recommendations and agree on actions to be taken. This agreement will be embodied in a memorandum of understanding which will be in effect until the completion of the next review cycle. This memorandum of understanding will be kept on file in the Offices of Academic Affairs and the Academic Senate.

Accredited Programs

For programs that are nationally accredited and undergo periodic accreditation review involving a campus visit by an accreditation team (see attachment), the accreditation review will normally substitute for academic program review with the following exceptions:

(a) Following receipt of notification from the accrediting body that a program has been re-accredited, representatives of the Instructional unit, College administration, and Office of Academic Affairs will develop a memorandum of understanding embodying agreements reached in the accreditation review. This memorandum of understanding will be in effect until completion of the next accreditation review and will be kept on file in the Offices of Academic Affairs and the Academic Senate.

(b) Upon special request of the Instructional unit, College Dean, and/or Vice President for Academic Affairs, an accredited program shall undergo academic program review in addition to accreditation review. In this event, the self-study prepared for accreditation may be adapted or substituted, as appropriate, for the purpose of program review, and the campus visit by the accrediting team may be substituted for the external review.

Program Review Schedule

As nearly as feasible, programs shall be reviewed on a six-year cycle by College, in alphabetical order of College, beginning in Fall, 1999. College Deans should assure that their Colleges' programs are reviewed in a timely fashion and that there is appropriate dissemination of information and recommendations.

The Liberal Studies and General Education programs shall also undergo review during the fifth cycle.

Handbook for the Fifth Cycle of Academic Program Review

A handbook will be prepared based on the Handbook for the Fourth Cycle of Academic Program Review, with the following modifications:

a. In preparing the fifth cycle handbook, the content of the fourth cycle handbook will be reviewed and edited for accuracy and for inclusion of the principles delineated in the following documents (currently included as appendices to the fourth cycle handbook):

   • The self-study guidelines which appear as Attachment A of Academic Senate Policy S69-151, "Guidelines for the Fourth Cycle of Academic Program Review."
   • "The APRC Perspective in Academic Program Review."

(b) The fifth cycle handbook will include changes made to program review as approved by the Academic Senate in the "Guidelines for the Fifth Cycle of Academic Program Review."

(c) The fifth cycle handbook will incorporate the following additional self-study guidelines:
To help maintain the currency of academic programs, academic programs will be asked to describe the use of community advisory boards or appropriate alternatives where such bodies exist.

Academic programs will be asked to describe the use of introductory courses/experiences which expose students to discipline-specific demands and ways of knowing, set standards of study in the discipline, provide feedback on the quality of student work, and identify opportunities to meet expected standards.

Academic programs will be asked to describe how the curriculum integrates and enhances students' basic skills, including critical thinking, written and oral communication, quantitative reasoning, and information access competence. Academic programs will also be asked to describe how the basic skill development is promoted and reviewed within the major program.

Academic programs will be asked to identify to what extent their programs are interdisciplinary, to articulate the interdisciplinary philosophy of their programs and how the curriculum reflects it, and to describe any plans they may have for cross-department and/or cross-college collaborations.

Graduate programs will be asked to address the level of preparation of admitted students, the investment of faculty and other resources in the graduate program compared with the undergraduate program(s), student research/scholarship (publications, exhibitions, public presentations, etc.), completion rates of the culminating experience, and average time to degree.

**APPROVED BY PRESIDENT CORRIGAN ON MARCH 2, 1999**

SFSU PROGRAMS SUBJECT TO PERIODIC REVIEW FOR NATIONAL ACCREDITATION

**Spring 1999**

<table>
<thead>
<tr>
<th>COLLEGE</th>
<th>PROGRAM</th>
<th>DEGREE(S)</th>
<th>ACCREDITING ORGANIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td>Business Admin.</td>
<td>BS/MS/MBA</td>
<td>American Assembly of Collegiate Schools of Business</td>
</tr>
<tr>
<td></td>
<td>Hospitality Mgmt</td>
<td>BS</td>
<td>American Assembly of Collegiate Schools of Business</td>
</tr>
<tr>
<td></td>
<td>Taxation</td>
<td>MS</td>
<td>American Assembly of Collegiate Schools of Business</td>
</tr>
<tr>
<td>Creative Arts</td>
<td>Art</td>
<td>BA/MA/MFA</td>
<td>National Association of Art and Design</td>
</tr>
<tr>
<td></td>
<td>Drama</td>
<td>BA/MA</td>
<td>National Association of Schools of Theatre</td>
</tr>
<tr>
<td>Music</td>
<td></td>
<td>BA/MA/BB/MM</td>
<td>National Association of Schools of Music</td>
</tr>
<tr>
<td>Education</td>
<td>Communicative</td>
<td>BA/MS</td>
<td>American Speech-Language-Hearing Association</td>
</tr>
<tr>
<td></td>
<td>Disorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field</td>
<td>Degree Level</td>
<td>Accrediting Body</td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------</td>
<td>-------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>MA/EdD/PhD</td>
<td>National Council for Accreditation of Teacher Education</td>
<td></td>
</tr>
<tr>
<td>Special Education</td>
<td>MA</td>
<td>National Council for Accreditation of Teacher Education</td>
<td></td>
</tr>
<tr>
<td>HHS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counseling</td>
<td>MS</td>
<td>Council for Accred. of Counseling &amp; Related Ed. Programs</td>
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</tr>
<tr>
<td>Dietetics</td>
<td>BS</td>
<td>American Dietetic Association</td>
<td></td>
</tr>
<tr>
<td>Family &amp; Consumer Sci.</td>
<td>BA/MA</td>
<td>American Association of Family and Consumer Sciences</td>
<td></td>
</tr>
<tr>
<td>Nursing</td>
<td>BS/MS</td>
<td>Commission on Collegiate Nursing Education</td>
<td></td>
</tr>
<tr>
<td>Physical Therapy</td>
<td>MS</td>
<td>American Physical Therapy Association</td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td>BA/MS</td>
<td>National Recreation and Park Association</td>
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</tr>
<tr>
<td>Rehabilitation Counseling</td>
<td>MS</td>
<td>Council on Rehabilitation Education</td>
<td></td>
</tr>
<tr>
<td>Social Work</td>
<td>BA/MSW</td>
<td>Council on Social Work Education</td>
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<tr>
<td>Humanities</td>
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<td>Science &amp; Engineering</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Biomedical Lab. Science</td>
<td>BS/MS</td>
<td>National Accrediting Agency for Clinical Lab. Sciences</td>
<td></td>
</tr>
<tr>
<td>Computer Science</td>
<td>BS/MS</td>
<td>Computing Sciences Accreditation Board</td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>BS</td>
<td>Accreditation Board for Engineering and Technology</td>
<td></td>
</tr>
</tbody>
</table>
Fall 2007 Graduating Biology Major Survey

Introduction

Congratulations on your intent to file your SFSU Graduation Application as a Graduating Biology Major!

The SFSU Department of Biology is committed to the continual improvement of its programs and courses. The professors and lecturers in the SFSU Department of Biology are very interested in hearing your opinions on your learning experiences in SFSU biology courses.

Thank you in advance for your honest and complete answers to the following questions. All responses will be kept strictly anonymous.

Your Learning Experiences in SFSU Biology Courses

The biology faculty invest substantial time and effort in developing and teaching biology courses that:
1) inspire students' interest in biology,
2) promote learning of biological concepts, and
3) support students' career goals.

Please reflect on all of your learning experiences in SFSU biology courses. Think about which of your learning experiences in your biology courses were MOST VALUABLE to you and which were LEAST VALUABLE to you. In the pages that follow, you will be prompted to briefly describe these experiences.

There are NO right or wrong answers. We want to know what you think! Please share your ideas in as much detail as possible, and please write in complete sentences. Your ideas are very valuable to us, and we appreciate your time and energy in answering these questions honestly.

MOST Valuable Learning Experiences in SFSU Biology Courses

What were the THREE MOST VALUABLE learning experiences you had in your SFSU biology courses?
Please describe these learning experiences briefly in the three boxes below...

1. MOST Valuable Learning Experience

[Box for description]

2. MOST Valuable Learning Experience

[Box for description]
Fall 2007 Graduating Biology Major Survey

3. MOST Valuable Learning Experience

LEAST Valuable Learning Experiences in SFSU Biology Courses

What were the THREE LEAST VALUABLE learning experiences you had in your SFSU Biology courses?
Please describe these learning experiences briefly in the three boxes below...

1. LEAST Valuable Learning Experience

2. LEAST Valuable Learning Experience

3. LEAST Valuable Learning Experience
Fall 2007 Graduating Biology Major Survey

A Few Final Questions...

Please answer the following questions, based on your experiences as an SFSU biology major.

1. I am more enthusiastic about biology now than when I started my biology major at SFSU.
   - Disagree
   - Somewhat Disagree
   - Neutral
   - Somewhat Agree
   - Agree

2. My undergraduate biology education at SFSU has prepared me well for my future career plans.
   - Disagree
   - Somewhat Disagree
   - Neutral
   - Somewhat Agree
   - Agree

3. The biology LECTURE course that contributed MOST significantly to my learning was:

   __________________________________________________________

4. The biology LECTURE course that contributed LEAST significantly to my learning was:

   __________________________________________________________

5. The biology LABORATORY/FIELD course that contributed MOST significantly to my learning was:

   __________________________________________________________

6. The biology LABORATORY/FIELD course that contributed LEAST significantly to my learning was:

   __________________________________________________________

7. I consider myself a biologist.
   - Disagree
   - Somewhat Disagree
   - Neutral
   - Somewhat Agree
   - Agree
8. I felt supported and encouraged during my experiences as an SFSU Biology major.
   ○ Disagree  ○ Somewhat Disagree  ○ Neutral  ○ Somewhat Agree  ○ Agree

9. I came to SFSU specifically for one of the specialized biology majors (e.g. botany, physiology, ecology, marine biology, microbiology, cell and molecular biology, zoology).
   ○ Disagree  ○ Somewhat Disagree  ○ Neutral  ○ Somewhat Agree  ○ Agree

10. I would have attended SFSU to get my biology degree even if specialized biology majors were not offered.
    ○ Disagree  ○ Somewhat Disagree  ○ Neutral  ○ Somewhat Agree  ○ Agree

11. I would recommend the SFSU undergraduate biology program to potential students.
    ○ Disagree  ○ Somewhat Disagree  ○ Neutral  ○ Somewhat Agree  ○ Agree

12. In one sentence, what will you remember most about your learning experiences as an SFSU biology major 10 years from now?

13. Upon completion of my biology degree, I plan to pursue a career in...

14. What else, if anything, would you like to share with us about your learning
Fall 2007 Graduating Biology Major Survey

experiences as an SFSU Biology major?

More About You...

Please answer the following questions to help us better understand the similarities and differences in the experiences of different populations of SFSU biology students.

1. What is your specific biology major?
   ○ General Biology
   ○ Botany
   ○ Cell and Molecular Biology
   ○ Clinical Science
   ○ Ecology
   ○ Marine Biology/Limnology
   ○ Microbiology
   ○ Physiology
   ○ Zoology

2. Did you major or minor in another field at SFSU?
   ○ No
   ○ Yes
     If Yes, what was your other major or minor?

3. I am...
   ○ Female
   ○ Male

4. I most closely identify as...
   ○ Asian
   ○ African-American
   ○ Caucasian
   ○ Filipino
   ○ Latino
   ○ Decline to State
   ○ Other (please specify)
5. Are you a transfer student?

- No
- Yes

Transfer Student Follow-Up Question

1. My experiences in SFSU biology courses were superior to my experiences in biology courses at other institutions.

- Disagree
- Somewhat Disagree
- Neutral
- Somewhat Agree
- Agree

To Verify Your Participation in This Survey

The questions below will allow us 1) to notify the SFSU Biology Department that you completed this survey and 2) to keep in touch with you as an SFSU Biology Department Alumnus.

This personal information will in NO WAY be affiliated with your responses to the previous questions on this survey.

1. Your Name
   - First Name
   - Middle Name
   - Last Name
   - Other Name/Nick Name

2. Your Permanent Address
   - Street Address
   - City
   - State
   - Zip Code

3. Your Current Email Address(es)
   - Preferred email address
   - Other email address

4. Your Current Phone Numbers
5. Your SFSU information
First Year Attended SFSU
SFSU ID Number

6. What is your birth date?
My birth date is...

7. What is today's date?
Today is...

Thank You!

Thank you for your time and thoughtfulness in responding to this survey of SFSU Graduating Biology Majors.

If you have any concerns about this survey or suggestions for its improvement, please contact:

Kimberly Tanner, Assistant Professor
Department of Biology, San Francisco State University
kdtanner@sfsu.edu
### 2. MOST Valuable Learning Experience

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Skipped question</td>
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</tbody>
</table>

### 3. MOST Valuable Learning Experience

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
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<tbody>
<tr>
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<td>184</td>
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<td>Skipped question</td>
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</tbody>
</table>

### 4. LEAST Valuable Learning Experience

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answered question</td>
<td>182</td>
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<tr>
<td>Skipped question</td>
<td>2</td>
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</tbody>
</table>
6. LEAST Valuable Learning Experience

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answered question</td>
<td>182</td>
</tr>
<tr>
<td>Skipped question</td>
<td>2</td>
</tr>
</tbody>
</table>

7. "Plants get their food from the soil." Please choose an answer below that reflects how much you agree with this statement.

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>16.6%</td>
<td>29</td>
</tr>
<tr>
<td>Agree</td>
<td>49.1%</td>
<td>86</td>
</tr>
<tr>
<td>Disagree</td>
<td>25.7%</td>
<td>45</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>8.6%</td>
<td>15</td>
</tr>
</tbody>
</table>

Briefly explain your answer choice in complete sentences. 169

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answered question</td>
<td>175</td>
</tr>
<tr>
<td>Skipped question</td>
<td>9</td>
</tr>
</tbody>
</table>
9. The majority of actual weight (dry biomass) gained by plants as they progress from seed to adult plant comes from which one of the following?

<table>
<thead>
<tr>
<th>Response</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substances in the soil that are taken up by plant roots.</td>
<td>36.0%</td>
<td>63</td>
</tr>
<tr>
<td>Molecules in the air that enter through holes in the plant leaves.</td>
<td>20.6%</td>
<td>36</td>
</tr>
<tr>
<td>Water taken up directly by plant roots.</td>
<td>23.4%</td>
<td>41</td>
</tr>
<tr>
<td>Energy from the sun.</td>
<td>20.0%</td>
<td>35</td>
</tr>
</tbody>
</table>

Briefly explain your answer choice in complete sentences.

- answered question: 175
- skipped question: 9
11. What is photosynthesis? Briefly explain your ideas about photosynthesis in complete sentences.

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>175</td>
</tr>
<tr>
<td>skipped question</td>
<td>9</td>
</tr>
</tbody>
</table>

12. I am more enthusiastic about biology now than when I started my biology major at SFSU.

<table>
<thead>
<tr>
<th>Response</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>4.6%</td>
<td>8</td>
</tr>
<tr>
<td>Somewhat Disagree</td>
<td>5.2%</td>
<td>9</td>
</tr>
<tr>
<td>Neutral</td>
<td>16.8%</td>
<td>29</td>
</tr>
<tr>
<td>Somewhat Agree</td>
<td>24.3%</td>
<td>42</td>
</tr>
<tr>
<td>Agree</td>
<td>48.1%</td>
<td>85</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>173</td>
</tr>
<tr>
<td>skipped question</td>
<td>11</td>
</tr>
<tr>
<td>Somewhat Agree</td>
<td>45.1%</td>
</tr>
<tr>
<td>Agree</td>
<td>31.8%</td>
</tr>
</tbody>
</table>

14. The biology LECTURE course that contributed MOST significantly to my learning was:

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>173</td>
</tr>
<tr>
<td>skipped question</td>
<td>11</td>
</tr>
</tbody>
</table>

15. The biology LECTURE course that contributed LEAST significantly to my learning was:

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>173</td>
</tr>
<tr>
<td>skipped question</td>
<td>11</td>
</tr>
</tbody>
</table>
17. The biology LABORATORY/FIELD course that contributed LEAST significantly to my learning was:

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>173</td>
</tr>
<tr>
<td>skipped question</td>
<td>11</td>
</tr>
</tbody>
</table>

18. I consider myself a biologist.

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>2.9%</td>
<td>5</td>
</tr>
<tr>
<td>Somewhat Disagree</td>
<td>7.5%</td>
<td>13</td>
</tr>
<tr>
<td>Neutral</td>
<td>19.1%</td>
<td>33</td>
</tr>
<tr>
<td>Somewhat Agree</td>
<td>34.1%</td>
<td>59</td>
</tr>
<tr>
<td>Agree</td>
<td>36.4%</td>
<td>63</td>
</tr>
</tbody>
</table>

| Answered question  | 173    |
| skipped question   | 11     |
20. I came to SFSU specifically for one of the specialized biology majors (e.g. botany, physiology, ecology, marine biology, microbiology, cell and molecular biology, zoology).

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>16.8%</td>
<td>29</td>
</tr>
<tr>
<td>Somewhat Disagree</td>
<td>8.1%</td>
<td>14</td>
</tr>
<tr>
<td>Neutral</td>
<td>18.5%</td>
<td>32</td>
</tr>
<tr>
<td>Somewhat Agree</td>
<td>17.9%</td>
<td>31</td>
</tr>
<tr>
<td>Agree</td>
<td>38.7%</td>
<td>67</td>
</tr>
</tbody>
</table>

answered question: 173
skipped question: 11
22. I would recommend the SFSU undergraduate biology program to potential students.

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>5.8%</td>
<td>10</td>
</tr>
<tr>
<td>Somewhat Disagree</td>
<td>3.5%</td>
<td>6</td>
</tr>
<tr>
<td>Neutral</td>
<td>20.2%</td>
<td>35</td>
</tr>
<tr>
<td>Somewhat Agree</td>
<td>33.5%</td>
<td>58</td>
</tr>
<tr>
<td>Agree</td>
<td>37.0%</td>
<td>64</td>
</tr>
</tbody>
</table>

answered question 173
 skipped question 11

23. In one sentence, what will you remember most about your learning experiences as an SFSU biology major 10 years from now?

<table>
<thead>
<tr>
<th>Response Count</th>
<th>173</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>173</td>
</tr>
<tr>
<td>skipped question</td>
<td>11</td>
</tr>
</tbody>
</table>
25. What else, if anything, would you like to share with us about your learning experiences as an SFSU Biology major?

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>173</td>
</tr>
<tr>
<td>skipped question</td>
<td>11</td>
</tr>
</tbody>
</table>

26. What is your specific biology major?

<table>
<thead>
<tr>
<th>Subject</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Biology</td>
<td>17.3%</td>
<td>30</td>
</tr>
<tr>
<td>Botany</td>
<td>1.7%</td>
<td>3</td>
</tr>
<tr>
<td>Cell and Molecular Biology</td>
<td>17.3%</td>
<td>30</td>
</tr>
<tr>
<td>Clinical Science</td>
<td>2.9%</td>
<td>5</td>
</tr>
<tr>
<td>Ecology</td>
<td>4.6%</td>
<td>8</td>
</tr>
<tr>
<td>Marine Biology/Limnology</td>
<td>1.7%</td>
<td>3</td>
</tr>
<tr>
<td>Microbiology</td>
<td>21.4%</td>
<td>37</td>
</tr>
<tr>
<td>Physiology</td>
<td>31.8%</td>
<td>55</td>
</tr>
<tr>
<td>Zoology</td>
<td>1.2%</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>173</td>
</tr>
<tr>
<td>skipped question</td>
<td>11</td>
</tr>
</tbody>
</table>
### 28. I am...

<table>
<thead>
<tr>
<th>Gender</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>71.7%</td>
<td>124</td>
</tr>
<tr>
<td>Male</td>
<td>28.3%</td>
<td>49</td>
</tr>
</tbody>
</table>

### 29. I most closely identify as...

<table>
<thead>
<tr>
<th>Name</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian</td>
<td>32.9%</td>
<td>57</td>
</tr>
<tr>
<td>African-American</td>
<td>5.2%</td>
<td>9</td>
</tr>
<tr>
<td>Caucasian</td>
<td>19.1%</td>
<td>33</td>
</tr>
<tr>
<td>Filipino</td>
<td>11.6%</td>
<td>20</td>
</tr>
<tr>
<td>Latino</td>
<td>9.8%</td>
<td>17</td>
</tr>
<tr>
<td>Decline to State</td>
<td>3.5%</td>
<td>6</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>17.9%</td>
<td>31</td>
</tr>
</tbody>
</table>

answered question 173
skipped question 11
31. My experiences in SFSU biology courses were superior to my experiences in biology courses at other institutions.

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>4.0%</td>
<td>7</td>
</tr>
<tr>
<td>Somewhat Disagree</td>
<td>5.3%</td>
<td>10</td>
</tr>
<tr>
<td>Neutral</td>
<td>38.2%</td>
<td>66</td>
</tr>
<tr>
<td>Somewhat Agree</td>
<td>27.7%</td>
<td>48</td>
</tr>
<tr>
<td>Agree</td>
<td>24.3%</td>
<td>42</td>
</tr>
</tbody>
</table>

answered question 173
skipped question 11

32. Your Name

<table>
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<tr>
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<th>Percent</th>
<th>Count</th>
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</thead>
<tbody>
<tr>
<td>First Name</td>
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</tr>
<tr>
<td>Middle Name</td>
<td>69.8%</td>
<td>120</td>
</tr>
<tr>
<td>Last Name</td>
<td>99.4%</td>
<td>171</td>
</tr>
<tr>
<td>Other Name/Nick Name</td>
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answered question 172
skipped question 12
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<th>Question</th>
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<th>Response Count</th>
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<tr>
<td>34. Your Current Email Address(es)</td>
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<td></td>
</tr>
<tr>
<td>Preferred email address</td>
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</tr>
<tr>
<td>Other email address</td>
<td>45.3%</td>
<td>78</td>
</tr>
<tr>
<td>35. Your Current Phone Numbers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>62.2%</td>
<td>107</td>
</tr>
<tr>
<td>Cell</td>
<td>73.3%</td>
<td>126</td>
</tr>
<tr>
<td>Work</td>
<td>7.6%</td>
<td>13</td>
</tr>
<tr>
<td>Other</td>
<td>1.7%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>answered question</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td>skipped question</td>
<td>12</td>
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</tbody>
</table>
37. What is your birth date?

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>My birth date is</td>
<td>100.0%</td>
<td>172</td>
</tr>
</tbody>
</table>

38. What is today's date?

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Today is</td>
<td>100.0%</td>
<td>172</td>
</tr>
</tbody>
</table>
SFSU's CENTER FOR SCIENCE AND MATHEMATICS EDUCATION

1. The Problem: A Crisis in Math and Science Education
2. What Can Be Done To Address This Problem?
3. Specific Goals and Objectives of the Center
4. Benefits of the New Center
5. Citations

The Problem: A Crisis in Math and Science Education

The 2005 report from the National Academies, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, (ref 1) chronicles the United States' loss of its long-standing global lead in the production of engineers, and the erosion of its lead in the production of other science, technology, engineering and mathematics professionals. The implications are disturbing: continuation of the current trend directly threatens the future state of the U.S. economy and the U.S. standard of living.

In California, the threat is real. More than in almost any other state, industries that drive California's economy depend heavily upon a continuously growing scientifically and mathematically literate work force. The California Council on Science and Technology (CCST) (ref 2) reports that in 2000, the demand in California for workers with science and engineering B.A. degrees exceeded the 20,000 science and engineering B.A. degrees granted by California universities by 14,000. Some statistical data highlights the problem:

- In 2002-03, 25% of math teachers, 22% of life science teachers, and 30% of physical science teachers in California high schools had a teaching credential in an unrelated subject area or no credential at all. (ref 3)
- That same year, the total need for new mathematics teachers was 2,131, but California colleges and universities awarded only 1,389 mathematics degrees, a 40% shortfall. (ref 4)
- In 2004, California schools hired 4,135 people to teach science and math classes, but California colleges and universities certified only 1,466 credentialed science and math teachers, a staggering 65% shortfall. (ref 3)
- Nearly one-third of California's existing teaching work force is expected to retire in the next decade. (ref 4)

Factors cited by the CCST as contributing to this shortfall include poor preparation of high school students for college, particularly in math, science and engineering, and low levels of interest expressed by K-12 students in science and engineering. Both of these factors are attributed to a lack of exposure to science and engineering in K-12, and to the inadequate qualifications of many K-12 science and mathematics teachers. This lack of teacher training is, in turn, attributed to the growing shortage of secondary science and mathematics teachers available to teach.

These problems contribute to a spiraling cycle: the shortage of qualified K-12 science and mathematics teachers in California contributes to the poor preparation of students entering college, which in turn contributes to another startling statistic: after only four year of teaching, qualified and certified K-12 science and mathematics teachers nationally have an attrition rate of nearly 40 percent. (ref 4)

The attrition rate in California overall is even higher – as high as 60% within the first 19 months in the Los Angeles Unified School District (ref 5) - and tie...
attrition rate of science and engineering students in the California State University (CSU) system is nearly 66%!

What Can Be Done To Address This Problem?

In Washington, in response to the Rising above the Gathering Storm Report (ref 1), concerned members of Congress and the Administration, speaking and acting with some urgency, appear to have begun to take legislative steps (ref 6), to implement the report’s recommendations, including the following:

- Increase America’s talent pool by vastly improving K-12 science and mathematics education;
- Sustain and strengthen the nation’s traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life;
- Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world.

Two of the report’s action items (ref 1) are particularly relevant to this proposal:

- (Action A-1) Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds.
- (Action A-3) Enlarge the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics by increasing the number of students who pass advanced placement and international baccalaureate science and mathematics courses.

At SFSU, a group of faculty in the Colleges of Education and Science & Engineering, proposed to confront this problem directly by creating a Center for Science and Math Education. The goals of the Center will be to recruit, support, and develop good science and mathematics teachers; to establish and support research into math and science education and promote its application; and to establish a community of math and science education scholars, teachers and students to support and sustain these efforts into the future. Ultimately, the goal is to focus on and encourage the fledgling interest of SFSU students in science, technology, engineering and mathematics (STEM) subjects, and nurture, develop and sustain that interest, so that SFSU and other CSU schools can begin to generate a growing pool of well qualified K-12 STEM teachers, who in turn will support and encourage a growing number of STEM professionals.

Specific Goals and Objectives of the Center

To meet the threefold goals of the Center, three overlapping circles of activities will be developed, as shown in Figure 1. Positive feedback loops between the circles of activities will help alleviate the recognized crisis in math and science education. In more detail, objectives within each area include the following:

I. To recruit, support and develop good science and mathematics teachers.
Projects in this area will include

a. Developing, administering, and assessing subject-matter preparation programs;

b. Recruiting, mentoring, advising, and tracking the training
experiences of potential mathematics and science teachers; and

c. Training graduate teaching assistants and in-service K-12 math and science teachers.

II. To establish and support research into K-18 math and science education and promote application of that research. Projects in this area will include

a. Supporting the initiation of grant proposals, supportive collaborations, and the implementation of funded projects;

b. Establishing academic concentrations and a Master's program in STEM education; and

c. Revising and improving the curriculum and pedagogy of SFSU math and science courses so that students who are interested in these areas remain interested.

III. To establish a community of math and science education scholars, teachers and students to support and sustain these efforts into the future. Projects in this area will include

a. Promoting collaboration across SFSU departments and sponsor programs that can build community among STEM students and faculty;

b. Reaching out to other educational institutions, including K-12, 2- and 4-year schools, and universities, both public and private, to improve K-18 science education on both the State and National level;

c. Enriching undergraduate and graduate STEM major programs with actual STEM teaching experiences;

d. Establishing a physical resource center for educational materials, information and advising; and

e. Establishing a dedicated space for aspiring STEM teachers to meet and network.

Benefits of the New Center

In addition to the benefits outlined above, the Center will, among other things, also:

- better track data across the COSE regarding course performance, experiences with teaching and tutoring, and trajectories after graduation;
- perform better assessments of academic programs in the COSE;
- improve and smooth the pipeline of graduates from COSE into credential programs and, in particular, into the SFSU credential program;
- respond more quickly and comprehensively to changes in state single-
subject matter program standards and CSU priorities

- assemble an Advisory Board from across COSE, COE, and Industry and school partners.

In support of fostering math and science education research and promoting its application, the Center will also:

- support grant-proposal writing by providing editorial resources, finding collaborators, and sharing results of other SFSU work on grants and human subjects processes;
- support the implementation of funded projects by providing, for example, administrative support, and support for dissemination; and
- provide research facilities, such as computer software, including statistical and qualitative analysis software, equipment for audiotaping or videotaping interviews and model teaching.

Eventually it is hoped that the Center will provide a model teaching research laboratory where new laboratory experiments can be piloted. This laboratory will have state-of-the-art electronic collaborative classroom equipment for student data acquisition, interactive software, and instant survey methodologies. The Center will also

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top of page

Citations
5) Personal communication, Dean Gilbert, President, California Science Teachers Association, May 5, 2006.

People Projects Community Students Contribute News Contacts

The CSME is a collaboration of the COE and the COSE.
College of Education
College of Science & Engineering
Appendices for Standards:

Standard 10: Coordination
Center for
Science and Mathematics Education

Advisory Board of the Center for Science and Mathematics Education.

The Advisory Committee’s role includes the following:

- Advice on setting research and project agendas;
- Review and advice on mathematics and science subject-matter preparation program;
- Help in setting budgetary polices and priorities for spending and investment; and
- Help in establishing collaboration and funding from external sources.

The Advisory Committee membership includes eleven SFSU faculty and additional members from external organizations and industry:

- Advisory Committee Chair: Prof. and Assoc. Dean Sung Hu;
- Chairs or designee of the Departments of
  - Biology
  - Chemistry and Biochemistry
  - Computer Science
  - Geosciences
  - Mathematics
  - Physics and Astronomy
- Department of Secondary Education (one from math, one from science)
- Department of Elementary Education (one from math, one from science)
- K-12 Representatives; Teachers and/or Administrators
- Science Education Organizations
- Industrial Representatives
The CSME is a collaboration of the COE and the COSE.
College of Education
College of Science & Engineering

http://csme.sfsu.edu/people/advisory_board.html
Center for Science and Mathematics Education

Participating Faculty in the Center for Science and Mathematics Education.

Faculty members in the College of Education and the College of Science and Engineering are involved in the Center's activities. The following are current participants. We anticipate more faculty to join as the Center begins operation. Please let us know if you would like to join the Center.

- Jennifer Breckler, Ph.D., Department of Biology
- Nan Cervin, Ph.D., Department of Biology
- David Dempsey, Ph.D., Department of Geosciences
- Sung Hu, Ph.D., Department of Engineering and Associate Dean, College of Science & Engineering
- Eric Hsu, Ph.D., Department of Mathematics
- Judy Kysh, Ph.D., Department of Secondary Education
- Carol Langbert, Ph.D., Department of Elementary Education
- Nilgun Ozer, Ph.D., Department of Engineering
- Stephanie Sisk-Hilton, Ph.D., Department of Elementary Education
- John Stobie, Ph.D., Department of Biology
- Kimberly Tanner, Ph.D., Department of Biology
- Ray Trautman, Ph.D., Department of Chemistry and Biochemistry

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College of Education
College of Science & Engineering
SFSU’s CENTER FOR SCIENCE AND MATHEMATICS EDUCATION

1. The Problem: A Crisis in Math and Science Education
2. What Can Be Done To Address This Problem?
3. Specific Goals and Objectives of the Center
4. Benefits of the New Center
5. Citations

The Problem: A Crisis in Math and Science Education

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In California, the threat is real. More than in almost any other state, industries that drive California’s economy depend heavily upon a continuously growing scientifically and mathematically literate work force. The California Council on Science and Technology (CCST) (ref 2) reports that in 2000, the demand in California for workers with science and engineering B.A. degrees exceeded the 20,000 science and engineering B.A. degrees granted by California universities by 14,000. Some statistical data highlights the problem:

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Factors cited by the CCST as contributing to this shortfall include poor preparation of high school students for college, particularly in math, science and engineering, and low levels of interest expressed by K-12 students in science and engineering. Both of these factors are attributed to a lack of exposure to science and engineering in K-12, and to the inadequate qualifications of many K-12 science and mathematics teachers. This lack of teacher training is, in turn, attributed to the growing shortage of secondary science and mathematics teachers available to teach.

These problems contribute to a spiraling cycle: the shortage of qualified K-12 science and mathematics teachers in California contributes to the poor preparation of students entering college, which in turn contributes to another startling statistic: after only four year of teaching, qualified and certified K-12 science and mathematics teachers nationally have an attrition rate of nearly 40 percent. (ref 4)

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What Can Be Done To Address This Problem?

In Washington, in response to the Rising above the Gathering Storm Report (ref. 1), concerned members of Congress and the Administration, speaking and acting with some urgency, appear to have begun to take legislative steps (ref. 6), to implement the report’s recommendations, including the following:

- Increase America’s talent pool by vastly improving K-12 science and mathematics education;
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- Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world.

Two of the report’s action items (ref. 1) are particularly relevant to this proposal:

- (Action A-1) Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds.
- (Action A-3) Enlarge the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics by increasing the number of students who pass advanced placement and international baccalaureate science and mathematics courses.

At SFSU, a group of faculty in the Colleges of Education and Science & Engineering, proposed to confront this problem directly by creating a Center for Science and Math Education. The goals of the Center will be to recruit, support, and develop good science and mathematics teachers; to establish and support research into math and science education and promote its application; and to establish a community of math and science education scholars, teachers and students to support and sustain these efforts into the future. Ultimately, the goal is to focus on and encourage the fledgling interest of SFSU students in science, technology, engineering and mathematics (STEM) subjects, and nurture, develop and sustain that interest, so that SFSU and other CSU schools can begin to generate a growing pool of well qualified K-12 STEM teachers, who in turn will support and encourage a growing number of STEM professionals.

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1. To recruit, support and develop good science and mathematics teachers.
   Projects in this area will include
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- Training graduate teaching assistants and in-service K-12 math and science teachers.

II. To establish and support research into K-18 math and science education and promote application of that research. Projects in this area will include

- Supporting the initiation of grant proposals, supportive collaborations, and the implementation of funded projects;
- Establishing academic concentrations and a Master’s program in STEM education; and
- Revising and improving the curriculum and pedagogy of SFSU math and science courses so that students who are interested in these areas remain interested.

III. To establish a community of math and science education scholars, teachers and students to support and sustain these efforts into the future. Projects in this area will include

- Promoting collaboration across SFSU departments and sponsor programs that can build community among STEM students and faculty;
- Reaching out to other educational institutions, including K-12, 2- and 4-year schools, and universities, both public and private, to improve K-18 science education on both the State and National level;
- Enriching undergraduate and graduate STEM major programs with actual STEM teaching experiences;
- Establishing a physical resource center for educational materials, information and advising; and
- Establishing a dedicated space for aspiring STEM teachers to meet and network.

Benefits of the New Center

In addition to the benefits outlined above, the Center will, among other things, also:

- better track data across the COSE regarding course performance, experiences with teaching and tutoring, and trajectories after graduation;
- perform better assessments of academic programs in the COSE;
- improve and smooth the pipeline of graduates from COSE into credential programs and, in particular, into the SFSU credential program;
- respond more quickly and comprehensively to changes in state single-
subject matter program standards and CSU priorities; and
• assemble an Advisory Board from across COSE, COE, and industry and school partners.

In support of fostering math and science education research and promoting its application, the Center will also:

• support grant-proposal writing by providing editorial resources, finding collaborators, and sharing results of other SFSU work on grants and human subjects processes;
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Citations
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Center for Science and Mathematics Education

Projects Directed by Faculty Associated with SFSU's Center For Science And Mathematics Education

Numerous faculty in the College of Education and in the College of Science & Engineering are involved in science or mathematics education projects. Some projects are focused on research into science and mathematics education; some involve the development of new curriculum materials; some support in-service or pre-service K-12 teachers; others are fostering the development of in-person or on-line communities of science or mathematics educators.

Each project listed below provides opportunities for people to help alleviate the problem of insufficient number of high quality scientific, technological, engineering, and mathematics professionals. Only brief descriptions are provided below; please read the full description of projects that you find interesting by navigating to the project's home page.

<table>
<thead>
<tr>
<th>Title</th>
<th>Project Website</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPAL</td>
<td><a href="http://www.sfsu.edu/~sepal/">http://www.sfsu.edu/~sepal/</a></td>
<td>The Science Education Partnership and Assessment Laboratory, funded by the National Science Foundation, partners SFSU science graduate students with K-12 teachers in the SFUSD to improve science teaching and learning for students in grades K through 16.</td>
</tr>
<tr>
<td>SF-ROCKS</td>
<td><a href="http://sf-rocks.sfsu.edu/">http://sf-rocks.sfsu.edu/</a></td>
<td>The SFSU Reaching Out to Communities and Kids with Science in San Francisco project, funded by the National Science Foundation, partners SFSU science graduate students with K-12 teachers in the SFUSD to improve science teaching and learning for students in grades K through 16.</td>
</tr>
<tr>
<td>REvitalizing ALgebra</td>
<td><a href="http://math.sfsu.edu/hsu/msp/">http://math.sfsu.edu/hsu/msp/</a></td>
<td>The REAL partnership, funded by the National Science Foundation, is a model for a professional development system that brings together three groups: algebra teachers in grades 8-10, university mathematics majors, and mathematics graduate students who are teaching remedial courses at the</td>
</tr>
</tbody>
</table>
Online Communities | university level.
---|---
[http://math.sfsu.edu/hsu/career/](http://math.sfsu.edu/hsu/career/) | The Online and Live Communities of Teachers project, funded by a National Science Foundation CAREER award to Prof. Eric Hsu, is searching for appropriate ways to use the Internet for teacher professional development. A combined online and live course and support structure is being developed for graduate algebra instructors at SFSU, and will then be adapted for graduate instructors of the PDP Treisman workshops at UC Berkeley.

The first CSME mini-grant program RFP was held in Spring 2007. The projects funded for Summer and Fall 2007 are:

<table>
<thead>
<tr>
<th>Investigators</th>
<th>Department</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamie Chan, Amber Johnson, Robert Patterson, and Kimberly Tanner</td>
<td>Department of Biology</td>
<td>Moving Towards Inquiry in a Biology Laboratory</td>
</tr>
<tr>
<td>Deborah Curtis</td>
<td>Department of Administration and Interdisciplinary Studies</td>
<td>A Hierarchical Linear Model Analysis of the Mathematics Pathways and Pitfalls Lessons</td>
</tr>
<tr>
<td>Eric Hsu</td>
<td>Department of Mathematics</td>
<td>Early Field Experiences for Math Majors</td>
</tr>
<tr>
<td>Kimberly Tanner</td>
<td>Department of Biology</td>
<td>Exploring Undergraduate Student Conceptions of Environmental Science: What Role Does Biological Knowledge Play in Environmental Literacy?</td>
</tr>
<tr>
<td>Maika Watanabe</td>
<td>Department of Secondary Education</td>
<td>DVDs of Successful Teaching Practices in Detracked Math and Science Classrooms</td>
</tr>
</tbody>
</table>
The CSME is a collaboration of the COE and the COSE.

College of Education
College of Science & Engineering
The Lower-Division Transfer Pattern Project

The Lower Division Transfer Pattern (LDTP) by Major project is one of several ways that California Community College (CCC) students may use to prepare for study at the California State University (CSU). CCC students who know the major they wish to pursue at which CSU campus, traditional major preparation articulation and transfer admission agreements are valuable. However, for transfer students who are uncertain about which CSU campus they will attend, the LDTP provides a measure of flexibility and options for preparation. LDTP may provide articulation for students whose community college does not have existing CSU articulation.

Each LDTP major discipline has a statewide and campus-specific component. The statewide component of the LDTP is appropriate for any CSU campus offering the major and is comprised of general education coursework and courses within the discipline. The campus-specific component identifies discipline related coursework relevant to the major at the specific CSU campus. These components for an LDTP discipline will total at least sixty units, the number needed to transfer to CSU as an upper-division student.

Students who complete any portion of the statewide component of an LDTP benefit because CSU campuses offering the discipline will honor the preparation for the major and the progress towards the CSU degree. Just as CSU GE-Breadth is a statewide alternative to each CSU campuses’ unique General Education program, the LDTP is a statewide alternative to each CSU campuses’ lower-division major preparation.

Please refer to the Memorandum of Understanding between the California Community Colleges, Office of the Chancellor and the California State University, Office of the Chancellor or the links below for more detailed information on the LDTP Patterns, Newsletters, and Course Descriptors.

http://www.calstate.edu/acadaff/ldtp/
Appendices for Standards:

Standard 11: The Vision for Science
Mission Statement
The mission of the College of Science and Engineering at San Francisco State University is to provide an encouraging environment to develop the intellectual capacity, critical thinking, creativity, and problem solving ability of its students so that they may become honorable, contributing, and forward-thinking members of the science and engineering community of the San Francisco Bay Area and beyond; to foster a conducive environment for scholarly and creative activities so that new knowledge or solutions to problems are discovered or created; and to provide science education to all students in the University so that they may be equipped to succeed in the modern world.

Vision Statement
The San Francisco Bay Area is a world center for science and technology. It needs large numbers of well-educated scientists and engineers. The College is committed to serving this need by recruiting talented students, providing them with high-quality and up-to-date curricula, and fostering an effective teaching/learning environment. The College will be a leading provider of first-rate scientists and engineers in the Bay Area.

The College is committed to offering students an academic experience of “thinking, learning, and doing.” The best way to provide this experience is through involving students in research and the solution of real world problems. Thus, teaching and research are mutually supportive and one cannot excel without the other. The College encourages the faculty to carry on research which involves students and which serves the science and engineering community. The College will be competitive in science and engineering research and teaching at the national level.

The College is committed to full participation in the community through service. This service applies the knowledge and experience of its faculty, staff and students to the solution of problems facing the University, industry, government, or civic organizations. The College will expand its already strong cooperative relationship with various local and national organizations, especially in areas related to K-12 science and math education.

