SYSTEMWIDE COMMITTEE AND DIVISIONAL CHAIRS

On behalf of Chair Powell, I enclose a request for systemwide review of a proposal to expand the Area "d" laboratory science admissions requirement to include courses in Earth, Environmental and Space Sciences.

This review was originally requested by the Davis division. The Academic Council referred it to BOARS for study. Although the BOARS report recommended against the proposed change, the Academic Council voted to submit the proposal for Senate review. In preparation for the review, Council asked BOARS and a member of Council who favored the proposal to assemble a packet of material to facilitate the review. That material is attached to the enclosed letter from BOARS to Council Chair Powell.

As the Senate's designated authority on admissions requirements, BOARS will be asked to assess the comment that results from this review and make a final recommendation to Council.

Please submit your comments to senatereview@ucop.edu by **Wednesday, June 23, 2010** so that Academic Council can discuss it at its meeting on June 30. As always, if you feel that the issue is not within your purview, you may decline to comment.

Best,

Clare Sheridan
Senior Policy Analyst
Academic Senate
University of California

Phone: 510.987.9467
Fax: 510.763.0309

UNIVERSITY OF CALIFORNIA

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BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS (BOARS)
Sylvia Hurtado, Chair
sylvia.hurtado@gmail.com

Assembly of the Academic Senate
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Oakland, CA 94607-5200
Phone: (510) 987-9466
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March 23, 2010

HENRY POWELL, CHAIR
ACADEMIC COUNCIL

Re: Systemwide Review of Proposal to Expand the Area (d) Laboratory Science Admission Requirement to Include Earth, Environmental, and Space Sciences: BOARS Recommendation for Materials to Include in Packet of Information Sent to Campuses

Dear Harry,

In June 2008, the Davis Academic Senate Division requested a University-wide review of the possible expansion of UC's Laboratory Science ('d') admissions requirement to include earth, environmental and space sciences (EESS). In July 2008, Academic Council voted unanimously to refer the issue to the Board of Admissions and Relations with Schools, with a request that BOARS deliver a report and recommendation for next steps, if any, by December 2008. At its January meeting, after reviewing BOARS' recommendation against the proposed change, the Academic Council voted to send the proposal out for systemwide review.

Since that time, in consultation with the Academic Council, BOARS has assembled a number background documents to help facilitate the review and answer common questions Senate members may have as they consider the proposal. BOARS regrets the delay in compiling these materials. The time it took to administer, collect, and assess the results of a survey of UC Science and Engineering departments, with the assistance of individuals who volunteered their time, accounts for much of that delay.

The enclosed packet contains further background information to facilitate this review. We have included the volume of materials sent by lobbying groups, and BOARS position is well-articulated in several documents. The review items are attached as follows:

Item 1: The Davis Request, the Proposal, and Background ***(Page 4)***
This includes the Davis division request (dated June 12, 2008) and the February 28, 2008 memo from UC Davis Distinguished Professor Emeritus Eldridge Moores and UC Santa Barbara Professor Bruce Luyendyk, which includes the specific proposed change to area ('d') and the rationale for the request. The Moores-Luyendyk proposal was accompanied by a February 2008 petition signed by several dozen members of the Academic Senate.

Item 2: EESS Brochure ***(Page 24)***
On September 10, 2009, Professor Moores submitted copies of an Earth Science Literacy Principles brochure.

Item 3: Petition from CalESTA's Wendy Van Norden ***(Page 37)***
On March 13, 2010, BOARS received a petition signed by 450 EESS educators in support of the amendment to area 'd'.

Item 4: The 2008 BOARS Response ***(Page 40)***
The December 11, 2008 BOARS response to Council regarding the Moores-Luyendyk proposal reviews the purposes of a-g, and outlines BOARS' perspectives on the various pros and cons of the proposal. BOARS concluded:

> "…that the overwhelming majority of EESS courses as currently offered at the ninth grade level are inadequate for the 'd' requirement by the criteria that define BOARS' work, as articulated in the "a-g" guide and expressed by University faculty in their prerequisites for freshman Science courses. BOARS recommends no change in current policy."

Item 5: BOARS' November 2005 response to 2005 request from EESS proponents ***(Page 44)***

Item 6: Purposes of 'a-g' ***(Page 49)***
This page defines the purpose, responsibility and general criteria for the "a-g" requirements as stated on the UC Admissions website. Considerations by BOARS and the Senate in relation to "a-g" policy are guided by these purposes.

Item 7: New Area (d) Language ***(Page 50)***
At its January 2009 meeting, BOARS approved revisions to language describing the area ('d') requirement recommended by a Task Force that met during the 2007-08 academic year. The Task force, which included math and science faculty from the three segments of California higher education and California high schools was charged to update and clarify the language in areas (c) and (d). Although the Task Force was not charged with making substantive policy changes, it did have lengthy and vigorous discussion of the Moores-Luyendyk proposal, and in the end recommended no change.

Item 8: Background on the Science Standards ***(Page 53)***
The Moores-Luyendyk proposal discusses two sets of Science Standards, the Science Content Standards for California Public Schools and the National Research Council's National Science Education Standards. This document explains what these two sets of Standards are, what they contain, and gives appropriate references. Also included is information about the Intersegemental Committee of Academic Senate's Statement of Preparation in Natural Science Expected of Entering Freshmen. BOARS notes that the two sets of standards cited by Moores-Luyendyk describe general high school standards and general scientific literacy, but are not the same standards UC faculty expect college-going students to meet, particularly those preparing for a UC education.

Item 9: Background on Earth Environmental & Space Science Courses in CA High Schools ***(Page 54)***
This document contains information about: (1) The number and types of Science courses and their enrollment in California High Schools from the California Basic Education Data (CBED);

(2) 2008 Results from the California Standards Tests (CST); (3) Information about Science Credential Requirements; and (4) Data on Science Completion for UC Applicants (based upon 2007 CPEC Data.) Enrollment data show that most EESS courses are courses in Earth Science that are pitched at a 9th grade level as evidenced by CST test taking patterns, and only about half of them meet a-g standards. Also the students taking the CST in Earth Science do not do as well as test takers in biology, chemistry and physics.

Item 10: Science Admission Requirements at Comparable Public Universities ***(Page 58)***
This document lists admission requirements in science at UC's "comparison eight" institutions and the so-called "public ivies". The list shows that although there is variation in science requirements from UC comparison institutions, many require three years and it is rare for a school to require two science courses (like UC) and to include EESS in the list. However, UC is also unique in that the two science courses must meet a laboratory requirement.

Item 11: Survey of UC Math and Science Departments ***(Page 62)***
In a survey of UC Science, Mathematics, and Engineering chairs, conducted by the Higher Education Research Institute (UCLA), questionnaire items asked about the importance of key high school courses to preparation for their introductory courses. Fifty (50) department chairs across the system responded by listing two introductory courses and providing information about the relevance of high school preparation for these courses. Respondents could rank the relevance of high school courses according to five levels: 1= Not Applicable, 2=Not Important, 3=Somewhat Important but not Necessary, 4=Very Important/Preferred, and 5= Essential, Required, or Should be Required.

For the primary introductory course chairs listed, only 10.4% (5 out of 48 responses) indicated that high school Earth Science/Geology courses and 12.5% indicated Environmental Studies courses were essential or very important as preparation. Chairs were least likely to designate that marine sciences/oceanography offered in high school was necessary for university preparation (4.2%). This compares with high school Calculus 29.2%, Biology 33.4%, Physics 48%, and Chemistry 52.1%. There was complete agreement among EESS dept. chairs about the essential need for Chemistry for their introductory courses, but not in any other subject area. Although fewer responded (36 responses) to the importance of high school courses as preparation for a second introductory course in their department, the pattern was similar indicating Earth Science and Environmental Studies was the lowest in importance (11.2% and 11.4, respectively) in comparison with Biology (32.3%), Calculus (40%), Physics (43.6%) and Chemistry (47.4%). The detailed tables representing the results of this aspect of the survey are attached on Page 67, along with information about its administration.

Sincerely,

Sylvia Hurtado

Sylvia Hurtado
BOARS Chair

cc: BOARS
Martha Winnacker, Senate Executive Director

UNIVERSITY OF CALIFORNIA, ACADEMIC SENATE

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Chair of the Assembly and the Academic Council
Faculty Representative to the Board of Regents
University of California
1111 Franklin Street, 12th Floor
Oakland, California 94607-5200

August 27, 2008

MARK RASHID
CHAIR, BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS

Re: Proposal to Reassess the "d" Requirement

Dear Mark,

The Davis Division recently requested a Universitywide review of the expansion of UC's "d" laboratory science admissions requirement to include earth, environmental and space sciences. As you may know, BOARS considered similar proposals in 2003-04 and 2004-05, but its recommendations were not reviewed systemwide.

At its July 23, 2008 meeting, Academic Council considered this request and voted unanimously to refer the issue to BOARS, requesting that it reassess the "d" requirement and deliver a report and recommendation for next steps, if any, by the December 2008 Council meeting.

I have enclosed the BOARS' and UCEP's prior recommendations, as well as the current request, for your reference. Please do not hesitate to contact me if you have any questions regarding Council's comments.

Sincerely,

Michael T. Brown, Chair
Academic Council

Copy: Academic Council
Martha Winnacker, Senate Director

Encl. 3

UNIVERSITY OF CALIFORNIA, DAVIS

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OFFICE OF THE ACADEMIC SENATE
ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616-8502
TELEPHONE: (530) 752-2231

June 12, 2008

MICHAEL T. BROWN, CHAIR
University of California
Academic Council
1111 Franklin Street, 12th Floor
Oakland, CA 94607

Re: Request to Review the Admissions "d" Requirement

On behalf of the Davis Division Executive Council, I write to endorse the request for Universitywide review of expanding the UC "d" Laboratory Science Admission requirement to include earth, environmental and space sciences. Faculty from several UC campuses have suggested inclusion of courses in these areas when available and question of whether the current admission requirement is inclusive of all opportunities for scientific literacy. The enclosed information provides some of the justification for reviewing the requirement. Based on the information provided to our Executive Council and enclosed, we recommend that UC review the depth and breadth of our admissions requirement.

Sincerely,

Linda F. Bisson
Professor of Viticulture & Enology
Chair of the Davis Division of the Academic Senate

Enclosures:
1. February 28, 2008, request to support to modernize UC "d" requirement
2. Petition to BOARS and UCEP
3. March 4, 2008, status report

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DEPARTMENT OF EARTH SCIENCE

SANTA BARBARA, CALIFORNIA 93106-9630
FAX (805) 893-2314

February 25, 2008

A request and proposal to modernize the UC area d science entrance requirement.

Dear UC Colleague:

Enclosed please find petitions in electronic form, either signed or explicitly supported, from Academic Senate members of the Berkeley, Davis, Irvine, Los Angeles, Merced, Riverside, San Diego, Santa Barbara, and Santa Cruz campuses, requesting that the fields of Earth, Environmental, and Space Sciences be added as an additional choice to UC's "d" Laboratory Science Admission Requirement. Faculty of the Department of Geological Sciences, San Diego State University (SDSU) also have signed the petition and that is included.

The proposed revision of the UC Area – d requirement would stipulate:
…"two and preferably three courses (from at least two areas), of the following sciences: 1) biology, 2) chemistry, 3) physics, and 4) Earth, environmental, and space sciences."

Earth, Environmental, and Space Sciences are included in national standards (National Academy of Science/National Research Council, American Association for the Advancement of Science, and Council of Scientific Society Presidents) and the California State School requirements for Grades 10-12 science. UC's science admission requirements are not in compliance with either the National or the California State School standards.

In this time of resource depletion, environmental degradation, and climate change, all students need the information given in these courses. In addition, California students in particular need information on hazards, such as landslides, earthquakes, volcanic eruptions, sea level rise, water supply and management, which are covered only in these courses.

Modern courses in Earth, Environmental, and Space Sciences cover all requisite requirements for courses satisfying the d" requirement including mathematics, the scientific method, and laboratory exercises, or easily can be designed to do so. Furthermore, revolutionary new teaching aids, supported by NASA and NSF, allow students to download images of their own home area and use these images in rigorous scientific laboratory exercises. These developments make these courses very appealing to all students, especially those from disadvantaged backgrounds.

Many larger California school districts have added Earth, Environmental, and Space Sciences to their curricula in order to make their students more competitive on state and national examinations. UC's failure to list these courses as satisfying its "d" requirement has a harmful effect on the teaching of these courses. High school administrators around California perceive that the absence of Earth, Environmental, and Space Sciences in the "d" requirement indicates that UC does not value these courses. These courses end up being classified as the soft or

"drop out" science courses as a result. A recent effort by the San Diego Unified School District to design an earth science curriculum to meet the "d" requirement was thwarted by UC Office of the President because of the rigid stance of UC on this issue (documents on request).

Data from California's "STAR" (high school advanced science achievement) tests over the past four years indicate that allowing Earth, Environmental, and Space Sciences as satisfying the "d" requirement will have little effect on the numbers of students taking biology, chemistry, or physics. Although the number of students taking the Earth Science test has tripled between 2003 and 2007, the number of students taking biology, chemistry, and physics tests also has increased. These data support the idea that courses in Earth, Environmental, and Space Sciences motivate students to take more science.

Thus we request that "Earth, Environmental, and Space Sciences" be added to the listing of laboratory courses satisfying the "d" requirement, for implementation, if possible, for the 2008-2009 year, and failing that, for the 2009-2010 year. Our California High School students deserve no less.