The College is committed to serve a student population that reflects the diversity of the region and includes many international students. The College supports a number of programs designed to encourage and support all students to pursue careers in science and engineering. The College will support and retain a diverse group of faculty, staff, and students, both domestic and international.
SFSU's CENTER FOR SCIENCE AND MATHEMATICS EDUCATION

1. The Problem: A Crisis in Math and Science Education
2. What Can Be Done To Address This Problem?
3. Specific Goals and Objectives of the Center
4. Benefits of the New Center
5. Citations

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Factors cited by the CCST as contributing to this shortfall include poor preparation of high school students for college, particularly in math, science and engineering, and low levels of interest expressed by K-12 students in science and engineering. Both of these factors are attributed to a lack of exposure to science and engineering in K-12, and to the inadequate qualifications of many K-12 science and mathematics teachers. This lack of teacher training is, in turn, attributed to the growing shortage of secondary science and mathematics teachers available to teach.

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- **(Action A-1)** Annually recruit 10,000 science and mathematics teachers by awarding 4-year scholarships and thereby educating 10 million minds.
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At SFSU, a group of faculty in the Colleges of Education and Science & Engineering, proposed to confront this problem directly by creating a Center for Science and Math Education. The goals of the Center will be to recruit, support, and develop good science and mathematics teachers; to establish and support research into math and science education and promote its application; and to establish a community of math and science education scholars, teachers and students to support and sustain these efforts into the future. Ultimately, the goal is to focus on and encourage the fledgling interest of SFSU students in science, technology, engineering and mathematics (STEM) subjects, and nurture, develop and sustain that interest, so that SFSU and other CSU schools can begin to generate a growing pool of well qualified K-12 STEM teachers, who in turn will support and encourage a growing number of STEM professionals.

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To meet the threefold goals of the Center, three overlapping circles of activities will be developed, as shown in Figure 1. Positive feedback loops between the circles of activities will help alleviate the recognized crisis in math and science education. In more detail, objectives within each area include the following:

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Projects in this area will include

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Benefits of the New Center
In addition to the benefits outlined above, the Center will, among other things, also:

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Citations
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Dave,

Our mission statement is officially under revision right now, but what I’ve got is two tag lines and a statement I hope will help:

Advancing global health & the biosphere.
Educing future generations of scientists, health professionals, teachers & citizens.

The core mission of the Department of Biology is to provide an outstanding education, at the graduate and undergraduate levels, preparing the next generation of leaders in the field and ensuring the nation’s future with a science-literate, educated public. Students are exposed to an integrated approach to biology at the molecular, cellular, organismal and ecosystem levels, in the context of our society. Our education emphasizes hands-on laboratory experience and the excitement of discovery through cutting-edge investigation conducted in our own nationally-recognized research laboratories. We are committed to serving the needs of a student population with diverse backgrounds and goals, a geographic region rich in ecological complexity, and a community operating at the forefront of basic science, biotechnology and medicine.

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Hike,

A few years ago (or more than a few by now?), each COSE department was asked to formulate a vision statement and a mission statement and submit it to the Dean’s office. (The equivalent statements for COSE as a whole are posted on the COSE Web page.)

However, I don’t find the versions for Biology on the Department of Biology Web site—do you have a copy? We could use it as we continue work on the current draft the Single Subject Subject Matter Program proposal for Biology, which is making steady progress and is on track to submit by the end of this semester, thanks to the work of Janet Hopson under the auspices of the Center for Science and Math Education.

-- Dave
Welcome to the Institute For Civic and Community Engagement (ICCE)

*Learning together. Creating positive change.*

The Institute for Civic and Community Engagement (ICCE) provides opportunities for civic engagement and leadership development at San Francisco State University for students, faculty, and community members. Through innovative courses, experiential learning, political engagement, participatory action research, and direct services, we partner the resources and expertise of the urban university with the knowledge and assets of diverse communities. Working locally, statewide, nationally, and internationally, we cultivate strong leaders who will effectively advocate for social, economic, and educational inclusion, and fully participate in the civic life and political processes of their communities.

**Who We Serve**

**Faculty:** We promote professional development through grants and administrative support for community-based teaching and research. We offer training and support for incorporating community service learning and civic engagement activities into courses across the curriculum.

**Students:** We offer placement opportunities with community-based organizations, internships with civic organizations, and scholarships that recognize exemplary service. We promote the recognition of service learning activities on academic transcripts.

**Community:** We facilitate partnerships between SF State and civic and community organizations to promote education, research, and service that make a difference in the work you do.

**Methods of Civic Engagement**

Already a national leader in community service learning, ICCE supports collaborative, interdisciplinary research projects and the development of innovative university courses; sponsors seminars and forums; negotiates opportunities for civic and community engagement with government agencies and nonprofit organizations; and develops programs that proactively deal with critical social issues.

http://www.sfsu.edu/~icce/
San Francisco State is one of 62 colleges and universities nationwide to receive the Carnegie Foundation's *Community Engagement, Outreach & Partnerships classification*, which recognizes SF State's dedication to community service learning and to collaborative partnerships that are mutually beneficial to scholarship and to the community.

Watch our 6 minute Video "CSU San Francisco State Community Service Learning" on YouTube.

If you would like to support our work through a donation, click here, and then in the section "About Your Gift," enter ICCE in the space that says if "Other," enter designation.
Plagiarism--The Do's and Don'ts

Why is everyone so concerned about plagiarism? We hope you too will become concerned after reading the information and explanation we've provided here for you. This is a guide to what plagiarism means and how to avoid it.

<table>
<thead>
<tr>
<th>What is Plagiarism?</th>
<th>How to Avoid It</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples</td>
<td>Conclusion</td>
</tr>
</tbody>
</table>

**What is Plagiarism?**

Plagiarism has been defined as: "The unacknowledged use of another person's work, in the form of original ideas, strategies, and research as well as another person's writing, in the form of sentences, phrases, and innovative terminology."1

This means that if you use the words or ideas of others without giving proper credit, you are a plagiarist.

**Why should you be concerned about plagiarism?**

- Plagiarism is a violation of the UCD Code of Academic Conduct which may result in a student's suspension or dismissal from school.
- Plagiarism is dishonest because it misrepresents the words and ideas of another as one's own.
- If you do commit plagiarism, you are cheating yourself. You don't learn to develop and write out your own thoughts.2
- Plagiarism is unfair because it undermines the value of other students' work; students shouldn't have to compete with professional writers.3
- It is morally wrong to steal another's possessions; an author's original words and ideas are possessions for which the author is entitled to receive value and/or credit when they are used by another.
- It is illegal under the law of copyright to steal another's words or expressions of ideas.
- You have a stake in the reputation of this institution because your diploma bears its name; if UCD is known as a school where students plagiarize, the bad reputation can undermine or destroy the value of your diploma.

In short, plagiarism hurts you and others.

**How can you avoid plagiarism?** Plagiarism can be intentional or unintentional. Intentional plagiarism involves deliberate copying or use of another's words or ideas. Unintentional plagiarism usually results from ignorance of the rules for documenting sources or from sloppy research and note-taking. Even if plagiarism is unintentional, it is still a violation of the Code of Academic Conduct. The following guidelines, provided by J. Raymond Hendrickson, may help you to avoid plagiarism:

- When writing a paper try to use your own words the majority of the time.
- When you do use another person's words, use quotation marks and give credit to the
source, either within the text or in a footnote.
- Don't make slight variations in the language and then fail to give credit to the source. If the expression is essentially the same, the author still deserves credit.
- Even if you aren't directly quoting the material, you should still document information and ideas which you use in your paper whenever they are new to you (something which you discovered in your research).
- If you're unsure, add the footnote or citation. It is better to be extra cautious than not to give credit when you should.4

Examples

Now that you have a basic understanding of plagiarism, let's look at some examples which illustrate this concept.

A. Use of Another's Ideas.

As Brenda Spatt says in her book, Writing from Sources, "If you present another person's ideas as your own, you are plagiarizing even if you use your own words."5 She illustrates this point with the following example.6

Original Version (from Leo Gurko, Ernest Hemingway and the Pursuit of Heroism)

The Hemingways put themselves on short rations, ate, drank, and entertained as little as possible, pounced eagerly on the small checks that arrived in the mail as payment for accepted stories, and were intensely conscious of being poor. The sensation was not altogether unpleasant. Their extreme youth, the excitement of living abroad, the sense of making a fresh start, even the unexpected joy of parenthood, gave their poverty a romantic flavor.

Student Version (unacceptable without documentation)

Despite all the economies that they had to make and all the pleasures that they had to do without, the Hemingways rather enjoyed the experience of being poor. They knew that this was a more romantic kind of life, unlike anything they'd known before, and feeling that everything in Paris was fresh and new, even their new baby, made them sharply aware of the glamorous aspects of being poor.

Even though the student has used his/her own words here, the student still must cite Gurko or be guilty of plagiarism because the student is using information taken directly from Gurko's book.

B. Use of Another's Words:

Brenda Spatt provides guidelines for documenting your sources when you use another's words:

"When you quote a source, remember that the quoted material will require two kinds of documentation: the acknowledgment of the source of the information or ideas (through a footnote and possibly through citation of the author's name in your text) and the acknowledgment of the source of the exact wording (through quotation marks)."7

The following examples of both an acceptable and an unacceptable use of words from a source
are taken from James D. Lester's book, *Writing Research Papers*.

**Original Version**

Probably the long-distance marriage works best when there are no minor-aged children to be considered. It probably also works better with those relatively rare men and women who are equipped by temperament and personality to spend a considerable amount of time alone.

**Student Version #1 (unacceptable)**

There are certain factors which facilitate the implementation of this living arrangement. Probably the long-distance marriage works best when there are no children to be considered. It probably also works better with those men and women who are equipped by temperament and personality to spend a considerable amount of time alone.15


Student version #1 is plagiarism, according to Lester, even though the student provided documentation. This is because the student "has obviously copied almost directly from the source, changing only a few words and phrases. The student also fails to introduce the borrowed materials; thus, the reader is uncertain about the note number. Does it refer to the entire paragraph or only the final sentence? As a research writer, you may avoid these errors by introducing the material as direct quotation or, if you prefer, as a ... paraphrase that might include direct quotation of a few significant or well worded phrases."9

**Student Version #2 (acceptable)**

There are certain factors which facilitate the implementation of this living arrangement. William Nichols points out several conditions which would add to the success of a long distance marriage. He states that it "works out best when there are no minor-aged children to be considered," the two people are "equipped by temperament and personality to spend a considerable amount of time alone," and they are both able to "function in a mature, highly independent fashion."15


Student version #2 is acceptable, according to Lester, since it introduces the source and provides quotes, with quotation marks, of the key phrases used from the source.

**Conclusion**

We hope these examples have helped you to understand what plagiarism is. Whenever you are using sources to write a paper, you should keep these guidelines in mind. Remember, whether it is intentional or not, plagiarism is wrong and should be avoided. If you have further questions on how to document your sources properly, other resources on citing sources and writing papers are available in Shields Library. Also, the Learning Skills Center has drop-in consultation and a writing hot-line (752-2013). Finally, a staff member of Student Judicial Affairs can be reached at 752-1128 if you have questions about the Code of Academic Conduct, plagiarism, or the student...
Cheating and Plagiarism

Each faculty member who requires outside written work as part of course requirements should carefully define the meaning of plagiarism and outline the proper methods for using outside sources. Students should be cautioned about the consequences should plagiarism be discovered.

If cheating or plagiarism occurs, it is the instructor's responsibility to handle the situation. The grade assigned must be based on the student's academic performance and must not be used as a punitive measure. The Judicial Affairs Officer in the Office of Student Affairs will assist the instructor and is responsible for determining whether formal disciplinary action should be taken.

As a result of faculty and student discussions, the following list of suggestions to prevent cheating on examinations has been developed:

- Proctor examinations in person as there is no honor system.
- Space students as widely as possible to avoid sharing information or misinformation during examination.
Formal Lab Write-up
Due November 16

You have a choice of three labs to do. The labs on enzymology, cellular energetics or photosynthesis are all goods labs to do because they are data labs. You will have to use class data and explain it, as well as the data your group generated. Include at least two outside references – this does not include the class text or laboratory manuals, so it will require library work. If doing a lab that uses the Dolphin manual, you can use the references at the end of the lab. Upper division textbooks are permissible. The report must have a Title.

Introduction: Be comprehensive. It should completely say what your paper is about, including the theory and concepts behind the lab. This is where citations from outside references and outside materials will be useful. Be sure to state near the end of the introduction the purpose of the experiments you performed, but not the results.

Materials/Methods: You will have to include a detailed account of what was used and done, not simply reference the lab manuals. A person should be able to use only your report and do the experiments and exercises in the lab. Note any changes that were made from the lab manual. You might want to include a list of materials and solutions in addition to the description of how to do the experiments. Use past tense.

Results: Label everything neatly, completely and accurately. All graphs should be labeled as a Figure, and all tables should be labeled as a Table. Give an explanatory sentence for each figure or table. Be sure to include results from everything that was done in the lab; do not choose only a selection of the exercises that were done. Make sure to show data tables, as well as the graphs generated from the data. The text in the results section should describe the results. For example, you can describe the shape of a graph or how the reaction changes in different conditions, but do not explain why these results are occurring. Use past tense. Be careful to avoid analyzing – that is saved for the Discussion.

Discussion: This is where you analyze results and integrate your data with the concepts of the lab. Use your data to support explanations and concepts. Remember the data are numbers, but the interpretation of the data is the story, and that is what you are creating in the discussion. The reference to the data in the results section should use past tense, but the explanation of what the data show usually requires present tense. For example, “There was a linear relationship between.... This suggests that ....” In terms of text, it generally is the longest section. This is where references are valuable. Be sure and incorporate your references into the text. Do not use footnotes. For example:

By contrast, Sarafian, et al., have recently cloned and sequenced the tonoplasty pyrophosphatase to compare homologous sequences. 2

Then include a bibliography at the end using the following format:


Format is: 1) number of reference; 2) then the author(s); 3) title of the article (or book chapter), underlined or in quotation marks; 4) the year it was published in parenthesis; 5) the title of the journal the article is from (or the book the chapter is from) either bold-faced or underlined; 6) the volume; 7) colon, followed by page numbers.

A word on citations: When you cite a source, if quoting directly, put the citation in quotation marks and include the reference number of the source from your bibliography. If you are paraphrasing a source, make sure you give attribution to the source:

(e.g. Sitt describes how the energized membrane functions in malate uptake by use of a proton pump. 3)

and include the reference number at the end of the sentence.

You must cite your sources, whatever you use to understand the material. Otherwise, uncited quotations or paraphrasing is considered plagiarism.
Animal Subjects Protocol Form and Instructions

This section contains the forms needed to obtain University Animal Care and Use Committee (UACUC) review and approval of research and teaching projects using live, vertebrate, non-human animals, as required by federal law and SFSU policy.

Regulations require that:

- The UACUC reviews all animal use carried out in university facilities, as well as fieldwork and research at other institutions conducted by SFSU personnel. All projects are to be approved prior to the actual use of animals, whether it involves research/teaching or warm/cold blooded vertebrates or vertebrate animal products.

- The approval of animal use will be granted for a three-year period for non-USDA regulated species and one year for USDA regulated species (e.g., rabbits, guinea pigs). The UACUC is required to review activities annually, even though it may be a multiple-year project.

The forms are designed to help provide sufficient information to allow a meaningful review of your proposed animal use. To obtain project approval, please follow these instructions:

- Provide a TYPED copy of your completed Animal Subjects Form. Handwritten copies will be returned without review.

- Complete all information and be explicit, but brief, when providing details. "See attached proposal" is not an acceptable response. Forms submitted with inadequate information will be returned.

- Attach a copy of the grant application, proposal, or other documents giving detailed descriptions of all procedures involving animals.

- All researchers are required to pass the SFSU online animal research certification course (or its equivalent from other institutions), which takes approximately 2 hours. A certificate is issued to the researcher upon successful completion of the course. The certificate must be printed out and included in the protocol materials. Researchers must provide a copy of the certificate with each protocol they submit.

Be advised that the Animal Subjects Form is a public record and may be released upon request. Should certain information be confidential (e.g., experimental design/hypothesis, materials used, etc.), please indicate such items.

Sufficient lead-time is necessary to obtain approval and should be taken into consideration in planning start dates or need for approval for funding agencies. Please allow 2 months for UACUC review and decision.

Assistance for animal procedures and use of anesthetic/analgesic procedures and methods of euthanasia is available. The attending veterinarian must be consulted in the planning of potentially painful/stressful procedures. Should you have questions regarding specific items on the form or general questions involving animal regulations/policies, contact the UACUC administrator at 415-338-1093 or protocol@sfsu.edu.
Narrative (For survival surgery, also complete the supplemental Survival Surgery Form)

A. Objective/Significance. Describe in non-technical terms, the scientific or educational aims of the project. Justify the project in terms of its potential value in obtaining or establishing significant information relevant to the understanding of humans or animals, maintenance and improvement of human or animal health and welfare, improvement of animal management or production, or achievement of educational objectives.

B. Lay Description of Experimental Design: In language that will be understood by members of the general public, provide a succinct outline of the formal scientific plan and direction for experimentation. If several experimental groups or sequential studies are to be included in the protocol, description of the experimental design for each separate experimental group should be contained in sub-parts of this section.

C. Methods. Describe the experimental protocol in detail. Include information on behavioral, dietary, environmental, pharmacologic, physiologic, surgical, etc., manipulations. Describe procedures designed to minimize discomfort, distress, pain and injury to the animals. If anesthetics, analgesics or tranquilizers are to be used, detail the dosage, route of administration, and duration.

For field research, include details of animal capture, handling, restraint, marking, and release. (While the research design may not include euthanasia, this may be necessary if animals are inadvertently injured. Emergency euthanasia methods need to be identified below.)

D. Euthanasia. Explain the methods to be used and the reasons for their selection. List agents, dosages and routes of administration. Provide information on the final disposition of the animal.

E. Investigator Qualifications. Describe your qualifications and training for carrying out all animal procedures and what training you will provide for persons handling animals. It is your responsibility as the PI to ensure that all personnel handling animals have been appropriately trained.

F. Animal Use. Justify the use of animals vs. non-animal alternatives, the choice of species (why this is the most appropriate species/strain to use in these studies), and the numbers of animals to be used (provide a breakdown of the animals into experimental group, identifying each experimental group and the numbers of animals in each group).

In discussing alternatives, consider the “3 Rs”:

a. Replacement: Those methodologies (computer programs, tissue culture techniques, epidemiological data, etc.) which replace the use of animals.

b. Reduction: Those methodologies which reduce the numbers of animals used in the protocol.

Refinement: Those methodologies which refine the procedure to minimize the amount of discomfort that the animal may experience.
Include the computer database searched (e.g., Medline, Index Medicus, etc.) or other sources, such as journals or meetings that you used to determine that: a) there are no appropriate alternatives for this research and/or b) this protocol does not unnecessarily duplicate previous experiments by yourself or others. A computer search of at least two databases is required. A search for alternatives may include words such as "cell culture", "in vitro", or "computer models" or it may include a less sentient animal species. The search should be for reduction and refinement, not just replacement of animals.

Provide the databases searched, the key words used, the years searched, and the date of your search. Summarize the outcome of your search. If there are any hits, explain: a) why these would not be acceptable as a replacement for your in vivo work and/or b) how your study differs from previous work.

Two databases designed specifically to search for alternatives that you might want to use are:

http://altweb.hsph.edu/

G. References/Bibliography
ASBMB'S CODE OF ETHICS

The code of ethics is an important document that outlines the professional standards and responsibilities for members of the ASBMB (American Society for Biochemistry and Molecular Biology). It provides a framework for maintaining ethical conduct in the field of biochemistry and molecular biology, ensuring that members contribute to the advancement of human welfare.

**CODE OF ETHICS**

Members of the ASBMB are engaged in the quest for knowledge in biochemical and molecular biological sciences with the ultimate goal of advancing human welfare. Underlying this quest is the fundamental principle of trust. The ASBMB encourages its members to engage in the responsible practice of research required for such trust by fulfilling the following obligations.

**In fulfilling OBLIGATIONS TO THE PUBLIC, it is EXPECTED that:**

- Investigators will promote and follow practices that enhance the public interest or well-being;
- Investigators will use funds appropriately in the pursuit of their research;
- Investigators will follow government and institutional requirements regulating research such as those ensuring the welfare of human subjects, the comfort and humane treatment of animal subjects, and the protection of the environment;
- Investigators will report research findings resulting from public funding in a full, open, and timely fashion to the scientific community; and
- Investigators will share unique propagative materials developed through publicly-funded research with other scientists in a reasonable fashion.

**In fulfilling OBLIGATIONS TO OTHER INVESTIGATORS, it is EXPECTED that:**

- Investigators will have actually carried out experiments as reported;
- Investigators will represent their best understanding of their work in their descriptions and analyses of it;
- Investigators will accurately describe methods used in experiments;
- Investigators will not report the work of others as if it were their own;
- Investigators in their publications will adequately summarize previous relevant work;
- Investigators acting as reviewers will treat submitted manuscripts and grant applications confidentially and avoid inappropriate use; and
- Investigators will disclose financial and other interests that might present a conflict-of-interest in their various activities such as reporting research results, serving as reviewers, and mentoring students.

**In fulfilling OBLIGATIONS TO TRAINEES, it is EXPECTED that:**

- Investigators serving as mentors will provide training and experience to advance the trainees' scientific skills and knowledge of ethical research practices;
- Investigators will provide appropriate help in advancing the careers of the trainees;
- Investigators will recognize research contributions of the trainees appropriately;
- Investigators will encourage and support the publication of results of trainees' research in a timely fashion without undisclosed limitations; and
- Investigators will create and maintain a working environment that encourages cultural diversity.

January 1998
Title: Search for Solutions

GE Status: [Reg. Ed. 11.3 (1)]

U.S. History
and
Government:

Prerequisites: 18 units in science and consent of instructor.

Term(s)
Offered:

Units: (3)

Description: The interrelationships among science, technology, and society. Students work in teams to research a significant science-based phenomenon, its effects on society, and how these effects could be mitigated.

Effective: Fall 2000

Latest
Offering:
Appendices for Standards:

Standard 12: General Academic Quality
The first 3 problems are exercises in calculating averages (also called means), starting with the method you are already familiar with and then demonstrating two mathematically equivalent ways (these will be useful later, when we will calculate the average phenotype of individuals of different genotypes in a population). The 4th problem is about calculating a measure of the variation among values, called a variance.

1. You have counted the number of spines on the belly of 10 spiny-bellied worms. Here are the data for the sample: 3, 3, 3, 4, 5, 5, 5, 5, 5, 5. What is the mean number of spines/worm in this sample?

2. In your reading of papers about spiny-bellied worm morphology, you discovered an old French data set that read as follows: 4% of the worms had 3 spines, 50% of the worms had 5 spines, and 10% of the worms had 4 spines. What is the mean number of spines/worm in this sample? How does that relate to problem 1?

3. Another French study showed that blue worms averaged 3 spines, red worms averaged 5 spines, and green worms averaged 4 spines. What is the mean number of spines/worm in a population of 40% blue worms, 50% red worms, and 10% green worms? How does that relate to problems 1 and 2?

4. In another study of spiny-bellied worms, two populations were measured. Population A had spine counts of 1, 1, 2, 2, 4, 6, 7, 8, 9, and 10. Population B had values of 4, 4, 5, 5, 5, 5, 5, 6, 6, 6. What are the mean spine counts of the two populations? Which population is more variable, both intuitively and judging by the value of the variance? The variance, as you will recall from Bio 2.0, is simply the average squared deviation from the mean of all of the values, or \[ \sum (x - \bar{x})^2 \]/ number of values.

Answers (Hey!! Don't look until you've tried it yourself.)

1. \[ 3 + 3 + 3 + 3 + 4 + 5 + 5 + 5 + 5 + 5 / 10 = 4.1 \] spines/worm

2. \[ .4 (3) + .1(4) + .5 (5) = 4.1 \] spines/worm. Problem 1 and 2 are the similar, except that the solution to problem 2 is more general (because it can be applied without knowing the actual sample size). To see that the problems are similar, note that you could solve problem 1 by grouping into CLASSES the individuals with the same number of spines.
   \[ 3 + 3 + 3 + 3 + 4 + 5 + 5 + 5 + 5 + 5 / 10 = \]
   \[ .1(3) + .1(3) + .1(3) + .1(3) + .1(5) + .1(5) + .1(5) + .1(5) + .1(5) + .1(5) = \]
   \[ \sum (x - \bar{x})^2 \] = \[ .4 (3) + .1(4) + .5 (5) = 4.1 \]

3. \[ .4 (3) + .1(4) + .5 (5) = 4.1 \] spines/worm. Of course, this problem is similar to problem 2, except that we formed our three classes of individuals by their color, not by their number of spines. Note that there can be variation among the worms of each class, but you can still get the average as long as you know the mean of each class.

   In general, when you want to take an average you can 1) add up all the individual values and divide by the number of values:
   \[ (\Sigma \text{values of individuals}) / (\text{Number of individuals}) \]

or 2) sum over all classes the product of the frequency of a CLASS times the value of that class:
   \[ \Sigma (\text{Frequency of individuals in a particular group}) * (\text{average value of individuals in the group}) \]

4. You already know how to calculate the averages of these two groups by summing the observations and dividing by the number of observations. If you do this with Population A and Population B, you will get a mean of 5 spines for each group. To calculate the variance, merely subtract the mean (5) from each observation, square the result, add the squares, and divide by the number of observations (10).

   Pop. A: \[ [(5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2] / 10 = 10.6 \]
   Pop. B: \[ [(5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2 + (5 - 5)^2] / 10 = 0.4 \]

The units of these variances are spines², but more important is the magnitude of the value. Pop.A has a much larger variance in spine number among individuals than does Pop.B. This should match your intuitive conclusion, because Pop. A has many individuals with spine counts far from the mean, while Pop. B has no individuals that differ by more than 1 spine from the mean. Variance is just a way to quantify the variability. We will use the concept of variance frequently in this class.
Problem Set 2  Evolution

1. You have a breeding population of people (mostly college professors) that are all heterozygous for sesquipedalianism, a disease exhibited by homozygotes for a recessive allele. If we label the two alleles in this population S (dominant) and s (recessive), answer the following questions about this population.

   A. What is the frequency of the S allele?
   B. What is the frequency of the s allele?

   Now let the population breed, meeting all of the Hardy-Weinberg assumptions. (Of course, this means an infinite population of college professors, perhaps a frightening thought for most of you. But take heart - the discrete generations assumption means that they die after they have kids.)

   C. What are the genotype frequencies now?
   D. What are the allele frequencies now?

   Using this new generation as parents, create another generation:

   E. What are the genotype frequencies now?
   F. What are the allele frequencies now?

   G. When does Hardy-Weinberg equilibrium start for allele frequencies? For genotype frequencies?

   H. After the population achieves Hardy-Weinberg equilibrium, what is the frequency of normal individuals in the population?

2. A population consists of the following individuals: 48 Aa, 10 AA, and 42 aa. Does this population have Hardy-Weinberg genotype frequencies?

Answers

1. A. $0.5 \left[ \text{Freq SS} + 0.5(\text{Freq Ss}) = 0 + 0.5(1.0) = 0.5 \right]$  
   B. Also 0.5  
   C. $SS=p^2=0.25$, $Ss=2pq=0.5$, $ss=q^2=0.25$  
   D. $p=0.5, q=0.5$, see answer to A  

   E. SS: 0.25, Ss: 0.5, ss: 0.25  
   F. $p=0.5, q=0.5$  
   G. Immediately. After 1 generation  
   H. Freq. SS + Freq Ss = 0.25 + 0.5 = 0.75

2. First, calculate the genotype frequencies:
   
   $\text{Freq (AA)} = 10 \text{ AA's}/100$ total individuals = 0.10. Similarly, Freq (Aa) = 0.48 and Freq (aa) = 0.42.

   Next, calculate the allele frequencies in the population. Let $p$ and $q$ be the frequencies of the A and a alleles, respectively.

   $p = 0.10 + 0.5(0.48) = 0.34$  
   $q = 0.42 + 0.5(0.48) = 0.66$

   Expected Hardy Weinberg frequencies for AA, Aa, and aa are $p^2$, $2pq$, and $q^2$, respectively:

   $p^2 = (0.34)^2 = 0.1156$,  
   $2pq = 2(0.34)(0.66) = 0.4488$  
   $q^2 = (0.66)^2 = 0.4356$

   Since the observed genotype frequencies do not equal those expected under Hardy Weinberg, this population cannot be in Hardy Weinberg equilibrium. It has too few heterozygotes and too many of each homozygote.
1. For which alleles could Rumplestiltskin be identical by descent? What is Rumplestiltskin's inbreeding coefficient?

2. A population of 10 ideal individuals breeds for 10 generations. Assuming $F_0 = 0$, what is the inbreeding coefficient of this population in the 10th generation? Repeat for a population of 500 individuals.

3. You have a breeding population of elephants. If you were to survey them from the air, you would count 300 individuals, 150 males and 150 females. However, wildlife biologists on the ground have discovered that only 3 bulls do all the mating. They each mate with 50 different females. Calculate the inbreeding coefficient after 10 generations for this population, using the following numbers as the population size in the equation relating $F$ to $N$:
   - A. 300 individuals (the data available from the air survey)
   - B. 153 individuals (the number of breeding individuals)
   - C. The effective population size (Use your notes to determine the correct equation for calculating $N_e$ from this sort of population).

   Answer the following questions about the elephants:
   - D. Which method gives the correct conclusion?
   - E. What is the amount of error in using the wrong choice of A, B, or C?

4. A population of annual poppies has the following history:

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<thead>
<tr>
<th>Generation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pop. Size</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>5</td>
<td>100</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
</tr>
</tbody>
</table>

   A. What is the average size of the population over 9 generations?
   B. What is the effective population size?
   C. How much inbreeding would you expect after 9 generations in this population? What would $F_9$ have been if you had mistakenly used the answer to A?

5. Which population has the most inbreeding after t generations, one in which each individual reproduces equally, or one in which each individual has an equal chance of leaving offspring but some do and some don't?
Answers to Problem Set 3:

1. Alleles $A_3$ and $A_4$ are the only ones for which Rumpelstiltskin could be identical by descent. The value of $f$ for $A_3$ is $(1/2)^4$, the value of $f$ for $A_4$ is $(1/2)^4$, so the probability of identity by descent for any allele is $1/16 + 1/16 = 1/8$.

2. $1 - (1 - (1/20))^{10} = 0.4013$, $1 - (1 - (1/1000))^{10} = 0.009955119$

3. A. $F_{10} = 1 - (1 - (1/600))^{10} = 0.0165$
   B. $F_{10} = 1 - (1 - (1/306))^{10} = 0.0322$
   C. $N_e = 4(3)(150)/(3+150) = 11.76$, therefore $F_{10} = 1 - (1 - (1/23.52))^{10} = 0.3524$
   D. C, since the equation for $F_t$ only applies to $N_e$, not to $N_{actual}$.
   E. A underestimates $F_{10}$ by 21 fold ($0.3524/0.0165 = 21.36$)
   B underestimates $F_{10}$ by 11 fold ($0.3524/0.0322 = 10.94$)

4. A. $(10000+10000+10000+5+100+10000+10000+10000+10000)/9 = 7789.44$
   B. $1/[(0.0001+.0001+.0001+.01+.0001+.0001+.0001+.0001)/9] = 42.71$
   C. $F_9 = 1 - (1 - (1/(2*42.71)))^9 = 0.1006$, [wrong $F_9 = 1 - (1 - (1/(2*7789.44)))^9 = 0.0006$

5. Using the equation $N_e = [4N_{actual}] / [2 + (2 * variance)]$, (where variance means the variance among individuals in the number of offspring produced), we can see that more inbreeding accumulates in the population in which some individuals have offspring and others don't. This is because when each individual reproduces equally, variance is zero and $N_e = [4N_{actual}] / [2 + (0)] = 4N_{actual} / 2 = 2(N_{actual})$, but when some individuals reproduce and others don't the variance is greater than zero and $N_e = [4N_{actual}] / [2 + (2 * something)] < [4N_{actual}] / [2]$
1. Farmer Smith is raising geese. He wishes to increase their neck length by artificial selection, because trying to stretch their necks just resulted in a flock of annoyed geese. The average neck length when he started was 15 inches. Farmer Smith chose the 20% of his geese that had the longest neck length to breed to create the next generation. The breeders had a mean neck length of 16 inches. Heritability for neck length is 0.2. What will be the population average neck length in the next generation?

2. Using the information in problem 1, what must the average neck length of the breeders be to get a neck length of 16 inches in the next generation? Would this mean that Farmer Smith chose more or fewer geese as breeders (compared to problem 1)?

Answers:

1. The selection differential, \( S = 16 - 15 = 1 \).
   The response to selection, \( R = S(h^2) = 1 \times 0.2 = 0.2 \).
   The neck length in the next generation is the mean of the parental generation plus the response (how do I know this?) and will be \( 15 + 0.2 = 15.2 \) inches.

2. Since \( R = S(h^2) = \text{mean of the offspring} - \text{mean of the parental generation} \), and if the mean of the offspring = 16 inches, then
\[
16 - 15 = S(h^2) = S \times 0.2 \quad \text{therefore} \quad 1/2 = S = 5 \text{ inches}.
\]
This means that Farmer Smith must have chosen breeders that had necks that were 5 inches longer than the parental generation as a whole, or 20 inches long. To do this he would have chosen fewer geese as breeders (because fewer geese will have this more extreme trait value).
Problem Set 5 (and lecture notes, so bring to class) * Evolution

I. Additive gene effects:

Let's say we have a population of *Heterocephalus glauber* that have an average body weight of 50 g. Let's also pretend that body weight is affected by 2 loci, A and B, with two alleles each. Let the alleles relate to body wt. as follows:

\[
\begin{align*}
A &= 10g \\
B &= 20 g \\
a &= 15 g \\
b &= 5 g
\end{align*}
\]

Assuming no environmental effects \((V_e = 0)\), that means that the genotype body weights are:

\[
\begin{align*}
AABB: 60g & & AABb: 45g & & AAbb: 30g \\
AaBB: 65g & & AaBb: 50g & & Aabb: 35g \\
aaBB: 70g & & aaBb: 55g & & aabb: 40g
\end{align*}
\]

**Problem 1.** Cross any two genotypes. Calculate the genotypes of each offspring, their relative proportions, and their body weights. Calculate the average bodyweight of the two parents and the average body weight of their offspring (remember, the average of the offspring is calculated by multiplying the frequency of that kind of offspring by the body weight and summing those products over all offspring genotypes). Is the average body weight of the offspring equal to the average body weight of the parents? How predictable is body weight from genotype? How predictable is body weight of offspring from the average body weight of the parents? How does this relate to the concepts of \(V_p, V_g, V_a\), and \(h^2\)?

**Sample answer:** Let's cross AABB with aabb. The possible offspring are AaBb and aaBb in equal numbers. That means a frequency of 0.5 for each of the two types of offspring. The average body weight of the offspring is 0.5(50 g) + 0.5(55 g) = 52.5 g. The average of the parents is .5(65 g) + .5(40 g) = 52.5 g. An individual's body weight is completely predictable from its genotype. And the average offspring body weight is completely predictable from the average parent body weight. (This will be true for any two parents that you might choose. If you don't believe me, try some more crosses.) In other words, the variation in body weight \((V_p)\) is all due to genetic variance \((V_g)\) and all of the genetic variance is additive genetic variance \((V_a)\). So \(V_p = V_a\). That means that \(V_a / V_p = 1\) which means that \(h^2 = 1\).
II. Interactive (=nonadditive) gene effects:

Now let's examine the genotype bodyweights when gene effects are not additive. In this case, we can't assign a weight to an allele, since the alleles do different things in different combinations. We can, however, state that if $V_e = 0$ then body weight is completely determined by genotype. Here is an example:

- AABB: 60g
- AaBB: 50g
- aaBB: 10g
- AABb: 12g
- AaBb: 55g
- AAbb: 70g
- aabb: 60g

**Problem 2.** Repeat problem 1 for this new situation.

**Sample answer:** Let's cross AABB with aabb again. The possible offspring are AaBb and aBb in equal numbers. That means a frequency of 0.5 for each of the two types of offspring. The average body weight of the offspring is $0.5(12g) + 0.5(55g) = 33.5g$. The average of the parents is $0.5(50g) + 0.5(60g) = 55g$. An individual's body weight is completely predictable from its genotype ($V_p = V_g$). But, average offspring body weight is not predictable from the average parent body weight (Again, try other examples to convince yourself). In our example, two fairly large parents produced small and large offspring in equal numbers. In other words, the variation in body weight ($V_p$) is all due to genetic variance ($V_g$) but all of the genetic variance is interactive genetic variance ($V_{il}$).

So $V_e = 0$ and $h^2 = 0$. There will be no response to selection on body weight in this case.

**Warning:** I have oversimplified the concepts of additive and nonadditive genetic variation. Actually, these values also incorporate allele frequencies. That is, the similarity between parent phenotype and offspring phenotype can vary with allele frequency, even with the same genotype/phenotype values. The math to describe this is too complicated for this class, but we will illustrate the effect of altering allele frequency in class, using computer simulation.
1. At generation zero, a population with discrete generations has a mean height of 6 inches. Only individuals who are 8 inches or higher are breeders. The mean of these breeders is 10 inches. What will be the mean height of the next generation, and the value of the Response to Selection (R), under the following circumstances:

A. The heritability ($h^2$) equals 1.0.
B. The heritability equals 0.3.
C. The correlation among full sibs in this population for height equals 0.25.
D. The phenotypic variance ($V_p$) of height in this population equals 72 inches$^2$ and the additive genetic variance ($V_A$) for height equals 57.6 inches$^2$.
E. The additive genetic variance $V_A = 57.6$ inches$^2$, the interactive genetic variance ($V_I$) = 12 inches$^2$, and the environmental variance ($V_e$) = 65 inches$^2$.

***************

Answer:
For all four problems the Selection Differential (S) = the mean of the actual parents - the mean of the parental generation. Therefore $S = 10 - 6 = 4$ inches.

A. Because $R = h^2 S$, $R = 1.0 \times 4 = 4$ inches.

Because $R$ = mean of the offspring - mean of the parental generation, the mean of the next generation = $R$ + the mean of the parental generation = $4 + 6 = 10$ inches.

B. $R = 0.3 \times 4 = 1.2$ inches. The mean of the next generation is $1.2 + 6 = 7.2$ inches.

C. The correlation among full sibs (C) is equal to half the heritability, or $C = 0.5 \times h^2$.

Therefore $h^2 = 2(C) = 2(0.25) = 0.5$

As above, $R = 0.5 \times 4 = 2$ inches and the mean of the next generation is $2 + 6 = 8$ inches.

D. Because $h^2 = V_A/V_p$, in our case $h^2 = 57.6 / 72 = 0.8$.

As above, $R = 0.8 \times 4 = 3.2$ inches and the mean of the next generation is $3.2 + 6 = 9.2$ inches.

E. $V_p = V_A + V_I + V_e = 57.6 + 12 + 65 = 134.6$ inches$^2$. As above, $h^2 = 57.6 / 134.6 = 0.428$.

As above, $R = 0.428 \times 4 = 1.712$ inches and the mean of the next generation is $1.712 + 6 = 7.712$ inches. Note that even with the same additive genetic variance as in D, the heritability is lower because the environmental variance is greater and has inflated the phenotypic variance. Therefore there is less response to selection.
### The Application of Numbers in Science: Scientific Measurement and Uncertainty

#### Requirements for this Exercise:

**Mode:** Inquiry, groups of 2  
**Prelab Exercise:** Yes  
**Grading:** Lab Performance, Lab Report (one per group)  
**Reading in text:** 1.9, 1.10, 1.11, 1.12  
**Reading in manual:** Appendix 2 Glassware (at end of this exercise)

#### I. Background

Chemistry is an experimental laboratory science. The theories that are prevalent in Chemistry as well as other fields of science are based upon careful experimentation. In order for one to gain

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**Chemical Classification and Potential Hazards of Chemicals Used in Experiment**

<table>
<thead>
<tr>
<th>CHEM 115 Exp 13</th>
<th>Chemical Classification</th>
<th>Possibility of:</th>
<th>NFPA Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poison A</td>
<td>Flammable Liquid</td>
<td>Flammable Solid</td>
</tr>
<tr>
<td>Bismuth Metal</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cadmium Metal</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Copper Metal</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Lead Metal</td>
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<td>X</td>
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<td>Nickel Metal</td>
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<td>X</td>
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<tr>
<td>Tellurium Metal</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Tin (white) Metal</td>
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</tr>
<tr>
<td>Titanium Metal</td>
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<tr>
<td>Zinc Metal</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>

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**Numbers in Science**
acceptance by the scientific community, this experimentation required measurements that stood the test of reproducibility. While some scientific observations may be qualitative such as a color change or the formation of a solid precipitate (recall the kinds of observations you made for Lab Exercise 4 Deductive Chemical Reasoning), it is only when quantitative measurements are made that hypotheses can evolve into scientific theories.

In today’s world many things and events are expressed in terms of numbers and their units. To observe the pervasiveness of this quantitation in everyday life, just listen for a few minutes to the casual conversation that surrounds you. How much of that conversation revolves around numbers and their units: how long it took to commute to school in minutes or hours, an hourly pay rate in dollars/hour or pesos/day, someone’s age or weight in pounds or kilograms, a class average in percent, the outdoor temperature in Fahrenheit or Celsius degrees. Some of the numbers are obtained by simple counting or estimating whereas others are obtained by reading a measuring device such as a watch, a thermometer, a weight scale, etc.

In science, most quantitative measurements are a result of comparing two quantities. This is the case whenever a measuring device or instrument is used. For example, measuring the length of a piece of paper would involve the use of a ruler or meter stick, examples of a measuring device. In making the length measurement you are actually comparing the length of the paper with a length designated on the ruler or meter stick by its calibration lines. The calibration lines provide the numerical markings needed to make the measurement but they mean nothing unless the units, i.e. inches or centimeters, are also designated on the ruler. You already have experience making measurements using a variety of devices such as a ruler, an analog watch, the speedometer in your car, or the weight scale in your bathroom. Now you will sharpen these skills and apply them to making scientific measurements, ones that you will need to show are able to withstand the test of reproducibility. In addition you will need to take into account the accuracy, precision and uncertainty of your measurements and learn how to communicate your scientific results through the use of equations and graphs.

A. Taking Measurements

When taking a measurement with a device such as a ruler or scale it is necessary to make an estimate of the last numerical value in the measurement. Take for example the length measurement shown below using a ruler in units of centimeters. The length of the line clearly falls between two calibration marks and thus an estimate of where the line actually ends is required. This last number will vary depending upon who is making the measurement but because the calibration lines are designations of 0.1 cm each, this last number will not vary by more than +/- 0.05 cm. Thus the length must be read to two places past the decimal because this is the precision that this particular device allows. Even if the line ended exactly on a calibration mark, it would be necessary to include the appropriate number of zeroes past the decimal point in order to properly communicate the precision of the ruler being used. See the example below.

Exercise 13
The diagram below shows a liquid contained in a graduated cylinder, a measuring device for volume. Try reading the volume of the liquid indicated by the meniscus (curved line) in the graduated cylinder. Record your measurement (remember to include your units!) in the box and then check your measurement with the one reported on the following page. If your measurement is different, reread this section and try to understand where the difference occurred. Uncertainty in the measurement is inherent in the piece of equipment. Check Appendix A at the end of this exercise for the errors associated with graduated cylinders. Report this error as part of your measurement (measurement +/- error). Check your units and check the places past the decimal that you used to report your measurement. Make sure you understand why the measurement is reported as shown on the next page.
Volume measurement = 12.4 +/- 0.2 mL

B. Accuracy, Precision, and Uncertainty

Every measurement contains some error associated with the actual taking of the measurement. This is unavoidable. In science it is essential to communicate the magnitude and the possible source of the error associated with any reported measurement and experimental result that was calculated from those measurements. Scientific measurements and data are judged by the two criteria of accuracy and precision. Accuracy refers to how closely the measured value is to the "true" value. For example, a poorly manufactured volumetric pipette might deliver 27.00 mL of water when its calibration markings indicate it is suppose to deliver 25.00 mL of water. The pipette is not accurate because the actual measured amount of water delivered is not very close to the "true" value. Precision is an indication of the reproducibility of the measurement made with the same device. For example, using the same poorly manufactured volumetric pipette, several measurements could be made which result in an average of 27.00 ± 0.02 mL. This pipette would be considered very precise, although it is not very accurate. Accuracy and precision are related to two common types of error:

Systematic error often results from the inexperience or carelessness of the experimenter taking the measurement. It may also occur when there is a flaw in the design or manufacture of the measuring device. In both cases the result is poor accuracy. In other words, systematic errors produce a measurement that is inaccurate. Systematic errors are suspected when the measurement is consistently too high or too low. Most often systematic errors can be eliminated by the experimenter becoming more familiar with the measurement or by being more careful. Systematic errors which result from a poorly manufactured instrument, can be eliminated by recalibrating the instrument or changing to another one.

Random error occurs in every measurement because of one's inability to obtain exactly the same numerical value for numerous measurements of the same quantity. For example, in taking a mass measurement on a scale that has a digital balance you will find that the last digit does not stay the same. Instead it changes, wavering around some particular value. This is due to small vibrations as well as small air currents around the balance. These effects can be minimized but not eliminated, thus each time you measure the mass of the same sample you will read a slightly different number. Random error is identified when the measurement is sometimes high and sometimes low. In other words, it fluctuates around an average value or mean. The magnitude of the fluctuation determines the precision of the measurement.

There is a certain degree of uncertainty in all measurements made in the laboratory. An analysis of the uncertainty is an estimation of the error introduced into the measurement that is due to random error. This analysis affects the precision of the measurement. Notice from the description of systematic error above, that the accuracy of the measurement is determined primarily by the experimenter. Therefore it is the responsibility of the experimenter to try to eliminate the systematic error. Random error can only be reduced by the experimenter but not eliminated. It is the magnitude of the random error that needs to be reflected in every experimental measurement that you report.
The uncertainty and therefore the precision of the measurement is indicated by the number of significant figures present in the measurement as well as by the magnitude of the fluctuation of the last significant digit in the measurement. For example, suppose you were weighing a sample on the digital balance and observed the following three successive readings on the digital scale in grams: 8.409, 8.407, 8.411. The calculated mean (or average value) is 8.409 grams and the fluctuation around this mean is ± 0.002 g. This fluctuation is calculated as a standard deviation using equation 1 below. Therefore, you would report the mass of the sample as 8.409 ± 0.002 g. Notice that this reported measurement has three equally important parts, the mean value of the measurement (8.409), the uncertainty of the measurement (± 0.002), and the units of the measurement (g, grams). It is important that you develop the habit of writing measurements with all three components. Furthermore, be sure that you are reading the measuring device to its allowed precision. It would not be correct to round off the mass measurements above to 8.41 g when your balance allows a more precise measurement. It would also not be appropriate to add or estimate an additional significant figure such as 8.4092 g when the balance only reads to the nearest milligram, i.e. the thousandths decimal place.

C. Calculation of Precision

As noted above, precision is reported as a fluctuation around the mean value for a group of measurements. This means that each measurement must be taken multiple times, at least two but three or more are better as time allows. The mean is calculated by summing the measurements followed by dividing the number of measurements in the sum. For example, suppose you measured a volume of a liquid using a graduated cylinder and found the volume to be: 20.4 mL, 20.1 mL, 19.7 mL. The mean value would be calculated as follows:

\[
\text{mean } \bar{x} = \frac{20.4 + 20.6 + 19.7}{3} = \frac{60.7}{3} = 20.23 \text{ mL}
\]

(Although the mean will be reported as 20.2 mL, the calculated value, 20.23, will be used to determine the precision of the measurement.)

The precision of this measurement is then calculated by determining the standard deviation. This can often be easily accomplished by using the statistics mode on your calculator or by using the following formula:

\[
\text{standard deviation } \sigma = \sqrt{\frac{\sum(x_i - \bar{x})^2}{N - 1}} \quad (1)
\]

In this equation, \((x_i - \bar{x})\) represents the deviation from the mean \((\bar{x})\) of each measurement \(x_i\) and \(N\) represents the total number of measurements. Using the three volume measurements and the mean value, the standard deviation would be calculated as shown below.

\[
\sigma = \sqrt{\frac{(20.4 - 20.23)^2 + (20.6 - 20.23)^2 + (19.7 - 20.23)^2}{3 - 1}} = \sqrt{\frac{0.45}{2}} = \sqrt{0.225} = 0.47
\]

Since the mean is precise to only the tenths place (because the actual measurements were made to just the tenths place), the standard deviation must also be reported to just the tenths place. The

\[000013\]
standard deviation will be rounded up to 0.5, and the measurement would be reported as \(20.2 \text{ mL} \pm 0.5 \text{ mL}\) (or \(20.2 \pm 0.5 \text{ mL}\)).

D. Error Analysis in Calculated Results

Quite often it is not the directly measured quantities that are of primary interest. Rather, to obtain the desired result, you may need to mathematically combine one or more measured quantities in an equation in order to calculate the result. An example is found in the experimental determination of density. Density is defined as the mass of a sample divided by its volume, or \(D = \text{mass/volume}\). Experimentally we would measure the mass on the balance and the volume using a volumetric piece of glassware. We would then use these two measurements in a calculation to determine the density. The density that we report must reflect the uncertainty of the measurements used to calculate it. In addition, if the true value of the density is known, then the accuracy of the density should also be reported.

The process of deducing the uncertainty of a calculated result, knowing explicitly the individual uncertainties of the measured quantities and constants involved, is called "propagation of error". The method we will use in this laboratory course is described, with examples, in the following paragraphs. As you advance to your upper division courses in science, you will find that your calculations will become more involved and thus will require a more advanced method of propagation of error. These advanced methods will be introduced to you in those courses where you will become aware of the importance of applying them.

The method of propagation of error described here uses the mean values of the measurements needed in the calculation. In the case of a density calculation, you would make several mass measurements and several volume measurements. You would then calculate the mean value of the mass and of the volume. Using these mean values and their uncertainties, you would then calculate the density. The value of the density that you report would be based on the allowed number of significant figures for that calculation. The rules for determining significant figures are described in your textbook in section 1.11. When doing a calculation, the final result cannot be more precise than the least precise measurement in the calculation. An example of a density calculation is shown in Example 1.

Example 1. Suppose the experimental problem you need to solve is to determine the density of a metal sphere. Therefore, you need to experimentally determine the mass and the volume of the sphere. You measure the mass by weighing the sphere on a milligram balance. You calculate the average value of the mass and the standard deviation and obtain a value of \(84.091 \pm 0.003 \text{ g}\). After measuring the volume three times you find that the mean volume measurement is \(24.8 \pm 0.4 \text{ mL}\). Using these average values, you can proceed to your calculations.

The density is equal to the mass divided by the volume. So the calculation is,

\[
\frac{84.091 \text{ g}}{24.8 \text{ mL}} = 3.3907 \frac{\text{g}}{\text{mL}}
\]

However, this result is more precise than the least precise measurement of volume with only 3 significant figures. Therefore you would round off this result to 3.39 g/mL.

The calculation of the uncertainty of the density is a little more involved. In the case where the calculation involves multiplication and/or division, the uncertainty can be calculated using the following formula:

Exercise 13
For the function, \( y = \frac{a \times b}{c} \), \( \sigma_y = y \times \sqrt{\frac{(\sigma_a)^2}{a} + \frac{(\sigma_b)^2}{b} + \frac{(\sigma_c)^2}{c}} \) \hspace{1cm} (2)\\

This calculation is used in Example 2 to demonstrate how to determine the uncertainty of the density calculation done in Example 1 on the previous page.

Example 2. In this example, \( y = 3.3907 \text{ g/mL} \) as calculated in example 1. The uncertainty in \( y \) will be determined by the uncertainty in the mass measurement (± 0.003 g) and the volume measurement (± 0.4 mL).

\[ \sigma_y = 3.3907 \frac{\text{g}}{\text{mL}} \times \sqrt{\left(\frac{0.003}{84.091}\right)^2 + \left(\frac{0.4}{24.8}\right)^2} = 3.3907 \frac{\text{g}}{\text{mL}} \times 0.016 = 0.05469 \frac{\text{g}}{\text{mL}} \]

Since uncertainty is typically reported with one significant figure, \( \sigma_y \) is rounded to 0.05. Therefore, the density calculation yields a density measurement correctly reported as:

\[ 3.39 \pm 0.05 \frac{\text{g}}{\text{mL}} \]

If addition and/or subtraction occur in a calculation, then the formula for determining the uncertainty of the final result is:

For the function, \( y = a + b + c \), \( \sigma_y = \sqrt{\sigma_a^2 + \sigma_b^2 + \sigma_c^2} \) \hspace{1cm} (3)\\

Example 3. Suppose that a solid is isolated from a slurry by filtering. To determine the mass of solid obtained, the experimenter first weighed a piece of filter paper, performed the filtration, dried the solid, and finally weighed the filter paper containing the solid. The mass of the filter paper was found to be 4.15 ± 0.01 g; the mass of the filter paper plus the solid was found to be 23.28 ± 0.02 g. What is the mass of the solid?

\[ \text{Mass of solid} = \text{mass of (solid plus filter paper)} - \text{mass of filter paper} \]
\[ = 23.28 \text{ g} - 4.15 \text{ g} \]
\[ = 19.13 \text{ g} \]

Uncertainty of mass of solid \( = \sqrt{0.02^2 + 0.01^2} = 0.02236 \text{ g} \)

The mass must be reported to the hundredths place, so the uncertainty must also be reported in the hundredths place. Thus, the mass of the solid is reported as 19.13 ± 0.02 g

E. Reporting Precision and Accuracy ★

Precision and accuracy are two related but different concepts. (See the previous discussion on page 3.) It is possible to have a very highly precise result that is not very accurate. Therefore it is useful to report not only the uncertainty of a measurement (precision) but also indicate the accuracy when possible. Accuracy is determined by comparing the experimental result with the "true" value. Sometimes a true value is not known and therefore accuracy cannot be reported. However, whenever the "true" value is known, the comparison between it and the measured value is essential. This comparison allows you to determine the presence of systematic error. Recall that systematic error can be minimized or eliminated by correcting the cause of the systematic error and repeating the experiment. In order to report the accuracy, a calculation of the absolute or relative error must be done. This is a different calculation than what was done...
above to determine uncertainty. Therefore, in order to report both the precision and accuracy of your experimental result, you need to report two separate numbers: 1) the result +/− the uncertainty and, 2) the absolute or relative error.

Using the density determination reported in the previous section for the metal sphere, the relative error is calculated as follows. The "true" value for the density of the sphere is found in a reference handbook, e.g., the Handbook of Chemistry and Physics, to be 3.59 g/mL at 25°C. First we will determine the absolute error by subtracting the "true" value from the experimental value.

\[
\text{Absolute error} = \text{Experimental value} - \text{True value} = 3.39 \text{ g/mL} - 3.59 \text{ g/mL} = -0.20 \text{ g/mL}
\]

The absolute error may be used to report the accuracy or a further calculation to report relative error may be used. Relative error is equal to the absolute error divided by the "true" value and is reported either as an error, or as a relative % error:

\[
\text{Relative error} = \frac{\text{Absolute error}}{\text{True value}} = \frac{-0.20 \text{ g/mL}}{3.59 \text{ g/mL}} = -0.0557 \approx -0.06
\]

Relative % error = 100 * relative error = 100 * -0.06 = -6%

Only one significant figure is reported in the value of the relative error, and it is a unitless quantity. (Relative error is always dimensionless.) In reporting any one of these three values, absolute error, relative error, or percent error, the sign of the error must be included. In this example, because the absolute error is negative so are the relative error and percent relative error.

We can now report both the precision and the accuracy of our experimental determination of the density of the metal sphere:

Density of the sphere = 3.39 ± 0.05 g/mL

Relative error = -0.06

Relative percent error = -6%

Comparing the relative percent error, which is a reflection of the accuracy of the measurement, and relative percent uncertainty, which is a reflection of the precision of the measurement, helps identify if there were any systematic errors in the measurement(s). For example, if a measurement is precise but very inaccurate, there must have been some systematic error. Relative percent uncertainty is calculated by dividing the uncertainty of the measurement by the measurement, followed by multiplying by 100. For the density example,

\[
\text{Relative percent uncertainty} = \frac{0.05 \text{ g/mL}}{3.39 \text{ g/mL}} \times 100\% \approx 1.47\% \approx 1\%
\]

From this example, you can see that the precision of the result is greater than the accuracy. This means that the true value lies outside of the range of the measured value and therefore systematic error is present. The source of the systematic error should be identified, corrected and the experiment should be repeated.

Exercise 13
Prelab Assignment

1. Read the suggested sections in Chapter 1.
2. In your lab notebook, list four pieces of volumetric glassware and order them according to their precision of volume measurement. See Appendix 2, pg 146.

II. Exercise

The purpose of this exercise is to apply the principles of good measurement and error analysis in order to identify an unknown metal sample from its measured density. Keep in mind that there are three parts to reporting measurements:

1) Determine the uncertainty of each measurement (precision).
2) Determine the error associated with a calculated result based on experimental measurements and their uncertainties (error analysis or propagation of error).
3) Determine the accuracy of the reported result.

You and your partner will be assigned one of the problems on the next page to solve during this laboratory period. You have just one laboratory period to solve the problem, so it will be important to be organized and not waste time on unnecessary tasks. Schedule your tasks so that you will have about 30 minutes at the end of the period to review your data with your partner and discuss how you will analyze it. You and your lab partner will turn in one report. Your report will be evaluated in the following categories:

1. Experimental Design – Clarity and effectiveness of the experiments carried out, proper choice of equipment and glassware, recording of data.
2. Calculations – appropriate choice, clarity of presentation, correctness.
3. Justification – organized and well written argument that justifies your answer to the problem and includes your error analysis as supporting evidence.
4. Accuracy of result.

Be sure that both you and your partner each write a description of your experimental design and record all measurements in your own laboratory notebook.
III. Laboratory Report

Only one report need be turned in for the partnership. Make sure both partners' names are on the report!

The report should include:

1. The problem number assigned
2. The unknown number if problem 2 was assigned
3. A brief description of experimental design (equipment used, how many measurements taken, etc).
4. Table of Data and Results to include:
   a. measurements, including uncertainties in the measurement
   b. average mass with standard deviation and average volume with standard deviation.
   c. density (ies), including uncertainty(ies)
   d. relative % error and relative % uncertainty in density measurement

5. Sample calculations on a separate sheet for all calculations reported in 4b, c and d above.
6. Answer to your problem with justification. Can you distinguish between pre- and post-1982 pennies or draw a conclusion about the identity of your metal given your data? Is the nature of the error systematic or random and how did you draw that conclusion?
Problem 1

In 1982 the U.S. government began the minting of pennies that were no longer made of pure copper metal. It has been proposed that pennies minted before 1982 can be unambiguously distinguished from pennies minted after 1982 by determining their density. Using a sample that contains pennies minted before and after 1982, design and carry out an experiment using the available equipment and glassware (see list below) that will determine if this proposal is true or false.

The reported density of pure copper metal at 20 °C is 8.92 ± 0.04 g/mL.

Problem 2

During a recent earthquake, several jars containing metals fell off the shelves in the chemistry stockroom and broke. In the hurried clean-up that followed, the metals were all swept together into a dustpan and transferred to a box. The problem now is to determine the identity of the metal samples based on their density. Using the sample of metal provided to you and your partner, design and carry out an experiment using the available equipment and glassware (see list below) that will enable you to identify the metal from the list of possible choices given below. Depending upon your particular sample, you may only be able to narrow the choice of possibilities to two or more metals.

<table>
<thead>
<tr>
<th>List of Metals That Were Stored in Jars in the Chemistry Stockroom</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metal</strong></td>
</tr>
<tr>
<td>Bismuth</td>
</tr>
<tr>
<td>Cadmium</td>
</tr>
<tr>
<td>Lead</td>
</tr>
<tr>
<td>Nickel</td>
</tr>
<tr>
<td>Tellurium</td>
</tr>
<tr>
<td>Tin (white)</td>
</tr>
<tr>
<td>Titanium</td>
</tr>
<tr>
<td>Tungsten</td>
</tr>
<tr>
<td>Zinc</td>
</tr>
</tbody>
</table>

**Equipment and Glassware Available:**

- Analytical Balance
- Measuring pipets
- Rulers
- Burets
- Strips of paper
- Graduated cylinders
- All equipment and glassware in your locker

Exercise 13
## Chemical Classification and Potential Hazards of Chemicals Used in Experiment

### Reactions of Copper - The Copper Cycle

<table>
<thead>
<tr>
<th>CHEM 115 Exp 14</th>
<th>Chemical Classification</th>
<th>Possibility of:</th>
<th>NFPA Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poison A</td>
<td>Flammable Gas</td>
<td>Flammable Liquid</td>
</tr>
<tr>
<td>Copper Metal</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrochloric Acid, 6 M</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Magnesium, Metal</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nitric Acid, 6 M</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sodium Hydroxide, 8 M</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sodium Phosphate, 0.5 M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfuric Acid, 2 M</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

### Requirements for this Exercise:

**Mode:** Workshop and Inquiry, individual work.

**Grading:** Workshop participation; lab performance (goggles) and lab report

**Reading in text:** 3.3, 3.4, 3.7, 3.9, 4.4, 4.5, 4.6, 4.7

**Latex or nitrile gloves recommended, use care with HNO₃**

### I. Background

Much of what we know about the chemical behavior of the elements comes from the very careful observations of change made by chemists through the centuries. Many of these observations were made without the use of sophisticated instrumentation that has become a permanent part of working laboratories today. Most of us would not consider drawing a conclusion about a change in mass without the use of an analytical balance similar to the ones you now use in this Copper Cycle
laboratory. Yet the correct chemical formula for water, H₂O, was determined without the aid of sophisticated balances, by observing and measuring the relative volume of H₂ (g) and O₂ (g) needed to produce a measured volume of water.

In this activity, you will have many opportunities to observe chemical change. In addition you will be able to measure these changes using the analytical tools such as the balances, volumetric glassware, and visible spectrometers that are available in the laboratory. You will need to make careful observations as you follow the course of the reactions in this activity. These reactions will form compounds that you will be able to identify as a result of your observations. The quality of your results is dependent upon how well you make the observations and measurements.

A. Overview of Task

This activity involves setting up a cycle of reactions such that the starting point and the finishing point is elemental copper. It is up to you to determine what the cycle of reactions will be based on the list of chemical reagents described on the next page. Your outline for the sequence of reactions will need to start with a reaction that uses elemental copper and finish with a reaction that produces element copper. The goal is to obtain essentially the same amount of copper from the last reaction as you started with in the first reaction.

The first laboratory period for this exercise will be devoted to completing the worksheet found on the next page. It will help you design your reaction scheme and will provide the basis on which you will carry out your chemical reactions. Be sure that you use all of the reagents listed on the worksheet. The scheme should show the sequence of reactions that you plan to perform in the order that you will carry them out. Each reaction equation in the sequence needs to be balanced and all the physical states of the reactants and products should be indicated.

Good laboratory technique is necessary for the successful cycling of the copper through the sequence of reactions. Pay careful attention to the transfer of solutions and solids from one container to the next. Make sure that you completely precipitate insoluble products before filtering the reaction mixture. Be aware of good filtration technique. The amount of elemental copper that you obtain from your last reaction will be a measure of the quality of your laboratory technique.

II. Cu Cycle Workshop

A. Reaction Cycle Worksheet

Record all information in this worksheet in your laboratory notebook. This worksheet is provided to assist you in preparing your cycle of copper reactions. As described above, it is your task to develop a cycle of reactions involving copper that begins with the use of elemental copper and ends with the production of elemental copper. Shown below are the 6 reactions involved in the Cu cycle listed in random order, with only the reactants given for 5 of the reactions. The first reaction listed is complete.

1. 3 types of reactions have been discussed in this class — acid-base reactions, precipitation reactions and oxidation-reduction reactions. Based on the reactants given, decide which type of reaction will be taking place and write the complete, balanced chemical equation for that reaction, including physical states.
A) \( \text{Cu(s)} + 4\text{HNO}_3(aq) \rightarrow \text{Cu(NO}_3)_2(aq) + 2\text{NO}_2(g) + \text{H}_2\text{O(l)} \)

B) \( \text{Cu(OH)}_2 + \text{H}_2\text{SO}_4 \rightarrow \)

C) \( \text{Cu}_3(\text{PO}_4)_2 + \text{HCl} \rightarrow \)

D) \( \text{Cu(NO}_3)_2 + \text{NaOH} \rightarrow \)

E) \( \text{CuCl}_2 + \text{Mg} \rightarrow \)

F) \( \text{CuSO}_4 + \text{Na}_3\text{PO}_4 \rightarrow \)

2. The reactions given above are listed in random order. It is necessary to place them in the order that you will follow when you perform the reactions in the laboratory. Remember that you need to start with elemental copper and end with elemental copper. The reactions proceed in the direction written above (none of these reactions will proceed in the reverse direction). Write the reactions in the sequence that will yield the 'copper cycle.'

3. The first reaction in the cycle will be initiated by adding 6 M nitric acid to elemental copper. Weigh out between 0.600 and 0.650 grams of copper powder into a 50 mL beaker. Record the mass of Cu in your laboratory notebook.

Calculate the amount of 6 M nitric acid needed to react with the amount of copper you weighed out in a stoichiometric fashion. Calculate the yield in moles of the copper-containing product.

4. The other reagents available include:

- elemental magnesium
- 2M sulfuric acid
- 6 M hydrochloric acid
- 8 M sodium hydroxide
- 0.5 M sodium phosphate

Do a similar calculation as above for each of the other 5 reactions in the copper cycle. Keep in mind that the reactions are to be set up to proceed in a stoichiometric fashion and that the amount of Cu-containing salt obtained in one reaction is the amount of Cu-containing reactant in the next reaction in the cycle.

5. If the reaction cycle goes perfectly, and you have perfect technique, what mass of Cu should be obtained at the end of the reaction cycle? Write a formula to calculate the % recovery of Cu.

6. Prepare a table in your laboratory notebook that lists all the reagents you will use and the calculated quantity of each reagent needed. Include one blank column to record the amount of Copper Cycle

000022
each reagent that you actually used when you do the experiment, and one column for observations.

Please read B. Chemical Hazards of the Copper Cycle Reactions and III. A. General Guidelines of Good Laboratory Technique before you start bench work on this experiment.

B. Chemical Hazards of the Copper Cycle Reactions

Ira Remsen (1846-1927) was an influential chemist in America. He founded the chemistry department at John Hopkins University and initiated the first center for chemical research in this country. Here is his description of his experience with nitric acid and copper.1

While reading a textbook on chemistry, I came upon the statement "nitric acid acts upon copper." I was getting tired of reading such absurd stuff and I determined to see what this meant. Copper was more or less familiar to me. For copper cents were then in use. I had seen a bottle marked "nitric acid" on a table in the doctor's office where I was then "doing time." I did not know its peculiarities but I was getting on and likely to learn. The spirit of adventure was upon me. Having nitric acid and copper, I had only to learn what the words "act upon" meant. Then, the statement, "nitric acid acts upon copper," would be something more than mere words.

All was still. In the interest of knowledge I was even willing to sacrifice one of the few copper cents then in my possession. I put one of them on the table; opened the bottle marked "nitric acid"; poured some of the liquid on the copper; and prepared to make an observation.

But what was this wonderful thing which I beheld? The cent was already changed, and it was no small change either. A greenish blue liquid foamed and fumed over the cent and over the table. The air in the neighborhood of the performance became dark red. A great cloud of fumes arose. This was disagreeable and suffocating — how should I stop this? I tried to get rid of the objectionable mess by picking it up and throwing it out of the window, which I meanwhile opened. I learned another fact — nitric acid not only acts upon copper but it acts upon fingers. The pain led to another unpremeditated experiment. I drew my fingers across my trousers and another fact was discovered. Nitric acid also acts upon trousers.

Taking everything into consideration, that was the most impressive experiment, and, relatively, probably the most costly experiment I have ever performed. I tell of it even now with interest. It was a revelation to me. It resulted in a desire on my part to learn more about that remarkable kind of action. Plainly the only way to learn about it was to see its results, to experiment, to work in the laboratory.

We don't want your experience with nitric acid and copper to be quite as memorable as Remsen's! In addition to wearing your splash goggles and being careful and deliberate when performing all experiments, you must perform the first reaction, between nitric acid and copper in the fume hood, as shown in the figure.

CAUTION!!! The reaction of nitric acid and copper must be done in the bench-top fume hood. The noxious and toxic NO₂(g) produced

---


Exercise 14
during the reaction must not be allowed to escape into the lab air. Do not under any circumstances add the nitric acid to the copper metal unless your beaker centered against the back wall of your bench-top fume hood.

Fire Diamond (NFPA Hazard Rating)

The hazard identification signal is a color-coded array of four numbers or letters arranged in a diamond shape. An example is shown to the left. The blue (health), red (flammability), and yellow fields (reactivity) all use a numbering scale ranging from 0 to 4. A value of zero means that the material poses essentially no hazard; a rating of four indicates extreme danger. The fourth field (white) tends to be more variable, both in meaning and in what letters or numbers are written there. In the NFPA system, specific symbols are shown in the white field to indicate special hazards (for example, reacts with water; radioactive; corrosive). The numerical hazard ratings are:

- 0 Minimal Hazard
- 1 Slight Hazard
- 2 Moderate Hazard
- 3 Serious Hazard
- 4 Severe Hazard

<table>
<thead>
<tr>
<th>HYDROCHLORIC ACID, 6 M Soln</th>
<th>POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR INHALED.</th>
</tr>
</thead>
<tbody>
<tr>
<td>NITRIC ACID, 6 M Soln</td>
<td>Nitric acid is extremely hazardous; it is corrosive, reactive, an oxidizer, and a poison. POISON! DANGER! OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. INHALATION MAY CAUSE LUNG AND TOOTH DAMAGE.</td>
</tr>
<tr>
<td>SULFURIC ACID, 2 M Soln</td>
<td>DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR CONTACTED WITH SKIN. HARMFUL IF INHALED. AFFECTS TEETH. CANCER HAZARD. STRONG INORGANIC ACID MISTS CONTAINING SULFURIC ACID CAN CAUSE CANCER.</td>
</tr>
<tr>
<td>SODIUM HYDROXIDE, 8 M Soln</td>
<td>POISON! DANGER! CORROSIVE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. CAUSES BURNS TO ANY AREA OF CONTACT. REACTS WITH WATER, ACIDS AND OTHER MATERIALS.</td>
</tr>
<tr>
<td>MAGNESIUM METAL</td>
<td>WARNING! FLAMMABLE SOLID. MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT.</td>
</tr>
</tbody>
</table>

Copper Cycle
Copper may be toxic through contact, inhalation, and ingestion. Animal studies suggest that copper compounds have the potential to cause damage to the liver, kidneys, spleen, and blood. Copper reacts violently with ammonium nitrate, bromates, iodates, chlorates, hydrogen peroxide, sodium peroxide, sulfuric acid, and sodium azide.

III. Exercise

Each student does this exercise as an individual. You now have everything you need to conduct the copper cycle experiment. You know what reactions you are going to carry out and have calculated the amounts of each reagent needed for each reactant. It is up to you to determine what glassware you want to use and the technique details, but some guidelines are given here for you to incorporate into your lab.

A. General Guidelines of Good Laboratory Technique

1. Make sure glassware is clean and reasonably dry before beginning. Use a small enough beaker to contain the volume of solution, but not so small that the beaker is full, or so large that the depth of the solution is very shallow.

2. It is a good practice to take an aliquot of a reagent to your bench in a beaker. Take a little more reagent than you think you’ll need in case of spills and in case you need a little extra for your reaction. The amount of reagent needed for your experiment can be measured into a graduated cylinder or pipeted from this aliquot at your bench, rather than directly from the stock bottle. This helps ensure that the stock solution used by everyone won’t get contaminated, and that there won’t be a long wait at the stock bottle while people carefully measure out the reagent.

3. Label your beakers of reagents and chemicals. Lots and lots of chemicals are clear liquids which makes it difficult to distinguish between them in the absence of a label. If you don’t know what’s in that beaker, dispose of it in hazardous waste and start again.

4. Add reagent to your experiment slowly and carefully, using a pipet to add reagent dropwise. Stir the reaction mixture and carefully observe the reaction.

Your goal is to completely react the copper-containing reactant in each step. There are different ways to ensure this, depending on the physical state of the copper salt:

5. If a reactant is a solid, a good clue that the reactant is gone is the disappearance of that solid. If the solid hasn’t disappeared after you’ve added the amount of reagent calculated, try the following:
   a. Gently heat the reaction (simmer, do not boil – if you boil off the solution, you will have to start over). To gently heat a reaction, use a low flame and leave the beaker over the flame only long enough to heat up. Then remove and repeat as necessary.
   b. Add more reagent in small aliquots (a few drops at a time) and swirl or stir the mixture, until the solid disappears. If you do this, be sure to record the amount of additional reagent added.
   c. Carefully pour or filter the solution with the dissolved copper salt into a clean beaker or flask (warning: you want to keep the solution, so don’t let it get contaminated). Add a little more reagent in small aliquots to the remaining solid in a beaker until it dissolves. Combine the solutions.
6. If the copper reactant is a solution and the product is a solid, the reaction is complete once the addition of reagent results in no further production of solid. In this circumstance, it is good practice to continue adding reagent until no further precipitation is seen, collect the solid, and then test the supernatant liquid or filtrate (the solution) for more precipitation by adding more reagent to it. There are two ways to collect the supernatant or filtrate: decantation and filtration. **Make sure you collect the filtrate into a clean beaker or flask.** You are going to test this filtrate, so you don’t want it to be contaminated by residue in the flask.

   a. **Decantation:** If your solid is gelatinous looking, decantation is preferred to filtration because the fine particle size of the solid will make filtration very slow.

   When the precipitate has settled in the reaction beaker, carefully pour the solution off of the solid into a clean beaker (this is the supernatant liquid). Set aside the beaker with solid for later. Add more reagent in small amounts to the supernatant. If precipitation is seen, the reaction is not complete. Continue adding reagent until no more precipitate forms. Collect the solid from the supernatant as before and test the new supernatant. Repeat until no more solid forms from the supernatant.

   Once the reaction is complete, combine all the solid collected into one beaker. Wash the solid by adding ~ 20 mLs of distilled water with stirring or swirling. Allow the precipitate to settle and pour off the water (treat as waste). Repeat this wash once or twice more. Washing the solid is important because it removes unreacted reagent and the unwanted products which may interfere or slow down the next reaction in the cycle.

   The supernatant and water rinses should be disposed of in a hazardous waste container.

   b. **Filtration:** Set up a clean Büchner funnel with filter paper and a clean filter flask connected to a trap and vacuum source, as shown in the stoichiometry lab (Exercise 12). Wet the filter paper with the vacuum on and add the contents of your reaction beaker. Rinse solid from the beaker into the funnel with a minimal amount of water (you don’t want to dilute the filtrate too much).

   Turn off the vacuum and pour the filtrate out of the filter flask into a clean beaker. Leave the solid in the funnel for now. Test the filtrate for precipitation by adding small amounts of reagent. If precipitation is seen, the reaction is not complete. Continue adding reagent until no more precipitate forms. Collect the solid as before in the Büchner funnel (you can use the same funnel with the solid initially collected (turn vacuum on before adding anything to the funnel), or get a new funnel and clean filter paper) and test the new filtrate. Repeat until no more solid forms from the filtrate.

   Once the reaction is complete, combine the solid into one Büchner funnel (if you are adding solid from a filter paper, you can rinse the filter paper with a generous amount of water to get all of the solid, but if you are rinsing directly into a Büchner funnel, make sure the vacuum is on before adding so that nothing gets beneath the filter paper). Add distilled water to the funnel to cover the solid. With the vacuum off, carefully stir the solid and water, being careful not to tear the filter paper. Turn the vacuum on to remove the wash. Repeat the washing a second time. If you are nervous about doing this in the funnel, you can wash all of the solid into a beaker, add distilled water, stir, and filter into the funnel with a new piece of filter paper.

   Copper Cycle
All of the filtrate and washes should be disposed of in a hazardous waste container.

B. Getting Started – Read and understand A. General Guidelines, and C. Specific Guidelines before getting started!

1. Transfer the Cu you weighed out into a 50 mL beaker. Put the beaker into the center back of the hood on your bench (if unsure of where the benchtop hood is, ask your lab instructor).

2. Add the calculated amount of 6 M HNO₃ to the copper while located in the center-back of the hood. Caution: this reaction is initially vigorous. To avoid boil over and loss of Cu, add HNO₃ in small aliquots and wait for the reaction to subside before adding more HNO₃. The brown gas evolving is NO and NO₂ which are irritants, so leave the beaker in the hood until the reaction is complete. Record all observations in your lab notebook. It should take about 30 minutes for the Cu to dissolve, however the reaction slows down significantly as it goes, so you might need to invoke one of the suggestions from General Guideline 5, addition of excess HNO₃ by drops; gentle heating or decanting the solution away from the solid and adding extra HNO₃ to the undissolved Cu, to finish the reaction.

Record all observations in your laboratory notebook.

3. Carry out the rest of the reactions in the order you determined in the workshop. Refer to sections A and C as you go.

C. Specific Guidelines for the Cu Cycle – for the following pairs of reactants:

Note: When the product is a solid, it is good practice to collect that solid and wash it with water (see General Guideline 6) to remove unreacted reagents and unwanted products. These unwanted chemicals can interfere with or slow down the next reaction in the cycle.

\[ \text{Cu(s)} + 4\text{HNO}_3(\text{aq}) \rightarrow \]
This reaction must be performed in the center and back of the benchtop hood (see CAUTION!!! in section II. B.). This reaction should be initially vigorous, but will slow down substantially as it goes. It can take as long as 30 minutes and may need a little help to dissolve all of the copper (described above in B).

\[ \text{Cu(OH)}_2 + \text{H}_2\text{SO}_4 \rightarrow \]
Do not start this reaction unless you have time to do the next reaction in the cycle. If you did not collect the solid and wash it, you may need to add extra H₂SO₄ to drive this reaction to completion.
III. Laboratory Report

If you will be weighing the mass of Cu recovered on the day this lab report is due, parts A and B should be completed before you arrive at lab. It should take you only 10 minutes to complete part C and part D and turn in the lab report.

A. Write out the complete, balanced reactions of the Cu cycle including physical states and in the proper order. Characterize each reaction into one or more of the following reaction types, and explain how you reached your conclusion.
   - Precipitation
   - Brønsted-Lowry Acid-Base neutralization reaction
   - Oxidation/Reduction

If a reaction falls into none of these categories, state “none”.

B. Give the chemical name of all the chemical compounds used and formed in each reaction.

C. Report the following:
   1. The initial and final mass of elemental copper.
   2. The percentage of copper recovered.

D. Place the Cu in a weigh bottle (small glass bottle with lid from your locker) with your name on it, and give it to your lab instructor.
Cu₅(PO₄)₂ + HCl → No specific guidelines. If you did not collect the solid and wash it, you may need to add extra HCl to drive this reaction to completion.

Cu(NO₃)₂ + NaOH → Add NaOH dropwise with stirring or swirling until the solid that forms doesn’t redissolve. The added NaOH initially does two things – it forms the solid and it reacts with the excess acid from the previous step. Until that acid is gone, it will dissolve the solid that forms. The way to know that the acid is gone is to add NaOH until the solid that initially forms no longer dissolves. At this point, add the stoichiometric amount of NaOH in small portions to continue forming the solid. Be careful - excess NaOH will redissolve the solid, so if you think the solid is dissolving, even if it’s before you’ve added the stoichiometric amount, STOP adding the NaOH. Decant the supernatant from the solid (See General Guideline 6a, decantation) and test the supernatant for more precipitation with NaOH. Combine all solid formed and wash as described in General Guideline 6a.

If your solid completely redissolves after you’ve added the stoichiometric amount, you can get it back by adding HNO₃ dropwise – consult your instructor.

CuCl₂ + Mg → Crushing the Mg may facilitate this reaction. This reaction should occur vigorously and you should see product form right away. If it does not, inform your instructor. Once it appears that all of the magnesium has reacted, add a few extra drops of HCl to make sure all of the magnesium is dissolved. The solution will clear to a very pale blue as it approaches the end of the reaction.

CuSO₄ + Na₃PO₄ → Add Na₃PO₄ dropwise with stirring or swirling until the solid forms and stays, to neutralize any excess acid from the previous step. Then add the stoichiometric amount of Na₃PO₄ to form product. Collect the solid and test the filtrate as described in General Guideline 6b. Wash the solid.

Collecting solid Cu at end of cycle: Use the Büchner funnel to collect the solid Cu. Make sure any large pieces are not unreacted Mg by breaking them up with the end of a stir rod. Wash the Cu 2 or 3 times with water. Allow the sample to air dry completely before weighing.

Copper Cycle
EXPERIMENT 3 – WATER ANALYSIS and REMEDIATION

How To Measure Contaminants In Water and Remove Them

OBJECTIVE

The purpose of this exercise is to become proficient at using various methods to quantitatively measure the amount of certain ions in water samples that may affect water quality, and to develop and evaluate a remediation plan that will reduce an undesirable contaminant to an acceptable limit. You will learn to

- Determine the concentration of fluoride in a water sample using the ion selective electrode analysis method;
- Determine the concentration of iron in a water sample using the spectrophotometric (colorimetric) analysis method;
- Determine total water hardness using a titration method; and
- Develop, evaluate, carry out and optimize the remediation of a water sample containing an undesirable level of fluoride, iron, or water hardness.

BACKGROUND

Imagine that you are working at a water treatment plant and are responsible for deciding if the water that you are releasing to the public is safe to drink, and, if not, what you need to do to reduce its contaminant levels to meet standards established by the Environmental Protection Agency (EPA) and/or other governmental agencies.

Sources of drinking water include rivers, lakes, streams, ponds, reservoirs, springs and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or human activity.

Contaminants that may be present in source water include:

- Microbial contaminants, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.
- Inorganic contaminants, such as salts and metals, which can be naturally occurring or result from urban storm water discharges, oil and gas production, mining, or farming.
- Pesticides and herbicides, which may come from a variety of sources such as agriculture, urban storm water runoff, and residential uses.

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2) Adapted from the Albuquerque, New Mexico’s Public Works Department’s website, http://www.cabq.gov/waterquality/usepaysays.html.
• Organic chemical contaminants, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and can also come from gas stations, urban storm water runoff, and septic systems.

• Radioactive contaminants, which can be naturally occurring or be the result of oil and gas production and mining activities.

In addition to chemicals that accumulate as water percolates through the soil, the dissolution of soluble atmospheric gases, including SO₂ and CO₂, can affect the pH of water, which in turn can affect the solubility of minerals and other organic and inorganic substances in water.

The exact composition of water depends on the source and nature of the soil. Water from an area with a lot of granite, such as the Hetch Hetchy reservoir near Yosemite — the source of San Francisco water — contains relatively low amounts of dissolved ions. Water in the Midwest, where there is a lot of limestone, has a very high mineral content. Usual natural constituents of surface water include Na⁺, Ca²⁺, Mg²⁺, K⁺, HCO₃⁻, SO₄²⁻, Cl⁻ and SiO₂ (silica), all of which may be present in concentrations ranging from 1.0 – 1,000 mg/L (a variety of units³ are used to specify the quantities of contaminants in water). Other common constituents that may be present in concentrations ranging from 0.01 – 10.0 mg/L include Fe²⁺, Mn²⁺, CO₃⁻, NO₃⁻, F⁻ and BO₃⁻. Species present in trace amounts include Cu²⁺, Zn²⁺, H₂PO₄⁻/HPO₄⁻, P₂O₇, Sr²⁺ and Ba²⁺. The EPA has established legal standards for the quantities of bacteria, chemical species such as nitrate and pesticides, metals such as lead, and the appearance and taste of water. Of the many contaminants that are measured to ensure water safety and quality, this exercise focuses on quantitative measurement of fluoride ions, iron ions, and water hardness. These have been chosen to illustrate three common but distinctly different methods of chemical analysis.