Sincerely,

Eldridge Moores, Distinguished Professor Emeritus UC Davis

Bruce Luyendyk, Professor UC Santa Barbara

TO THE ACADEMIC COUNCIL, BOARS, AND UCEP
FROM UC FACULTY

We, the undersigned request that the UC High School "D" requirements for laboratory science be amended to include "Earth, Environmental, or Space Sciences" as a choice for admission to the UC system:

I. Currently the UC High School area "d" requirement states that students shall take "two and preferably three courses from the following sciences: biology, chemistry, and physics".

II. We, the undersigned, request that the "area d" requirements for laboratory science be amended to include **Earth, Environmental, and Space Sciences** as an additional choice for admission to the UC system. Earth, Environmental, and Space Sciences broadly defined include content in Astronomy, Ecology, Geology, Meteorology, Oceanography, Earth System Science, Environmental Science, Planetary Science and other topics within the integrative study of all or parts of the Earth's Atmosphere, Hydrosphere, Biosphere, and Lithosphere, of the Solar System, and of the Cosmos. The text of the UC Area – d requirement is proposed then to read:

"two and preferably three courses from the following sciences: 1) biology, 2) chemistry, 3) physics, and 4) Earth, Environmental, and Space Sciences."

III. To be considered for certification in the "d" subject area, courses (in Earth, Environmental, and Space Sciences) must (see: http://www.ucop.edu/a-gGuide/ag/content/Guidetoa-gReqs_2008.pdf):
"- specify, at a minimum, elementary algebra as a prerequisite or co-requisite
- take an approach consistent with the scientific method in relation to observing, forming hypotheses, testing hypotheses through experimentation and/or further observation, and forming objective conclusions, and
- include hands-on scientific activities that are directly related to and support the other classwork, and that involve inquiry, observation, analysis, and write-up. These hands-on activities should account for at least 20% of class time, and should be itemized and described in the course description."

IV. We make this request in consideration of the following points:

- Earth (including Space) Sciences are currently included in the required California State Board of Education curriculum for California high schools. Earth Science is one of four science achievement examinations, of which CA High School students must take two.
- The number of Earth Science classes in CA high schools is rapidly increasing, and the number of high school students taking the Earth Science exam has tripled in the past three years. UC does a disservice to high school students by not recognizing the Earth Science classes that they complete.
- Modern Earth, Environmental, and Space Science courses are taught with rigorous, solid content, using problem-based learning including laboratory work and fieldwork. These courses, for which many curricula are available, fit all the current certification criteria for the "d" requirement.
- In general, the number of students taking science is decreasing, despite the increased need for scientists and engineers. If the U.S. is to be competitive in the new global environment, the state needs to find ways to entice students to consider science as a career. Students who

TO THE ACADEMIC COUNCIL, BOARS, AND UCEP
FROM UC FACULTY

We, the undersigned request that the UC High School "D" requirements for laboratory science be amended to include "Earth, Environmental, or Space Sciences" as a choice for admission to the UC system:

take Earth, Environmental, and Space Science classes tend to get "hooked" on science, and often go on to take other science classes (e.g., biology, chemistry and physics.) and pursue science majors in college.

- Earth, Environmental, and Space Science classes are especially attractive to disadvantaged students because they address practical problems that are inherent in the students' surroundings and daily life.
- Many issues facing society require knowledge of Earth and Environmental Science that is not covered in any standard biology, chemistry, or physics courses. These issues include climate change, water supply and quality, soil quality and preservation, resource use and depletion, disaster awareness and preparedness (landslides, earthquakes, floods, etc.), and resultant land-use planning, to name but a few.
- The National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, and the Council of Scientific Society Presidents all recommend that Earth and Space Science classes be included as part of standard high school curricula.
- In California the UC statewide science deans, the current and past NAS presidents Dr. Ralph Cicerone, and Dr. Bruce Alberts, both of whom are UC faculty, and numerous UC faculty have already supported the addition of the Earth, Environmental, and Space Science to the UC 'area d" requirement.

TO THE ACADEMIC COUNCIL, BOARS, AND UCEP
FROM UC FACULTY

We, the undersigned request that the UC High School "D" requirements for laboratory science be amended to include "Earth, Environmental, or Space Sciences" as a choice for admission to the UC system:

Name	Signature	Department	Campus	Email

From: Bruce Luyendyk <luyendyk@geol.ucsb.edu>
Date: March 4, 2008 6:06:13 PM PST
To: Eldridge Moores <moores@geology.ucdavis.edu>, Bruce Luyendyk <luyendyk@geol.ucsb.edu>, Joel Michaelsen <joel.michaelsen@senate.ucsb.edu>, Winston Ko <wko@ucdavis.edu>, Mark Richards <Mark_Richards@ls.berkeley.edu>, "Wenk H.-R." <wenk@berkeley.edu>, David Kimbrough <dkimbrou@geology.sdsu.edu>, Lisa Tauxe <ltauxe@ucsd.edu>, Cheryl Peach <cpeach@ucsd.edu>, Peggy O'Day <poday@ucmerced.edu>, Lisa Grant <lgrant@uci.edu>, David Osleger <osleger@geology.ucdavis.edu>, Ray Ingersoll <ringer@ess.ucla.edu>, James Gill <jgill@pmc.ucsc.edu>, Susan Trumbore <setrumbo@uci.edu>, George Brimhall <brimhall@calmail.berkeley.edu>, Mary Droser <mary.droser@ucr.edu>
Subject: UC area d: Status of revision request

Dear UC-d Colleagues;

Last week we presented our proposal and petitions to upgrade and modernize the “area d” requirement to system-wide BOARS and the BOARS Task Force (attached). Their response was resistance to reconsidering this matter (a version for including Earth and Space Sciences in the “d” requirement was turned down a couple of years ago). However, the Academic Council chair Michael Brown is willing to bring it up again with Senate backing. To trigger a consideration, our proposal needs to be supported by Divisional Academic Senates, or in other words the individual campus senates.

Thus, we have nearly succeeded in putting the issue in play by showing wide faculty support, but there will not be full consideration of our proposal without support coming through campus senates.

What to do next: Each campus has a representative to BOARS (list attached) and Senate committees that rule on admissions and undergraduate matters. At UCSB the committees are the Undergraduate Council and its subcommittee, the Committee on Admissions, Enrollment & Relations with Schools (our BOARS representative is chair of this). Each campus will have something similar to this organization.

The goal is to obtain endorsement of our “d” proposal from these campus committees (your campus equivalent of the UCSB undergraduate council). The procedure would be for you to send the chair of your campus undergraduate committee and your BOARS representative our proposal/petition and ask for their support in a request to the Academic Council and BOARS to reconsider the matter. This may involve you visiting with the committee (or a

subcommittee) to dialogue and answer questions. I am visiting with our campus committee in April.

We have more work to do but it is not a daunting chore. It should be straightforward to put this in motion on individual campuses. The timetable is uncertain but clearly as soon as possible is important if we want to get any serious movement this year.

Let me know if you have further questions.