Fluoride

Fluoride ion is found in soil as fluoroapatite (Ca₁₀(PO₄)₆F₂) or fluorite (CaF₂) and typically does not exceed concentrations of 10 mg/L in groundwater and 1.0 mg/L in surface water. It is often added to drinking water to promote dental health. Fluoride ion concentrations of 0.6 – 1.7 ppm water are suggested to strengthen tooth structure and reduce tooth decay. However, concentrations above 1.5 ppm can cause tooth enamel to become mottled, and drinking water with fluoride concentrations above 6 ppm over many years can result in bone disease, motting, and disfiguration of teeth. The EPA has set both primary (mandatory limits; identified as maximum contaminant level or MCL) and secondary (voluntary limits; identified as secondary maximum contaminant level or SMCL) standards for fluoride ion: The MCL is 4 ppm and the SMLC is 2 ppm.

Iron

Iron is frequently found in drinking water and has an EPA-specified SMCL of 300 ppb (there is no MCL for iron). It is introduced into water supplies by human and mineral sources, such as water percolating through soil and rock and iron pipes. Four forms of iron are commonly found in water samples: inorganic ferrous (Fe²⁺) and ferric (Fe³⁺) complexes, organic iron, and iron

³ The most common unit is ppm (one part per million; e.g., one milligram contaminant per one kilogram of water). In aqueous solutions, one ppm is equivalent to one mg/L. Trace contaminants are often reported as ppb (parts per billion; one microgram contaminant per kilogram).
bacteria. In deep wells, where oxygen content is low, the water is clear and colorless, since it contains mostly soluble Fe$^{2+}$, which is the more soluble, colorless form of iron. The iron ion remains in the 2+ state as long as it is protected from atmospheric oxygen. When in contact with air, Fe$^{2+}$ oxidizes readily to Fe$^{3+}$, creating rusty-brown solid particles that settle out as ferric oxide or hydroxide. The gelatinous Fe(OH)$_3$ precipitate causes water turbidity, stains plumbing fixtures and laundry, and gives water an unappetizing taste and odor. Due the low solubility of Fe(OH)$_3$, very little Fe$^{3+}$ is dissolved in natural waters in the pH range of 7.0 – 8.5. In fully aerated water, the concentration of Fe$^{3+}$ is generally less than 0.5 ppm. However, groundwater with a pH below 7.0 may contain as much as 10 ppm Fe$^{3+}$. Acidic water from thermal springs and industrial and mine wastes may contain more than 6000 ppm Fe$^{3+}$.

Although the SMCL for iron is 300 ppb, its presence in water is not considered a health problem. In fact, iron is essential to human health. Depending on age and gender, the recommended dietary allowance (RDA) ranges from 10 to 15 mg. However, because very little iron is excreted from the human body, iron can build up to toxic levels, leading to a condition called hemochromatosis.

High iron concentrations in drinking water supplies may give water an unpleasant metallic taste while still being safe to drink. When iron reacts with tannins in coffee, tea, and some alcoholic beverages, a black sludge is formed, which affects both taste and appearance. Vegetables cooked in iron-containing water turn dark. Iron bacteria, which are found in groundwater and some surface waters, are not considered health threatening. However, they can give water an off-taste or color, cause splotchy yellow stains on laundry, and clog water systems. They appear as stringy, slimy, mucous-like substances in fresh water, may be colored brown, red, or white, thrive on iron or metal parts of the water system, and are most easily seen on the inside of the toilet tank.

**Water Hardness**

The term “hard water” originally meant that soap would not suds very well in it. Today, water hardness usually refers to the total amount of calcium and magnesium dissolved in the water. Very soft water is not desirable; it will be corrosive and attempt to dissolve any source of calcium or magnesium around. Hard water is usually defined as water with 130 ppm or higher concentration of calcium carbonate. It makes suds formation difficult and can result in deposits. Water hardness is not regulated by the EPA, but is of considerable interest to most consumers.

“Sufficient” hardness levels vary, depending on pH, total alkalinity, temperature and total dissolved solids (TDS) of the water sample. The EPA has established SMCL standards for TDS and pH.

Water hardness is commonly reported as mg/L (or ppm) of calcium carbonate, regardless of the specific distribution of cations contributing to the total hardness. Hardness is sometimes also expressed as grains per gallon (gpg), which is related to ppm by the formula, 1 ppm = 17.1 gpg. Water hardness is classified by the U.S. Department of Interior and the Water Quality Association as listed in Table 1.

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4) For more information, see http://water.usgs.gov/owq/explanation.html or http://www.aawatertesting.com/hardness.htm#epa.

Water Analysis & Remediation  Exp 3 - 3  SFSU CHEM 216  000032
Table 1. Water Hardness Levels and Classification

<table>
<thead>
<tr>
<th>Grains per gallon (gpg)</th>
<th>Milligrams per Liter (mg/L)</th>
<th>Hardness Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>1 - 17.1</td>
<td>soft</td>
</tr>
<tr>
<td>1.1 - 3.5</td>
<td>17.1 - 59.9</td>
<td>slightly hard</td>
</tr>
<tr>
<td>3.6 - 7.5</td>
<td>60 - 128.2</td>
<td>moderately hard</td>
</tr>
<tr>
<td>7.0 - 10.5</td>
<td>128.3 - 179.6</td>
<td>hard</td>
</tr>
<tr>
<td>above 10.5</td>
<td>above 179.7</td>
<td>very hard</td>
</tr>
</tbody>
</table>

Selected data from the San Francisco Public Utilities Commission 2001 Annual Water Quality Report is shown in Table 2 below. The name of each substance, the highest level allowed by regulation (MCL), ideal goals for public health (PHG), amounts detected, typical sources, footnotes explaining findings with a key to units of measurement are included. The entire report is available online.

Procedure Overview

This is a six- to seven-day project, consisting of two parts. Teams of two students perform the experimental work. In part A, the analytical methods for the quantitative measurement of fluoride, iron and hardness will be learned and tested. In part B, a remediation plan to reduce one of the contaminant levels (fluoride, iron or water hardness) in a water sample will be designed, tested, and evaluated by each team.

You must work efficiently, carefully planning your team’s activities and dividing common tasks. Prepare a schedule for carrying out each part of the project and discuss this schedule with the instructor. Each student must read the procedure for each analysis before beginning the laboratory work. Data acquisition for the fluoride and iron analyses is not time consuming, but equipment is limited and measurements must be performed carefully. New data for the fluoride and iron calibration curves must be collected every time a new analysis is performed, and results should be examined immediately (i.e., in the laboratory, not later at home). Do not waste time. If you are waiting for a particular instrument to become available, use that time to prepare solutions required for another analysis, to discuss results, or to plan subsequent work. To avoid instrument bottlenecks, the instructor may have sign-up sheets for the instruments and/or may assign the order for a team to perform each analysis.

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Water Analysis & Remediation

Exp 3 - 4

SFSU CHEM 216

000033
Table 2. City of San Francisco Water Quality Data 2001 (2)

<table>
<thead>
<tr>
<th>DETECTED CONTAMINANTS</th>
<th>Unit</th>
<th>MCL(G)</th>
<th>PHG(4)</th>
<th>Range</th>
<th>Average</th>
<th>Typical Sources in Drinking Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORGANIC CHEMICALS (City of San Francisco Treated Water)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Coliform</td>
<td>%</td>
<td></td>
<td>5 (12)</td>
<td>&lt;0.3</td>
<td>0.1</td>
<td>Naturally present in the environment</td>
</tr>
<tr>
<td>MICROBIOLOGICAL (City of San Francisco Treated Water)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INORGANIC CHEMICALS (Source Waters)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;20 - 27</td>
<td>&lt;20</td>
<td></td>
</tr>
<tr>
<td>Chlorate</td>
<td>ppb</td>
<td>NS</td>
<td>N</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>By-product of drinking water chlorination</td>
</tr>
<tr>
<td>Natural Fluoride</td>
<td>ppm</td>
<td></td>
<td>2</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>Erosion of natural deposits</td>
</tr>
</tbody>
</table>

Secondary Standards - Source Water (14)

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>SMCL (3)</th>
<th>Range</th>
<th>Average</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>ppb</td>
<td>300</td>
<td>&lt;100 - 280</td>
<td>&lt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>ppm</td>
<td>500</td>
<td>&lt;3 - 23</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Conductance</td>
<td>µS/cm</td>
<td>1600</td>
<td>11 - 280</td>
<td>189</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>ppm</td>
<td>500</td>
<td>0.6 - 23</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Dissolved Solids (TDS)</td>
<td>ppm</td>
<td>1000</td>
<td>15 - 170</td>
<td>111</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Secondary Standards - Treated Water (18)

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>SMCL (3)</th>
<th>Range</th>
<th>Average</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>ppb</td>
<td>200</td>
<td>&lt;50 - 88</td>
<td>&lt;50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>units</td>
<td>0.5</td>
<td>&lt;5 - 15</td>
<td>&lt;5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Odor</td>
<td>TON</td>
<td>0.5</td>
<td>1 - 2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OTHER CONSTITUENTS - Treated Water (18) (19)

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>SMCL (3)</th>
<th>Range</th>
<th>Average</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity (as CaCO3)</td>
<td>ppm</td>
<td>NS</td>
<td>11 - 124</td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>ppm</td>
<td>NS</td>
<td>4 - 29</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoride - City of San Francisco Treated Water</td>
<td>ppm</td>
<td>NS</td>
<td>&lt;0.1 - 1.7</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness (as CaCO3)</td>
<td>ppm</td>
<td>NS</td>
<td>9 - 136</td>
<td>52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>ppm</td>
<td>NS</td>
<td>&lt;0.5 - 10</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>Units</td>
<td>NS</td>
<td>7.5 - 9.8</td>
<td>9.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:  ppb: parts per billion  ppm: parts per million  µS/cm: microSiemens/centimeter  NTU: Nephelometric Turbidity Unit  TON: Threshold Odor Number  NS: No Standard

(2) All results met State and Federal drinking water regulations.
(3) Maximum Contaminant Level (MCL) and Secondary Maximum Contaminant Level (SMCL) set by U.S. EPA/DHS.
(4) Public Health Goal (PHG) adopted by the State Office of Environmental Health Hazard Assessment (OEHHA) of the California EPA.
(5) Maximum Contaminant Level Goal (MCLG) set by U.S. EPA.
(12) Monthly positive samples in City of San Francisco treated water.
(13) Based on 1999 untreated water data obtained from Calaveras, San Antonio, and San Andreas Reservoirs.
(14) Data for untreated water obtained from Hetch Hetchy, Calaveras, San Antonio, Lower Crystal Springs, San Andreas, Stone Dam, and Pillaritos Reservoirs.
(18) Data obtained from Alameda East Portal, Sunol Valley, and Harry Tracy Water Treatment Plants.
(19) Note that arsenic, chromium, perchlorate, and MTBE were not detected in the source or treated water.
Water Hardness Titration Chemistry Worksheet

This exercise you will explore the effect of various metal ions on two complexation agents, EDTA and EBT, which are used to determine total water hardness.

Procedure

- Carefully clean 12 small test tubes. Rinse with distilled water and drain. Transfer ~5 mL of 0.01 M EDTA solution into one test tube and ~3 mL of pH 10 water hardness buffer solution into another test tube. Arrange the remaining ten test tubes to match the pattern below. Perform the procedure listed in the left-hand column and record your observations directly onto this worksheet.

<table>
<thead>
<tr>
<th></th>
<th>Ca$^{2+}$</th>
<th>Mg$^{2+}$</th>
<th>Na$^+$</th>
<th>K$^+$</th>
<th>Distilled water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place 5 drops of 0.01 M soln of the specified cation and 5 drops of pH 10 buffer soln into each test tube. Add 1 drop of EDTA soln to each test tube. Record the color of the soln.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Ca$^{2+}$</th>
<th>Mg$^{2+}$</th>
<th>Na$^+$</th>
<th>K$^+$</th>
<th>Distilled water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place 5 drops of 0.01 M soln of the specified cation and 5 drops of pH 10 buffer soln into each test tube. Add 1 drop of EBT soln to each test tube. Record the color of the soln.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Ca$^{2+}$</th>
<th>Mg$^{2+}$</th>
<th>Na$^+$</th>
<th>K$^+$</th>
<th>Distilled water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add 10 drops of EDTA soln to each test tube. Record the color of the soln.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Review your observations and answer the following questions:

1. What effect does the presence of metal cations have on the color of a solution containing EBT at pH 10?

2. What effect does the presence of metal cations have on the color of a solution containing EDTA at pH 10?
3. Which ligand, EBT or EDTA, should be used as an indicator for a metal complexation reaction? What metal(s) could this indicator be used for? Why?

4. Which ligand, EBT or EDTA, has a greater affinity for metal cations? What observations support your answer?

5. The water hardness titration is performed by first adding EBT and pH 10 buffer to the water sample, and then titrating with EDTA solution. Assuming that the water sample has only calcium cations, what will be the color of the solution before and after the endpoint is reached?
Part B: Remediation of a Water Sample

How can unhealthy or undesired contaminants be removed from water? One method is to distill the water, as is often done in analytical laboratories. This is often impractical for household or commercial purposes, because it is extremely costly. In this part of the project, you will learn about different methods of water remediation and examine one method of your choice in detail.

There are five distinct chemical methodologies that are usually used for water remediation: adsorption, chemical reaction, ion exchange, precipitation, and reverse osmosis. (The reverse osmosis process will not be discussed.) If the water is treated in batches, any of the first four methods can be used. If the water is treated as it flows through a treatment facility, all except the precipitation method can be used.

Adsorption

Adsorption for remediation involves the addition of an insoluble solid that has a high surface area to which the contaminant adheres (or adsorbs). The particle size of the adsorbent determines the efficiency of the adsorption process. Smaller particles have higher surface area and can remove more contaminant per gram of adsorbent. However, smaller particle size creates a larger resistance to water flow, resulting in a slower filtration process. Activated charcoal is commonly used as the adsorbent in household water purifying systems because it is an inexpensive, versatile agent that can remove cationic, anionic, and non-ionic contaminants, including many organic compounds. Adsorption agents are typically more expensive than precipitation agents, but have a high capacity for contaminants and usually require only very short contact time. They are rarely regenerated; when an adsorbent’s capacity has been reached it is replaced with new material.

Chemical Reaction

Chemical reactions are often used to remove microorganisms from water. Chlorine, the most common disinfectant in the U.S., is effective in killing most pathogenic bacteria and viruses. Municipal potable water supplies are usually chlorinated to provide a residual concentration of 0.5 - 2.0 ppm, to protect the water as it travels from the treatment plant to the consumer. However, undesirable byproducts are formed when chlorine reacts with organic substances in water. Trihalomethanes (THMs) such as chloroform, a known carcinogen, are found in nearly every chlorinated public water supply. Health risks resulting from chlorination byproducts must be compared to the health risks of untreated water. If left untreated, drinking water supplies, usually from surface water sources, can spread waterborne diseases such as cholera, typhoid and dysentery. Many public water systems also treat their water with ozone, which is much more effective than chlorine in killing protozoans like Cryptosporidium.

8) Total THM concentrations of 0.7 - 540 µg/L, with a mean value of 26.4 µg, have been measured. Edstrom Industries, http://www.edstrom.com/Resources.cfm?doc_id=187.

9) The recent cholera epidemic in Latin America presents a clear example of the constant threat from waterborne disease: “The cholera epidemic in Latin America was fostered, at least in part, by the misconception that DBP's pose a greater risk to public health than pathogens. The epidemic which began in January 1991 and has now spread to all but one Latin American country, has caused 1.3 million illnesses and almost 12,000 deaths.” H. Otterstetter, Pan American Health Organization and Gunther Craun, Journal AWWA Sept. 1997, as quoted by the Chlorine Chemistry Council, http://c3.org/chlorine_knowledge_center/waterfacts.html.
Ion Exchange

Ion exchange is a simple, reversible chemical reaction in which an ion in solution, either positively or negatively charged, is exchanged for a similarly charged ion that is electrostatically attached to an immobile solid particle, called an ion exchange resin. Most ion exchange resins are based upon a copolymer of styrene with 4–12% divinylbenzene, synthesized as described in eq 8.

\[
\begin{align*}
\text{H}_2\text{C} &= \text{CH} & \text{H}_2\text{C} &= \text{CH} \\
\text{x} &\quad \quad & \text{+} &\quad \quad & \text{y} \\
\text{H}_2\text{C} &= \text{CH} & \text{H}_2\text{C} &= \text{CH} & \text{H}_2\text{C} &= \text{CH}
\end{align*}
\]

(8)

By the addition of ionic functional groups to the polymer network, these hydrophobic polymers are converted into water-swellable resins with ion exchange properties. To create a cation exchange resin, the benzene rings of the copolymer are reacted with sulfuric acid, resulting in the sulfonated species shown in Figure 5. The \( \text{SO}_3^- \) group is covalently (permanently) bonded to the benzene ring, yielding a negatively charged polymer matrix, whereas the hydrogen cation (proton) is mobile and exchangeable. These hydrogen ions can be exchanged on an equivalent charge basis with other cations, such as \( \text{Na}^+ \), \( \text{Ca}^{2+} \), \( \text{Fe}^{3+} \), etc. The electrical neutrality of the polymer will always be maintained, so, for example, two \( \text{H}^+ \) will be exchanged for one \( \text{Ca}^{2+} \)(aq).

\[
\begin{align*}
\text{H}_2\text{C} &= \text{H}_2\text{C} & \text{H}_2\text{C} &= \text{H}_2\text{C} & \text{H}_2\text{C} &= \text{H}_2\text{C} \\
\text{H}_2\text{C} &= \text{H}_2\text{C} & \text{H}_2\text{C} &= \text{H}_2\text{C} & \text{H}_2\text{C} &= \text{H}_2\text{C}
\end{align*}
\]

Figure 5. Sulfonation of poly(styrene) to yield a cation exchange resin. The exchangeable, mobile positive hydrogen ions can be replaced by other cations from solution.

To create an anion exchange resin, the benzene rings of the copolymer are reacted with chloromethyl methyl ether followed by trimethylamine, resulting in the aminated species shown in Figure 6. The \( \text{CH}_3\text{N} \)(CH\(_2\))\(_3\)\(^+ \) group is covalently (permanently) bonded to the benzene ring, yielding a positively charged polymer matrix, whereas the chloride anion is mobile and exchangeable. These chloride ions can be exchanged on an equivalent charge basis with other anions, such as \( \text{OH}^- \), \( \text{NO}_3^- \), \( \text{SO}_4^{2-} \), etc. The electrical neutrality of the polymer will always be maintained, so, for example, two \( \text{Cl}^- \) will be exchanged for one \( \text{SO}_4^{2-} \)(aq).
B1: Experimental Procedure for the Remediation Project

Each student team will design a remediation plan, and explore the affect of one variable on the efficiency of the remediation. The project consists of the following six steps:

**Step 1: Measurement of Contaminant Concentrations in a Water Sample**

1) The team is assigned a water sample to remediate.
2) The team determines the fluoride, iron, and water hardness of the assigned water sample. New calibration curve data must be collected for the fluoride and iron analyses.

**Step 2: Design A Remediation Plan**

1) The team determines which contaminant is to be remediated.
2) The team reviews the remediation overview, discusses the methods and materials available for remediation of that contaminant, and selects a specific remediation plan. The remediation targets are:
   \[
   \begin{align*}
   F^- & : 1 \text{ ppm} \\
   Fe^{2+}/Fe^{3+} & : 0.3 \text{ ppm or less} \\
   Mg^{2+}/Ca^{2+} & : \text{Total hardness level between 60 and 100 ppm CaCO}_3
   \end{align*}
   \]
3) Using the Water Remediation Plan Worksheet, the team plans two individual remediation experiments, one for each student of the team. Each student must record in her or his notebook the specific remediation protocol, a brief summary of the experimental plan and the individual assignments.

**Step 3: Perform the Remediation**

1) Each team member performs her or his remediation experiment.
2) Each team member analyzes her or his processed water to determine the new contaminant level. To save time, the team should perform this analysis collectively. New calibration curve data must be collected for fluoride or iron analyses.

**Step 4: Analysis of the Initial Round of the Remediation**

1) The class will meet to discuss the results of the remediation experiments: What difficulties were encountered? Was the remediation goal met? Which variable was most important for meeting the remediation goal? Which experiment was the most time effective?
2) Determine what modification(s) might be made to improve your remediation plan.

**Step 5: Refining the Remediation Plan**

1) The team designs a new remediation plan, based upon your analysis of the results of the first remediation.
2) The team performs the new remediation and analyzes the treated water sample. New calibration curve data must be collected for fluoride or iron analysis.
3) The team evaluates the results of the refined remediation plan.

Generalized procedures for the various remediation methods are described below. Following these procedures, suggestions for a variable to examine are given.
Review of Initial Round of Remediation

After you have completed the first round of experiments, meet with other students who remediated the same contaminant and discuss your results. Take notes in your laboratory notebook. Address the following issues:

1) What were the results of the remediation experiments?

2) What were the experimental difficulties encountered in each experiment?

3) Were the desired remediation goals reached?

4) Which variables seemed to be the most important for reaching the remediation goals?

5) Which experiment was most time effective?

6) Which experiment was the best overall? Why?

7) What else could be done to improve the remediation?

Refining the Remediation Plan

During the review of the initial remediation results you identified ways in which your remediation plan could be improved. Using this knowledge, design and carry out another remediation experiment to improve your results. Take notes on the procedure and the analysis of the results.

How do the results of the refined experiment compare to the results of the initial experiments?
<table>
<thead>
<tr>
<th>Date</th>
<th>Lab Exercise Topic</th>
<th>Ex. #</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/5</td>
<td><strong>LAB EXERCISE TOPIC</strong>&lt;br&gt;• Plant Tissue Culture&lt;br&gt; 1 Regenerating plantlets from Tobacco callus <em>prepare media</em>&lt;br&gt; 2 Examine 3/30 carrot and <em>Arabidopsis</em> root explants&lt;br&gt;• Mutant selection <em>(Day 2)</em>: ©transfer cold-treated WT and mutagenized seed to culture plates (control and selection plates)&lt;br&gt;• Analyzing transgenic <em>Arabidopsis</em> <em>(Day 2)</em>:&lt;br&gt; 1 Expt 1 © transfer sterilized pTA-GUS seed to <em>(Δ dex)</em> media;</td>
<td>9&lt;br&gt;10 &amp; hand-outs</td>
</tr>
<tr>
<td>4/7</td>
<td>• Tissue culture - transplant Tobacco callus to medium prepared 4/5&lt;br&gt; 1 examine carrot/<em>Arabidopsis</em> callus cultures&lt;br&gt;• Mutant selection © <em>(Day 3)</em> - examine plates for germination&lt;br&gt;• <em>(Lecture: Background for transgenic plant analyses (2 experiments))</em>&lt;br&gt;• Tentative: Plan phototropism experiment © - planned exp to determine action spectrum for phototropism designed apparatus</td>
<td></td>
</tr>
<tr>
<td>4/12</td>
<td><strong>CAM REPORT DUE</strong>&lt;br&gt;• Phototropism experiment&lt;br&gt;• Mutant selection © <em>(Day 4)</em> examine plates of WT &amp; mutagenized Arabidopsis&lt;br&gt;• examine carrot/<em>Arabidopsis</em> callus cultures&lt;br&gt;• Analyzing transgenic <em>Arabidopsis</em> - Experiment 2 ©&lt;br&gt; <em>(Day 1)</em>: sterilize and cold treat <em>(DH5-GFP)</em> seed</td>
<td></td>
</tr>
<tr>
<td>4/14</td>
<td>© Transgenic Expt 1 <em>(Day 3)</em>: © Reporter gene (GUS) assay in seedlings growing in Δdex media&lt;br&gt;• Identifying <em>Arabidopsis</em> mutants <em>(Day 5)</em>: transfer candidate developmental mutant seedlings to soil; note selection results on selection plates&lt;br&gt;• Analyzing transgenic <em>Arabidopsis</em> - Experiment 2 ©&lt;br&gt;<em>(Day 2)</em>: plate <em>(DH5-GFP)</em> seed&lt;br&gt;<strong>If time, examine tobacco callus cultures</strong></td>
<td></td>
</tr>
<tr>
<td>4/19</td>
<td>© Transgenic Expt 1 <em>(Day 4)</em>: Observe, record data and analyze results of GUS expression in seedlings grown in Δdex media&lt;br&gt;Examine Tobacco callus cultures - record observations&lt;br&gt;Lecture: Confocal Microscopy</td>
<td></td>
</tr>
<tr>
<td>4/21</td>
<td>Analyzing transgenic <em>Arabidopsis</em> - Experiment 2 ©: <em>(Day 3)</em>: Examining gene expression in DH5-GFP plants <em>(Experiment and Analysis using Confocal Microscopy)</em>&lt;br&gt;Exercise: Western Blotting Technique to identify specific proteins</td>
<td>hand-out</td>
</tr>
</tbody>
</table>
Selection of Arabidopsis plants with desired mutations and Investigating gene expression and function in transgenic Arabidopsis

Today we will begin two of three experiments that will allow you to gain some technical experience with selecting Arabidopsis mutants and investigating gene expression and function.

For the first of these experiments we will use Arabidopsis seed produced by plants that were treated as seed with EMS (ethyl methane sulfate), a potent mutagen that randomly induces point mutations in DNA. Thus, in a population of seeds obtained in this way, there are potentially many seeds with embryos that carry mutations and these mutations are likely to be in different regions of the DNA; thus, if the mutations are in genes, they are likely to be in different genes. If the mutation is in a critical portion of a functional gene, a mutant phenotype may result.

With a suitable detection method, one can “select” mutants exhibiting a desired phenotype. The selection might be visible, for example, a researcher interested in functions of cell wall components might select plants exhibiting a phenotype that would be consistent with a cell wall mutation. The selection for some mutation might also be done by performing some test, for example, herbicide exposure to select for mutants that are resistant to the herbicide treatment.

For the second experiment, to examine gene expression and ways in which experimenters can manipulate expression (turn it on when desired) or relative degrees of expression (i.e. control relative amounts of protein being produced), we will use seed from transgenic (engineered) Arabidopsis. The gene that has been engineered into the genome of these plants is a bacterial gene that encodes the bacterial enzyme, β-glucuronidase (GUS). A very useful assay for the presence of the protein product of this gene (β-glucuronidase) has been developed. The assay involves incubating tissue in an “artificial, aka synthetic, substrate called “X-Gluc”. This substrate is colorless, but the chromophore (the “X”) when cleaved from glucuronic acid via the action of GUS, is blue. Thus, a blue color in cells of a plant incubated in X-Gluc, indicates the presence of the gene product, GUS and hence, the expression of the transgene in these cells. This system can be exploited in many ways. We will utilize these plants to investigate how an experimenter can either “track” or manipulate the expression of a gene of interest. For us, the gene of interest is the gene that encodes GUS.
The task for today (lab period 1):

Since we will be working with plants grown in sterile culture, our first task is to surface sterilize 1) EMS treated seeds and 2) the transgenic (pTA-GUS) Arabidopsis seeds, cold treat them for two days, and then plant them in sterile medium so they will germinate and produce plantlets.

Each team (pair) should obtain:
1 Eppendorf tube with ~2000 mutagenized (EMS treated) seed (~40 mg of seed)
1 Eppendorf tube with ~2000 pTA-GUS Arabidopsis seed (~40 mg of seed) and

Perform the following sterilization and cold treatment procedure to the seeds in each tube.

I. Sterilizing seeds.

Choose a clean bench, wipe the bench top with 95% ethanol (or amphiyl).

1. Add 500 μl of sterile water to the Eppendorf tube and soak the seeds in this for at least 20 min.

2. Briefly spin the tube in a microcentrifuge (~10 sec), discard the water by pipetting it off the seeds (use a sterile tip)

3. Resuspend the seeds in 1 ml of 50% Chlorox (bleach) with triton-X100 (a detergent) for 15 minutes (use a sterile tip). Briefly spin the tube (10 sec) and pipette off and discard the bleach.

4. Wash the seed with 1 ml of sterile water. Spin, pipette off the water and discard it. Repeat this step 3 more times.

5. Finally resuspend the seeds in ~100-200 μl of sterile water.

II. Cold treating the seeds

1. Be sure your seeds are in labeled tubes, with your name and seed source clearly indicated.

2. Put seeds in microfuge tube holder in the refrigerator at 4° C for at least 2 days.
III. Plating the transgenic seeds on growth media (lab period 2)

1. Obtain six petri dishes, one dish with medium containing each of the following Dex (dexamethasone) concentrations: 0 μM, 0.005 μM, 0.01 μM, 0.05 μM, 0.5 μM, and 1.0 μM Dex.

2. Obtain the tube with your cold treated pTA-GUS transgenic seeds.

3. Under a sterile hood, add 550 μL of top agarose (0.1%) to the tube (use a sterile tip). Invert the tube several times to mix the seeds.

4. Continue working under the sterile hood. Transfer 100 μl of resuspended seeds into each of the 6 plates. Add 2 ml of top agarose (0.1%) to each plate and gently rotate the plate until the seeds are evenly distributed.

5. Leave the lid open and let the plates dry under the hood. This will take about an hour.

6. After the plates are dry, place the lid on the plate and seal with a parafilm strip. The plates can then be placed in a plant growth chamber.

IV. Plating the EMS treated seed on non-selective and selection media

1. Obtain your cold treated EMS seeds

2. Each team obtains 2 MS (standard growth medium) and 2 MS+ Cadmium plates. Label plates with your name, the medium, and “EMS seeds”

3. Under a sterile hood, add 550 μL of top agarose (0.1%) to the tube containing the EMS treated seeds (use a sterile tip). Invert the tube several times to mix the seeds.

4) Transfer 100μl of resuspended EMS seeds to your MS and MS+ Cd plates for EMS seed. Add 2 ml of top agarose (0.1%) to each plate and gently rotate the plate until the seeds are evenly distributed.

5) Follow steps 5 and 6 in protocol for transgenic seed.
Biology 526 Plant Physiology Laboratory

Gene expression in transgenic Arabidopsis plants and gene inducible systems.

Objectives:
To learn how reporter gene fusions can be used to study plant gene expression in plant development.
To learn how gene inducible systems can be utilized to analyze gene functions.

What is a reporter gene?
In a transgenic plant, a reporter gene can be fused to a developmental gene to aid investigation of that gene. The reporter gene's product catalyses a color reaction, showing exactly where the fused developmental gene is expressed. For example, the cis-active region of the developmental gene is fused to a bacterial reporter gene such as β-glucuronidase (GUS). This construct can be integrated into the plant's genome using a T-DNA vector. Expression, of the fused gene can be shown by adding a chromogenic substrate, X-Gluc. Cells that have expressed the fused gene turn blue. If the developmental gene is regulated at the level of transcription, the importance of different parts of the cis-active region can be investigated in transgenic plants after fusion with the reporter gene.

If the transcription of a developmental gene is regulated, an ectopic expression can give clues to the gene's biological effect. To express the gene ectopically, cDNA of the gene is fused with a strong constitutive promoter, for example the cauliflower mosaic virus (CaMV) 35S promoter. This construct is then integrated into the plant's genome via T-DNA mediated transformation.

GUS (β-glucuronidase) assay in a young Arabidopsis seedling. Notice the specific locations of GUS staining.
Why an inducible system?
An inducible system is a powerful tool to specifically manipulate when and how much a gene will express. The information gained from the inducible studies will be important in understanding how that particular gene functions during plant development.

Diagram of the DEX-inducible system.
EXERCISE 7. KINETIC CHARACTERISTICS OF TURNIP PEROXIDASE

Peroxidases (H₂O₂-oxidoreductases) are ubiquitous in plants. Peroxidases are iron containing heme-proteins that catalyze the hydrogen peroxide (H₂O₂) dependent oxidation of a number of different substrates. Peroxidases in plant cell walls, for example, are involved in generating the reactive forms (free radicals) of phenylpropanoid alcohols that polymerize (non-enzymatically) in the wall to form lignins. It has also been noted that an increase in peroxidase activity is a common response to mechanical or herbivore generated damage to plant tissues. This increase in peroxidase activity contributes to a generalized, non-specific defense response of plants toward potentially damaging "predators".

Peroxidases can be assayed conveniently by following the oxidation of non-physiological dyes that can serve as substrates for these enzymes. We will exploit this property to examine the kinetics of turnip peroxidase in a crude enzyme preparation. Our study of turnip peroxidase will serve as a model for understanding how enzymes function and identifying the factors that affect rates of enzyme catalyzed reactions. Specifically, we will focus on examining the effects of enzyme concentration and of substrate concentration on the rate of the reaction catalyzed by peroxidase. The latter study will provide information for computing the kinetic constants, Kᵣ and Vₘₐₓ, for turnip peroxidase. To further understand enzyme function, we will also examine pH and temperature effects on peroxidase activity. Finally, we will consider the effects of enzyme activators and inhibitors on enzyme activity (i.e. on rates of reaction).

PROTOCOLS:

Preparation of a crude extract of turnip containing turnip peroxidase:

One preparation will be made for the class.
1. Obtain 3 g of turnip and 300 ml of 0.05 M phosphate buffer, pH 7.0.
2. Slice and chop the slices of turnip into small pieces. Place the pieces in a cold mortar. Add a small amount of buffer (from the 300 ml) and grind the turnip to produce a homogeneous mixture.
3. Add the turnip extract to a cold blender. Rinse the mortar with some of the buffer, add the rinses to the blender.
4. Add the rest of the 300 ml of buffer to the blender. Blend 30 sec.
5. Filter the extract through 8 layers of cheesecloth. Squeeze all liquid through the cheesecloth.
6. Each group should obtain an aliquot of the extract for their own use. Be sure to mix the extract before removing the aliquot and before each addition to experimental tubes.

KEEP THE EXTRACT ON ICE.

Quick test of peroxidase activity in the crude extract:

Before setting up the more elaborate set of tubes in exercise 1, we need to know if we have sufficient peroxidase activity in our extract to proceed (or if we have so much activity that we need a dilution before we begin). Several teams should prepare to do a single assay while the extract is being prepared so that collectively we can make a decision about the suitability of the extract.

1) Prepare 1 tube: 2 ml 0.2M phosphate pH 5 buffer, 0.5 ml guaiacol, 1 ml 12 mM H₂O₂.
2) Put the solution in a cuvette and use it to set the spectrophotometer A₅₀₀=0
3) Take the cuvette from the holder. Time reaction from time of extract addition.
Teams 1, 2, 3 add respectively, 0.1 ml, 0.25 ml, 0.5 ml of the turnip extract to the cuvette, quickly mix by inversion of the cuvette, and replace the cuvette in the holder. Take A₅₀₀ readings at 15 sec intervals for 1.5 minutes. Quickly determine the reaction rate (ΔA / min.)
Report results on the front board.
EXPERIMENT 1. The effect of peroxidase concentration on reaction velocity.
(From the results of this experiment we will also determine an appropriate enzyme concentration to use in subsequent experiments.)

1. Obtain 4 test tubes. Prepare an appropriate small amount of the following dilutions of the "crude enzyme preparation". (You will be using 0.5 ml of each enzyme preparation so prepare enough of each to be able to accurately remove 0.5 ml)

   1) no dilution
   2) 1:2 (1 ml crude prep diluted to final vol. of 2 ml)
   3) 1:4 (how will you make this??)
   4) 1:8 (how will you make this??)

Dilutions are made with 0.05 M phosphate buffer, pH 7.0. Mix each preparation gently, but thoroughly.

Keep the enzyme dilutions on ICE. Always MIX the preparations AGAIN before removing an aliquot for an assay.

2. Prepare the reaction tubes for the assay of peroxidase activity as a function of peroxidase concentration according to TABLE 1.

TABLE 1. Preparation of reaction mixes for experiment 1.

<table>
<thead>
<tr>
<th>Assay</th>
<th>Tube No.</th>
<th>Pi Buffer pH 5 (ml)</th>
<th>Guaiacol (ml)</th>
<th>H₂O₂ (12 mM) (ml)</th>
<th>H₂O (ml)</th>
<th>Turnip Extract (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td></td>
<td>2.0</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>crude undiluted</td>
<td>1A</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>-</td>
<td>0.5 (crude)</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1:2 dilution</td>
<td>2A</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>-</td>
<td>0.5 (1:2 dil)</td>
</tr>
<tr>
<td></td>
<td>2B</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>-</td>
<td>0.5 (1:4 dil)</td>
</tr>
<tr>
<td></td>
<td>3B</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4A</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>-</td>
<td>0.5 (1:8 dil)</td>
</tr>
<tr>
<td></td>
<td>4B</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

3. Set the spectrophotometer wavelength selector to 500 nm. Adjust A₅₀₀=0 (%T=100%) with the blank.
4. To conduct the assay:
   a. For the crude undiluted extract assay—Mix the contents of tubes 1A (containing the substrates, guaiacol and H₂O₂) and 1B (containing the enzyme) by pouring the contents of one tube into the other. START THE STOP WATCH EXACTLY WHEN THESE TUBES ARE MIXED.
   b. Partner 1: quickly pour the mix into a cuvette. Insert the cuvette in the spectrophotometer. Read the instantaneous A₅₀₀ of the mix every 20 sec for a total of 2 min.
5. Repeat step 4 to assay enzyme activity with diluted extracts, i.e. tubes 2A-B, 3A-B, 4A-B.

CAUTION: THE REACTION MAY GO VERY FAST. BE PREPARED TO MAKE INSTANTANEOUS DETERMINATIONS OF ABSORBANCE AT THE PROPER TIMES.
**Preparation for subsequent experiments:** Prepare stock enzyme solution to use for all subsequent experiments.

Determine from Experiment 1 the enzyme dilution that gives a change in A per min of approximately 0.25. Prepare 20 ml of this dilution using 0.05 M phosphate buffer, pH 7.0 to dilute the crude stock solution. Be sure to mix the undiluted extract before removing an aliquot to make this dilution. Keep the diluted enzyme stock solution on ice.

USE THIS DILUTED STOCK ENZYMES PREPARATION FOR ALL OTHER EXPERIMENTS.

**EXPERIMENT 2 (ALL GROUPS): EFFECT OF SUBSTRATE CONCENTRATION ON THE RATE OF THE PEROXIDASE CATALYZED REACTION**

1. Note: 3 stock concentrations of \( \text{H}_2\text{O}_2 \) are available (24 mM, 12 mM, and 1.2 mM.) Be sure to use the right stock to prepare the tubes below.
2. Prepare the reaction tubes as given in TABLE 2. Conduct assays of enzyme activity at each substrate concentration as for experiment 1.

**TABLE 2. Preparation of Assay Mixes For Experiment 2.**

<table>
<thead>
<tr>
<th>Assay (final ( \text{H}_2\text{O}_2 ))</th>
<th>Tube No.</th>
<th>Pi Buffer pH 5 (ml)</th>
<th>Guaiacol (ml)</th>
<th>( \text{H}_2\text{O}_2 ) (ml) (stock)</th>
<th>( \text{H}_2\text{O} ) (ml)</th>
<th>Turnip Extract (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td></td>
<td>2.0</td>
<td>0.5</td>
<td>1.0 (12mM)</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>6 mM</td>
<td>1A</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0 (24mM)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>3 mM</td>
<td>2A</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0 (12mM)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>1.5 mM</td>
<td>3A</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5 (12mM)</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>0.75 mM</td>
<td>4A</td>
<td>1.0</td>
<td>0.5</td>
<td>0.25 (12mM)</td>
<td>0.75</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>0.3 mM</td>
<td>5A</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0 (1.2mM)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>0.15 mM pipette accurately</td>
<td>6A</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5 (1.2mM)</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>6B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>0.09 mM pipette accurately</td>
<td>7A</td>
<td>1.0</td>
<td>0.5</td>
<td>0.3 (1.2mM)</td>
<td>0.7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>0.06 mM pipette accurately</td>
<td>8A</td>
<td>1.0</td>
<td>0.5</td>
<td>0.2 (1.2mM)</td>
<td>0.8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>8B</td>
<td>1.0</td>
<td>-</td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
</tbody>
</table>
EXPERIMENT 3. The purpose of this experiment is to determine the effect of the hydroxylamine (or other selected inhibitor) on the peroxidase catalyzed reaction and to obtain data that will allow your team to hypothesize the mechanism of inhibition for the chosen inhibitor.

(Reference for help with analysis: use Taiz and Zeiger, Ch 2, kinetic analysis of Inhibition, or any biochemistry textbook)

An alternate exercise may be substituted for this experiment.

Procedure: the procedure is essentially the same as for Expt. 2 except that hydroxylamine (or other inhibitor) is included in the assay system.

<table>
<thead>
<tr>
<th>Assay (final $[H_2O_2]$)</th>
<th>Tube No.</th>
<th>Pi Buffer pH 5 (ml)</th>
<th>Hydroxylamine in buffer pH 5 (ml)</th>
<th>Guaiacol (ml)</th>
<th>$H_2O_2$ (ml) (stock)</th>
<th>$H_2O$ (ml)</th>
<th>Turnip Extract (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td></td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0 (12mM)</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>6 mM</td>
<td>1A 1B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0 (24mM)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3 mM</td>
<td>2A 2B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0 (12mM)</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>1.5 mM</td>
<td>3A 3B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5 (12mM)</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>0.75 mM</td>
<td>4A 4B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.25 (12mM)</td>
<td>0.75</td>
<td>-</td>
</tr>
<tr>
<td>0.3 mM</td>
<td>5A 5B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0 (1.2mM)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.15 mM pipette accurately</td>
<td>6A 6B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5 (1.2mM)</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>0.09 mM pipette accurately</td>
<td>7A 7B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.3 (1.2mM)</td>
<td>0.7</td>
<td>-</td>
</tr>
<tr>
<td>0.06 mM pipette accurately</td>
<td>8A 8B</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>0.2 (1.2mM)</td>
<td>0.8</td>
<td>-</td>
</tr>
</tbody>
</table>
EXPERIMENT 4  DETERMINING THE pH AND TEMPERATURE OPTIMA FOR PEROXIDASE FROM A SPECIFIC PLANT ORGAN/TISSUE

Your research team may elect to design and conduct an experiment to either determine the pH or the temperature optimum for turnip root peroxidase. Be prepared to conduct the experiment, beginning with new turnip extract preparation, in the next lab period.

In a short paragraph, state the goal of your research and summarize the strategy you will use. Write out the materials needed and the steps you will utilize. Submit this to the instructor.

Use the same assay for peroxidase used for Experiments 1-3.

A blank table below is provided and may be useful as you as you determine exactly how you will set up the assay tubes for your experiment.

**TABLE 4. Preparation of Reaction Mixtures for Experiment 4:**

<table>
<thead>
<tr>
<th>Assay Variable</th>
<th>Tube No.</th>
<th>0.2 M Pi Buffer (ml) (source)</th>
<th>Guaiacol (ml)</th>
<th>12 mM H₂O₂ (ml)</th>
<th>H₂O (ml)</th>
<th>Turnip Extract (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td></td>
<td>2.0</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE 1.

<table>
<thead>
<tr>
<th>Time-&gt;Treatment</th>
<th>20 sec (0.33 min)</th>
<th>40 sec (0.67 min)</th>
<th>60 sec (1 min)</th>
<th>80 sec (1.33 min)</th>
<th>100 sec (1.67 min)</th>
<th>120 sec (2 min)</th>
<th>Rxn Rate ΔA/ min</th>
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</thead>
<tbody>
<tr>
<td>Crude</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1:2 dilut'n</td>
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<tr>
<td>1:4 dilut'n</td>
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<tr>
<td>1:8 dilut'n</td>
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### TABLE 2.

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<th>100 sec (1.67 min)</th>
<th>120 sec (2 min)</th>
<th>Rxn Rate ΔA/ min</th>
</tr>
</thead>
<tbody>
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</table>

### TABLE 3.

<table>
<thead>
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<th>Time-&gt;Treatment</th>
<th>20 sec (0.33 min)</th>
<th>40 sec (0.67 min)</th>
<th>60 sec (1 min)</th>
<th>80 sec (1.33 min)</th>
<th>100 sec (1.67 min)</th>
<th>120 sec (2 min)</th>
<th>Rxn Rate ΔA/ min</th>
</tr>
</thead>
<tbody>
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<td></td>
</tr>
</tbody>
</table>

### TABLE 4.

<table>
<thead>
<tr>
<th>Time-&gt;Treatment</th>
<th>20 sec (0.33 min)</th>
<th>40 sec (0.67 min)</th>
<th>60 sec (1 min)</th>
<th>80 sec (1.33 min)</th>
<th>100 sec (1.67 min)</th>
<th>120 sec (2 min)</th>
<th>Rxn Rate ΔA/ min</th>
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</thead>
<tbody>
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</tr>
</tbody>
</table>

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000052
Turnip Peroxidase Kinetics

Data Preparation and Analysis for the Lab Report

(An appropriate introduction, brief narrative methods section, a descriptive results section, and an interpretive discussion section are required. Your team should work to decide what should be covered in each of the sections. Work together to outline points to be reported in the results section and to be discussed in the discussion section. Be sure you can explain why reaction rates changed or didn't change with change in reaction component. These explanations should form the basis of your discussion section. Think about peroxidase in its inter/intracellular environment. Interpret your data (make some predictions) in a way that is relevant to peroxidase in situ.)

Comments below are to help you with data preparation and data analysis that should be done prior to writing the report.

1. Prepare a graph of extent of reaction (A500 vs. time) for each experiment. Plot all treatments on the same set of axes.

2. Determine the rate of the peroxidase catalyzed reaction (ΔAA / min) under each experimental condition. Use initial linear portions of reaction time course plots to determine these rates. (Why?)

3. Prepare a separate table for experiments 1,3,4 with treatment and reaction rate (ΔAA/min) in separate columns.

4. Plot data in tables prepared in (3) to show reaction rate and the variable.

5. a. Prepare a table for experiments 2 and 5 with headings: [H2O2] (mM), rate of reaction (ΔAA/min), 1/[H2O2] , 1/rate of reaction. (add appropriate units for all columns).
   b. Plot data to show relation between reaction rate and [H2O2].
   c. Plot data to show relation between reciprocal of reaction rate and reciprocal of [H2O2].
      This plot is called a Lineweaver-Burk plot. (Expt 2 and 5 data can be plotted on the same graph)
   d. Determine Vmax and K_m for turnip peroxidase from the Lineweaver-Burk plot (see discussion below).
   e. Hypothesize from the change in Vmax and K_m, without and with hydroxylamine, the mechanism for hydroxylamine inhibition of turnip peroxidase.

The equation that describes hyperbolic-type kinetics (Fig. 1) characteristic of many enzyme catalyzed reactions is called the Michaelis-Menten equation and is given below (eq. 1):

\[ V_0 = \frac{V_{\text{max}} [S]}{K_m + [S]} \]

Where \( V_0 \) = initial reaction velocity, \([S]\) = substrate concentration, \( V_{\text{max}} \) is the maximum velocity, and \( K_m \) is the Michaelis-Menten constant.

If you take the reciprocal of this equation and rearrange the terms of the equation you will generate what is known as a Lineweaver-Burk transformation (eq. 2) of the Michaelis-Menten equation.

\[ \frac{1}{V_0} = \frac{1}{V_{\text{max}}} \left( \frac{1}{K_m} \right) + \left( \frac{1}{V_{\text{max}}} \right) \frac{1}{[S]} \]

The Lineweaver-Burk transformation is an equation for a straight line!! (y=mx+b)

Therefore, when \( \frac{1}{V_0} \) is plotted on the y-axis vs. \( \frac{1}{[S]} \) on the x-axis (Fig 2), the slope of the resulting line will be \( \frac{K_m}{V_{\text{max}}} \), the y-intercept will be \( \frac{1}{V_{\text{max}}} \), and the x-intercept is \( -\frac{1}{K_m} \) (set \( y=0 \) and solve for \( \frac{1}{[S]} \) if you want to determine this yourself.)

It is a snap to solve for \( V_{\text{max}} \) and \( K_m \) from the y and x intercept values!!

\( V_{\text{max}} = \frac{-y_{\text{intercept}}}{y_{\text{intercept}}} \)

\( K_m = \frac{-x_{\text{intercept}}}{y_{\text{intercept}}} \)
Appendices for Standards:

Standard 13: Integrated Study of Science
CIS 510: Search for Solutions

College of Science and Engineering
College of Education
San Francisco State University
1600 Holloway Avenue
San Francisco, California 94132

We anticipate the first offering of this course to occur in the Fall Semester, 1999, with class times of TTh 5:10 – 6:25. The phenomenon under study will be global climate change, and the course will be taught by Ray Trautman, Associate Professor of Chemistry and Dave Dempsey, Associate Professor of Meteorology.

- Development of the Course
- Tentative Course Syllabus
- Assessment
- Reading Assignments
- Course Resources
- Student Projects

History of CIS 510

This capstone course is being developed for K-12 science (biology, chemistry, geology, and physics) single subject credential candidates at SFSU by

- Kathleen O'Sullivan Professor of Education,
- Norm Owen Professor of Engineering and Civil Engineering Program Head,
- Ray Pestrone Professor of Geology,
- Ray Trautman Associate Professor of Chemistry, and
- Stan Williams Professor of Biology,

and high school teacher consultants

- Pamela Harman Oceana High School, Pacifica, and
- Rachel Kalish Oceana High School, Pacifica,

aided by comments from external reviewers.

We gratefully acknowledge support for the development and initial offering of this course from MASTEP and SFSU's College of Science and Engineering:
Course Overview

Connections among the various disciplines of science and the inter-relationships among science, technology and society are the focus of this problem-based course. Working with others as part of a team, you will be challenged to see the conceptual and operational relationships among the various sciences and between science and technology as you research a significant science-based phenomenon, its effects on society, and how these effects could be mitigated. And while the solutions are important, the emphasis will always be on the nature of the search. Understanding how data are derived, reported and interpreted will facilitate the search for solutions.

While the societal problem under study will vary from semester to semester, the approach and tasks will remain the same. The problem will always be interdisciplinary in nature and broad enough to allow for a diversity of specific questions to be addressed by each team. Complex phenomena which have multiple effects, both on a personal or local level and on the global community will be selected by the instructor(s). The goals are to study current scientific understanding of the selected phenomenon, examine its regional and worldwide impacts, and propose solutions for how society can effectively deal with its effects.

This course is required for future science teachers. Students who want to study science as an integrated entity, and understand the relationships among science, technology and society in a challenging, problem-solving format, are encouraged to enroll.

Course Goals

You can expect to develop an appreciation for the value of applying multidisciplinary approaches to problem solving and to recognize the benefits of integrating science and technology as mutually supportive activities. In addition, you will refine your interpersonal skills as a result of learning to work in a supportive team environment. You will also enhance your communication skills as you explore the nature of scientific inquiry and technologic applications. And, while you will learn much more about the phenomenon, you will also develop your investigative and analytical prowess.

During the conduct of the course, you will be actively engaged in the application of knowledge and skills previously acquired in science and mathematics courses. You will learn how to obtain and utilize information from a variety of resources, including academic, text, government, Internet, business and industry. The final course products will be a team poster session and an oral presentation.

Prerequisites

Completion of the Library Orientation requirement; current e-mail address; completion of 18
units in science; consent of instructor.

Learning Objectives

1. Examine the phenomenon and its effects and identify the contributions of each of the basic sciences to its study.

2. Identify a specific problem related to the phenomenon and develop a plan to investigate the issue in depth.

3. Use information collected in the investigation and apply critical thinking skills to propose and critique a convincing course of action to mitigate the effects of the phenomenon.

4. Describe and evaluate the various types of literature, including scientific research, on the phenomenon.

5. Develop skills in working as a member of an investigative team and keep an ongoing record of your team’s work and effectiveness.

6. Prepare and present the results of your team’s work in an oral, classroom presentation using PowerPoint software and as a written report.

7. Prepare and present the results of your team’s work in a poster for public review.

Assessments and Evaluation

Several elements are used to assess performance in the class; these are listed in the table below. Additional information will be provided for these. Note that 50% of the assessments overall is based on work done by teams. Letter grades are based on the standard scale of 93–100%, A; 90–92, A–; 88–89, B+, etc. College level standards are expected in all written and oral assessments. Full attendance and participation is required.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Team</th>
<th>Individual</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral presentation of research and analysis; due at the end of the course.</td>
<td>10%</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>Poster presentation of research and analysis; due at the end of the course.</td>
<td>15%</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td>Work log and reflective journal, ongoing; assessed at three points during the semester.</td>
<td>0%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Literature presentations; one individual and one team; made near the beginning of the course.</td>
<td>5%</td>
<td>20%</td>
<td>.25%</td>
</tr>
</tbody>
</table>
Written evaluations of pertinence to team project of literature presented by other team members; and participation in class activities, including feedback to other class members.

| 0% | 15% | 15% |

Assessments: Brief Descriptions

Oral Presentation (20%)

Each team will develop and present a report on their research and analysis of a sub-topic related to the phenomenon under study. For example, if the phenomenon were global climate change, a team might focus on the role of the oceans and the effects of ocean changes on human society. Each team, with the guidance and assistance of the instructor and consultants, would be responsible for defining their area of study and methods of collecting data, i.e., their project prospectus. Different teams would work on different sub-topics. The teams would use information collected from print and electronic sources, as well as personal interviews where applicable, and then analyze their findings to propose and critique a course of action to mitigate the effects. A summary of all aspects of their work would be prepared as a 30-minute oral presentation, using PowerPoint for the visuals, to the entire class. The instructor and other members of the class would use a rubric based on the learning objectives of the course to evaluate the work of each team, with 10% of the final score assigned to all members of the team and 10% based on individual performances during the presentation. (Present planning calls for all teams' PowerPoint materials to be combined on a CD-ROM, copies of which would be provided to each class member.)

Poster Presentation (20%)

This assessment would be similar in content to the oral presentation, but the format would be that used in poster presentations at conferences of scientific associations. The audience for these would include science faculty, secondary science teachers, other students, and possibly members from the wider science community. In addition to evaluation by the instructor, feedback would be sought from the attendees at the poster session. Again, a rubric would be used and the score assigned distributed between the team (15%) and the individual members (5%).

Work Log and Reflective Journal (20%)

The log portion of this assessment would be an ongoing, personal record by each student of his/her team's deliberations, investigations, planning, and discussions. The journal portion would include reflections on the guest speakers' presentations, the work of the team and the individual's role in this, the contributions of the various sciences to the team's work, and how various processes of science pertain to the former. The logs/journals would be reviewed by the instructor at three times during the semester for currency, completeness, and considered reflections. Journal evaluations would be based on each individual's performance on this assessment.

Literature Presentations (25%)

These presentations will likely be weekly or bi-weekly (if the class is sufficiently small). The first presentation is intended as a means for introducing the class members to each other and to the instructor, and the interests and science backgrounds revealed by these presentations are used
in forming the teams. Subsequent presentations will be a means by which team members can apprise each other of the literature potentially relevant to the team project. (Individual assessment, 20%). A summary presentation, done by teams (5%), is an assessment of the members' abilities to distinguish among and critically evaluate the types of literature, from that intended for the masses to that for intended for scientists within a discipline.

**Literature Evaluations and Participation (15%)**

This assessment is based largely on written evaluations of the pertinence to the team project of the literature presented weekly or bi-weekly by other members of an individual's team. It is also based somewhat on attendance at class, participation in discussions, and feedback provided to other class members and teams.

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**Reading Assignments**

- **Scientific American Articles** (9/23/99)

**Course Resources**

- **Relevant WWW sites, organizations, and government and industry contacts** for the course. (Revised 10/29/99.)
- **Web Resource Evaluation Techniques** (from Widener University)
  - PowerPoint presentation
  - Checklists
- **Searching on-line databases** at SFSU.
- Automatic forwarding of email from one internet account to another.

**Student Projects**

- "Climate Change: Possible Effects on Human Health", by Michael Garcia and Stephanie Rodgers
  - PowerPoint presentation
  - Written narrative
- "The Effect of Global Warming on Sea-Level Rise", by Kenyetta Cook and Byoung Lee
  - PowerPoint presentation
  - Written narrative (Kenyetta Cook)
  - Written narrative (Byoung Lee)

Ray Trautman / trautman@sfsu.edu
Dave Dempsey/ ddempsey@sundog.sfsu.edu
/ revised 17Dec99
Kimberly Tanner  
Biological Education  
Hensill 433/243  
(415) 405-3438  
Fax: (415) 405-0426  
kdtanner@sfsu.edu  
http://www.sfsu.edu/~sepal/

Research Interests:  
My research group, the Science Education Partnership and Assessment Laboratory (SEPAL), is interested in how people learn science, especially biology, and how teachers and scientists can collaborate to make science teaching and learning in schools and universities more like scientists practice science in their laboratories. Just like other science research groups, we ask questions about what we’re interested in, design ways to collect evidence to address our questions, and analyze and share the data that we collect with other researchers in our field. SEPAL is currently focused on two main lines of inquiry in the broad field of science education.

I. Investigations of Scientist-Teacher Partnerships

First, we are interested in systematically understanding the role of partnerships between scientists and teachers in influencing K-12 science education and promoting articulation between the K-12 and the college/university branches of the US educational system. Just some of the research questions that we’re interested in include:

- How do scientist-teacher partnerships influence scientists’ own professional identity and teaching philosophy?
- How do interactions with scientists in classrooms affect young students’ perceptions of science and scientists?
- How the benefits of a scientist-teacher partnership vary with the characteristics of the partnership, including geography (laboratory vs. classroom vs. after-school setting vs. professional development setting), duration, programmatic structure, and previous experiences of participants?

II. Exploring How Novices Understand Biology

Second, we are interested in understanding how novices – including young children, non-science majors, and elementary school teachers – think about biological concepts and living things. My group is interested in the development of novel assessment tools to explore and characterize conceptual development in biology among novices. In particular, we are interested in the development of scoring rubrics to support the systematic quantitative analysis of qualitative written assessment data, as well as the use of semi-structured interviewing and video-recording in understanding conceptual development in the life sciences. Similar to studies and approaches in the field of physics education, this research in biology education holds the promise of revealing insights into novice preconceptions in biology that can guide strategies for curriculum development and teaching and learning strategies in biology. Just some of the research questions that we’re interested in include:

- How do novices connect their understanding of physical principles and biological principles, e.g., what is the role of chemical reactions in the process of breathing?
- What do you children think about how the brain works and what role it plays in their own learning?

http://www.sfsu.edu/~biology/pages/facframe.html
• How do novices perceive biotechnology and the relationship between concepts such as genetic engineering, breeding, and cloning?

• What role does evidence play in the acceptance or rejection of a biological explanation by a novice? How do novices assess evidence?

Opportunities Available through SEPAL

SEPAL has a variety of short-term and long-term opportunities for undergraduate students, graduate students, postdoctoral fellows, and K-12 teachers to do scholarly work in science education.

• GK-12 Classroom-Based Partnerships: Scientist-Teacher Partnerships in Earth Science, Physical Science, and Life Science, grades 6-12.

• Science Education Partners in Biology: This 4-unit biology course, Bio 652, engages SFSU undergraduate students in partnerships with San Francisco elementary school teachers to co-plan and co-teach hands-on science lessons for students that support the California Life Science Standards.

• Research Partnerships to Understand Children's Ideas in Biology:

Teacher-Scientist Research Partnerships focused on designing novel assessment tools to identify student conceptions in science, grades K-12.

• Masters Degree in Biology Education: Coursework and thesis research on topics including concept development in biology for novices and the nature of scientist-teacher partnerships. In addition, graduate students conducting basic biological research in other labs can pursue smaller projects that could contribute an innovative, educational research chapter to their Master's thesis.

Science Education Journal Club: Reading and discussion of recent findings in conceptual development, alternative conceptions, and other science education topics, open to anyone interested in exploring topics in science education.

Recent Publications & Presentations (** = grad student):

SEPAL Publications and Presentations

Selected Science Education Publications and Presentations (* denotes SFSU student author † denotes SFUSD teacher author)


*Upshaw, C., †Akiyama, L., and Tanner, K.D., Elementary Teacher and Pre-Service Teacher Classroom Assessment Research Partnership: Investigating Student Conceptions of Sound, National Association for Research in Science


**Selected Neuroscience Publications and Presentations**


Welcome to the Stillman Lab!

We are located at the Romberg Tiburon Center for Environmental Studies, the marine research laboratory of San Francisco State University. In the broadest sense, our research focuses on understanding the ultimate and proximate causes of physiological diversity in relation to environmental variation and environmental stresses, and understanding the ecological consequences of physiological response limits. The main organisms that we study are coastal marine invertebrates, especially porcelain crabs in the genus *Petrolisthes*, but also other organisms such as corals and snails. The main research tools that we apply are in vivo physiological measurements, such as cardiac activity and metabolic rate, and molecular measurements at biochemical (e.g., enzymatic properties) and molecular levels (e.g., transcriptome profiling using cDNA microarrays). The focal project of the laboratory right now is to examine correlated changes in thermal phenotype and gene expression during thermal acclimation, thermal acclimatization, and responses to thermal stress in porcelain crabs. Please explore this website to learn more about our research interests and the interesting (and fun-loving) people who do the research!
Steve Weinstein
Molecular Biology
Hensill 223
(415) 338-1843
weinst@sfsu.edu

Research Interests:
The immune system is responsible for protecting us against a wide variety of infectious, disease-causing organisms. Macrophages are cells in the immune system that play a critical role in the early detection and response to infection. Activation of macrophages stimulates the release of substances that are directly toxic to invading microbes and the secretion of chemical mediators that promote the immune responses of other cells. My research is focused on understanding the signal transduction reactions that trigger the immune response of macrophages to infection. In particular, we are interested in the response of macrophages to bacterial lipopolysaccharide (LPS), a structurally conserved component of Gram- bacterial membranes and a potent activator of macrophages. Our investigation is directed toward identifying the initial signaling events presumed to occur at the plasma membrane as well as the more distal events that occur in the nucleus, resulting in altered gene transcription. Our research utilizes biochemical, molecular and immunological approaches to address these fundamental cellular communication questions.

Recent Publications & Presentations (** = grad student):


http://www.sfsu.edu/~biology/pages/gpages/weinstein.html


Presentations (* denotes student author)


# Graduate Seminar Colloquia

**Date and Time:** Wednesday, February 27th, 2008 at 5:30PM

**Location:** Thornton Hall 331

**Presenter:**
- 5:30 Chris Smith, San Francisco State University
- 5:50 Javier Arsuaga, San Francisco State University
- 6:10 Barry Levine, San Francisco State University

**Subjects:**
- **Dr. Smith:** Using Database and Semantic Web Tools to Link Genes to Complex Behaviors
- **Dr. Arsuaga:** Using Computational Persistent Homolgy for clustering Breast cancer CGH-datas
- **Dr. Levine:** Open Source Project Development Opportunitiess

**Abstracts:**
- **Dr. Smith:** In his lab at SFSU, Dr. Smith uses comparative genomics approaches and ~20 insect genomes to study conserved genes, regulatory elements, and repeated sequences. Using datamining and bioinformatics techniques he is currently working on a catalog of genes and gene networks involved in complex social behaviors including cooperation and group aggression. He will talk about projects that students can contribute to that employ the design of web site interfaces to simplify making complex database queries, using natural language processing to more efficiently extract behavior information from Medline abstracts and PDFs articles, and creating new visualization tools to better understand the relationships between gene networks and behavior.

- **Dr. Arsuaga:** I am interested in mathematical and computational modeling of chromosomes. In this talk I will mainly focus on our computational efforts to understand chromosome aberrations in cancer. It has been estimated than 1 in 3 people will developed cancer during their life time. One key problem is to identify patients at an early stage of cancer development and with aggressive tumors. I will present how one can use computational methods to interrogate chromosomes to infer properties of the tumor and will discuss how this can be used for personalized treatments. However these methods are in their infancy and there is an enormous need for new computational tools (data base management, data mining, imaging, etc...) to analyze the data.

- **Dr. Levine** will describe several ongoing projects being developed as open source projects. There is an ongoing need to attract students to contribute to these projects, which are gaining recognition in the international arena.

**Bios:**
- **Chris Smith** did his PhD work at UCSF probing the molecular structure of chromosome ends (telomores) and was a post-doctoral fellow and staff scientist at UC Berkeley and Lawrence
Berkeley National Lab, focusing on large scale computational analysis of the fruitfly genome.

**Javier Arsuaga** earned his PhD from Florida State University. His topic of research was chromosome organization in viruses. During this time he was a fellow of the Program in Mathematics and Molecular Biology (PMMB). After graduating he spent 3 years at UCB as a postdoctoral fellow in the Department of Mathematics and in the Department of Molecular and Cell Biology. During these years he investigated chromosome organization in Bacteria and the effects of radiation in chromosomes. After his postdoc and before joining SFSU he was a researcher at the UCSF Comprehensive Cancer center. His current research interests include chromosome organization across organisms and how aberrant organizations are related to disease.

**Dr. Levine:** Concurrently with his position at SFSU, Dr. Levine is Professor and Director of the Computer & Information Science Program at American University of Armenia (affiliate with the University of California). He initiated the CIS program at AUA in 2001. He has consulted for various organizations, including the World Bank, USAID, the U.S. Government and private industry. His interests include programming language design, compiler construction, functional programming, object-oriented programming and asynchronous distance learning. He has traveled and lectured worldwide in countries including Kenya, China, Jordan and Armenia. He is currently leading projects in collaboration with Sun (Armenian Virtual Science Library project, developed from the Iraqi Virtual Science Library project - https://www.ival.org/), Stanford (re-design of "Turing World" software), the Oakland Solar Energy initiative and Sakai (http://sakaiproject.org/).

http://cs.sfsu.edu/news/pernet/08/02-27-08.html
Appendices for Standards:

Standard 14: Breadth of Study in Science
satisfy requirements, or at least prerequisites, of the extended (depth) program. (The particular courses that overlap between the two depend on the concentration selected.) This reduces the total number of units required to complete the single subject matter program.

Table 14: Core (Breadth) Program of Study in Science

<table>
<thead>
<tr>
<th>Courses 1</th>
<th>Course Titles</th>
<th>Semester Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 115, 116</td>
<td>Introduction to Astronomy, Introduction to Astronomy Lab</td>
<td>3, 1</td>
</tr>
<tr>
<td>GEOL 110</td>
<td>Physical Geology [lecture (3) and lab (1)]</td>
<td>4</td>
</tr>
<tr>
<td>GEOL/METR 310</td>
<td>Planetary Climate Change [lecture (3) and lab (1)]</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 230</td>
<td>Introduction to Biology I [lecture (3) and lab (2)]</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 240</td>
<td>Introduction to Biology II [lecture (3) and lab (2)]</td>
<td>5</td>
</tr>
<tr>
<td>PHYS 111, 112 2</td>
<td>General Physics I, General Physics I Lab</td>
<td>3, 1</td>
</tr>
<tr>
<td>PHYS 121, 122 2</td>
<td>General Physics II, General Physics II Lab</td>
<td>3, 1</td>
</tr>
<tr>
<td>CHEM 115</td>
<td>General Chemistry I [lecture (3) and lab (2)]</td>
<td>5</td>
</tr>
</tbody>
</table>

Total core (breadth) units: 35

Footnotes:
1. For course descriptions, see Appendix B, pp. 3-7; App. C, p. 0a; App. D, pp. 0a-0g; and App. E, pp. 0a-0b.
2. The General Physics w/Calculus sequence and its associated labs, PHYS 220/222, 230/232, and 240/242 (each 3+1 units), may be used instead of the PHYS 111/112 and 121/122 sequence. MATH 226 and 227 (Calculus I and II, each 4 units) are prerequisites for PHYS 220, 230, & 240.

14.1 The program encompasses the general science specifications for subject matter knowledge and competence on pages 21 through 31, which includes the following general areas of study aligned with the K-12 student academic content standards.

Tables 14.1-2, 14.3-5, 14.6-7, 14.8-9, 14.10-11, and 14.12 on the following pages summarize how the core (breadth) program addresses the required elements for general science subject matter knowledge and competence.
Each entry in the tables is a reference to page(s) in an appendix. The references have the general form: "Letter-page#". For example, "F-14" refers to page 14 in Appendix F.

The number of semester units for each course listed in the left-hand column of each table has the general form: "(# lecture + #lab units)".

Not all of the required elements that are addressed by each listed course are necessarily referenced. However, for each required element, one or more courses that we judge to be minimally sufficient to address that required element are listed.
<table>
<thead>
<tr>
<th>Courses</th>
<th>1.1 Astronomy</th>
<th>2.1 Tectonic Processes and Features</th>
<th>2.2 Rock Formation</th>
<th>2.3 Surficial Processes &amp; Features</th>
<th>2.4 Energy in the Earth System</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 115, 116: Intro Astronomy &amp; Lab (3 + 1 units)</td>
<td>F-2 F-4 F-7</td>
<td>F-2 F-4 F-7</td>
<td>F-2 F-5 F-4 F-4</td>
<td>F-2 F-4 F-5</td>
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<td>GEOL 110: Physical Geology (3 + 1 units)</td>
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<tr>
<td>GEOL/METR 310: Planetary Climate Change (3 + 1 units)</td>
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86
<table>
<thead>
<tr>
<th>Courses</th>
<th>3.1 Earth Resources</th>
<th>4.1 Ecology</th>
<th>5.1 Genetics and Evolution</th>
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<td>(3 + 1 units)</td>
<td>F-27</td>
<td>F-27</td>
<td>F-46</td>
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<td>BIOL 240: Intro Biol II</td>
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<td>F-57</td>
<td>F-58</td>
</tr>
<tr>
<td>Courses</td>
<td>6.1 Biology and Biochemistry</td>
<td>7.1 Cell and Organismal Biology</td>
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<tr>
<td>BIOL 230:</td>
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<td>(c)</td>
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<td>Courses</td>
<td>8. Waves</td>
<td>9. Forces and Motion</td>
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<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
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<td>PHYS 111, 112: Gen Phys I &amp; Lab (3 + 1 units)</td>
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<td>PHYS 121, 122: Gen Phys II &amp; Lab (3 + 1 units)</td>
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<td>PHYS 220, 222: Gen Phys I w/Calc &amp; Lab (3 + 1 units)</td>
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<td>PHYS 230, 232: Gen Phys II w/Calc &amp; Lab (3 + 1 unit)</td>
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<td>PHYS 240, 242: Gen Phys III w/Calc &amp; Lab (3 + 1 units)</td>
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<td>Table 14.10-11</td>
<td>Subject Matter Requirements for Prospective Teachers: General Science</td>
<td>Content Domains for Subject Matter Understanding and Skill in General Science</td>
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<td>10. Electricity and Magnetism</td>
<td>11. Heat Transfer and Thermodynamics</td>
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<td>CHEM 115: Gen Chem I</td>
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<td>(b)</td>
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<td>PHYS 111, 112: Gen Physics I &amp; Lab</td>
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<td>10.1 Electricity and Magnetism</td>
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<td>12. Structure and Properties of Matter</td>
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<td>(p) F-198</td>
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<tr>
<td>CHEM 115: Gen Chemistry I</td>
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<td>F-197</td>
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</table>
14.2 The program addresses the subject matter skills and abilities applicable to the content domains in science listed below:

A- Astronomy
B- Dynamic Processes of the Earth (Geodynamics)
C- Earth Resources
D- Ecology
E- Genetics/Evolution
F- Molecular Biology and Biochemistry
G- Cell and Organismal Biology
H- Waves
I- Forces and Motion
J- Electricity and Magnetism
K- Heat Transfer and Thermodynamics
L- Structure and Properties of Matter

Tables II.1.1-1.3, II.1.4-1.5, II.2, and II.3 on the following pages summarize how the program addresses the required elements of subject matter skills and abilities applicable to the content domains in science.

Each entry in the tables is a reference to page(s) in an appendix. The references have the general form: "Letter-page#". For example, "F-113" refers to page 113 in Appendix F.

Semester unit values for each course listed in the left-hand column of each table have the general form: "(# lecture + # lab units)".

Not all of the required elements that are addressed by each course listed are necessarily referenced, nor are all courses in the program that address at least some required elements necessarily listed. However, for each required element, one or more courses that we judge to be minimally sufficient to address that required element are listed.
<table>
<thead>
<tr>
<th>Part II: Subject Matter Skills and Abilities Applicable to the Content Domains in Science</th>
<th>Table II.1.1-1.3</th>
<th>Courses</th>
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</thead>
<tbody>
<tr>
<td>1.1 Question Formulation</td>
<td>1.2 Planning a Scientific Investigation</td>
<td>1.3 Observation and Data Collection</td>
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<tr>
<td>(a) (b) (c) (d)</td>
<td>(a) (b) (c) (d)</td>
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<td>F-68 F-69 F-80 F-80</td>
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<td>F-70 F-75 F-80 F-80</td>
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Courses:

- BIOL 230: Intro Biology I (3+2 units)
- BIOL 240: Intro Biology II (3+2 units)
- CHEM 115: Gen Chem I (3+2 units)
<table>
<thead>
<tr>
<th>Part II: Subject Matter Skills and Abilities Applicable to the Content Domains in Science</th>
<th>Table II.1.4-1.5</th>
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<tr>
<td>Skill and Ability Domains in Science</td>
<td>1. Investigation and Experimentation</td>
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- F-68: Fall 1968
- F-73: Fall 1973
- F-75: Fall 1975
- F-90: Fall 1990
- 129: 129th Week
- F11 to F16: From Fall 11 to Fall 16
<table>
<thead>
<tr>
<th>Courses</th>
<th>2.1 Scientific Inquiry</th>
<th>2.2 Scientific Ethics</th>
<th>2.3 Historical Perspectives</th>
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<td>C-14</td>
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<tr>
<td>Courses</td>
<td>3.1 Science Literacy</td>
<td>3.2 Diversity &amp; Society</td>
<td>3.3 Science Technology &amp; Society</td>
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Appendices for Standards:

Standard 15: Depth of Study in a Concentration Area
Table 15A: Extended (Depth) Program of Study in Biological Sciences

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<th>Course</th>
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<th>Semester Units</th>
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<td>Introductory Biology I [lecture (3) and lab (2)]</td>
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<td>BIOL 240</td>
<td>Introductory Biology II [lecture (3) and lab (2)]</td>
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<td>BIOL 355</td>
<td>Genetics</td>
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<td>BIOL 337</td>
<td>Evolution</td>
<td>3</td>
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<tr>
<td>BIOL 652</td>
<td>SFSU Science Partners in K-12 Schools</td>
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<td>BIOL 525, 612 or 630</td>
<td>Physiology course (plant, human, or animal)</td>
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<td>BIOL 350, 401, 435, 450, 524, or CHEM 349</td>
<td>Cell Biology course</td>
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<td>BIOL 351, 402, 436, 526, 613, or 631</td>
<td>Cell Biology or Physiology Lab</td>
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<td>BIOL 482, 529, or 585</td>
<td>Ecology (general, plant, or marine) [lecture (2 or 3), field and/or lab (2 or 1)]</td>
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<td>CHEM 115¹</td>
<td>General Chemistry I [lecture (3) and lab (2)]</td>
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<td>CHEM 215/216</td>
<td>General Chemistry II, Gen Chem II Lab</td>
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<td>CHEM 130</td>
<td>Organic Chemistry</td>
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<td>PHYS 121/122¹</td>
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<td>Total Biological Sciences Depth Program Units:</td>
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Footnotes:
1. CHEM 115 and PHYS 111/112 and 121/122 also satisfy core (breadth) program requirements.
15A.1 Encompasses the biological science requirements for subject matter knowledge and competence on pages ___ through ___, which are aligned with the K-12 student academic content standards.

Tables 15A.1.1-1.4, 15A.1.5-2 and Table 15A.3-4 on the following pages summarize how the extended (depth) program in biological sciences addresses the required elements for subject matter knowledge and competence.

Each entry in the tables is a reference to page(s) in an appendix. The references have the general form: “Letter-page#”. For example, “B-8” refers to page 8 in Appendix B.

Semester unit values for each course listed in the left-hand column of each table have the general form: “(# lecture + # lab units)”.

Not all of courses in the biological sciences program that address required elements are listed in these tables. However, for each required element, one or more courses that we judge to be minimally sufficient to address that required element are listed. Other courses in the program (not listed) build additional depth of knowledge for subsets of required elements. For example, BIOL 355 (Genetics) addresses all required elements in Domain I.1.1, 1.2, 2.1-2.5, 3.1, and 3.3, and also I.3.2.c. BIOL 337 (Evolution) addresses Domain I.2.2.a, 2.2.c, 2.4.b, and all required elements in 3.1, 3.2 and 3.3. Similarly, options to meet the Cell Biology and Physiology program course requirements address required elements I.1 and Ecology course options address required elements I.4.
<table>
<thead>
<tr>
<th>Biology Courses</th>
<th>1.1 Prok &amp; Euk Cells</th>
<th>1.2 Cellular Reproduction</th>
<th>1.3 Plant and Animal Cell Anatomy and Physiology</th>
<th>1.4 Integration and Control of Human Organ Systems</th>
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</thead>
<tbody>
<tr>
<td>BIOL 230: Intro Biology I (3 + 2 units)</td>
<td>B-8&lt;br&gt;B-10&lt;br&gt;B-13&lt;br&gt;B-25&lt;br&gt;B-29</td>
<td>B-8&lt;br&gt;B-10&lt;br&gt;B-13&lt;br&gt;B-25&lt;br&gt;B-26</td>
<td>B-8&lt;br&gt;B-21&lt;br&gt;B-25&lt;br&gt;B-25&lt;br&gt;B-25</td>
<td>B-8&lt;br&gt;B-24&lt;br&gt;B-11&lt;br&gt;B-32&lt;br&gt;B-8</td>
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<td>BIOL 240: Intro Biology II (3 + 2 units)</td>
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<td>B-17&lt;br&gt;B-28&lt;br&gt;B-32&lt;br&gt;B-18&lt;br&gt;B-20&lt;br&gt;B-35</td>
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<tr>
<td>Biology Courses</td>
<td>1.5 Physiology of the Immune System</td>
<td>2.1 Chrom. Structure &amp; Function</td>
<td>2.2 Patterns of Inheritance</td>
<td>2.3 Gene Expression</td>
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<tr>
<td>Biology Courses</td>
<td>3.1 Natural Selection</td>
<td>3.2 Evolutionary Patterns</td>
<td>3.3 Mechanisms for Speciation</td>
<td>3.4 History &amp; Origin of Life</td>
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15A.2 Encompasses the subject matter skills and abilities applicable to the content domains in science as stated in the SMR Part II section on pages ___ to ___.

Tables II.1.1-1.3, II.1.4-1.5, II.2, and II.3, which appear under Required Element 14.2 of Standard 14 in this document, summarize how the program addresses the required element of subject matter skills and abilities for the content domains of science. The courses listed in those tables are all part of the core (breadth) program and are therefore common to all four extended (depth) studies programs described in this document.
Appendices for Standards:

Standard 16: Laboratory and Field Experiences
Principles of Enzymatic Analysis
Animal Physiology, Biol 631, Spring 2008

Spectrophotometric (colorimetric) analysis of enzymatic activities: basic considerations. One of the most convenient ways to measure the activities of enzymes is by recording the change in Absorbance (formerly often referred to as Optical Density (OD)) of a solution during the enzymatically catalyzed conversion of substrate to product. This type of assay is termed a colorimetric measurement, to indicate that the color (= absorbance spectrum) of a solution changes during a reaction. In many enzymatic reactions, the substrate and product have distinctly different absorbance spectra, such that by monitoring the Absorbance of the solution at an appropriate wavelength, one can obtain a continuous, real-time measure of the disappearance of substrate (= appearance of product). In cases where the absorbance spectra of the substrate and product are not different (at least at wavelengths that are convenient to measure), one can often use a coupled reaction system, which involves using additional reagents that react with the product of the enzymatic reaction to give a change in Absorbance.

For example, the enzymatic reaction catalyzed by the malate dehydrogenase (MDH) enzyme is below to illustrate the simplicity and application of colorimetric assays. The MDH reaction will be followed in the direction of malate production:

\[ \text{Oxaloacetate} + \text{NADH} + H^+ \rightarrow \text{Malate} + \text{NAD}^+ \]

The conversion of oxaloacetate to malate, in and of itself, does not provide a useful basis for a colorimetric assay. However, the conversion of NADH to NAD\(^+\) does provide a very convenient means for following this reaction. As illustrated below, the absorbance spectra of NADH and NAD\(^+\) are very different near 340 nm (nanometers). NADH absorbs very strongly, whereas NAD\(^+\) is virtually non-absorbing ("colorless"). Thus, as NADH is converted to NAD\(^+\) (or, in other words, as oxaloacetate is converted to malate), the Absorbance of the solution decreases.

This basic type of colorimetric reaction allows any type of pyridine nucleotide (NADH or NADPH)-coupled reaction to be studied by monitoring the change in Absorbance at 340 nm. Most dehydrogenases, such as lactate dehydrogenase (LDH), glyceraldehyde-3-phosphate dehydrogenase, and isocitrate dehydrogenase, can be measured in this way. Furthermore, pyridine nucleotide-coupled dehydrogenases may prove to be useful reagents for studying enzymes that are not directly linked to the reduction or oxidation of NAD(H) or NADP(H). For example, the glycolytic enzyme pyruvate kinase (PK) generates pyruvate from phosphoenolpyruvate (PEP). Although there is no conveniently measured change in Absorbance during this conversion, by adding lactate dehydrogenase and NADH to the assay medium, one can couple the disappearance of PEP to the oxidation of NADH, as is shown below:

![Figure 1. Absorbance spectra of NADH (or NADPH) and NAD\(^+\) (or NADP\(^+\)). Note how a wavelength of 340 nm allows maximal resolution of the extent of interconversion of oxidized and reduced pyridine nucleotides](image-url)
Pyruvate Kinase (PK): $\text{PEP} + \text{ADP} = \text{Pyruvate} + \text{ATP}$

$\text{LDH}: \text{Pyruvate} + \text{NADH} + H^+ = \text{NAD}^+ + \text{Lactate} \Rightarrow \Delta A_{340}$

A large number of enzymatic reactions which themselves do not yield a change in Absorbance can be measured with such coupled assay systems. Assays of the $\text{Na}^+/\text{K}^+\text{ATPase}$ also work as a coupled assay using PK and LDH, but in this case the limiting reagent is the ADP (for PK) as this compound must be produced by the activity of the $\text{Na}^+/\text{K}^+\text{ATPase}$ in order for the reaction to proceed.

$\text{ATPase: } \text{ATP} + H_2O = \text{ADP} + P_i$

Pyruvate Kinase (PK): $\text{PEP} + \text{ADP} = \text{Pyruvate} + \text{ATP}$

$\text{LDH}: \text{Pyruvate} + \text{NADH} + H^+ = \text{NAD}^+ + \text{Lactate} \Rightarrow \Delta A_{340}$

Another type of strategy commonly used in colorimetric analysis is to react the colorless product of a reaction with a chemical that yields a colored product. For example, citrate synthase (CS), a Krebs citric acid cycle enzyme that is a good indicator of a tissue's capacity for aerobic generation of ATP, yields Coenzyme-A (CoA) as a reaction product. The $\text{SH}$ group on CoA is chemically reacted with dithionitrobenzoic (DTNB) acid, to yield a colored (yellow) product (maximal Absorbance at 412 nm). [Note: CS is a bit more complex and a much more costly enzyme (because of time and reagents).]