Cheers;
Bruce

--
.....
Bruce P. Luyendyk luyendyk@geol.ucsb.edu

Prof., Dept. Earth Science http://www.geol.ucsb.edu/faculty/luyendyk
2036 Webb Hall (805) 893-3009, 893-3471 voice
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BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS (BOARS)
Michael T. Brown, Chair
mbrown@education.ucsb.edu

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November 16, 2005

CLIFF BRUNK, CHAIR
ACADEMIC COUNCIL

RE: Request for Academic Council Action – Earth and Space Science (ESS) Eligibility Subject Requirement Proposal

Dear Cliff,

At its November 4, 2005 meeting, the Board of Admissions and Relations with Schools (BOARS) approved the enclosed request for Academic Council to endorse BOARS' position that no change to the laboratory science ('d') or elective ('g') subject requirements be made at this time. This "no change" position is in response to a proposal, considered by both BOARS and UCEP in 2003-04 and 2004-05, to add Earth and Space Science (ESS) to the subject ('a-g') requirements for UC eligibility. The committee asks that the enclosed request be included in the agenda as an action item for the November 30, 2005 Academic Council meeting.

Fiat Lux,

Michael T. Brown, Chair
BOARS

cc: John Oakley, Vice Chair, Academic Council
Maria Bertero-Barcelo, Executive Director, Academic Senate
BOARS

MTB/kp

BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS

Request for Academic Council Action: Resolution of the Proposal Regarding Earth and Space Science (ESS) Courses in Fulfillment of the University of California's Laboratory Science ('d') Requirement

REQUEST FOR ACTION: BOARS requests the Academic Council endorse BOARS' position that no change to the laboratory science ('d') or elective ('g') subject requirements be made at this time.

BACKGROUND

Laboratory Science 'd' Requirement Policy

The subject ('a-g') requirements are a set of high school courses, approved by the Academic Senate, as appropriate for fulfilling the minimum eligibility requirements for admission to the University of California. The main purpose of the 'a-g' requirements is to ensure that students are adequately prepared to succeed in the undergraduate curricula offered by UC campuses. Other purposes include providing a fair and equitable basis for guaranteeing admissions consideration and access to the University, and signaling to students and schools how college-bound students should, at a minimum, prepare for the University.

The laboratory science or 'd' requirement is set forth in Senate Regulation 424:

> (d.) Laboratory science, 2 units, two years of laboratory science providing basic knowledge in at least two of the fundamental disciplines of biology, chemistry, and/or physics.

The *University of California 'a-g' Guide*, published online at www.ucop.edu/doorways, provides more detailed information to students and schools on the criteria that science courses must meet to be approved as fulfilling the 'd' requirement. For example, the guide explains that courses in the laboratory science requirement should incorporate principles of the scientific method and scientific thinking, and it strongly recommends that students take three units, not just the required two units, of laboratory science. The guide also explains that a course can fulfill the 'd' requirement for laboratory science if it:

- Covers the core concepts in one of the fundamental disciplines of biology, chemistry, or physics; or
- Is an advanced laboratory science course that has as a prerequisite of biology, chemistry, or physics, and builds upon that knowledge and offers substantial additional new material. Such a course may include elements of another scientific discipline; or
- Is a course in the last two years of a three-year integrated science course sequence.

Earth and Space Science Proposal

Professor Emeritus Eldridge Moores (UCD) has proposed that Earth and Space Science be explicitly included in the language of the laboratory science ('d') subject requirement for UC eligibility. Two options for this modification of the language of the 'd' requirement, in order of

stated preference, have been proposed:

1. Replace "biology, chemistry, and physics" with "life science, physical science, and earth and space science."
2. Include Earth and Space Sciences among biology, chemistry, and physics as one of the "fundamental disciplines"

Proponents of the ESS proposal argue that:

1. Earth and space science (ESS) should be treated by UC in a co-equal fashion with biology, chemistry, and physics as a laboratory science because a command of ESS knowledge is an important element of scientific literacy, particularly in a seismically active state like California.
2. ESS is a distinctive field and a highly engaging one that would stimulate high school students' interest in scientific fields of study.
3. The current UC 'd' eligibility requirement: (a) is not consistent with the National Academy of Sciences K-12 science education standards for achieving the goal of science literacy; (b) does not provide enough encouragement or incentive to high schools to offer earth and space science courses; and (c) ignores a possible doorway to expanding interest in science (and in a democratic fashion).
4. A number of highly respected figures in the scientific community, including the current president of the National Academy of Sciences, support his position and argue UC's current science requirements do not promote strong science preparation in the high schools.
5. An integrative science such as Earth and Space Sciences could be an important conduit to scientific fields of study at the University, especially for women and racial/ethnic minorities.
6. The "special status" enjoyed by biology, chemistry, and physics is archaic, and is the result of historical accident.

BOARS and UCEP Responses

BOARS and UCEP considered the Earth and Space Science proposal during the 2003-04 academic year and again during the 2004-05 academic year. Both committees were unanimous in expressing value for more Earth and Space Science and other "integrated science" curricula in the high schools, but both committees also recommended that no change be made to the current 'd' eligibility requirement. The reasons behind these decisions differ in some of the particulars between BOARS and UCEP, as well as between 2003-04 and 2004-05, but include the following:

1. The central purpose of eligibility requirements is to ensure minimum preparedness for academic success at the University. It is abundantly clear that the prevailing curricular philosophy at UC holds that biology, chemistry, and physics, as appropriate, are foundational subjects for further study in any science-related field. Baccalaureate degree programs in science and science-related majors at UC overwhelmingly include introductory sequences of courses in biology, chemistry, and physics as part of their

lower-division requirements. The same is not true for ESS courses. Many of these introductory, lower-division courses specify high-school chemistry and/or physics as prerequisites. Even Geology 50 on the Davis campus, which is required for all baccalaureate degrees in Geology, specifies as its only prerequisites "high school physics and chemistry." Given this reality, it would be unwise to change the 'd' requirement in any manner that would result in lower levels of preparation in biology, chemistry, and physics among entering freshmen.

2. A change in policy is not needed because it is already possible for ESS and other integrative science courses to be approved as fulfilling the 'd' requirement, if such courses are properly designed. In particular, such courses must present at least a core set of knowledge in one or more of biology, chemistry, and physics; or must be advanced courses that have approved courses in one of these core disciplines as prerequisite. UC's approved-course database contains many examples of high school courses certified in the 'd' subject area that are not specifically in biology, chemistry, or physics. This includes courses in ESS subjects. In light of this reality, the main consequence of adopting the Moores Proposal would be the approval of ESS courses that would not be approved under the current 'd' policy (i.e., courses that neither present fundamental material in chemistry and physics, nor constitute advanced treatments that rely on such fundamental material). Such approvals would weaken, not strengthen, UC science preparedness, in the opinions of BOARS and UCEP.

3. There is no agreement among UC faculty that ESS is "co-equal" with biology, chemistry, and physics. There is agreement that ESS courses that would not be approved under the current 'd' requirement are NOT "co-equal" with UC-approved biology, chemistry, and physics courses.

4. Expanding the list from "biology, chemistry, and physics" to include ESS is not defensible from the stand-point of other "integrative sciences" (e.g. anthropology, engineering, psychology) or other science-related subject areas (e.g., computer science, geography). How could a decision to elevate ESS and not many other subject areas be rationalized?

5. The "national standards" to which Professor Moores refers are contained in a major 1996 report from the National Academy of Sciences. This report sets forth a blueprint for K-12 educational reform, with the goal of promoting scientific literacy in society as a whole. It adopts the broad categories "life science," "physical science," and "earth and space science" for its own purposes, and this categorization appears to be the basis of Professor Moore's claims that UC is "out of step with national standards." The NAS report does not address university admissions in any way. The goal of a more scientific literacy among the general population is a worthy one, but is different from the fundamental intent of UC's eligibility requirements.

6. Increasing the 'd' requirement to a mandatory three years, or increasing the current 'g' elective requirement to two years, would not, by itself, address the concerns raised by Professor Moores. Adding to the existing 'g' requirement is not necessary: students can take an approved Earth and Space Sciences class NOW under the existing 'g' requirement. Further, restricting an additional 'g' unit to ESS would be impossible: what about other integrative sciences, or indeed other fields altogether?

7. Adding a unit to the ‘d’ or ‘g’ requirement would be irresponsible, given what we current know about the ability (and inability) of schools to offer the current requirements in a quality way. Adding to the ‘d’ or ‘g’ requirement would exacerbate schooling inequities, especially in these tight budgetary times for California: students attending poorly resourced schools are rendered ineligible (and do not appear in campus applicant pools), not as a function of personal decision-making or lack of ability, but because they simply attended a school that either does not offer the requirements, offers them infrequently, or offers them on a restricted basis (“tracking”). At present, there are 34 high schools in California that do not offer a complete complement of approved ‘a-g’ courses.
8. Changing or adding to the ‘d’ or ‘g’ requirement would increase alignment tensions between CSU and UC admissions requirements. We have been working to close the gap: UC requires the 2 units of laboratory science to be in biology, chemistry, or physics; CSU also requires 2 units of laboratory science, but one of these units must be in biology. The present lack of alignment causes difficulties for students preparing for both UC and CSU.

BOARS considered every possible way of incorporating the assumed value of the Earth and Space Sciences proposal, but these eight concerns spoke compellingly against a change. For all of these reasons, it was judged to be bad policy to go forward with either (1) expanded options for fulfilling the current ‘d’ requirement, (2) an increased ‘d’ requirement restricted to Earth and Space (or even “integrated”) sciences, or (3) an expanded ‘g’ requirement.

BOARS POSITION: BOARS does not find the arguments offered to date to be compelling or persuasive, and therefore recommends no change to the laboratory science (‘d’) or elective (‘g’) subject requirements.

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BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS (BOARS)
Michael T. Brown, Chair
mbrown@education.ucsb.edu

Assembly of the Academic Senate
1111 Franklin Street, 12th Floor
Oakland, CA 94607-5200
Phone: (510) 987-9466
Fax: (510) 763-0309

August 3, 2005

Eldridge M. Moores, Professor Emeritus
Department of Geology
University of California, Davis
One Shields Avenue
Davis, CA 95616

Dear Eldridge:

As I promised you during our conversation of August 2, 2005, I am preparing a formal response to your request to consider modifying UC's a-g subject requirements in such a way that Earth and Space Sciences would be considered on a co-equal basis with biology, chemistry, and physics as a "d" (Laboratory Science) requirement. As you know, the BOARS Articulation and Evaluation Subcommittee (formerly known as the High School Subcommittee) and the University Committee on Educational Policy (UCEP) have considered this policy each of the last two years. I write to inform you that the BOARS Subcommittee has decided, again, to recommend no changes to the current subject requirements. We are happy to talk with you about our reasoning but I am writing in order to convey that reasoning as clearly as I can.

As we understand the issue, you are arguing that Earth and Space Sciences should be treated by UC in a co-equal fashion with biology, physics, and chemistry as a lab science. Your view is that Earth and Space Science is an integrative AND reductionistic science just as are biology, physics and chemistry. You even make the case that Earth and Space Science is a distinctive field and a highly engaging one that would stimulate high school student interest in becoming a scientist. You have marshaled considerable support from important science luminaries to bolster your position and argue our current science requirements do not assure strong science preparation in the high schools. You have also argued that an integrative science such as Earth and Space Sciences could be an important conduit to the sciences, especially for women and racial/ethnic minorities. In your view, changing the current "d" requirement to include Earth and Space Sciences as one of the options or increasing the 2 unit "d" requirement to 3 or more in order permit an Earth and Space Sciences requirement would bring UC in conformance with best practices in science preparation.

BOARS committee members were sympathetic to many if not all of those views. BUT

1. There is no support from BOARS or UCEP for adding Earth and Space Sciences to UC's present "d" requirement under the scenario where 2 units of a laboratory science continue

to be required. There is no agreement that Earth and Space Science is co-equal with biology, chemistry, and physics. There would be real concern that students would be inadequately prepared for UC if such a modification to our requirements was instituted.

2. Adding to the "g" elective would not address your central concern about the co-equal status of Earth and Space Sciences to the other accepted laboratory sciences. In addition, adding a another requirement is not necessary: students can take an approved Earth and Space Sciences class NOW under the existing "g" requirement and adding another appears irresponsible given what we current know about the ability of schools to offer the current requirements in a quality way. Requiring an additional "g" requirement could not be restricted to Earth and Space Sciences – what about other integrative sciences, other reductionistic sciences, or other fields? We believe that UC's requirements assure strong science preparation in the high schools.

3. Adding to the "d" or "g" requirement would exacerbate schooling inequities, especially in these tight budgetary times for California. BOARS believes that this is the wrong thing to do, especially when the educational justification described above is inadequate.

4. Adding to the "d" or "g" requirement would increase alignment tensions between CSU and UC admissions requirements. We have been working to close the gap and we already lack alignment here: UC requires the 2 units of laboratory science for the "d" requirement to be in biology, chemistry, or physics; whereas CSU also requires 2 units of laboratory science, but one of these units must be in biology.

5. Adding to the "d" or "g" requirement would shift the perceived balance in admissions requirements among the disciplines/fields. Other even more ubiquitous science, as well as "non-science," disciplines could make the same equally valid arguments as you have for increasing unit requirements.

6. If UC were to add an "integrative science" requirement to the "d" or "g" requirement, UC would have to re-evaluate all currently approved and future courses for suitability as an "integrated science" course. Would psychology qualify? What about all those engineering courses? Earth and Space Sciences could end up lost in the mix, even more than now. There is no support for adding a requirement specifically for Earth and Space Sciences.