**Quantification of activity: the Lambert-Beer Relationship.** These, then, are the basic concepts underlying colorimetric measurements of enzymatic activity. We now consider the quantitative foundations of colorimetric analysis, namely, the physical relationships that underlie the linkage between Absorbance and concentration. The analysis below is a relatively simple and streamlined version of the story. Appendix I will provide you with some more basic and detailed information about the physical principles that underlie both absorbance and fluorescence spectrometry.

You all have heard of the Lambert-Beer Relationship:

$$\text{Absorbance} = \text{Extinction coefficient} \times \text{Concentration} \times \text{length of light path}, \text{or}$$

$$\text{Absorbance} = \varepsilon \times C \times l$$

The extinction coefficient ($\varepsilon$) is a characteristic of the chemical in question, and often is expressed as a molar extinction coefficient. For NADH, $\varepsilon$ is $6.22 \times 10^3 l \times \text{mol}^{-1} \times \text{mm}^{-1}$ at 340 nm. You will gain experience using $\varepsilon$ and changes in Absorbance to get units of enzyme activity (see below: Quantifying enzyme activity: International Units). The light path used in many enzymatic analyses, including the MDH assays we will conduct, is 1 cm, so the Lambert-Beer Relationship commonly reduces to: $\text{Absorbance} = \varepsilon \times C$.

As is evident from this simple equation, changes in the concentration ($C$) of the light absorbing compound will lead to a corresponding change in Absorbance that, in turn, provides a quantitative index of the enzyme's activity. To employ the principles inherent in the Lambert-
Beer: Relationship to gauge the amounts of a particular enzymatic activity in a tissue, we need to ensure that we can back-calculate from the measured change in Absorbance in our cuvette to the amount of activity likely to occur within the tissue prior to homogenization. We need to be comfortable with doing dilutions and calculating their effects.

Note: In saying that we want to back-calculate to the “amount of activity present in the tissue,” we are making a somewhat misleading statement. In cells and tissues, the concentrations of substrates are almost always well below saturating levels (“saturation” refers to a situation in which addition of more substrate fails to lead to an increase in reaction velocity). In our assay cocktails, we try to maximize signal by using high concentrations of substrate, that is, we strive to get close to saturation with respect to substrate. Activity levels measured in vitro with such protocols thus do not give us an indication of the “amount of activity present in a tissue,” but rather an estimate of how much activity would occur if the tissue contained un-physiologically high concentrations of substrate.

Are we mis-designing our assay media, then? Not really, for as stated, we want to detect the activity as effectively as possible, and using high concentrations of substrates allows us to do this. The data we obtain provide good comparative information, even though rates are higher in vitro (other things like enzyme stability being equal) than they would be in vivo.

Quantifying enzyme activity: International Units per gram of tissue. Before we consider the steps that must be taken to work backwards from a solution in a cuvette to the tissue that was the source of our enzyme, let’s consider how best to normalize our enzymatic activities. What is meant by normalize in this context? Here, we refer to the need to anchor our measured rates of change in Absorbance to some common denominator, such that we can carry out repeated measurements on different tissues and arrive at a data set that is internally consistent and useful for comparisons with other data sets. There are a number of ways to normalize enzymatic activities, and each has its pro’s and con’s in terms of convenience, expense, and, most importantly, biological relevance.

Activities per gram fresh (=wet) weight of tissue often are used. There are two reasons for choosing this mode of normalization. First, as should be apparent, this is an easy and cheap way to work! All one needs to do is to accurately weight the initial tissue sample used to prepare the homogenate and, then, keep track of the dilutions throughout the steps of the protocol: (i) dilution in the initial homogenate (often 1:4 or 1:9, yielding 5X and 10X dilutions; see below), (ii) any subsequent dilutions to adjust the activity of the enzyme downwards to a value that can be measured conveniently (see below), and (iii) the dilution entailed in adding a small amount of the homogenate to the cuvette in which the activity measurement occurs. Secondly, normalization to gram wet weight is a realistic type of normalization in that it tells us how much enzymatic activity is likely to occur in a given mass of tissue. For instance, if we determine the amount of enzymatic activity in a gram of skeletal muscle, we can dissect out the entire musculature, determine its mass, and, then, calculate how much enzyme power is in the entire tissue. It’s always nice when the laziest approach possible is also the most appropriate approach!

Activities normalized to units of protein. Some people prefer to express enzymatic activities in terms of amount of protein in the sample (homogenate or supernatant). To some, this normalization appears more “rigorous” in that it involves precise chemical analysis rather than mere weighing of a tissue sample on a balance. In fact, if one can quantitatively extract the proteins from a tissue, enzymatic activities normalized to protein content will provide a
quantitative estimate of how this particular enzyme’s activity compares to the total levels of all proteins. If an enzyme is changing in concentration due to some environmental or physiological factor, whereas total protein concentration is remaining essentially constant, then normalization to protein may tell us something about how a specific protein is changing. However, if our interests are in determining how enzymatic activity is changing in a tissue, regardless of how total protein is changing, then expressing activities in terms of fresh weight is adequate—and a lot faster, easier, and cheaper.

Furthermore, comparability among data sets is apt to be better when normalization is to mass of tissue. There are at least three reasons for this conclusion. First, weighing tissues is easy and accurate; even a complete klutz is likely to do this well. Protein measurements are trickier and more likely to have variation. Second, many different protein assays are in use, and each method is likely to give a slightly different result. This means that comparisons of data gathered in other labs, with other methods, can be difficult. Third, protein measurements will differ depending on whether a crude (uncentrifuged) homogenate or a supernatant is used. If one lab centrifuges its homogenates and a second lab does not, protein-based normalization is not going to yield good comparability between data sets.

In our work, we will express enzyme activity as **International Units (I.U.) of Activity per Gram Fresh Weight (gfw) of Tissue**. What are “International Units”? Again, conventions have been set up to allow comparability of results from study to study, and International Units reflect this goal. International Units are expressed as **micromoles of substrate converted to product per unit time** (typically one minute in most applications). For example, our assay cocktail for MDH starts out with a 150μM concentration (here, μmoles per liter) of NADH. Or, in terms of the amount (μmoles) of NADH in a single ml of solution, we are starting with 0.150 μmoles of NADH. The cuvette holds 2.0 ml, so the total amount of NADH present before the reaction begins is 0.30 μmoles. If all of the NADH were to be oxidized during a one-minute-long reaction, a total of 0.30 μmoles per minute would be converted to NAD⁺. In other words, 0.30 I.U. of activity would be recorded. However, in your assays, the amount of NADH oxidized per minute will be considerably less than 0.30 μmoles, so how will we be going about computing our I.U. of activity?

Because the micromolar extinction coefficient of NADH is 6.22 ml μmol⁻¹cm⁻¹, and the volume of the reaction mixture in the cuvettes you will use is 2.00 ml, we can write the following equation for our MDH assays:

\[
\text{Activity (I.U.)} = \frac{(\Delta\text{Absorbance}/\text{min} \times 2.00)}{6.22}.
\]

This equation yields the number of micromoles of NADH that are converted to NAD⁺ per minute in our 2.00 ml assay cocktail. Thus, if you multiply your change in Absorbance by 0.322 (= 2/6.22) you will obtain the number of μmoles of substrate that were converted to product per minute by the enzyme you added to the cuvette. You’ve obtained International Units of activity. So far so good!

Now comes a slightly more complicated step: converting the μmoles of substrate oxidized per minute (the International Units of activity) into a form that expresses the amount of activity in a gram of fresh tissue. To accomplish this normalization, the easiest route is to calculate how much tissue was added to the cuvette when you started the reaction. Once you’ve determined the number of grams (fraction of a gram in reality) added to the cuvette, all you need to do is divide your I.U. value by this mass of tissue and you’ll have International Units per gram fresh (wet) weight of tissue. Here’s an example of how you go about this task.
Let's assume that the initial homogenate was a 5-fold dilution of the tissue (that is, 1 part tissue by mass was diluted in 4 parts buffer by volume. Note: we will use gram and ml interchangeably here, assuming that a gram of tissue has a volume of 1 ml). Therefore, one ml of homogenate contains only 0.2 g of tissue. Now, let's assume that you start the enzymatic reaction by adding 25μl of homogenate to your assay cocktail. This means that the amount of tissue you're adding to the cocktail is 25/1000ths of 0.2 g, or 0.005 g. To get I.U. per gram fresh weight, all you need to do is to divide your I.U. number (change in absorbance multiplied by 0.322) by 0.005 g.

To summarize, for MDH (or any reaction where the interconversion of NADH and NAD⁺ is monitored) in order to get rates in terms of International Units per Gram Fresh Weight of Tissue (I.U./gfw) use the equation:

\[ \text{I.U./gfw} = \left( \frac{\Delta \text{Absorbance}}{\text{min}} \times 0.322 \right) + \text{g tissue added to cuvette} \]

When a 1:4 dilution is used in making the original homogenate and 25μl of this homogenate are added to the cuvette containing 2.0 ml of cocktail, you can multiply your ΔAbsorbance/min by the factor 64.4 (0.322 + 0.005). If you use homogenates of different dilution or if you add different amounts of enzyme to start the reaction, another factor will need to be calculated. It might be a good mental exercise to calculate these factors for different conditions, e.g., a 1:9 homogenate of which you use only 10μl to start the reaction. (Aren't you glad there's no final exam?)

Enzyme Activity Assay Recipes:

Preparing tissue homogenates. **We will be able to measure activities of multiple enzymes from the same tissue homogenate, assuming that there is adequate tissue volume.** See the “getting one’s feet wet” handout for more information on homogenization. Consider measuring enzyme activity in five tissues: gill, mantle, hepatopancreas, foot, and adductor muscle. The first task is to dissect these tissues from the clams. A good protocol is to have a full ice bucket handy in which you can store your tissues prior to weighing and homogenization. It is convenient to place dissected tissues on to small pieces of tinfoil that is sitting on the ice prior to determining their wet (fresh) weights. Once you have your tissues dissected, carry the ice bucket to the balance room and begin weighing the samples. Tare a fresh piece of weighing paper on the pan of the analytical balance. You will be weighing relatively small amounts of tissues (less than 1 g in most cases), but either the top-loading balance or the analytical balance can give you an accurate weight to 0.01 g. Use a forceps to transfer the tissue sample on to the paper on the pan of the balance. Record the mass of the tissue in your notebook (later, you will use this number to calculate the amount of buffer to be used in making up your homogenate). Place the tissue back on the piece of foil in the ice bucket. Repeat these steps for the other samples of tissue.

Chill your homogenization buffer (50mM potassium phosphate, pH 6.8) in the ice bucket. Have a Pipetman™ available for dispensing the required amount of buffer into the Duall™ homogenizer vessel, which should be chilled in the ice bucket. Let’s say that you’ve dissected out gill tissue and found it to weight 0.63 g. To make a 5X homogenate, you will need to dispense 2.52 ml of homogenization buffer into the Duall™ homogenizer. [The maximum volume of the homogenizers is 7 ml, so if your tissue is much bigger, cut a bit away and reweigh it.] Then, add the sample of gill tissue. You might want to mince the tissue with a scalpel before you place it into the homogenizer. Before the tissue fragments sink to the bottom of the vessel,
insert the pestle and begin homogenizing. You should be able to "work" the tissue between the wall of the vessel and the pestle. Continue homogenizing until the suspension is, well, homogenous, more or less. Keep the homogenizer cold.

After homogenization is complete, transfer the homogenate into 1 or more microfuge (Eppendorf) tubes using a disposable glass pipet (Pasteur pipet) for this purpose. A box of Pasteur pipets and rubber bulbs should be kept nearby. Centrifuge the homogenates - a five minute spin at low speed (e.g., 2000 rpm) in a microcentrifuge will pellet the big "crud" and leave you with a turbid supernatant that is easier to pipet. Getting rid of the insoluble crud is helpful in producing clean, linear traces during the enzyme assay. A faster spin (e.g., top speed 15 min) can be used although it is possible that membrane-bound enzymes will also pellet.

**Measuring enzyme activity.**

**Reagents.** Some of the assay reagents (e.g., imidazole/Cl buffer) are stable for weeks; others need to be prepared fresh each day (e.g., NADH (actually is stable in the dark and cold for several days, but prepare daily to be on the safe side). You will need to prepare fresh each day the assay cocktail for each enzyme, which contains, in addition to the buffer, the substrate (oxaloacetate) and the cofactor or co-substrate, NADH. The recipe is given below for a volume of cocktail of 50 ml. This is enough cocktail for 24 assays of 2.00 ml each. 50 ml of assay cocktail may be enough for a single day's assays. It's better to make up a fresh batch of cocktail every few hours than to make up a large lot and use it over a full day or measurements. NADH and oxaloacetate degrade over time, so keep it dark and cold (wrapped in foil and on ice).

As a rule, you should run duplicate assays (at least) on a sample. If these two assays differ by more than, say, 5%, run a third assay and average the three together for your mean value. Or, if one measurement is clearly an outlier (e.g., you grossly mis-pipetted the enzyme), use an average of two other assays for your mean. With experience, you will find the variation in your assays to decrease and you will develop a sense of what a "good" assay looks like. Rather than generate a lot of prose in an attempt to define "goodness," we will show you during the laboratory exercises how data vary in quality—and how to maximize quality. Below is the recipe for MDH cocktail and assay procedure. Assaying other enzymes follows the same general practices, and their recipes are given below.

<table>
<thead>
<tr>
<th>MDH Cocktail preparation:</th>
<th>Amount needed for 50 ml</th>
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<tbody>
<tr>
<td>Concentration in cocktail.</td>
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<tr>
<td>0.20 M imidazole/Cl buffer (pH 7.0 @ 20°C)</td>
<td>50 ml</td>
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<tr>
<td>0.15 mM NADH</td>
<td>0.0054 g</td>
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<tr>
<td>0.2 mM oxaloacetate</td>
<td>0.0014 g</td>
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</table>

In preparing the cocktail, the following steps are advisable. Add about half the buffer you need to a 50 ml conical bottom screw cap tube. Transfer the dry chemicals into the tube. If any chemical adheres to the weighing paper, rinse the chemical from the paper into the cylinder using a Pasteur pipet filled with buffer. After the dry chemicals have been transferred, add buffer to the top, which is just about 50 ml. Cap the tube and invert it to thoroughly dissolve the
oxaloacetate and NADH. Cover the tube with foil to keep it dark (NADH degrades in the light) and place it into an ice bucket, to keep it cold.

Running an MDH assay.

1. Prepare several cuvettes with 2.00 ml of assay cocktail. We will use disposable plastic cuvettes. Use a Pipetman™ to transfer cocktail into the cuvettes (P1000 set at 1.00ml or P5000 set at 2.00 ml). Put the cuvettes into the water bath, to thermally equilibrate them. We will be running our assays at 25°C, which is close to room temperature. However, because rates of enzymatic reactions rise by about 10% for each 1°C increase in temperature, we need to use accurate temperature control in our assays. Be sure to only handle the cuvettes on the frosted sides – never the side that the light path takes.

2. Dry one cuvette with a kim-wipe and place it into the spectrophotometer’s cell holder. Allow the cuvette to attain thermal equilibrium. This only takes a couple of minutes @ 25°C.

3. Be sure that the spectrophotometer is on and the attached computer is ready to record data (this will be demonstrated to you).

4. Using a P10 or P20 pipettor, add 10-20 µl of your homogenate. Quickly cover the cuvette with parafilm, press the parafilm to the cuvette with the end of your thumb, and rapidly invert several times to mix. This entire process should not take more than 3-4 seconds. Replace the cuvette, close the lid of the spectrophotometer, activate the computer to record, and watch the enzyme do its work. If several pairs of hands are available, this process can be more efficient.

5. After the enzyme has reduced the Absorbance by about one-half, stop recording data. Then, open the lid, remove the cuvette, and place a fresh cuvette into the holder. Dump the spent reagent into a waste container and place the cuvette into a bucket filled with soapy water.

6. Measure the change in Absorbance using the computer software. You will probably find this change not to be linear over the entire time period of the assay. This procedure™ will be demonstrated to you. It’s a high art form.

7. Use the slope of your line (change in Absorbance per minute) to calculate IU per gram fresh weight (gfw). Record in your notebook both the measured change in Absorbance and the IU per gfw numbers.

8. Repeat the above until you have assayed all of your samples 2-3 times.

Assaying the activity of Citrate Synthase (CS)

Recall, CS catalyzes the following reaction in the citric acid cycle:

\[
\text{Oxaloacetate + Acetyl Coenzyme A} \rightarrow \text{Citrate + Coenzyme A-SH}
\]

On the second page of this handout, we discussed how reacting Coenzyme A-SH with DTNB produces a yellow product that we can assay by monitoring an increase in absorbance at 412 nm (in contrast to the decrease in absorbance at 340nm as NADH is converted to NAD+ by MDH). The micromolar extinction coefficient of DTNB is 13.6.
CS Assays

Measuring CS activity is a bit more cumbersome than measuring MDH activity. The major differences are, firstly, that a substantial background activity (color change without added substrate) occurs and, secondly, that the reaction is a lot slower due to the low level of CS activity in some tissues. The background activity is due to the reaction of DTNB with sulphydryl groups on proteins and other compounds in the homogenate. It is necessary to measure the rate of this background activity before adding the oxaloacetate to start the CS reaction. [Why didn't we worry about the background activity in the MDH reaction, e.g., background due to potential oxidation of NADH by other constituents of the homogenate? To be completely thorough, one should always measure background rates (no substrate added). However, from past experience with assaying MDH activity in fish muscle, there is essentially zero background activity, so we have not bothered to make this measurement in the class.]

The protocol for the CS measurements thus involves both similarities and differences relative to the MDH protocol.

1. Preparing the stock cocktail. To a 50 ml graduated cylinder, add the 4 below items, seal with parafilm and mix thoroughly.
   (a) 25.5 ml of assay buffer,
   (b) 3.0 ml of MgCl₂,
   (c) 1.5 ml of DTNB, and
   (d) 3.0 mg of Acetyl CoA.
   * see below for details on each one of these

CS Cocktail Stock solutions:

a. Assay buffer. 50 mM imidazole/HCl, pH 8.2 at 20°C. (store @4°C)

b. MgCl₂. A 15 mM solution prepared in assay buffer (store @4°C).

c. Coupling reagent. DTNB. Weigh out 8 mg of DTNB powder (stored @4°C) and dissolve in 10 ml of assay buffer. DTNB doesn't dissolve too readily, so be sure to mix the tube well until all crystals are dissolved. (Put a piece of Parafilm over the top of the tube and invert repeatedly until all DTNB is in solution.) DTNB will slowly turn yellow during the course of the day. Don't worry about this because you're adding the reagent in large excess. Discard the DTNB solution at the end of the workday.

d. Acetyl CoA. You will be provided with Eppendorf tubes containing 3 mg of acetyl CoA and stored in the freezer. You should add this dry powder to your CS Cocktail mix at the very end. After the CS Cocktail is complete except for Acetyl CoA, pipet up a couple mls of cocktail, using a Pasteur pipette, and add the solution to the Eppendorf tube. Cap the tube and invert it several times to ensure that all of the acetyl CoA has gone into solution. Then, transfer the acetyl CoA to the graduated cylinder with the rest of the CS cocktail. Rinse the Eppendorf tube 1 time with some of the CS cocktail and transfer this liquid back to your CS Cocktail. [Why do we employ this extra careful handling of Acetyl CoA? It's because this reagent is very expensive. By pre-weighting and aliquotting the dry powder we can ensure that a minimal amount of Acetyl CoA is wasted, and by adding it at the end, we safeguard against having to start-over if errors are made in mixing up the cocktail.]

Oxaloacetate. Weigh out 53 mg and dissolve in 10 ml of assay buffer. Place the solution on ice in an ice bucket. This solution is NOT added to your cocktail until after the background rates are measured, so be sure to keep it separate.
2. Prepare several cuvettes by adding 2 ml of cocktail, and place them in the cuvette holder in the water bath.

3. Place one cuvette into the cell holder in the spectrophotometer, and leave it there for a couple of minutes to reach thermal equilibration.

4. Start a CS reaction by pipetting homogenate into the cuvette, as described for the MDH reaction.

5. Start recording data, and allow the reaction to run for a few minutes. The Absorbance should increase slightly during this time. It may go up a little and then plateau.

6. After a few minutes, add 25 μl of oxaloacetate to start the actual CS reaction. The Absorbance should now increase more quickly. The reaction should be linear for several minutes, and run the reaction for at least 4-5 minutes.

7. Terminate the reaction (as above for MDH) and determine the slope of the background rate and the rate after addition of oxaloacetate. Subtract the background rate from the oxaloacetate-dependent rate to get the CS activity.

8. Run a replicate of the assay to get a sense of how much variability exists in your protocol. There should be very little.

9. Calculate the International Units of CS activity per gram fresh weight of tissue, using the appropriate conversion factor for going from Absorbance change per minute to tissue CS activity. Recall that the micromolar extinction coefficient for DTNB is 13.6 (not 6.22 as for NADH). Thus, the change in Absorbance per minute must be multiplied by (2/13.6 or 0.147) to get I.U. values.

10. Repeat ad naseum. Enzyme assays are so fun!

Assaying the activity of Pyruvate Kinase (PK)

Cocktail recipe:
20 ml PK assay buffer: 160 mM Tris/Cl, 200 mM KCl, 20 mM MgSO₄, and 200 μM Fructose BisPhosphate (FBP). Make 500 ml and store at 4°C

0.15 mM NADH
1.0 mM PEP (can make a 10 mM stock solution, store frozen). Add 4 ml.
5.0 mM ADP (make a 100 mM stock solution and adjust pH to 6.8 (ADP is very acidic). Store frozen, and add 2 ml of the stock solution per cocktail.
50 Units/ml LDH coupling enzyme (dilute LDH from stock accordingly)
Add water to 40 ml final volume. Store on ice covered in foil.

Performing this reaction is pretty much just like the MDH reaction.

Na⁺/K⁺ ATPase Activity Assay

Measuring this enzyme is more complicated than the above assays, but is not difficult. One consideration is that there are two highly toxic compounds being used: cyanide and ouabain. Both will kill you if you drink the solutions, so please don’t do this. Be extra careful not to stab anyone or squirt or spill. If spills do happen, alert everyone and clean up the spill as quickly as possible. Your instructor has done hundreds of these assays and has lived to tell the tale. Hopefully (:-)) so will you.
1. Tissue preparation:
Homogenize tissue in the following buffer:
50mM Imidazole/Cl, pH 7.3, 20mM Na₂EDTA, 300mM sucrose. If desired 0.2mM PMSF and 5mM beta mercaptoethanol (BME) can be added for protease inhibiton and reduction of S-S bonds. Centrifuge only to remove large particles (15s at 14,000 RPM is max).

2. Preparation of Assay Mixture

Assay Buffer:
148mM NaCl, 23.7mM KCl, 7.74mM MgCl₂, 35.5mM Imidazole, 0.59 mM EGTA, 0.47mM KCN, pH 7.25 @ 25°C. Store at 4°C.

** What is KCN? Why, it's potassium cyanide. Yes, cyanide. It's toxic. It'll kill you if you drink it. Don't even smell it (yummy almond smell). Why do we put cyanide in this? Because cyanide disrupts processes involved in the oxidative synthesis of ATP (it poisons mitochondrial activity), and thus blocks the activity of any F-type ATPases present in the homogenate (recall, the NaK Pump is a p-type ATPase).

Substrate Stock Solution (prepare fresh each day): 22.5mM Na₂ATP, 4.5mM Na₂NADH, 45mM Phosphoenolpyruvate (Mono cyclohexyl ammonium salt). Dissolve in water.

Ouabain (inhibitor) solution (prepare fresh each day): 11.25mM Ouabain in water. *** Not all isoforms of Na⁺/K⁺ ATPase are sensitive to ouabain, and we'll have to see how the clams enzymes respond to the inhibitor. If Ouabain doesn't inhibit the reaction, you may have to prepare a K-free assay buffer to measure rates of the ion pump with and without K present. To do this, will need to replace KCl with NaCl, and KCN with NaCN.

Assay Cocktail:
   a. Mix 1 parts Assay Buffer with 1 part Substrate Stock Solution.
   b. Measure pH and correct to 7.25 with HCl or NaOH.
   c. Add Pyruvate Kinase enzyme to 67.5 U/ml and LDH enzyme to 45U/ml

3. Measurement procedure:
For each assay, you will require 2 cuvettes, one with and one without the Na⁺/K⁺ ATPase inhibitor, Ouabain. The amount of ATPase activity accountable to Na⁺/K⁺ ATPase is the difference in activity between these cuvettes. You can measure the activity in these cuvettes one after the other (recommended at least initially) or can measure the difference in absorbance between the 2 cuvettes by putting one in the reference cell and one in the sample cell. To prepare your cuvettes, mix 2ml Assay Cocktail with either 200 µl water or 200 µl Ouabain solution. Incubate these for at least 3 min at 25°C, and start reaction with 25-50µl of your tissue supernatant (as for MDH assays). The reactions should be linear within the first few minutes. Run for at least 15 minutes, and maybe longer depending on ATPase activity. If ATPase activity is very low, then consider preparing multiple cuvettes and reading each of the cuvettes every minute for 30-45 minutes.
An alternative method for measuring NaK ATPase activity is not to measure the ATP hydrolysis, but to measure the formation of inorganic phosphate (Pi). Below is the protocol for assaying the enzyme using that method:


*** Dr. Stillman’s note: We may adjust volumes for this assay to make it work in 96-well microplate format.***

Solutions:
Homogenizing medium (HM): 0.250 M sucrose (85.6 g/l), 6.00 mM EDTA (1.75) g/l
Albumin standard: 0.500 mg/ml bovine serum albumin (Sigma A-4503)
Phosphate standard: 0.600 mM Na2HPO4 (anhydrous, store desiccated), 0.0852 g/l
Bonling’s color reagent: in a 2000 ml graduated cylinder put:
   a) 1000 ml DH2O;
   b) 64.5 ml conc. sulfuric acid, mix well;
   c) 20.0 g molybdic acid (ammonium molybdate, Sigma M-0878), allow to dissolve;
   d) make to 2000 ml with DH2O and store in fridge.
Add 7.32 g FeSO4 (Fisher I-146)/150 ml of above to make stop solution; use within 4h.

Assay medium - "plus K":
167 mM NaCl (4.88 g/500 ml)
50 mM KCl (1.864 g/500 ml)
33.3 mM imidazole (Sigma I-0250; 1.135 g/500 ml)
Adjust to pH 7.20 w/HCl

Assay medium - "minus K":
217 mM NaCl (6.34 g/500 ml)
33.3 mM imidazole (1.135 g/500 ml)
1.67 mM ouabain (Sigma O-3125, 0.608 g/500 ml)
Adjust to pH 7.20 w/HCl

ATP/Mg "start" solution:
25 mM Na2ATP (Sigma A-5394, "vanadium-free"; 0.392 g/25 ml)
50 mM MgCl2.6H2O (Sigma M-9272; 0.254 g/25 ml)
Adjust to pH 7.20 by adding crystalline imidazole with stirring (pH is <3 without imidazole!) and store frozen in 3-5 ml aliquots in flint vials or plastic tubes. Once thawed and used in an assay, do not refreeze and/or reuse this solution.

Assay:
In this assay crude homogenates of gills or other ion transport tissues are prepared and the liberation of phosphate ion from ATP by the action of the Na, K-ATPase is measured in vitro. The assay has four parts: 1) preparation of the homogenates, 2) homogenate ATPase assay, 3)
homogenate protein assay and 4) calculations. The results are expressed as micromoles phosphate liberated per mg protein per hour. It is also possible to use this assay with membrane vesicles prepared by centrifugation of crude homogenates (see Holliday, 1985 for details).

1. Homogenate preparation:
Excise gills and rinse in ice-cold homogenizing medium using a volume (in microliters) of HM equal to 100-200 times the mass (in mg) of the tissue. NOTE: it is particularly important to avoid contaminating the gills with digestive juices from the crab's stomach or hepatopancreas when excising gills - a small amount of this fluid will ruin the assay because it is chock-full of proteolytic enzymes. Homogenize in a ground glass homogenizer (I prefer Kontes "Duall") for 20-40 strokes (use the same number of strokes for each homogenate). Homogenize just enough to eliminate any pieces of gill lamellae which remain. Store homogenates on ice until assayed and assay as soon as possible to minimize loss of enzyme activity.

2. ATPase assay:
Na, K-ATPase activity is measured as the difference between phosphate liberated in an assay medium with K+ present at optimal concentration and a medium without K+ (and with 1 mM ouabain, a specific inhibitor of the enzyme). "Other" or "residual" ATPase activity (Mg, Ca, HCO3 and other ATPases) may also be measured if a third assay tube, the homogenate blank is included. The homogenate is added after the reaction is stopped in the third tube and this allows calculation of phosphate present in the homogenate and/or released by non-enzymatic hydrolysis of ATP.

Make fresh "stop" solution as noted above and keep it on ice until needed for the assay. Do not use this solution more than 4 hours after the FeSO4 is added.

For each homogenate prepare two 10 x 75 mm flint glass test tubes (three if "other" ATPase is to be measured); the first is for the "+K" medium and the second is for the "-K" medium. For each batch of test tubes (no more than 60 tubes total if 15-sec intervals are used between tubes - see below) place two 5ml tubes in the test tube rack; these are for the blank and standard solutions.

Pipette 200 microliters of the proper medium into each tube, alternating "+K" and "-K" tubes for each homogenate in the rack. This will leave you with a pair of tubes for each homogenate.

Pipette 1.00 ml of DH2O into the 5ml blank tube and 1.00 ml of phosphate standard solution into the 5ml standard tube; these tubes get no homogenate or Mg/ATP solution during the assay.

Pipette 66.7 microliters of the appropriate homogenate into each pair of tubes (one pair of tubes for each homogenate) and mix each tube on the Vortex Genie. Place the test tube rack with the tubes in the water bath at 30 deg C for 5 min for thermal equilibration.

At 15-second intervals (12, 10 or 8 sec when you are adept) start the reactions by adding 66.7 microliters of the Mg/ATP "start" solution, vortex the tube and return it to the rack in the water bath. After exactly 15 min begin adding 1.50 ml aliquots of the ice-cold "stop" solution to each tube in the same order and time interval (15, 12, 10 or, if you dared, 8 sec) that you added the "start" solution, vortexing each tube before putting it back in a different rack out of the water bath. If this is done properly, each tube will have incubated exactly 15 minutes. When you have "stopped" all of the reaction tubes, add 4.50 ml of the stop solution to each blank and standard tube (this allows for extra blank and standard solution if needed for blanking or extra standard
readings), vortex them, too, and allow 20 min for color development. Read OD700 of each tube against the blank in a spectrophotometer.

3. Homogenate protein assay:
Set up duplicate 10 x 75 mm flint glass tubes for each homogenate and 5 ml tubes for the blank and standard solutions. Pipette 10 microliters of each homogenate into the appropriate pairs of tubes and pipette 20 microliters of dH2O into the blank tube and 20 microliters of the protein standard solution into the standard tube. Add 0.5 ml of diluted BIO-RAD protein assay concentrate to each tube and vortex. Allow color to develop for 20 minutes, but not more than one hour.

Measure OD595 against the blank for each tube and average the values for each pair of tubes.

4. Calculations:
Na, K-ATPase enzyme specific activity is calculated for each homogenate as follows:

\[
\text{OD595 protein std. / OD595 homogenate X}
\]
\[
\{[(+K OD700) - (-K OD700)] / PO4 std. OD700\} X 23.96
\]

The 23.96 is a constant derived as follows:

\[
\frac{[0.600 \text{ micromoles PO4 / ml X 0.333 ml reaction volume X 60 min / h}]}{[15 \text{ min X 0.0667 ml homogenate X 0.500 mg protein per ml}]}
\]

The units are micromoles PO4 per mg protein per hour.

Bibliography.

There are a number of good books that provide a general overview of how to perform enzymatic analysis. Below, a few of these volumes are listed. For the particular enzyme you wish to study, it is best to consult the original literature to learn how the particular enzyme was assayed, in the particular tissue and organism that served as the source of material. If you want to gather data that can be compared with those from other studies, then it is imperative to try to reproduce the methods of the relevant, earlier studies as closely as possible. This rule includes measurement temperature, which has such a large effect on reaction rates.


Appendix I: Principles of spectroscopy and spectrophotometry—all of the physics you’re likely to need to know.

UV-Visible Spectrophotometry. A large number of techniques, generically known as methods of “spectroscopy,” involve the study of the interactions between matter and electromagnetic radiation. (Mass spectroscopy is something of a misnomer in this sense.) Among the many spectroscopic methods used by biologists, techniques that involve the absorption of ultraviolet (UV), visible (to humans), and infrared (IR) radiation by matter are of critical importance in characterizing compounds and in estimating their concentrations. Studying changes in color intensity (colorimetry) is perhaps the most useful type of biochemical assay procedure.

To understand why UV-visible spectrophotometry is so useful, it may be helpful to review some of the basic physical principles involved in the absorption of radiation by matter. In particular, two phenomena should be appreciated. One is the nature of electromagnetic radiation, and the other is the nature of the changes that occur in matter when this radiation interacts with the atoms or molecules of interest to the investigator.

The energy spectra given on the next page illustrate some of the fundamental properties of the electromagnetic spectrum. As you can see, UV-visible spectrophotometry involves only a narrow window in the complete energy spectrum. Most biochemical techniques of usefulness to us involve radiation with wavelengths between approximately 200 nm (below this wavelength water absorbs very strongly and limits what one can measure in aqueous systems) to 800 nm. This range of wavelengths encompasses the spectral sensitivity of our visual systems, which runs from approximately 400 to 700 nm.

You are all familiar with the basic relationships between the frequency (ν) of radiation (sec⁻¹) and the energy (E) of that radiation:

\[ E = h\nu \]

where h is Planck’s constant. Frequency, in turn, is related to wavelength (λ) (in cm) by the equation:

\[ \lambda = \frac{c}{\nu} \]

where c is the speed of light. Suffice it to say that shorter wavelengths (higher frequencies) of radiation pack a greater punch than longer wavelengths. As the spectra on the next page show, shorter wavelengths lead to greater strengths of perturbation of the atoms and molecules being irradiated.

What does the energy in the UV-visible region of the electromagnetic spectrum do? At the wavelengths used in UV-visible spectrophotometry, the chief effect on the irradiated atoms and molecules involves the outer orbital (“valence”) electrons. These electrons may be involved in covalent bonding, so radiation in the range of approximately 200 to 800 nm can affect the bonds of irradiated molecules. Most commonly, however, in the analytical procedures we use in the biochemistry, these electrons absorb energy and later emit this energy, without the molecule of interest undergoing any change in structure.
Diagrammatic representation of the electromagnetic spectrum.

### TABLE 1: Transitions and associated spectroscopic techniques

<table>
<thead>
<tr>
<th>Energy term producing transition</th>
<th>Region</th>
<th>Usual defining quantity and units</th>
<th>Associated spectroscopic techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer orbital electrons</td>
<td>UV and visible</td>
<td>Wavelength (nm)</td>
<td>UV and visible spectroscopy Optical rotatory dispersion Circular dichroism Fluorescence spectroscopy IR spectroscopy Raman spectroscopy EPR (ESR) Spectroscopy</td>
</tr>
<tr>
<td>Molecular vibrations and rotations</td>
<td>IR</td>
<td>Wavenumber (cm⁻¹) or frequency (s⁻¹ or Hz)</td>
<td></td>
</tr>
<tr>
<td>Electronic orientation</td>
<td>Microwave (applied field)</td>
<td>Frequency (Hz)</td>
<td></td>
</tr>
<tr>
<td>Nuclear orientation</td>
<td>Radiowave (applied field)</td>
<td>Frequency (Hz)</td>
<td>NMR Spectroscopy</td>
</tr>
</tbody>
</table>
Table 1 on the previous page also lists the effects of radiation with wavelengths higher or lower than UV-visible radiation.

Quantum mechanics tells us that the absorption of energy by atoms and molecules can occur only in discrete units, quanta or photons. Although the absorption characteristics of molecules may seem smooth at the macroscopic level, the actual absorption events involve only discrete energy packets, for instance, light quanta in the UV-visible range, and these events lead to discrete, well-defined shifts in the energy levels of electrons. This pattern of energy absorption is illustrated below. Only the discrete energy jumps shown can occur in this system. Thus, the absorption of energy can occur only if the energy interacting with the atom or molecule has energy equal to nhν, where n is an integer. For the first jump to occur in the above case, the minimal energy absorbed has to be a quantum of energy sufficient to raise the system from the ground state to the first excited state. Higher energy photons (shorter wavelength) can drive the system to higher excited states, as shown. When several excited states are possible, a multi-peaked absorbance spectrum might be found, as shown.

You might be curious as to why absorption spectra are so smooth in appearance, and are not simply sharp lines that occur where the radiation of the right energy exists. The answer to this question is complex, and we can’t delve into this area in any depth. However, a few basic points should be mentioned. One factor giving broad absorption bands instead of sharp lines of negligible width is the existence of different vibrational energy levels at each energy state. Each electronic energy level is subdivided into a large number of vibrational levels. Thus, for each major energy transition there is a large family of subsidiary transitions that vary slightly in wavelength absorption maxima. Limitations in equipment design limit the extent to which the so-called “fine structure” of spectra can be measured.

What becomes of the electromagnetic energy that is absorbed by atoms and molecules? It’s obvious that the absorbed energy doesn’t remain with the electron indefinitely, otherwise the solution under study in the spectrophotometer would cease absorbing light at the excitation wavelength. The absorbed energy is emitted via a number of relaxation processes. One type of relaxation process involves the emission of light, a process that is very useful to biochemists, for instance, in fluorescence spectroscopy. Loss of energy from excited electrons also can involve a loss of thermal energy. A third mechanism of relaxation can lead to photochemical reactions; recall that the outer orbital (valence) electrons that are excited by the absorption of energy are the electrons involved in covalent bonding. The flip side of this type of relaxation process is the phenomenon of chemiluminescence, in which light is emitted during chemical reactions that involve alterations in the energy states of valence electrons. In chemiluminescence, light emission is not a process of re-emission of absorbed light, but rather the emission of de novo
produced light. Fluorescence is the re-emission of absorbed light energy at a wavelength different from that of the excitation radiation. Phosphorescence also involves re-emission of absorbed radiation, but at a slower rate than found in fluorescence.

**Appendix 2: Choice of a proxy—Which enzymes (or other biochemical factors) are best suited for my purposes of obtaining a quantitative index of physiological state?**

Several general guidelines pertain in making the decision as to the best enzymatic (or other) proxy to use in evaluating physiological state. First, and most obviously, choice of proxy will be determined in part by the particular physiological state that is of interest to you. If, for example, one is interested in determining the capacity of an organism for synthesizing proteins, the most appropriate proxy might be the ratio of ribonucleic acid (RNA) to deoxyribonucleic acid (DNA). If one is interested in getting an indication of the capacity of a tissue for generating ATP, then one or more enzymes involved in ATP-generating pathways may be examined. [Note that one need not measure an enzyme that is directly involved in synthesis of ATP, for example, pyruvate kinase (PEP + ADP = pyruvate + ATP). If an ATP-generating pathway is being up-or down-regulated, most, if not all, of the enzymes may vary together in activity, at least as a rough generalization. Therefore, to examine the effects of some factor, for instance, dietary level, on a tissue’s capacity for generating ATP, it is adequate to measure any enzyme within an ATP generating pathway whose activity varies with ATP production. Thus, one can choose the easiest and cheapest to measure enzyme, regardless of whether it catalyzes a reaction in which ATP is produced.] It may turn out that a particular biochemical characteristic like the activity of an enzyme within an ATP-generating pathway provides a good proxy for all sorts of energy-requiring processes, including protein synthesis, growth, and locomotory capacity. You may discover, for example, that the RNA:DNA ratio and the activity of MDH co-vary.

A second consideration, as just implied, is the convenience and expense of the proxy. If any enzyme within an ATP-generating pathway can be used as a proxy, then it is appropriate to use an enzyme that is easiest and least expensive to work with. Several criteria enter in at this point. One is the stability of the biochemical system you wish to use. Some enzymes hold up well during frozen storage, especially if specimens are kept in ultra-cold (−70°C to −80°C) deep freezes. Other enzymes denature. As a general rule, enzymes of ATP-generating pathways are fairly resistant to denaturation during freezing and cold storage, but you need to ascertain the stability of your study enzyme for each experiment. Enzymes that are highly stable and abundant are better than labile, low-activity enzymes.

A third criterion concerns not the biochemical proxy itself, but rather the tissue source you will use. Some tissues are better than others because (i) they are more abundant and easier to work with, and (ii) they may be more indicative of the state of the organism than another tissue.
Biol. 482  
Due Monday, March 1

Size and Age Structure of Sand Crabs

We sampled sand crabs (*Emerita analoga*) at Linda Mar Beach on February 18, 2004, noting the sex and size of each sand crab captured. Crabs were sampled by the bucket, and approximately equal numbers of buckets were sampled at each of three levels on the shore. The same sort of sampling was done at Linda Mar Beach each year from 1993 to 1997 and in 2001-2003. The results of sampling for all years are shown in the attached tables and figures. The tables (one for each sex) show (for each year) the number of buckets sampled, the number of crabs of each size, and the number of crabs per bucket sampled. The number of crabs per bucket is a measure of the density of the crabs, and standardizes the catches from each year for the number of buckets sampled. This catch rate will be used to compare numbers of crabs in the calculation of mortality rates. The figures show the length frequencies of the male and female sand crabs. Based on these data, you will (a) designate age groups on the basis of size, (b) estimate mortality and relative growth rates for different age groups of males, and (c) compare growth and mortality rates of males and females.

*Emerita* is an anomuran crustacean. Females normally bear eggs in late fall and early winter; the eggs hatch into larvae that drift in the plankton until late winter and spring. At the conclusion of their planktonic phase, young sand crabs settle on the beach and metamorphose into juveniles. Between the time of settlement and the beginning of the next reproductive season, sand crabs of both sexes eat and grow. Most males become sexually mature during their first winter, while females normally become mature in their second winter.

Your assignment (due Monday, March 1) is to analyze the data and answer some questions about the results and their interpretation. This is not a formal report; you will just present the calculations, etc., and write out answers to the questions. For series of questions (like in #3 below), you can write a paragraph that summarizes the answers.

1. Assigning ages to female sand crabs. For female sand crabs caught in 1993 through 1997 and 2001 to 2004, use the size frequency histograms to distinguish modes of size that might correspond to age classes. Try to distinguish between age classes by finding low points between modes of size. You can even allocate half the crabs at a size corresponding with a low point to each of the adjacent size modes. Growth rates may have changed slightly among years, but you should try to assign similar-sized crabs to the same age group over the years. For example, there is usually a size mode around 14-17/18 mm. This group should always be assigned the same age. One problem is the tail of small individuals that appears in 1993, 1995, 2001 and, to a smaller extent, in 1994. These could be misidentified males, or a smaller group of females that are the same age as the larger mode to the right (perhaps those born later in the same year). You can decide one way or the other, or try the calculations both ways (including or not including the smaller sand crabs within the one year old group), but they do not constitute a separate age group. Similarly, you may have trouble distinguishing a third year class; make a decision and explain your reasoning, or try two alternatives. In any case, there are two clear year classes (one and two year olds), in all years, and perhaps a small group of three year olds (and maybe four year olds!)
in some years.

For each year, then, make a table showing the size limits for each age group, the total number of female sand crabs in each age group, and the total catch rate (catch per bucket) for each age group. Discuss any problems you had assigning ages.

2. Assigning ages to male sand crabs. How many age groups of males seemed to be present in each year?


   A. Females. Assuming that our collections fell about on the birthdays of these animals, estimate \( p \), (the probability of surviving from age \( x \) to age \( x+1 \)) for \( x = 1 \) (and \( x = 2 \), and \( x = 3 \), if possible) for females. You need to use the catch per bucket of sand crabs to make these calculations (to correct for the different sampling effort between years). Do this both as individual static life-table estimates for each year from 1993 to 1997 and for 2001 to 2004, and as cohort life-table estimates for 1993-1997 and for 2001-2003. How do the static and cohort estimates agree? Which do you think are better, and why? How did mortality rates change from year to year?

   B. Males. You probably won't be able to estimate \( p \), for males (because they usually do not survive to age 2), but you can try to determine whether or not males and females survived to their first birthday at equal rates, assuming a 50:50 sex ratio at settlement. (This isn't hard; just think about it: which survived better to their first birthday?) How did the age 0 survival compare between males and females during each year?

4. Growth rates. Use the midpoint or mode of size in an age class to estimate roughly the average size of females in each age group. Assuming that newly settled individuals (0-year olds) are 5 mm long, how does growth rate change with age in females? How does first-year growth rate (i.e., between settlement and first birthday) differ between males and females?

5. Males vs. Females. Reviewing the life history of the sand crabs as described above, what do you think might be responsible for the differences in growth and mortality between males and females?
Community Structure of Kelp-forest Fishes

The purpose of this exercise is to use multivariate statistical techniques to analyze the species composition of kelp forest fishes and how it varies across habitats. You will be reanalyzing data gathered by Ebeling and colleagues (1980) on the fishes inhabiting kelp forests and other nearshore areas off the Santa Barbara mainland and off Santa Cruz Island, 20 miles offshore. Ebeling et al. were interested in determining the degree to which species of fish, and the assemblage of species, responded to differences in habitat. Among other things, they were interested in the effect of kelp per se on the composition of species in an area, relative to the effect of high-relief rocky bottom. Kelp typically grows on rocky bottom, not on sand or other unconsolidated substrates, so the effect of kelp on the composition of fish in an area might be confounded with the effect of rock. Some species of fish do seem to depend on rocky bottom, which supplies shelter, points of visual orientation, and substrate for the growth of attached algae and invertebrates, which in turn shelter prey for kelp-forest fishes. In addition to the density of kelp and the composition of the substrate, other variables that might influence the composition of the fish fauna include bottom depth, the position in the water column (near the bottom, in midwaters, or in the kelp canopy), and the kinds of algae and invertebrates growing on the bottom. To evaluate these factors, Ebeling and colleagues sampled the species composition and abundance of kelp-forest fishes in a variety of combinations of habitats, and employed a multivariate analysis to determine which species seemed to be associated with which habitat characteristics.

Ebeling et al. (1980) sampled fish using underwater movies ("cinetransects"). These were 2.5-min. Super-8 films taken by divers swimming at particular depths and within particular habitats. Divers panned the camera toward fish as they swam the transect, and later the fish were identified and counted by reviewing the films using slow motion and stop action. Divers recorded a number of habitat variables while conducting the transects (such as water depth, position in the water column, etc.), and additional habitat variables (such as kelp density and substrate type) were recorded while reviewing the films. See the attached sheet (p. 7) describing the habitat variables and their scoring. Another sheet (pp. 8-9) describes the 27 species of fish that occurred in three or more of the 175 transects made. Summaries of the counts of species in the transects are tabulated, but for only the 173 transects that contained fish (p. 10). The transect data are contained in two computer files. One contains the environmental data (filename = kelpenv.wkl), and the other contains the fish counts (filename = kelpfish.wkl). The fish counts are presented in the summary table as untransformed values, but the data in the computer file are log transformed (each value is the \log_{10}[count+1]). The computer files are stored in the subdirectory \pcordwin\kelp on the AST laptop computers.

Ebeling et al. analyzed their data using a multivariate technique known as factor analysis. Like most such techniques, factor analysis detects sets of variables that tend to vary together, and summarizes these covarying sets of variables as "factors." In their factor analysis they used not only counts of individual species, but composites of counts (such as total number of fish counted; and total number of species), and environmental variables as well. This produced five "factors", most of which were most strongly influenced by habitat variables, but also included the species
of fish that seemed to be associated with particular habitat variables. See the original paper and the handout for a summary of the factors.

In retrospect, the analysis performed by Ebeling et al. may have not been the most optimal for detecting relationships among fish species per se. First, factor analysis and related specific techniques of multivariate analysis are subject to problems when the relationships between species are not linear (that is, the abundance of one species does not increase or decrease linearly with the abundance of another species). Changes in species composition along environmental gradients are often nonlinear, as species increase and decrease in abundance at different points along the gradient. Second, the inclusion of environmental variables in the initial analysis, along with fish counts, leaves open the possibility that the analysis responded most strongly to the relationships between habitat variables, and only secondarily to fish counts. For example, the first factor may have been determined by habitat conditions found at Santa Cruz Island (high relief rock, lots of kelp, clear water), and the species that happened to be most closely associated with these variables fell in the habitat variables. However, the species themselves may have associated somewhat differently if not constrained by the presence of the habitat variables.

We will reanalyze the kelp-forest fish data using different techniques, and compare our results with those of Ebeling et al. (1980). Our primary method of ordination will be Detrended Correspondence Analysis (DCA), a technique that became popular for ecological work after Ebeling et al. conducted their work. DCA is useful in ecological work because it is less affected by nonlinear relationships among variables than some other techniques. We will also analyze the species associations separately from the relationship of species assemblages to environmental variables. We will do this by determining the degree to which habitat variables are related to the summarized trends of variation in fish species composition after determining the associations of species. You are also free to try other ordination techniques, particularly Nonmetric Multidimensional Scaling, or NMS.

We will use a program called PCORD to analyze data. This is a neat program that carries out the ordinations (and other analyses) in a relatively straightforward manner, and has excellent graphical capabilities for understanding both the ordination and the relationship of the resulting summaries to habitat variables.

To start PCORD from the AST laptop computers, make sure that Windows has started, and then double click on the PCORDWIN icon. Once the program starts, it is run from commands displayed in the menu bar at the top of the screen (File, Edit, etc.). To activate a menu, click on a menu item with the mouse, or simultaneously type alt and the first letter of the menu item. You can then choose from items on a submenu by highlighting an item (using the mouse or the arrow keys) and pressing enter, or double clicking with the mouse. Boxes may then pop up that request information that you may have to type in (like a title) or highlight (like a dot in a box corresponding to a particular choice). The navigation through these boxes is usually straightforward, even if the questions asked aren't. Below the menu bar, most of the remainder of the screen is devoted to displays of data and results. Often, the screen will be divided into two or more compartments containing different sorts of information. Moving the mouse over one of
I VARIATION IN THE NATURAL WORLD

Goals:  
1. Understand and provide examples of the major kinds of variation that are apparent in the natural world.  
2. Understand and provide examples of the implications of the differences between genetic and non-genetic variation.  
3. Understand the evolutionary implications of both interspecific and intraspecific variation.  
4. Understand the way in which variation is compared using the F test.  
5. Understand the meaning of the terms Variance, Degrees of Freedom, and Probability Level. In addition to understanding the meaning of these terms, you must know how and why they are important in measuring biological variation.

Outline:  
Introduction  
Variation within Species  
With Age  
With Season  
Due to position in Society  
Sexual dimorphism  
Non-sex associated Variation  
Variation among Species  
Convergent Evolution  
Divergent Evolution  
Measuring Variation in Repeated Parts  
The experiment  
Calculating Variance  
What we expect and how we're going to find out  
Significance and F values  
The relationship among sample size, chance events, and significance  
The F value  
A greater than 5% probability of occurring by chance alone?

Introduction

Variation is a pervasive characteristic of the natural world. Moreover, genetically based variation provides the raw material for evolutionary change. To understand patterns of the natural world, biologists must be able to recognize the variation among organisms due to a wide variety of factors, including genetic composition, the environment, age, sex, and evolutionary history. Variation among individuals may be either continuous, as in the size and weight of human beings, or it may consist of discrete differences among individuals, such as the number of petals of a flower or the number of legs of an animal.

In this lab you will examine examples of genetically and environmentally caused variation in organisms at the level of the individual, the population, the species, and higher taxonomic levels. You will also measure variation in fin supports of fishes so that you can gain experience analyzing variation in one characteristic of one group of organisms.
Intraspecific Variation

Individuals within a species may differ from one another. This is called **intraspecific** variation. Some of these differences are due to **genetic differences** among individuals: that is, their differences can be traced to genetic factors inherited from their parents. For example, some individuals may be large because they inherited genes for fast growth from their parents. Such variation is called **genotypic**—due to genes. Other differences can be **environmentally induced**; that is, even genetically-similar individuals may have different characteristics different because of exposure to different environmental conditions. For example, some individuals may be large because of their nutrition. Such differences are simply **phenotypic**—they are differences in the phenotype (what you see), but not in the genes. A more subtle source of differences among individuals are genetically programmed responses to the environment. For example, seasonal changes in the coloration of some organisms may be due to genetically-programmed responses to the passing of the seasons. What follows are some examples of intraspecific variation. Understand these examples, and try to evaluate the degree to which they are caused by genes, the environment, or a combination of the two.

(A) Variation with Age

Most organisms change dramatically in size, shape and behavior as they mature. The most striking changes occur in those species that have complex life cycles. Variation may occur in a single individual as it matures, as in the transition from as tadpole to a frog, or may result from an alternation of generations from one life form to another as in many plant groups or in the jellyfishes and their relatives. You will study individual life cycles in more detail in later exercises. Note the considerable variation that is seen in a single species at various points in its life cycle.

Examples of life cycles: fern; insect with complete metamorphosis; frog or salamander; jellyfish; fish.

(B) Variation with Season

Many species change in a number of characteristics as seasons change. These changes allow organisms to survive different environmental conditions encountered during different seasons. Deciduous plants, for example, lose their leaves in winter. Seasonal variation may occur within the same individual, as in the seasonal change in plumage of the starling and some other birds, or it may occur between consecutive generations of a species such as the alfalfa butterfly.

Examples of variation with season: starling plumage; winter and summer morphs of alfalfa butterflies; mammal pelt.

(C) Variation Due to Position in Society

Members of insect societies differ, in part, because of their social position (caste). The caste of an individual is usually determined by its environment. Especially important is the concentration of chemicals (pheromones) produced by the queen of the colony and sometimes also the diet an individual is fed. For instance, worker bees and queen bees in a honey bee colony are both
females; female larvae develop into workers if they are fed a diet of mostly pollen and honey. If the level of pheromone (queen substance) produced by the queen drops, workers select some young larvae and feed them only a glandular secretion called royal jelly. Female larvae fed only royal jelly become queens.

Examples of insect societies: honey bees; termites.

(D) Sexual Dimorphism

The sexes of most sexually reproducing species differ in both primary sexual characteristics (sex organs) and secondary sexual characteristics associated with mating and bearing young. Males are characterized by brighter colors and more elaborate structures such as horns. Bright colors may increase the attractiveness of males to females, while horns may serve as weapons for fighting with other males for control of a female.

Examples of sexual dimorphism:
- color dimorphism in Alfalfa butterflies
- color dimorphism in ducks
- structural dimorphism in horns of Scarab beetles
- structural dimorphism in antlers of deer
- sexual dimorphism in body shape, fin shape, and color in Swordtail fish
- contrast in morphology between staminate and pistillate flowers

(E) Genetic Variation that is unrelated to Gender

In general, no two individuals of a sexually reproducing species are genetically alike (except for identical twins). Thus there is considerable variation within each population of a species. A look around the room will confirm this for humans. In addition, populations of the same species often differ from one another depending upon where they are found. This variation is frequently the result of natural selection operating in different directions in different environments, but can also result from variation due to chance (genetic drift) or from different environments influencing the plasticity of the genotype.

Examples of variation NOT associated with sex:

(1) At the individual level
   - albinism in alfalfa butterflies
   - individual color variation in ladybird beetles
(2) At the population level
   - size variation in different populations of house sparrows
   - subspecific variation in checkerspot butterflies

**Interspecific Variation**

Not only do individuals of the same species differ from each other (at the individual or the population level), but different lineages of organisms belonging to different species obviously
differ from each other. Coyotes differ from wolves, members of the dog family (Canidae) differ from members of the cat family (Felidae), members of the order Carnivora differ from members of the order Ungulata (hooved mammals), mammals differ from fish, etc. Some of the differences between lineages of organisms is due to their differing ancestries. For example the differences between members of the Canidae and Felidae can be traced back long before the species alive today ever existed. On the other hand, closely-related species can differ from each other as well, in ways that can often be attributed to the immediate effects of natural selection and other evolutionary factors. In this section we illustrate differences between species by two interesting phenomena: convergent and divergent evolution. In convergent evolution, distantly related species have evolved to appear similar (at least superficially). In divergent evolution, closely-related species have evolved differences.

These examples also illustrate the difference between analogy and homology. Many organisms have similar features because they have inherited them from a common ancestor. For example, all mammals have three bones in the middle ear (the incus, malleus, and stapes), and all land vertebrates have a forelimb limb structure with one bone close to the shoulder (the humerus), two bones more distal (the radius and ulna), then the wrist bones (carpals), hand bones (metacarpals), and finger bones (phalanges). Such differences due to common descent are termed homologous – they are examples of homology. Other similarities may have evolved independently (convergently) from dissimilar ancestors. Such similarities are illustrated below, and are examples of analogy.

(A) Convergent Evolution

Distantly related organisms that live in similar environments often come to resemble one another. This is because organisms that have experienced similar environmental problems are subject to similar selective pressures, and their inherent genetic variation allows the evolution of similar phenotypes (appearances) in spite of different genotypes (genetic composition).

1. **Life in the Water.** Many swimming animals have converged on a streamlined body plan that helps reduce drag and allows efficient swimming.

   Examples of streamlined bodies: fish; squid; dolphin; water beetle.

2. **Life in the Air.** Several groups of animals have independently evolved the ability to fly. All have evolved wings of some sort, but these wings have resulted from different evolutionary pathways in each group. Compare the wing structure of a bird, a bat, and an insect.

   Examples: bird specimen and skeleton; bat specimen and skeleton; dragonfly.

3. **Life in the Desert.** Lack of water in the desert imposes many potential problems on plants. One solution evolving independently in a number of plant groups is the storage of water in succulent tissue. Striking convergences occur among many different plant families. One of the best examples is the convergence of the New
World cactus family and African members of the genus *Euphorbia*. Other examples are: *Euphorbia-Cereus-Stapelia; Aloe-Agave; Euphorbia-Fouquieria-Alluaudia*.

In these examples, the convergent groups still retain many of their ancestral characteristics, and this helps us to recognize that the superficial similarities between the species are due to convergent evolution, not to common ancestry. Pick one or two of the examples shown above, and try to identify characteristics that help you to recognize the different ancestries of the convergent groups. For example, how would you determine that a hummingbird and a vulture have characteristics in common due to their shared ancestry, but that the similarities between a bird and a bat are convergent?

**(B) Divergent Evolution**

Divergent evolution happens when different selection pressures cause two species to follow different evolutionary courses. Considerable phenotypic variation can result among species that genetically are closely related. One of the better examples of evolution within a genus of plants is the diversity of growth form in the genus *Tillandsia* of the pineapple family. Diversity in *Tillandsia* is the result of adaptations to obtain water in habitats ranging from tropical rain forests to the driest deserts. Most species of *Tillandsia* are epiphytes that live attached to branches trunks of trees. In some species such as "Spanish moss" (neither Spanish nor moss, by the way), the ability to form roots has been lost completely. Rather than depending upon root hairs for water uptake, these epiphytes rely on special leaf scales that trap water. Green, leafy species of *Tillandsia* inhabit wet areas and have their leaves organized in such a way as to catch water in the center of the plant, forming a kind of reservoir, where scales at the bases of the leaves take up the water. Species in drier habitats have leaves completely covered with scales, giving a silvery appearance. Such leaves do not hold a reservoir of water, but the scales are capable of taking up sufficient moisture from dew or fog. Also, the scales are highly reflective and protect the leaves from excessive heat. Some of these silvery species of *Tillandsia* thrive in the Atacama desert of western South America, one of the drier regions in the world.

Examples of a number of species of *Tillandsia* are available for you to examine. Darwin's Finches, which are a classic example of divergent evolution, are also on exhibit.
Measuring variation in repeated parts

Counts of repeated parts in organisms often show that there is variation among individuals within a species. Snakes, lizards, and fishes have scales on their bodies, and the number of rows of body scales usually varies within the same species. The same is frequently true for the numbers of vertebrae in these same animals. In fishes, the fins also are formed of repeated parts called fin rays, which support the membranes of the fins, and many species of fishes show variation in the number of fin rays.

To demonstrate the tendency to show variation in repeated parts, we will measure variation in the dorsal and anal fins of a local marine fish, Oligocottus snyderi, the fluffy sculpin. The fluffy sculpin (known for the “fluffy” bits of skin tissue that serve as camouflage) lives in tidepools, where it lies on the bottom and preys upon small invertebrate animals. It can make short swimming runs by pushing off strongly from the bottom with its huge pectoral fins, steadying itself in the water by raising its dorsal and anal fins like keels.

(A) The experiment

The object of our study today is to measure the degree of variation in the number of dorsal and anal fin rays in the fluffy sculpin, and to compare the degree of variation found in the two fins. The number of fin rays varies naturally, due to both genetic and environmental causes. By comparing the degree of variability in the two fins, we might be able to determine if the number of rays in each fin is controlled by the same or by different factors. If the number of rays is controlled by the same factor (such as the number of body segments laid down during the embryonic stage) we might expect the variation in dorsal and anal fin-ray counts to be the same, whereas if they are controlled by different factors, the variation in counts might be different.

With your laboratory partner, select five specimens of fluffy sculpin, placing them in a finger bowl covered with water. Make sure that you keep the specimens wet, as the counts are difficult to make on dried specimens.

Note that the dorsal and anal fins each are subdivided into an anterior and posterior part. For counting fin supports, however, we will consider two parts as a single fin. For each fish, one laboratory partner makes a count of the dorsal fin supports and also makes a separate count of the
anal fin supports. Hold the fish up to the light, if necessary, in order to see fin supports
distinguished from color pattern. With forceps, gently lift fin supports if any have folded down on
top of others; try not to tear fin membranes, or it will become difficult to make recounts.

The second laboratory partner then makes the same counts, preferably without knowing the
first partner's results. Whenever the two partners differ in their count, that count should be repeated
until agreement is reached. Record these counts.

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Dorsal Fin Count

Anal Fin Count

(B) Calculating Variance

Place your results on the class chalk board so that all data generated in the class are
available to all students. Carefully transfer all data to the data sheet provided below. You should
have at least 30 dorsal fin counts and 30 anal fin counts. Using all the data gathered by the entire
class for the dorsal fin, calculate the variance for the dorsal fin count. Do the same for the anal fin
count. The formula for variance is often given as follows:

\[ \text{Variance} = \frac{\sum (\text{value for each count} - \text{mean})^2}{\text{Sample size} - 1} \]

That is, for each fin, you calculate the average count (the mean), then add up the squared
differences between each count and the mean, and finally divide this sum by the number of
observations minus one. Note that when the individual counts differ greatly from the mean, the
variance will be larger, and when the individual counts do not differ as much from the mean, the
variance will be smaller. Dividing by the sample size is like calculating the average difference
from the mean. When you finish calculating the variances, record them on the data sheet.

(C) What we expect and how we're going to find out.

It is likely that, at the sensitive period in larval development when the fishes' body
segments are being formed, temperature and other environmental variables influence individual
phenotypes differentially with the result that there will be variation among individuals in the
number of body segments. Since the number of body segments approximates the number of
vertebrae a fish will have, the numbers of vertebrae within a population is therefore likely to show
variation. Numbers of fin supports in the dorsal and anal fins may also be related to the number of
body segments. If this is true for the fluffy sculpin, then we might expect that the variance, \( s^2 \), (an
estimator of variability) for the dorsal fin is about the same as the variance for the anal fin, that is,
that the two fins are equally variable. To test whether this is so, we will use a statistical test, the F-
test.
To find whether the two fins are equally variable, one calculates an F value, which is actually a ratio, and then compares it with a Table of Critical Values, which is available from your instructor. If the calculated F value is less than the critical F value found from the Table, then you may conclude that the two fins are equally variable. If the calculated F value is greater than the critical F value found from the Table, then you may conclude that the two fins have different degrees of variability. The calculated F value is determined by dividing the larger of the two variances by the smaller:

\[ \text{larger variance} = s_1^2 \quad \text{smaller variance} = s_2^2 \quad \text{and} \quad F = \frac{s_1^2}{s_2^2} \]

When you have your F value, you will need two more simple calculations in order to use the Table of Critical Values. These are the degrees of freedom of your two samples. The degrees of freedom for the numerator, \( \nu_1 \), is \( n_1 - 1 \) and for the denominator, \( \nu_2 \), is \( n_2 - 1 \). Discuss with your instructor the meaning of probability level and decide which probability level you will use. With this information, decide whether or not the dorsal fin has the same amount of variability as the anal fin in your sample of fluffy sculpin.
### Data Sheet: Dorsal and Anal Fin-Ray Counts

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Mean dorsal-ray count =  
Variance of dorsal-ray count =

Mean anal-ray count =  
Variance of anal-ray count =

Calculated F value =  
Critical F value =
Significance and F-Values

How do we know what size of F value to deem as significant? We can look it up in the table (as we will anyhow), but what does this mean?

The F test is one example of a statistical test that determines how unlikely your result to have been, if the two values you compared really weren’t different. Think of it this way: even if the variances of dorsal and anal fin-ray counts were not different in the whole population of fluffy sculpins, there is not a very good chance that in our sample of 30 fish that the F ratio would turn out to be exactly 1.0 (that is, the two variances equal each other exactly). Just by chance, through the luck of the draw, we might get different variances in our samples. But common sense tells us that small differences (and F values not very different from 1.0) might come up quite often if the variances were the same, but that big differences (and F values that are quite different from 1.0) would come up less commonly. So how big a difference in variances (how big a value of F) do we deem as indicating that the two variances are different, beyond a reasonable doubt? Here we depend on the mathematical wizardry of statisticians, who have worked out the chances of getting particular values of F, if the two variances really weren’t different. This is what we get from the F table.

The F table is organized according to the degrees of freedom in the numerator and denominator of the F ratio (the degrees of freedom depend on the sample sizes). Find the column of tabulated F values for \( \nu_1 = 30 \) (the closest value to 29) and \( \nu_2 = 29 \). The tabulated values of F in this column range from smaller numbers at the top of the column to larger numbers at the bottom of the column. At the margin of the table is a corresponding column of decimal fractions, ranging from .75 to .001. These values are probabilities, figured out by the mathematical wizards. They represent the chance of getting a calculated F value that large or larger, if the real variances of the two samples were the same. Note that there would be a 50:50 chance of getting a calculated F value of 1.0 or larger, if the real variances are equal to each other. This makes sense, since if the variances are equal, you should get F ratios around 1.0. As you move down the column, you see that larger F values would be less common: a calculated F value of 1.62 or larger would happen only 10% of the time (if the underlying variances were equal), a calculated F value of 1.85 or larger would happen only 5% of the time, and a calculated F value of 2.41 would happen only 1% of the time. We use these probabilities to decide if our results would happen very often, if the real variances were equal. If our calculated F ratio turned out to be uncommonly large, we could make the decision that maybe the variances really aren’t equal. In many areas of biology, we arbitrarily use the 5% level of probability, thinking that if the F ratio we calculated would happen only 5% of the time if the variances really were equal, we could and proceed with the assumption that the variances really are different, and accept a 5% chance of being wrong. Therefore, we might use the tabulated F value of 1.85 as our critical value, and if our calculated F value is larger, we would reject the notion (known as the null hypothesis, or \( H_0 \)) that the variances are equal, and accept the alternative notion, which is that they are unequal. If our calculated F value is smaller, we would not have the evidence to reject the null hypothesis, and would proceed with the assumption that the variances were equal. This type of logic is used in many other types of statistical tests, which compare averages and other measures, instead of variances.

If \( F_{\text{calculated}} > F_{\text{critical}} \), \( H_0 \) is rejected.
If \( F_{\text{calculated}} < F_{\text{critical}} \), \( H_0 \) cannot be rejected
Introduction to the Earth's Energy Budget

Objectives:

- Formulate several simple conceptual models of earth's energy budget.
- Use satellite observations of radiative energy fluxes to test the validity of these models quantitatively.
- Analyze satellite-based radiative flux data sets in several different ways to help raise questions about features, patterns, and differences in the spatial and temporal distributions of these fluxes.
- Begin to pose possible answers to these questions.
- Apply the Stefan-Boltzmann relation to compare emission fluxes of longwave IR radiation at earth's surface and the top of the atmosphere.

Introduction. In this lab activity you will explore some aspects of Earth's energy budget. Some of the questions below ask you to do or think about things that might not yet have been covered in lecture or the readings. Don't worry about being right or wrong, but pay close attention to why you are right or wrong, and include the insights you gain from this process in your answers.

Part 1: A Simple Model of Absorbed Solar Energy at Earth's Surface

(1) Before opening any of the data sets in WorldWatcher, draw a simple box-and-arrow diagram of the Earth's energy system (a qualitative budget) as discussed in lecture. Include the following components:

Boxes: Energy in the Earth's atmosphere & surface (combined in one box)

Arrows: Incoming solar radiation, reflected solar radiation, and outgoing (longwave) radiation

(2) We can also construct a budget for solar radiation only (so it doesn't include terrestrial radiation—that is, radiation emitted by Earth). Translate the parts of your box-and-arrow diagram above that deal only with solar radiation into a simple mathematical equation:

Solar Energy Absorbed by the Planet = ___________ +/- ___________

(where you have to decide if the operator above is "+" or "-").

(3) Both the diagram in (1) and the equation you wrote in (2) are models of the real world, abstract simplifications that, ideally, represent the some or all of the essential components of a planet's energy budget.

Now, using WorldWatcher, you'll see if actual satellite observations agree with your model budget equation for absorbed solar radiation. To do this, first start WorldWatcher; then click on the "Energy Balance" button;
then, on the WorldWatcher energy budget diagram, click on the parts of the energy budget listed below and open the data sets for March 1987:

- Incoming solar radiation
- Reflected solar radiation
- Absorbed solar radiation

Now make a plot of the sum or difference of terms that you put on the right-hand side of the equation in (2) above. To do this, follow the steps below. (Instructions on math operations are also available in the Help menu.)

1. Click on (that is, select) the plot of whatever quantity you said is the first term on the right-hand side of the equation in (2).
2. Either click on the "Window Math" button on the toolbar, or pull down the "Analysis" menu from the menu bar and select "Window Math Operation". You'll get a "Window Math Operation" dialog box.
3. In the dialog box, pull down the "Math" menu and select the window operation you want to perform. (In this case that will be either "A+B", which is the default, or "A−B". That is, the value in each cell of the plot in window "B" will be either added to or subtracted from the value in the corresponding cell in window "A").
4. Window "A" will be the one that you selected in step 1. Pull down the "Window B" menu and select the plot corresponding to whatever quantity you said is the second term on the right-hand side of the equation in (2).
5. In the "Result Window", enter an appropriate title for your plot.
6. Click the "OK" button to make your new plot.
7. To make it easier to compare your new plot to the plot of absorbed solar radiation (the left-hand side of the equation in (2)), readjust the "color set" of the new plot so that it matches the one for absorbed solar radiation. (The color set is the set of colors used on the plot and the way in which each color is assigned to particular values.) To do this:
   a. Select the absorbed solar radiation plot.
   b. Click on the "rainbow" icon on the toolbar, and note (1) the color set that it uses; (2) the scaling that it uses; and (3) the lower and upper limits specified (that is, the values assigned to the first and last color in the color set, respectively).
   c. Select your new plot, and click on the rainbow icon on the toolbar.
   d. Pull down the "Color Set" menu and select the same color set used by the absorbed solar radiation plot. Make sure that the scaling is the same, too.
   e. Enter the same lower and upper limits used on the absorbed solar radiation plot.
   f. Click the "OK" button.

Comment on any conceptual or technical difficulties that you encountered in this process.

(4) Compare your plot of the right-hand-side of the equation in (2) with your plot of the left-hand side. Was your initial model (equation) correct—that is, are satellite observations consistent with it? (If not, can you identify your error and correct it?)

**Part 2: Spatial Variations in Earth's Energy Budget**

... should have been able to convince yourself that satellite observations largely support a version of the
equation in (2) that states that absorbed solar radiation = incoming solar radiation minus reflected solar radiation. An even stronger test of this relation would be to add reflected and absorbed solar radiation together and subtract the results from incoming solar radiation—you should get values close to zero for all

Both the qualitative and quantitative forms of your models are useful in their own ways, but both are too
general to illuminate a critical aspect of all of earth science: the amount of solar radiation received,
reflected, and absorbed all vary from place to place. In this part of the lab activity, we will consider the data
sets more carefully and explore spatial variation within them using both maps and cross-sectional line plots.
(Note that we've already done this to a significant degree with incoming solar radiation in the context of the
understanding the cause of the seasons.)

(5) You have seen the incoming solar radiation plot before. More precisely, what quantity is plotted?
What units are used in this data set? What type of quantity do these units represent (flux, rate, something
else)?

(6) Open the information file for the data set (click toolbar button with the "i" symbol). How were
these data collected?

(7) Insolation (that is, the flux of incoming solar radiation) on a surface directly facing the sun
depends mainly on the distance from the sun; though also on the output of the sun, which can vary over
time. Why, then, does insolation on this plot vary so much with latitude? How can you tell from this plot
that insolation doesn't vary with longitude?

(8) For each of the months of January, March, and July, make a line graph along your choice of any
north-south line of cells. This line of cells will be 1° longitude in width because individual cells are 1°
latitude x 1° latitude in size. To do this:

1. Click on (select) the plot.
2. Pull down the "Select" menu from the menu bar and select "Select by Underlay". You'll get a "Select
   by Underlay" dialog box.
3. On the dialog box, pull down the "Underlay" menu, scroll to the top, and select "1 Degree Longitude".
   You'll see a list of longitudes (each the center of a north-south strip of cells, one cell wide), at 1°
   intervals.
4. Select one of the longitudes on the list. (It won't matter which one—there is no variation with
   longitude on the plot of incoming solar radiation.)
5. Click on the "OK" button. Note that a shimmering black and white-striped north-south band (one cell
   wide) appears on the plot along you selected longitude.
6. Now we want to make a line plot of values along your selected north-south strip of cells. Pull down
   the "Analysis" menu from the menu bar and select "New line plot from grid slices...". You'll get a
   "New Grid Slice Line Plot Window" dialog box.
7. Click on the "Selected Cells Only" box and on the "Create Vertical Slices" button. (In WorldWatcher,
a "vertical" slice is a north-south slice, while "horizontal" means east-west.)
8. If necessary you can adjust the vertical scale of the resulting line graph by pulling down the
   "Appearances" menu from the menu bar, selecting "Range", and entering appropriate values for the
   "vertical range".)

Copy and paste the January and July line graph into the March line graph. (To do this, click on the January

http://funnel.sfsu.edu/courses/gmo405/labs/act.04.IntroEnergy8dgt.html
graph, pull down the "Edit" menu, and select "Copy". Then click on the March graph, pull down the "Edit" menu, and select "Paste". Repeat for the July graph. Note that WorldWatcher automatically adjusts the vertical scale of the copied graph so that the superimposed graphs are on the same scale. [Note: WorldWatcher for Windows PCs won't allow you to copy and paste graphs from one window to another—you need to use the Mac version.]

Compare the graphs. What features of each graph and differences among them do you observe? Can you explain any of these features and differences based on what you've learned in the course so far?

**Part 3: Space-Bound Longwave Infrared Radiation**

If the earth system as a whole were not to gain or lose energy (and thereby warm or cool), the amount of energy leaving the Earth system as longwave infrared radiation must balance the amount of energy that the earth system absorbs.

(9) For the earth as a whole to have a balanced energy budget, which of the following do you think should equal the rate of emission of outgoing (space-bound) longwave IR radiation?

a. the rate of incoming solar radiation (i.e., solar radiation arriving at the top of the earth's atmosphere);
b. the rate at which reflected solar radiation leaves the earth;
c. the rate at which the earth absorbs solar radiation; or
d. some combination of these.

Explain your choice.

(10) Now, use satellite observations to test your answer. To do this:

1. Plot the space-bound energy (outgoing longwave radiation) flux data sets for January, March, and July. For each month, note the global-mean value (printed in the upper-left corner of each plot).
2. Plot the quantities or quantities that you chose in (9) for the same three months. For each month, note the global-mean value.
3. For each month, compare the global-mean values that you noted in steps 1 and 2.

Were you correct, or was your answer way off (that is, more than 20 Watts/m² different)? (If you were way off, you probably chose the wrong quantity in (9)!

(11) Even if you chose the correct quantity, you'll notice that the global mean values are not exactly the same. For each month, did the earth gain more energy energy than it lost or lose more than it gained? If this difference was real, what do you think it implies about global temperatures during that month?

Now consult the background information about absorbed solar radiation (click the "i" button on the toolbar for any plot of absorbed solar radiation). Can you be confident that your conclusion about the global temperature trend in March, 1987 was correct?

**Part 4: Variations with Latitude of Outgoing Longwave IR Radiation and Absorbed Solar Radiation**
(12) Plot the space-bound energy (outgoing longwave radiation) data sets for January, March, and July. Average the values along each east-west band of cells (each of which is 1° latitude across), as follows:

1. Pull down the "Analysis" menu from the menu bar, and select "Average by Underlay...". You'll get an "Average by Underlay" dialog box.
2. Pull down the "Underlay:" menu, scroll to the top, and select "1 Degree Latitude".

This *zonally average* the data, where a "zone" is a band of latitudes (in this case 1° wide) in a circle around the globe. The resulting zonal average graphs should show no east-west variations (because they've been averaged out), though north-south variations are preserved.

Now construct line graphs of outgoing longwave IR along any north-south line (following the same procedure as in (8) above), cut and paste the January and July graphs onto the March graphs, and compare the three. What dominant features do you see on each graph? Can you suggest possible explanations for any of them, based on what you've learned in class so far?

What differences between the three graphs do you see? Can you account for the differences?

(13) Plot the absorbed solar radiation data sets for January, March, and July. As in (12), zonally-average each data set and construct north-to-south line graphs. What dominant features do you see on these graphs? Can you suggest possible explanations for any of them?

Cut and paste the January absorbed solar radiation line graph onto the January outgoing longwave IR line graph and compare the two. Does outgoing IR radiation approximately balance absorbed solar radiation at each latitude? (That is, are differences between them less than, say, 20 W/m²?) Repeat for March and July.

If radiative absorption and emission were the only mechanisms by which particular latitude zones could gain and lose energy, what would any imbalances that you see at any particular time imply about the temperature at those locations at that time?

(14) Construct a plot of annual-average, zonal-average outgoing longwave IR radiation—that is, average together outgoing longwave IR data sets for all 12 months of a year and then zonally average it. To do this:

1. On the WorldWatcher Energy Budget diagram, click on "Space-bound Energy", which will present you with a short menu.
2. Select "Average Datasets..." from the resulting menu.
3. Select (highlight) all of the data sets to include in the average—in this case, all 12 months' worth from the year 1987. (Be sure not to include any labeled "Clear Sky"). To select multiple data sets:
   a. Select (highlight) the first month's data set (January, 1987).
   b. Either hold down the "Shift" key and select the last month's data set (December, 1987), or select each data set to include in the average one at a time while holding down the "Command" key (which on a Mac has a picture of an apple on it and a "%" sort of symbol, just to the left of the space bar).
4. Click on the "Average" button.
5. Zonally average the resulting plot, following the procedure described in (12).

Make a north-to-south line graph along any longitude line. What are the dominant features of the resulting
graph?

repeat the above for absorbed solar radiation. What are the dominant features? Can you suggest possible explanations for them?

Copy the line graph for annual-average, zonal-average outgoing longwave IR and paste it onto the corresponding line graph for absorbed solar radiation. Do the two balance at each latitude? If not, and if the graphs for this particular year are representative of other years, and if radiative absorption and emission are the only mechanisms by which latitude zones on Earth can gain and lose energy, what implication would any imbalances have for temperature at those latitudes over time? Do we in fact observe the behavior that you deduce?

Part 5: Outgoing Longwave IR Radiation from Top of Earth's Atmosphere vs. from Earth's Surface

(15) On your annual-average, zonal-average plot of the outgoing longwave IR data set, note the global average value (upper-left corner of the plot). We want to compare this value to the radiative emission flux from Earth's surface. WorldWatcher doesn't have such a data set, but it does have surface temperature data, which we can use to estimate the radiative emission flux from the surface using the Stefan-Boltzmann Law and assuming that Earth's surface behaves like a blackbody (not a bad assumption for most purposes).

It would be tempting to compute a global, annual-average surface temperature and use that value in the Stefan Boltzmann Law. Unfortunately, this could be misleading (that is, wrong!). The global, annual-average radiative emission flux does not necessarily equal the flux calculated using a global, annual-average temperature. (Can you explain why not? As a hint, try averaging two different temperatures and calculating the emission flux of an object at that average temperature, and then compute two emission fluxes from the first two temperatures and average the fluxes. Are they different? If so, why?)

Instead, we have to calculate the radiative emission flux in each cell for each month and average all of them together. This calculation can be tedious, so each person in class should choose one or more different months. We want to compute the temperature of each cell (in Kelvins) raised to the fourth power and multiply by the Stefan-Boltzmann constant. There is no direct way to do this in WorldWatcher, so you'll have to follow the procedure below.

1. Plot the surface temperature for a month, and convert the units from Fahrenheit to Kelvins (by selecting "Units" under the "Appearance" menu and un-checking the "Alternate units" check box, which will then default the units to Kelvins.)

2. Compute the cell-by-cell product of the temperatures to get the temperatures squared (using the "Window Math Operation" icon on the toolbar or pulling down the "Analysis" toolbar menu and selecting "Window Math Operation", and making sure that windows "A" and "B" are the same window; assign the title "TS(K)^2" to your new plot).

3. Repeat the previous step, this time operating on the TS(K)^2 window, which will raise the surface temperatures to the fourth power (by squaring the squared temperatures). Assign the title "TS(K)^4" to the new window that this operation will create.
4. Convert the units to energy flux by multiplying by the Stefan-Boltzmann constant. (To do this, pull down the "Appearances" menu; select "Units"; check the "Alternate units" check box; name "Alternate Units" to be "W/m^2"; and set the conversion factors "a", "b" and "c" so that your plot of TS(K)'^4 values is simply multiplied everywhere by the Stefan-Boltzmann constant. (Note that "Primary" in the conversion equation refers to the TS(K)'^4 values.)

5. Note the global-average radiative emission flux for your month, and repeat the process for any additional months that you've been assigned.

6. Average your value(s) with those calculated by your classmates to get a global, annual average emission flux estimate.

How does the global, annual-average radiative emission flux from the Earth's surface compare to the global, annual-average emission flux out the top of Earth's atmosphere to space? If the difference seems significant, *what must be happening to account for it?*

(16) There is an alternative approach that shows the same discrepancy between Earth as a whole (based on longwave radiation leaving the top of Earth's atmosphere) and Earth's surface. We can calculate a kind of "effective" global, annual-average temperature from the Stefan-Boltzmann Law using the global, annual-average radiative emission flux out the top of Earth's atmosphere. What "effective" global, annual-average temperature do you get from that calculation?

Now, use WorldWatcher to calculate a global, annual-average surface temperature and convert it to Kelvins. How does this value compare to the "effective" global-average temperature calculated above? Is the difference consistent with your result in (15)? Explain.
Final Presentation Evaluation
Biol 526, Plant Physiology, Spring 2004

The following project evaluation scheme is provided for your information and to provide perspective that may be useful as you plan your project presentation.