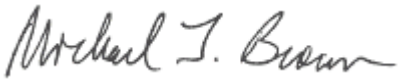
Back to the school/student equity issue, the fact that UC applicants already far exceed our threshold requirements is nowhere near as concerning as those students attending poorly resourced schools who are rendered ineligible (and NOT in our applicant pools), not as a function of personal decision-making or lack of ability, but because they simply attended a school that either does not offer the requirements, offers them infrequently, or offers them on a restricted basis ("tracking").

For all of these reasons, it simply would be bad policy to go forward with either (1) expanded options for fulfilling the current "d" requirement, (2) an increased "d" requirement restricted to Earth and Space (or integrated) sciences, or (3) an expanded "g" requirement. In any case, any

such recommendation would have to be vetted at the campus-level in addition to the Academic Council and Assembly of the Academic Senate review, and we believe that the arguments offered to date are not compelling or persuasive. There is no consensus among UC faculty that favors these changes and two systemwide Senate committees have looked at this matter for two consecutive years and have come to the same conclusion.

We are open to considering this matter further, Eldridge, though there is little enthusiasm for doing so without strong sentiment from campus faculty for a change in these requirements. In respect for you and the considerable time and effort you have spent on this issue, we are willing to supplement this correspondence with a meeting. An official response is forthcoming.

Most sincerely,



Michael T. Brown, Chair 2004-2006
Board of Admissions and Relations with Schools
Academic Senate
University of California

cc: BOARS Articulation and Evaluation Subcommittee
George Blumenthal, Chair, Academic Council
Cliff Brunk, Vice Chair, Academic Council
Maria Bertero-Barcelo, Executive Director, Academic Senate
Susan Wilbur, Director, Undergraduate Admissions
Jeanne Hargrove, Coordinator, High School Articulation

MTB/kp

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September 10, 2009

Professor Henry Powell, Chair
Academic Council
University of California
1111 Franklin St.
12th Floor
Oakland, CA 94607-5200

Dear Professor Powell,

Please find enclosed twelve copies of a brochure, entitled "Earth Science Literacy Principles". This document is the product of an NSF-supported endeavor, in cooperation with several societies and agencies, to lay out the nature of modern Earth Science (including environmental and space science:EESS), and its importance for every person's knowledge in this country and century, especially in an tectonically active and water-stressed state such as California. The brochure is also available on line at <www.earthscienceliteracy.org>. I have additional paper copies, if you need them.

The information in this brochure bears upon the four-year effort on the part of many UC faculty, including myself, Professor Bruce Luyendyk of UCSB, all UC Deans of Science, and faculty in many fields from most UC campuses, who have submitted petitions to BOARS, to request that UC's "d" Laboratory Science requirement be modernized to conform with the National Science Education Standards (1996: <http://www.nap.edu/openbook.php?record_id=4962>). The NSE Standards specify that grades 9 through 12 include education in the Earth and Space Sciences, Life Sciences, and Physical Sciences. At present, UC's "d" requirement does not recognize the Earth and Space Sciences. I understand that the Academic Council is preparing to send out a request for individual Divisional comment on the proposal that the words "Earth, Environmental, and Space Sciences" be added to "biology, chemistry, and physics" in UC's "d" Laboratory Science requirement.

As stated in the brochure, "There are many challenges facing humanity--dwindling energy and mineral resources, changing climates, water shortages--directly relating to the Earth sciences....We need governments that are Earth science literate....We need citizens and businesses that are Earth science literate...." I believe that every high school student in California needs the opportunity to learn about the EESS, in order to develop a well-informed citizenry ready to deal with current and future environmental issues. The key ingredient to this opportunity is UC's "d" requirement. Parents and high school principals want their children and students to attend UC, and they rely on "a-g" requirements to signal what courses UC values. The time has come for UC needs to meet national standards and signal that it values the EESS.

I remain confident that the addition of ESSS to the "d" requirement will greatly increase the

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number of California high school students taking ESSS classes, and that the classes will give them basic knowledge needed to deal with such critical problems as global warming, shortages of water, energy, and other resources, and the need for earth stewardship.

Therefore, I respectfully request that a copy of the brochure be included with the packet sent out to the various Academic Senate Divisions, and furthermore, that the Academic Council approve the addition of the words "Earth, Environmental, and Space sciences" to UC's "d" requirement.

For you information, I am appending below a document on fostering science literacy in California. Please let me know if you have any questions or comments, or need more brochures.

Sincerely,

Eldridge Moores

Eldridge Moores
Distinguished Professor Emeritus

cc: D.L. Simmons, Vice Chair

To Foster Science Literacy in California:
Adoption Of The 1996 National Research Council Recommendations.

If California is to foster scientific literacy that is relevant to the new century and the current needs of its students and citizens, the time has come for public schools and universities to adopt the 1996 NRC National Science Education Standards (NRCES) for secondary and post-secondary science. The NRCES include content for the Biological Sciences, Earth and Space Sciences (EESS), and Physical Sciences with recommendations for content and the formulation of investigation, data collection, critical thinking, and intelligent assessment of progress. In its departure from most current approaches to science, NRCES emphasizes education in EESS, which is addressed in the document.

Background: The current standard curriculum of "biology, chemistry, and physics" as epitomizing science is an obsolete concept that originated with the "Committee of Ten", in 1894. Consisting of one scientist and several theologians, this committee radically revised an earlier organization of science education that prominently featured geology. The irony is that historically, modern science arguably began with Earth science. Geology underlies everything: it founds the landscape, underpins most human activity, such as agriculture, patterns of human settlement, water, resources, and thus economics. Essentially everything that we have learned from the solar system exploration has been based on Earth and space science.

EESS Proposal: To improve students' understanding of science. EESS classes

1) Use accessible subject matter that allows students to learn basic concepts upon which they may then build difficult ideas.

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2) Provide tangible problems appropriate for teaching an appreciation of the scientific method and evidence-based reasoning,
3) Integrate biology, chemistry, and physics, and uses this integration to help students understand how the sciences relate to each other;
4) Introduce the environmental and geological sciences that are critical to Earth stewardship,
5) Teach the relationship of Earth to other planets, and
6) Develop both analytic and synthetic integrative thinking in students.

Need: Every citizen, particularly those in the western US, needs Earth science knowledge:

a. To make informed decisions about how to live with local Earth hazards including earthquakes, landslides, volcanic eruptions, mudslides, drought.
b. To understand the natural resources (starting with precious metals and including petroleum and energy, water, aggregates, energy) that have played such a critical role in the West's history and in our future; and
c. To understand environmental issues such as climate change, global warming, sea-level rise, water supply, air pollution, etc.

Summary: The science of the only planet on which one has any practical prospect of living needs to be considered an essential part of our science education for students. Modernizing secondary and post-secondary science curriculum to conform with the 1996 NRCES recommendation will enhance their understanding of science as inquiry, the relationship between science and technology, science in personal and social perspectives, and the science urgently needed to face the critical problems of global warming, water, energy, resources.

From the perspective of future civilizations, the 21st century will be defined by three things: climate change, water availablity, and energy resources. The fate of humanity will rest on how these three—all deeply rooted in the Earth Sciences–are handled in the next century. Many important political, legal and ethical decisions are being made related to these issues that already severely affect the lives of all Americans. The lack of clear, concise and comprehensive community-driven guidelines puts all Americans at risk of bad decisions made either through either ignorance or self-interest.

EARTH SCIENCE LITERACY PRINCIPLES

The Big Ideas and Supporting Concepts of Earth Science

EARTH SCIENCE LITERACY: The Big Ideas and Supporting Concepts of Earth Science

Each big idea is backed by supporting concepts comparable to those underlying the National Science Education Standards and the American Association for the Advancement of Science Benchmarks for Science Literacy.

What is Earth Science Literacy?

Earth Science Literacy is an understanding of Earth's influence on you and of your influence on Earth.

Earth Science Literacy Principles are defined by the scientists who carry out active research in many areas of Earth science and explain the complexities of how our planet works.

Earth Science Literacy is shaped by science educators, who can best translate the big ideas of Earth science into language and learning opportunities that can be understood by all.

Earth Science Literacy is an ongoing process, continually reshaped and rewritten by new discoveries in the areas of Earth science and learning theory.

An Earth-science-literate person:

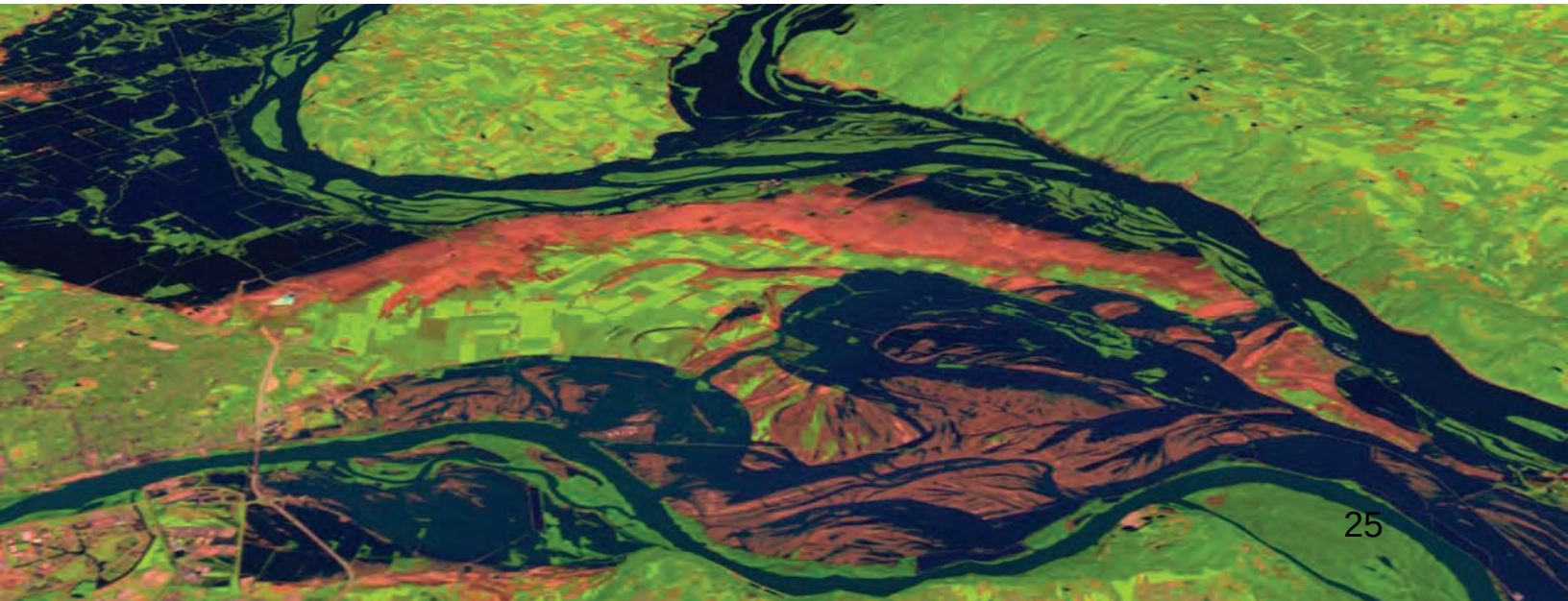
- understands the fundamental concepts of Earth's many systems
- knows how to find and assess scientifically credible information about Earth
- communicates about Earth science in a meaningful way
- is able to make informed and responsible decisions regarding Earth and its resources

Why is Earth Science Literacy Important?

Earth is our home. We rely upon it for our existence in many different ways. Its resources feed us and provide the materials of our way of life. Even modest changes to Earth's systems have had profound influences on human societies and the course of civilization. Understanding these systems and how they interact with us is vital for our survival.

Earth Science Literacy is especially important at this time in history. There are many challenges facing humanity—dwindling energy and mineral resources, changing climates, water shortages—directly relating to the Earth sciences. There are many difficult decisions that governments, local and national, will have to make concerning these issues, and how well humans survive the twenty-first century will depend upon the success of these decisions. We need governments that are Earth science literate.

Human history is a record of the creativity and ingenuity of people solving difficult problems. The solutions to the current Earth-science-related challenges will also come from human creativity, as individuals or corporate businesses. However, as our modern society and its needs have become increasingly complex, so have the solutions. It will take a deep and subtle understanding of Earth's systems for future generations to be able to feed, clothe, house, and provide a meaningful existence for all humans. We need citizens and businesses that are Earth science literate.



Junction of the Mississippi, Illinois, and Missouri rivers in August 1993 (near the peak of flooding) from Landsat-5/TM. (Courtesy NASA/Goddard Space Flight Center Scientific Visualization Studio)

Louisiana coast with suspended sediments and organic matter flowing out of the Mississippi and other regional river systems into the Gulf of Mexico (MODIS Aqua satellite image, November 19, 2003, courtesy of Liam Gumley, Space Science and Engineering Center, University of Wisconsin-Madison)

How Does the Scientific Process Work?

Science is an ongoing process of discovery of the natural world. Earth science is part of this process. Science draws upon the innate sense of curiosity that all humans share. We see it in a child's excitement in the discovery of her world. Millions of scientists formally pursue the process of discovery by making observations, testing hypotheses, and refining scientific models. Scientific understanding advances through many stages of preparation and review. Like medical doctors, scientists go through many years of professional training and practice. Scientific research projects are funded through a highly selective review process conducted by experts in the field. Results from scientific research are only published in journals if they satisfy a rigorous process that includes presentations at professional meetings, debates at scientific workshops, and written "peer" reviews by established experts in the field. The power of the scientific process is seen in its relentless march toward better explanations of how the laws of the universe operate. The complex technology of the modern industrial world, including cell phones, space exploration, and cures to many diseases, is a tribute to the success of the process of scientific discovery.

For more information about Earth Science Literacy, please visit www.earthscienceliteracy.org.