1. Introduction- (5 points):
   Clear presentation of the “problem” or “question”.
   Determined whether background information was needed – clear presentation of any relevant background information
   Reasonable hypothesis or hypotheses posed to address problem or question
   Clear presentation of hypothesis or hypotheses

2. Proper Methods and Rationale for choice of methods (8 pts)
   At least one analytical/biochemical method; at least one molecular/genetic method
   Three methods total
   Appropriate methods to address hypotheses posed
   Appropriate rationale presented for choosing these methods
   Presentation of the experimental design is organized and logical
   Appropriate controls for experiments presented in the experimental design

3. Expected Results and Explanation (i.e. Discussion) (7 pts)
   Expected results are logical and could be obtained with experimental design
   Good visual representations of data expected
   Clear presentation of expected results
   Clear presentation of rationale or explanation for expected results

4. Presentation and Interaction with Audience (5 pts)
   All members of the team participate in the presentation
   Planning for presentation evident – clear connections between parts of presentation and clear that each person knows what his/her responsibility is and how it fits in the overall presentation
   Team members are able to interact with audience and address questions

5. Participation log; individual effort to team project (5 points)
Project Assignment for Poster Presentation 50 points
Plant Physiology Lab - Spring 2004

Genetic, molecular and biochemical tools can be used to untangle the intricacies of physiological processes, answer our many questions, and bring us closer to understanding how various essential processes occur in plants.

Throughout the semester we have learned about and used a number of molecular, and genetic approaches that could be applied to investigate questions of interest in plant physiology. These methods include: 1) tissue culture methods to generate plant callus and induce the formation of plants or plant organs; 2) plant transformation (introducing a gene of interest); 3) mutant screening; 4) use of hormone regulated promoters (for example, dex or IAA regulated promoters) in engineered gene constructs to allow control of gene expression or monitor hormone concentrations; 5) use of reporter gene (in our case, β-glucuronidase, i.e. GUS or GFP); 6) Western blotting and 7) confocal microscopy.

Likewise, you have become familiar with several biochemical/analytical procedures this semester that can be brought to bear on questions of interest. These procedures include: 1) spectrophotometry (use of standard curves and absorption spectra and in enzyme assays to monitoring changes in substrates or products of reactions over time); 2) chromatographic methods to separate molecules of interest; 3) enzymatic assays to investigate enzyme properties (had to cancel this one, but in principle understand how to monitor progress of a reaction by monitoring concentrations of substrates or products over time, then determining from these data the “rates of reaction” under different conditions, for example pH, temperature, different initial substrate concentrations); 4) use of artificial dyes as electron acceptors to investigate rates of electron transport; 5) titration analysis to quantitate acid or base content in tissues; 6) polyacrylamide gel electrophoresis to separate proteins (in native and SDS gels); 7) determining protein molecular weights for proteins separated by SDS gel electrophoresis, 8) immunodetection methods (ELISA) and immunoblotting (Western blotting); 9) CO₂ and O₂ monitors to examine rates of respiration and photosynthesis, 10) pressure bomb to determine leaf water potential; 11) others (see syllabus for other methods).

The project you are being assigned today will allow you to be creative and design a set of experiments to gather data on a question of interest. We expect that you will draw exclusively, or at least heavily, on methods/procedures used in class this semester, but you are not restricted to these if a member of your team has other expertise.

For this assignment:
1) Work in groups as assigned.
2) Choose one of the following projects
3) Develop a set of hypotheses.
4) Design an approach to test a hypothesis or hypotheses the team selects

5) Prepare and present a poster that outlines your hypotheses, approaches to testing these (your experimental procedures), the rationale for your experimental approach and the techniques you have selected, your expected results and an explanation for these results.

Project requirements:

1) Projects must involve three techniques used in class this semester. Substitution of techniques not used in class is possible, but MUST be approved by the instructor.

2) Projects must include at least one molecular/genetics technique and at least one biochemical/analytical procedure.

3) Verbal presentation of your Poster to the class must involve all team members as presenters and should take about 15-20 minutes.

Possible Project 1. Gravitropism in stems
In the first "experiment" we did this semester, you observed that shoots exhibit negative gravitropism. If shoots are oriented horizontally, the stems soon grow/"bend" upward and the shoot regains a vertical orientation. This growth response is suggested to be promoted by IAA since it is known that IAA in the appropriate concentration range for stem or root tissue can promote cell elongation. Data also suggests that for a sustained IAA effect on cell elongation, protein synthesis is required. Design an experiment or experiments to determine whether IAA might be involved in the gravitropic response of plant stems and which proteins, if any, are involved in stem gravitropism.

Project 2. Is *Mesembryanthemum nodiflorum* an inducible CAM plant?
Some CAM plants are obligate CAM plants, but others can shift from C_4 to CAM in response to environmental changes. These plants are called "facultative" or "inducible" CAM plants. It is known that *M. crystallinum* can be induced to shift its photosynthesis mode to CAM when salt concentrations increase in the solution around its roots. The bay area salt flat plant, *M. nodiflorum* has properties that suggest it might also be an inducible CAM plant. Propose a study to determine whether CAM can be induced in *M. nodiflorum* and to investigate gene expression and/ or biochemical/physiological mechanisms that underlie this shift in metabolism.

Project 3. "Big Fruit"
In a search for genes that control the size of fruits, a gene named BIF (for big fruit) was identified in *Arabidopsis*. It has been suggested that the BIF gene product (the BIF protein) might be directly involved in fruit formation. Utilize at least two of the molecular techniques listed on page 1 and propose a study to analyze whether BIF is indeed involved in controlling fruit size. (Recall projects must use 3 techniques total.)
Project teams: Madeleine*, Scott, Natalia
           Jess*, Kana, Long Yan
           Andrew*, Cynthia
           Lia*, Triny, Laura

Assignments and due dates:

DUE MAY 11, before you leave class:
Team name (members), Project selected and hypotheses that will be tested.
(details not required, we just want to know what you are doing!)

DUE May 19th, last day of class
Poster and Oral presentation

DUE May 19th, last day of class
Keep a participation log, to be turned in on the final day along with your poster project.

The log is not meant to be cumbersome or a burden; it is simply a record that outlines what each person on your team contributed to the project.

Here is a suggested format and examples of possible entries

<table>
<thead>
<tr>
<th>Date</th>
<th>Record of team activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/6 (in class)</td>
<td>Team assembled, all members present, all contributed to determining which project we would develop and in deciding the experimental approach we would take; submitted project intent sheet to Nan</td>
</tr>
<tr>
<td>whenever</td>
<td>Met at the student union for ~1 hour. x,y,z brought materials they obtained via researching the topic and discussed these. Aaa couldn’t make the meeting but sent comments. We decided to do...... And ask Aaa to put this together</td>
</tr>
<tr>
<td>whenever</td>
<td>All met, x led discussion on how to present .... Y prepared graphs And figures for ..... and we approved two of these, but suggested Changes that Y will make in the third. Z gave progress report on Her part. A needed help with question and we addressed this.</td>
</tr>
</tbody>
</table>

Etc. enough to show what each person contributed
Exercise 3: Determining the CONCENTRATION OF STARCH in an "UNKNOWN"

Suppose that you were given a solution that contained starch, but you were not told what the concentration of the starch was in that solution. (Where could we obtain starch? What kind of organisms synthesize starch? What products obtained from these organisms might have a lot of starch?) Suppose further that you needed to know the concentration of starch in that solution. Let us see how to do just that in a very simple way.

**Procedure**

1. Measure into a test tube 5 ml of the prepared starch solution whose concentration is unknown to you. (Why do you use 5 milliliters?)

2. Add 0.5 ml of the I₂KI reagent. (Why 0.5 ml?) Gently mix.

3. Check to be sure that the spectrophotometer is still set at the wavelength of maximum absorbance for the starch-iodine complex. (Why use this wavelength?)

4. Calibrate the spectrophotometer to zero absorbance using the blank that you saved from exercise 2. (Why calibrate to zero?)

5. Measure the absorbance of the unknown starch solution.

6. Determine the concentration of starch in the unknown solution by using your standard curve for starch.

Exercise 4: Determining a STANDARD CURVE for PROTEIN

In this final exercise for today you will make the measurements to construct a second standard curve. This curve will be for protein in solution. Basically you will repeat all of the procedures you did in Exercise 2 to make a standard curve for starch. As in the case with starch, protein is colorless in solution. Therefore an indicator dye that gives a specific color reaction must be added so that we can make measurements in the visible light range. For protein we will use Biuret reagent which changes from blue to shades of pinkish-lavender in a specific reaction with protein. We will not take the time to construct an absorption spectrum for the protein-Biuret reagent complex to determine the wavelength of maximum absorbance. Instead it is simply given that the wavelength of maximum absorbance is 540 nm. So all of your measurements will be made at this wavelength. The standard curve that you construct from these data will be used in Laboratory 4 to determine the concentration of protein solutions derived from several biological sources. If you do not have time to complete this exercise today, there will be time at the beginning of Laboratory 4 to do it, and the materials will all be available.

**Procedure**

1. Obtain 6 test tubes. Number the tubes, and prepare mixtures of solutions in them as specified in Table III.

2. Add 5.0 ml of Biuret reagent to each tube, bringing the total volume of each tube to 8 ml.

3. Gently mix each tube. Remember to cover the mouth of each test tube with Parafilm before mixing.

4. Set the tubes aside for 20 minutes to allow the color reaction of the protein-Biuret reagent complex to go to completion.
5. Describe the color of the solution in each of the six tubes in the color-column of Table III.

6. Set the spectrophotometer to 540 nm.

7. Fill your control cuvette two-thirds full with the contents of tube 1, which is your blank preparation, and calibrate the spectrophotometer to zero absorbance.

8. Determine the absorbance in succession for the contents of each of the tubes 2 through 6, and enter the values in Table III.

Table III. Solution Mixtures and Absorbance Measurements for Construction a Standard Curve for Protein (Biuret Method)

<table>
<thead>
<tr>
<th>Test Tube Number</th>
<th>Protein Solution [6 mg/ml]</th>
<th>Water</th>
<th>Final Protein Concentration (in mg/ml)</th>
<th>Absorbance (A) @ 540 nm</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0 ml</td>
<td>3.0 ml</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>2.8</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>2.5</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.5</td>
<td>1.5</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.5</td>
<td>0.5</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Results:**

1. Construct a standard curve for protein by plotting your absorbance data against concentration of protein solution in the same manner as you did for the starch standard curve. Be sure to bring this graph with you to lab next time.

**Questions:**

1. Why was the wavelength of 540 nm used to measure absorbance in this exercise instead of 600 nm which you used in Exercise 2?

2. What is the relationship between absorbance at 540 nanometers and concentration of the protein solution?

**Possible discussion topics:**

1. The nature of "blank" solution in spectrophotometry.

2. Graphing techniques and conventions.

3. The uses of standard curves.
Biology 482. Ecology 4 units  
Fall, 2004

Format: 3 units classwork; 1 unit lab and fieldwork

**Learning Objectives:** Students in this course will study and develop an understanding of the science of ecology at the levels of the individual, population, community, and ecosystem.

**Course Content by Topical Sequence**

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture/Discussion Topic</th>
<th>Laboratory Topic</th>
</tr>
</thead>
</table>
| 1. 8/26 | **Introduction, Distributions**  
Diamond Lab Experiments, Field Experiments, & Natural Experiments, (not a critique paper)  
Krebs Chapter 1, 3-6 | **Sampling and basic statistics**  
**Ant distributions** |
| 2. 8/31 | **Ants at the Cal Academy**  
chapter 7-8  
Suarez and Case, The ecological consequences of a fragmentation mediated invasion: The Argentine Ant, Linepithema humile, in Southern California  
Krebs chapter 7-8 |  |
| 3. 9/7 | **Demography**  
Birkeland The Faustian Traits of the Crown-of-Thorns Starfish,  
Krebs chapter 9-10 | **Field: Cemetery demography** |
| 4. 9/14 | **Demography** | **Lab: Cemetery demography** |
| 5. 9/21 | **Population Growth and regulation 1 2**  
Computer: Life tables/ population gr.  
Harrison et al. Distribution of the Bay Checkerspot Butterfly ...  
Krebs chapter 11 |  |
| 6. 9/28 | **Life-history theory**  
*Exam 9/30* | **Field assignment** |
| 7. 10/5 | **Competition**  
Krebs chapter 12 | **Computer: simulations** |
| 8. 10/12 | **Competition Critique 1 due** |  |
| 9. 10/19 | **Predation**  
Krebs chapter 13, 14 | **Field: Dunes**  
[Req. El 16.5 (2)]  
**Field assignment** |
| 10. 10/26 | **Predation**  
Krebs chapter 16, 17 | **Field: Dunes** |
| 11. 11/2 | **Mutualism**  
Krebs chapter 14 | **Field: Dunes** |
| 11/4 | **Exam 11/4** |  |
| 12. 11/9 | **Ecological Communities**  
Peterson *Intertidal Zonation of Marine Invertebrates in Sand and Mud,*  
Krebs Chapter 20-21 | **Field: Structural complexity & diversity** |
| 13. 11/16 | **Ecological Communities**  
Krebs Chapter 22-24 | **Lab: Structural complexity** |
Appendices for Standards:

Standard 17: Safety Procedures
LABORATORY MANUAL

BIOLOGY 230
INTRODUCTORY BIOLOGY I

SAN FRANCISCO STATE UNIVERSITY

Spring 2008

Nan Carnal
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Biology Department Laboratory Rules for Health and Safety

You should be aware of some health and safety precautions that must be followed in each laboratory session. In several exercises, there are potentially dangerous chemicals present. Some of these chemicals can produce harmful fumes. Other chemicals are flammable. Caution must be exercised when working with these chemicals. In addition you will be working with glassware that can break. For your safety, follow these simple rules:

1. **DO NOT** eat food or drink liquids in the laboratory.

2. **Many of our laboratory solutions must not be poured down the drain.** Read all waste container labels and discard your waste only into the one designated for that specific chemical. If you are confused about how to dispose of the solutions in your lab, ask your instructor for the proper procedure.

3. Wearing safety goggles is required when working with solutions and live cultures.

4. Tie back long hair and do not wear loose jewelry.

5. Roll up long sleeves when working around open flames or using equipment. Do not wear shorts or expensive clothing to lab.

6. Keep open flames away from flammable chemicals, clothing and YOU.

7. Container labels and safety signs must be read and warnings heeded.

8. Know the location of the first aid kit.

9. Know the location of the fire extinguisher.

10. Report any injury to yourself or another student, no matter how minor, to the instructor.

11. Report any spills to your instructor and clean up spills immediately.

12. Pipetting by mouth is an unsafe practice and prohibited. A bulb must be used for pipetting.

13. Prior to leaving lab, all lab supplies and materials must be cleaned and stored in their designated place. Each person is responsible for his or her own area and equipment.

14. **WASH YOUR HANDS** after any contact with chemicals or biological materials and **always** before leaving the lab.

If you use proper biological techniques and procedures, your risk and the risk of your classmates and the environment will be minimal.
Biology 351: Experiments in Cell and Molecular Biology, Spring 2005
Instructor: Wilfred Denetclaw Jr., Ph.D.
San Francisco State University

Two Day-Old

Fluorescence Microscope Light Path

Fluorochrome excitation and fluorescence

Confocal Image Series of Nuclei & Chromosomes
Book References:

General Laboratory Procedures

1. All workspace (including common-use areas) must be cleared of all glassware, equipment, and reagents at the end of each laboratory period.

2. DO NOT write directly on any glassware or equipment with any type of lab marker. Instead, use label tape for all labeling. Remove the tape before returning the equipment or putting the glassware into the wash.

3. Dirty glassware will be washed in the lab.

4. Reusable pipettes will be placed in special containers provided.

5. Used needles and razor blades must be placed in special "Sharps" container provided.

6. All broken glass will be placed in special containers provided.

7. Petri dishes containing bacterial cultures will be discarded in special containers and then autoclaved before disposal.

8. Cell culture plates and plasticware should be discarded in special containers and then autoclaved before disposal.

9. All chemical waste must be placed in the labeled containers provided in the hood. NEVER pour a chemical down the sink!

10. Ordinary trash, such as paper towels and wrappers belong in wastebaskets. DO NOT add ordinary trash to any of the specially marked containers.

11. Before leaving the laboratory, refill your pipette tip box from the bulk pipette tip supply provided. Remove the old autoclave tape.

12. When you have finished cleaning up, wipe the tabletop at your station with a papertowel moistened with 70% alcohol and then dry it with a dry paper towel.

***** EMERGENCY PHONE NUMBERS *****

FIRE-POLICE-AMBULANCE: ........................................ 9-911

CAMPUS POLICE (24 hours) ........................................ 8-2222

EMERGENCY COORDINATOR Hensill Hall: Mike Blagoyevich ......... 8-2385

STOCKROOM .......................................................... 8-1091
Laboratory Safety

Personal Safety

Safety is of primary concern in working in the laboratory containing chemicals. For your own protection as well as that of others, follow these guidelines on a routine basis:

1. Please listen closely to instructions about the handling of certain chemicals.
2. Wear goggles and latex gloves when handling corrosive solutions.
3. Be sure to wear clothing and shoes that maximize protection.
4. Smoking is not permitted in any indoor areas on campus.
5. Wash hands before leaving the lab and before eating.
6. No food or drink is allowed in the lab.
7. Contact lenses can cause eye damage in the event of chemical or material contamination of the eyes and should not be worn in the laboratory without eye protection.
8. Tie back medium length and long hair when working near flames or entangling equipment.
9. Never mouth pipette. Bulbs and pipetting devices are provided.
10. Keep lab and other notebooks away from your reagents to prevent their contamination.
11. Maintain unobstructed access to all exits, fire extinguishers, and electrical panels.
12. Always report spills or accidents to the instructor or T.A. immediately.
13. Know the location of the emergency eyewash and shower and fire extinguisher.

Injuries/Illness

1. Report all injuries to the staff.
2. For life-threatening emergencies, CALL 9-911 from any campus phone.
3. For less serious cases, first-aid supplies can be found in the biology stockroom.

Hazardous and Toxic Spills

1. Students will be informed about any hazardous or toxic materials used in lab including instruction in correct handling procedures and disposal. If a spill occur notify the staff immediately.
2. If a spill presents an extreme hazard: evacuate immediately, pull the fire alarm, call 9-911 and give the exact location and nature of the spill.

Waste Disposal

1. Dispose of sharp items (i.e. razor blades, scalpel blades, etc.) into the red sharps disposal containers found in the room.
2. Broken glass should be cleaned up immediately and disposed of in the Broken Glass containers available in the room.
3. DO NOT put any sharp objects or broken glass into trash cans since this can cause an injury to building staff.
4. Infectious agents, animal wastes, and hazardous chemicals must be collected by the staff and disposed of in a proper manner - Not in the trash cans or down the sink.
5. NOTHING should be poured down the sink drains unless the staff has instructed you to do this.
Major Emergency Procedure

In the event of a major emergency affecting the entire building, campus, or community follow the instructions given by your instructor, the staff, or emergency assistance personnel. Information will be provided as soon as it becomes available. Your cooperation is necessary to insure the safety of everyone involved.

Procedures:

1. Upon the instruction of your instructor or the staff exit the building via the closest stairway in a calm and orderly fashion; do not use the elevator. Take time to familiarize yourself with evacuation routes in advance.
2. Assist the injured and handicapped when possible. Do not move the seriously injured unless there is danger of further injury. Disabled persons in wheelchairs should proceed to the nearest enclosed stairwell to await evacuation by the emergency responders. If there are deaf or hearing impaired persons nearby, be sure they know there is an emergency.
3. Once outside the building, go to a meeting area. Keep at least 100 feet away from the buildings to avoid danger from falling glass, etc. Make sure your instructor know that you have reached the meeting area.
4. Do not re-enter the rooms until police or fire personnel have determined that it is safe.
5. Remain at the assembly area to receive instructions.

Fires

1. If the fire alarm sounds, turn off any electrical equipment and evacuate the room immediately. Follow the evacuation procedure outlined above. Close all doors to help prevent fires from spreading as you exit.

To report a fire:
   a. Pull the nearest fire alarm
   b. Call 911 (9-911 from campus phones). Give location and extent of fire and any special circumstances such as presence of dangerous chemicals or animals.
2. ONLY WHEN FEASIBLE, attempt to put out the fire with the fire extinguisher. When fighting a fire, always position yourself between the exit and the fire. If the fire cannot be contained, GET OUT quickly!
   a. Know where the closest fire extinguisher is located.
   b. Direct the extinguisher at the base of the fire. Keep yourself between the fire and the door. DO NOT allow the fire to block your exit from the room.
   c. DO NOT risk personal injury in attempting to put a fire out. If it can not be contained, exit to the designated meeting site.
3. If you are able to put out a fire successfully, remain at the site to make a report with the Fire Department.

Earthquakes

1. Seek shelter under a desk, table, counter, or doorframe away from windows, DUCK, COVER AND HOLD.
2. DO NOT attempt to leave the room while the tremor is occurring.
3. When tremor stops, leave room immediately following the evacuation procedure outlined above. In case of possible gas leaks from other buildings DO NOT light matches or candles.
4. DO NOT use telephones except to report extreme emergencies.
Laboratory Manual
for
General Microbiology
Biology 402

Fig. 1 On the left is a photo of a Gram stain of *E. coli* (1000x) taken from a BHI streak plate. It shows Gram negative bacteria. Digital photo by Mohsen Shamai. The photo on the right shows the results of an indole test. A red ring around the top is indicative of a positive result. Digital photo by Cindy Wan. Both student photographers were from Bio 402.2, Fall 2007.

San Francisco State University
Spring 2008
Laboratory Safety Rules for Microbiology

It is important that you follow the laboratory rules! Points will automatically be deducted from your participation grade for even minor infractions. Repeated failure to follow these rules will result in your expulsion from this course! These rules pertain to all work done in the lab, including open labs!

**Safety:**

1. No eating or drinking in the laboratory.
2. Table tops will be wiped with Amphy1, the lab disinfectant, before and after each lab.
3. Hands should be washed at the beginning and after each lab.
4. No cultures should be removed from the lab.
5. Report accidents of any kind to the instructor immediately.
6. If a spill should occur, first pour Amphy1 on it and then report it to your instructor.
7. Be aware that soft contact lenses may absorb vapors from organic solvents that could lead to eye damage. The organic solvents in this lab are used in small amounts, minimizing the risk. If you have any concerns about exposure to these solvents, switch to glasses!
8. Pipetting by mouth is not allowed in the lab. You are required to use a pipette bulb or other device provided when needed.
9. There is an eye wash and shower located at the front of the room and to the right. **At no time will this area be blocked by carts, chairs or any other items.** There is also a fire extinguisher by the door in the lab.
10. All personal items are to be stored in appropriate areas. Coats/sweaters are to be placed in the coat cabinet in the back of the room. Backpacks/books/purses must be stowed under desk. Aisles must be clear at all times! Personal drawers will be assigned for lab coats, microscope slides, etc. These may be shared with another student.
11. Long hair must be tied back. Rubber bands are available the first day.
12. Lab coats/long shirts must be worn when performing lab work and must not be worn around campus. If you need to remove a lab coat from the lab for any reason it should be carried in a plastic bag. If you do not have a lab coat you will not be allowed to remain in the class that day. It is not a good idea to use the lab coat from micro in other labs unless you have washed it in bleach first.
Housekeeping Rules

1. All supplies for class will be placed on carts in the lab for your use at the beginning of class. Some reagents are always in the lab and located on the bookshelves in the front of the room.

2. If you need something that is neither on the cart nor on the bookshelf, ask your instructor: do not go to the media kitchen!!

3. When you take supplies from the cart, under no circumstances are you to return them to the cart without permission. Ex. Saline solution that you only used once. These supplies will go in the “morgue,” which is the discard area by the door.

4. When you are finished with cultures of microorganisms discard them in the morgue (area by the door), and please dispose of them in the proper place unless they are needed for another lab period:
   a. Plates go in the biohazardous bucket and are not recycled for class use so there is no need to remove writing.
   b. Tubes are discarded in the slanted baskets with caps on.
   c. Tubes must have any tape and/or writing removed, using acetone, before discarding because they are cleaned and recycled for class use.

5. There are also biohazardous bags located on each lab table. These are not trash containers for you convenience. They are for discarding small items that have been contaminated with LIVE microorganisms. For example: a Kimwipe that you used to blot a wet mount or wipe up a small spill, and pipette tips used for transferring bacteria. They are not for Kimwipes used to blot Gram stains. Those Kimwipes can be disposed of in the regular trash.

6. If you have a major spill that requires using paper towels discard them in the large bucket in the morgue, not in the small biohazardous bags.

7. There are red plastic containers located on the lab tables. These are for disposal of sharp items such as razor blades, glass pipets, and contaminated toothpicks. **They are not for your personal trash and points will be deducted if anything, other than sharp items, is found in these containers.

8. When Gram staining reagents and Amphyl bottles are low, please refill them from bottles located next to the morgue.

9. There are many classes meeting in the lab. Please keep your immediate area clean and any area you have used during your lab period or open labs.
   a. Pick up all trash from the floor
   b. Put all cans/tube holders back under the sinks
   c. Make sure there is no soil or paper in the sinks
   d. Please push chairs in so the media kitchen personnel can maneuver easily through the lab with their carts

10. Always leave the lab better than you found it.

I have read and understand the rules presented here, will abide by them and understand that my grade WILL be affected for infractions.

Signature: ___________________________ Date: ___________
Laboratory Safety:

The safety of yourself, your classmates', the staff and the environment is your #1 priority. You will be working with hazardous materials in this course—pathogens, human blood, needles, toxic chemicals, etc. Each of these can be handled and disposed of safely, if you are aware, use adequate precaution and follow prescribed procedures. If you ever have questions, ask the instructor.

A lab coat is required at all times in the lab. Open toed-shoes are not permitted. Eye protection and disposable gloves are recommended and, in some instances required (e.g. when working with human blood as per Universal Precaution Guidelines). You are required to provide a labcoat, eye protection and disposable gloves.

No eating or drinking is permitted in the lab room. No mouth pipetting is allowed in the lab. Use pipettors for all pipetting.

Report any chemical spills, glass breakage to the instructor.

Know the location of the eye wash and safety shower.

Know the proper disposal of all solutions, samples, labware.

No cell phones, pagers or visits by friends during class are permitted.

Laboratory Notebook

Your lab notebook is the sole record of your experimental work in this class. The notebook should be organized and contain a thorough record of your observations, results and conclusions. All writing in your notebook should be in permanent ink. A permanently bound notebook is required; 3-ring or spiral notebooks are not acceptable. In the front of the notebook create a table of contents. Each experiment should be listed in the table of contents as it is performed along with the inclusive pages. [Note that all of the pages in the notebook should be numbered consecutively]. These notebooks will be turned-in periodically for grading and comments. In general, your write-up of an experiment should be complete the week following the experiment.

For each experiment, you should include the following sections in your write-up:

Purpose: a statement of the experimental question(s) addressed by the lab exercise. Your statement should clearly indicate why the experiment is being performed i.e. what information is hoped to be gained.

Procedure: a step-by-step description of the experimental procedure (i.e. how was the experiment actually done). You may paste into your notebook the protocol provided to you. However, it is crucial to have an accurate record of what was
LABORATORY INTRODUCTION - GENERAL INFORMATION  
Biology 526 - Plant Physiology Laboratory  
Spring 2005

I. General Procedures:

For most laboratory exercises you will work in teams of two. Each team will receive a supply of laboratory glassware and other frequently used items. Please check the kit against the master list of provided equipment. If you are missing any items obtain them from the instructor. Sign the equipment list indicating you have received all items and return it to the instructor. All equipment is to be kept in the drawers provided. You are responsible for glassware, etc. and these items will be checked back in at the end of the semester.

II. Safety Measures:

General care must be exercised in the laboratory at all times. Many of the materials we will use are poisonous. Please do not eat or smoke in the general laboratory working areas. Please wash your hands well before leaving the laboratory.

A. Poisons

1. Many reagents including strong acids, bases, and oxidizing agents are not only poisonous, but also are harmful to skin and clothing. Always wash drops of such fluids from the outside of reagent bottles and bench tops. Immediately flush any skin area that has been in contact with acid/base/etc. with copious amounts of water. See instructor if you need further treatment.

2. Use a mechanical aspirator when pipetting poisonous reagents. Poisons will be clearly marked with labels.

3. Volatile poisons should only be used under the hood. Please do not remove these chemicals from the hood area.

4. Assume any unknown material is poisonous and treat it accordingly.

B. Fires/Open flames

1. Do not permit open flames near any volatile chemicals. (THIS CAUTION APPLIES PARTICULARLY TO ALCOHOLS (like ethanol) USED TO SURFACE/FLAME STERILIZE SCALPELS AND FORCEPS.)

2. Do not heat volatile solvents directly on a hot plate surface. Heat volatile solvents in a water bath of the appropriate temperature.

3. Always flush flammable solvents down the drain with copious amounts of water.

4. Never dispose of a hot match down a drain or sink.
C. Radioactive Materials

1. The use of radioactive materials will be restricted to the hood.
2. Special procedures for work with radioactive materials will be given. Please follow these instructions. Anything that comes into contact with radioactive materials must be discarded in specially designated and labeled waste receptacles.

III. Cleanliness:

Cleanliness and good techniques are of utmost importance in obtaining good laboratory results. It is extremely important to use clean glassware. Biochemical preparations are very sensitive to traces of certain substances, e.g., heavy metals and SOAP. Because concentrations of enzymes, etc., are much lower than concentrations of substances often used in analytical chemistry procedures, a small amount of an impurity can result in serious contamination problems.

Glassware Cleaning:
1. Ideally glassware should be rinsed as soon as it has been used and placed in warm soapy water to soak. Again, ideally, the glassware should be allowed to soak for several hours. (Because of time restrictions in this class just do the best you can!)

2. It is YOUR responsibility to clean any glassware you use. Please wash glassware before leaving class, if at all possible. Particularly dirty glassware may be left to soak, but please remember to take care of it during the next lab period.

3. WASHING GLASSWARE:
   a. Scrub the glassware thoroughly in CLEAN SOAPY WATER with an appropriate brush.
   b. Rinse glassware in cool tap water at least 6 times or until you are sure you have rinsed away soap residue. Then rinse the glassware with distilled water (from the DW (distilled water) tap) several times.
   c. Place glassware in an appropriate place to dry.

4. WASHING PIPETTES:
   Place dirty pipettes in the pipette washer basket with their TIPS UP. The pipettes will be washed for you and when dry will be placed in the pipette drawer.

IV. A Few Notes on Techniques:

A. Labelling Glassware, Samples, Reagents, Etc.:
1. Be diligent about labelling test tubes, beakers, etc., during the course of an experiment. 5 seconds spent labelling saves hours of grief!!

2. Any experimental materials left in the refrigerator, in the lab, or in the 526 prep room that you want saved should be clearly labelled with your name, date, contents, and Biology 526.

3. Ink from glass-marking pens will "run" if labelled containers are placed in a boiling water bath. Solution?: wrap a piece of tape all the way around the test tube, etc., so that the ends of the tape overlap. Label the tape with your marking pen or a pencil (ballpoint pen will run).
B. Pipetting

1. Please do not pipette directly out of reagent bottles or prepared reagents in flasks or beakers intended for use by the whole class. Estimate the amount of the reagent you require and pour it into a beaker or flask. (Please try to be conservative with the estimate!) Pipette the required amount from your personal container. Discard any excess. DO NOT return it to the original bottle. (Therefore, if you use a contaminated pipette or piece of glassware you mess up only your results not those for the whole class!)

2. Be sure to note whether the pipette you are using is a Mohr type or a serological ("blow-out") pipette and deliver volumes appropriately!!

3. Practice with the mechanical aspirators if you have never used them before. WHAT TO DO IF YOU ASPIRATE LIQUIDS INTO THE BULB:
   a. Rinse the bulb out with deionized water, squeezing out as much water as possible
   b. Place a C-clamp on the "A" and "S" pads of the aspirator just tight enough for the air channels to be open continuously through the aspirator. (Try to avoid overtightening the clamps.)
   c. Attach the aspirator to an air valve on the back lab bench and open the valve so a gentle stream of air flows through the bulb. Please make sure the air flow is slow enough to prevent "blowing up" the bulb!!

4. Adjustable Volume Micropipettes:
   a) Each team will be assigned a set of micropipettes, these are to be stored in the locked general lab cabinet when not being used.
   b) Please report any mechanical problems with pipettes
   c) Proper Use of Pipettes
      1) rotate volume adjustment knobs only within the range of volume measurements allowed
      2) disposable tips are used with the pipette apparatus
      3) plunger position for liquid uptake is determined by volume adjustment knob—depressing plunger to first resistance (stop point) positions the plunger properly for correct volume uptake
   d) general operation 1) choose appropriate pipette for volume desired
      2) P 20 (0-20 µl); P200 (20-200 µl); P1000 (100-1000 µl)
      3) firmly position disposable tip on pipette
      4) adjust volume knob to desired volume
      5) depress plunger to 1st stop
      6) position tip of tip under liquid desired
      7) release plunger (controlled release)
      8) to expel liquid, depress plunger past 1st stop, to second stop
      9) clicking plunger repetitively is not good practice
     10) manually or with mechanical tip separator; discard tip

C. Use of balances:

1) PLEASE—always use a plastic weighing boat or weighing paper between the sample and the balance pan. The pans rust and corrode easily.
2) If you spill chemicals on the balances, please clean them up
3) ASK if you do not know how to use or read the balance

D. Balance Centrifuge Tubes on Two Pan Balance before placing them opposite each other on the rotor
Biology Laboratory
Course Procedures and Safety Agreement

General Laboratory Procedures

1. All workspace (including common-use areas) must be cleared of all glassware, equipment, and reagents at the end of each laboratory period.
2. Dispose of needles and razor blades in the sharps containers provided.
3. Dispose of broken glass in the cardboard box specially marked for that purpose.
4. Dispose of biological waste in the biohazard waste containers.
5. Most chemical waste will be placed in the labeled containers for disposal; do not pour any chemical solutions down the sink unless directed to do so by an instructor.

Safety Procedures

1. Know where the nearest emergency eyewash, shower, and fire extinguisher are located.
2. No food or drink is allowed in the lab.
3. All students must bring a labcoat, gloves and safety goggles to class and wear them as directed by the instructor.
4. Listen closely to instructions about the handling of chemicals and equipment; wait for instructions before starting new experiments.
5. Tie back long hair and sleeves when working with flame, hazardous chemicals, or entangling equipment.
6. Never mouth pipette. Pipetting devices are provided.
7. Report spills or accidents to the instructor or T.A. immediately.
8. Wash hands before leaving the lab.

Course: __________  Section: __________  Instructor: ________________

I have read the Biology Laboratory Course Procedures and Safety Agreement, and agree to abide by these rules while participating in this laboratory course.

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**Biology Laboratory**  
**Course Procedures and Safety Agreement**

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(Note to instructor: Attach course roster to signature sheet and return to the Biology stockroom.)
Biology 230 – Safety Notes for GTA’s

Contacts
Campus Police       911 (from campus phones only) or 338-2222
Undergraduate Labs Manager Julie Tessener 338-6264

Building Evacuation Procedures
When you hear the evacuation alarm, turn off any necessary equipment and make sure everyone in your area leaves promptly.

Take the stairs

Assist persons with disabilities

Wait outside the building

Do not re-enter the building until it has been cleared by the campus police.

In the event of a major catastrophe, Cox Stadium is the designated gathering point for information and assistance.

Sudden Illness
If someone becomes seriously ill, call the Campus Police at 911 from any campus phone.
   If the person is conscious, ask him or her how you can help.
   Keep the ill person quiet and comfortable until help arrives.
   Try to allow the person some privacy.

Accidents and Injuries
Clean up small spills promptly.
Each lab has a jug of spill absorbent for containing spills.
If you have questions about cleaning up a spill, please contact Julie at 338-6264 or the Biology Stockroom at 338-1091.
If a chemical spill is too large or dangerous for you to handle, call the Campus Police at 911.

If a student is injured in the lab, you may offer bandages.
If the wound is too serious for a small bandage, please encourage the student to go to the Student Health Center for treatment. You may want to ask another student to escort the student to the Health Center.

After-hours, off-site medical services are available at:
St. Francis Memorial Hospital
Franciscan Treatment Room
1150 Bush St at Hyde
415-353-6305

Note: GTA’s are responsible for safety presentations. Students must sign a contract that they understand and will abide by.
MSDS

MSDS notebooks are located as follows:
- Bio 101 Lab (Trl J1) – on the instructor’s podium
- Bio 150 Lab (HSS 107) – on the shelf above the sink
- Bio 230 Labs (Trls O3 and O4) – on the instructor’s desk
- Bio 240 Lab (TH 523) – on the instructor’s podium
- Solutions Prep Lab (Trl J2) – in the drawer labeled “MSDS”
- Trl R2 – on the shelf behind the desk

A list of the components of each laboratory reagent used in the undergraduate labs can be found at the beginning of each MSDS notebook.

Labels

All reagent bottles, even squirt bottles or carboys with distilled water in them, have to be labeled.
If a label falls off of a bottle, please take the time to make a new label with a piece of tape.

Reagent labels should indicate the name of the reagent, the concentration (e.g. a bottle should never be labeled simply as “HCl” – it should indicate the concentration, “Conc. HCl”, “1N HCl”, etc.), the date prepared, and the initials of the preparer.

General Safe Work Practices in Labs

Wear approved splash goggles or safety glasses when in the lab.

Keep long hair pulled back or tightly secured.
Hair will burn if it contacts the Bunsen flame.
Also take off or secure necklaces, loose bracelets, etc. before working in the lab.

Avoid inadvertent contact with chemicals by not eating or drinking in the lab.
Step outside the lab if you need food or drink.
Don’t taste any chemicals or place your nose directly into a beaker, tube or flask.

Please note the distinction between Food Only refrigerators and Chemical refrigerators. Never put chemicals in Food Only refrigerators.
Don’t sit or lean on lab benches. You don’t know if residues of spilled materials are still there.

Know where the exits, safety shower, eyewash and fire extinguisher are.

If the evacuation alarm sounds, turn off all apparatus and leave the room for the nearest safe exit.
Note that spills could cause exposure problems and that many chemicals burn right through clothing. Wear shoes that completely cover your feet. Avoid shorts and short skirts in the lab.

Check glassware for cracks or damage. Do not throw broken glassware into trash but rather in a sharps container (red plastic box) or a designated box.

Note that hot and cool glassware look the same. Make sure your glassware is cool before you touch it or hand it to someone else.

Keep flammable liquids and ignition sources (Bunsen burner flames, hot plates, etc.) well separated.

Place a clear and readable label identifying your reagents, products, etc. on each container.

Put unused reagents or products of reactions into appropriate labeled containers as directed.

Wash your hands immediately before leaving the lab and after any possible chemical contact.

Take off gloves and lab coat when leaving the lab (especially to use restrooms or the elevators).

Waste
We have six basic types of waste containers in the labs, some for hazardous waste and some for non-hazardous waste:

1. Hazardous Waste bottles, jugs, jars with tags for specific chemical waste – each bottle will be labeled for the type of waste to be placed in it, and each bottle will have a completed waste tag attached.

2. Biohazard bags in a bucket – red bags for disposal of cultures on Petri dishes and any swabs, wood sticks or toothpicks used for inoculation.

3. Sharps containers – red plastic boxes for the disposal of glass coverslips, razor blades, scalpel blades and other sharps.

4. Broken Glass Box – generally a cardboard box labeled as "Broken Glass" for the disposal of any broken glassware.

5. Animal Waste Buckets – for the disposal of animal parts and animals from dissections.
6. Garbage Can – for the disposal of all other waste, including paper towels. Paper towels should not be placed in biohazard bags, animal waste buckets, or the broken glass box.

**More on waste bottles:**
Waste bottles are provided for the labs with labels and waste tags specific to the waste that they are to contain.

Waste bottles should be capped at all times when not in use.
A funnel is not a cap.
An uncapped waste bottle in an empty room can lead to hefty fines.

If your waste bottles are full, contact Julie for new ones.
If Julie isn't around, you can get waste bottles and waste tags from the stockroom (Trl Q).
The bottles must be labeled and tagged, so copy the information from the label and tag of your full bottle to the new labels and tags.
An untagged waste bottle can also lead to hefty fines.

**More on Safe Work Practices:**
For permanent fume hoods (as opposed to the portable fume hoods in the trailers), the exhaust fan should be on at all times.

The sash on permanent fume hoods should be pulled down at least to the safe working level (marked on the hood) to avoid splashes and to maximize the draw of the fume hood.

Examine electrical equipment for frayed or damaged cords or plugs.
Please take any damaged equipment out of service and leave a note on it.
Also encourage students to unplug equipment by pulling on the plug, not the cord.

Fire extinguishers are usually mounted by exits on a peg or in a cabinet. If you don't know how to use a fire extinguisher, report a fire or pull the alarm right away and evacuate the room.

**Housekeeping**
Please leave the lab in good condition for the sections that follow you.

Ask your students to wash any glassware they use and leave it out to dry or return it to its proper shelf.

Ask your students to wipe down the benches after messy labs, particularly labs using chemicals or preserved specimens.
# Biology Stockroom

**Phone:** (415) 338-1091 or (415) 338-1092  
**Location:** Hensill  
**Hall:** 539

**Stockroom Hours:**  
Monday - Friday 8:00 am - 12:00 pm; 1:00 pm - 5:00 pm

Welcome to the NEW Biology Stockroom Web Page

*Click on picture to go to that page or use the frame menu on the left.*

<table>
<thead>
<tr>
<th>About the Biology Stockroom</th>
<th>Biology Stockroom Personnel</th>
<th>What's New?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplies Recharge Program</th>
<th>Department Ordering Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SHIP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hazardous Materials Guidelines</th>
<th>Biohazardous Materials Procedure</th>
<th>Autoclave Operation Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MSDS Links</th>
<th>Downloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

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Comments and questions about this web site are appreciated and maybe directed to Michael Fong