About This Guide

This guide presents the big ideas of Earth science that all citizens should know, determined by the Earth science research and education communities. Several workshops involving hundreds of scientists and educators from academia, government, and industry were dedicated to creating this document, and it has undergone an extensive period of public review. This document, representing the current scientific knowledge in Earth science, is helping to shape decisions by government and industry and helping to guide the direction of educational curricula. It is a work in progress because the scientific process continues to improve our understanding of Earth. For the latest version of this document, as well as information about its construction, please visit www.earthscienceliteracy.org.

Using This Guide for Education

U.S. science education is structured around the National Science Education Standards. To serve the broader education community, the Earth Science Literacy Principles have been aligned with these standards. The matrix of this alignment can be found at http://www.earthscienceliteracy.org/education.html. This literacy document is being used to direct Earth science education funding within the National Science Foundation. Textbook companies are using it in the creation of new educational materials. Museums and science centers are using this document as a foundation for educational displays and exhibits. Teachers and school boards are using it to shape class instruction ranging from individual lessons to whole curricula.

BIG IDEA 1. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

1.1 **Earth scientists find solutions to society's needs.** Earth scientists work on challenging problems that face humanity on topics such as climate change and human impacts on Earth. Earth scientists successfully predict hazards to humans and locate and recover natural resources, making possible the flourishing of humans on Earth.

1.2 **Earth scientists use a large variety of scientific principles to understand how our planet works.** Earth scientists combine study of Earth's geology with aspects of biology, chemistry, physics, and mathematics in order to understand the complexities of the Earth system.

1.3 **Earth science investigations take many different forms.** Earth scientists do reproducible experiments and collect multiple lines of evidence. This evidence is taken from field, analytical, theoretical, experimental, and modeling studies.

1.4 **Earth scientists must use indirect methods to examine and understand the structure, composition, and dynamics of Earth's interior.** With the exception of wells and mine shafts drilled into Earth, direct observations of Earth's interior are not possible. Instead, Earth scientists observe the interior of the planet using seismic waves, gravity, magnetic fields, radar, sonar, and laboratory experiments on the behavior of materials at high pressures and temperatures.

1.5 **Earth scientists use their understanding of the past to forecast Earth's future.** Earth science research tells us how Earth functioned in the past under conditions not seen today and how conditions are likely to change in the future.

1.6 **Earth scientists construct models of Earth and its processes that best explain the available geological evidence.** These scientific models, which can be conceptual or analytical, undergo rigorous scrutiny and testing by collaborating and competing groups of scientists around the world. Earth science research documents are subjected to rigorous peer review before they are published in science journals.

1.7 **Technological advances, breakthroughs in interpretation, and new observations continuously refine our understanding of Earth.** This Earth Science Literacy framework must be a living document that grows along with our changing ideas and concepts of Earth.

Research Experiences in Solid Earth Science for Students (RESESS) participant Miriam Garcia joined researchers from the United States, Iceland, and Switzerland in August of 2008 to install high-rate GPS stations in Iceland. Data from this network will increase our understanding of volcanic and tectonic interactions. (Courtesy of P.I. Richard Bennett and RESESS)

BIG IDEA 2. Earth is 4.6 billion years old.

2.1 Earth's rocks and other materials provide a record of its history. Earth scientists use the structure, sequence, and properties of rocks, sediments, and fossils to reconstruct events in Earth's history. Decay rates of radioactive elements are the primary means of obtaining numerical ages of rocks and organic remains. Understanding geologic processes active in the modern world is crucial to interpreting Earth's past.

2.2 Our Solar System formed from a vast cloud of gas and dust 4.6 billion years ago. Some of this gas and dust was the remains of the supernova explosion of a previous star; our bodies are therefore made of "stardust." This age of 4.6 billion years is well established from the decay rates of radioactive elements found in meteorites and rocks from the Moon.

2.3 Earth formed from the accumulation of dust and gas, and multiple collisions of smaller planetary bodies. Driven by gravity, Earth's metallic core formed as iron sank to the center. Rock surrounding the core was mostly molten early in Earth's history, and slowly cooled to form Earth's mantle and crust. The atoms of different elements combined to make minerals, which combined to make rocks. Earth's ocean and atmosphere began to form more than 4 billion years ago from the rise of lighter materials out of the mantle.

2.4 Earth's crust has two distinct types: continental and oceanic. Continental crust persists at Earth's surface and can be billions of years old. Oceanic crust continuously forms and recycles back into the mantle; in the ocean, it is nowhere older than about 200 million years.

2.5 Studying other objects in the solar system helps us learn Earth's history. Active geologic processes such as plate tectonics and erosion have destroyed or altered most of Earth's early rock record. Many aspects of Earth's early history are revealed by objects in the solar system that have not changed as much as Earth has.

The Grand Canyon represents one of the most awe-inspiring landscapes in the United States. At the deepest parts of the canyon, nearly two-billion-year-old metamorphic rock is exposed. The Colorado River has cut through layers of colorful sedimentary rock as the Colorado Plateau has uplifted.

2.6 Life on Earth began more than 3.5 billion years ago. Fossils indicate that life began with single-celled organisms, which were the only life forms for billions of years. Humans (*Homo sapiens*) have existed for only a very small fraction (about 0.004%) of Earth's history.

2.7 Over Earth's vast history, both gradual and catastrophic processes have produced enormous changes. Supercontinents formed and broke apart, the compositions of the atmosphere and ocean changed, sea level rose and fell, living species evolved and went extinct, ice sheets advanced and melted away, meteorites slammed into Earth, and mountains formed and eroded away.

BIG IDEA 3. Earth is a complex system of interacting rock, water, air, and life.

3.1 The four major systems of Earth are the geosphere, hydrosphere, atmosphere, and biosphere. The geosphere includes a metallic core, solid and molten rock, soil, and sediments. The atmosphere is the envelope of gas surrounding Earth. The hydrosphere includes the ice, water vapor, and liquid water in the atmosphere, the ocean, lakes, streams, soils, and groundwater. The biosphere includes Earth's life, which can be found in many parts of the geosphere, hydrosphere, and atmosphere. Humans are part of the biosphere, and human activities have important impacts on all four spheres.

3.2 All Earth processes are the result of energy flowing and mass cycling within and between Earth's systems. This energy is derived from the sun and Earth's interior. The flowing energy and cycling matter cause chemical and physical changes in Earth's materials and living organisms. For example, large amounts of carbon continually cycle among systems of rock, water, air, organisms, and fossil fuels such as coal and oil.

Steam vigorously rises from the hot waters of Grand Prismatic Spring, known for its rainbow colors produced by thermophilic ("heat loving") organisms. This hot spring is fueled by heat from a large reservoir of partially molten rock (magma), just a few miles beneath Yellowstone, that drives one of the world's largest volcanic systems.

3.3 Earth exchanges mass and energy with the rest of the Solar System. Earth gains and loses energy through incoming solar radiation, heat loss to space, and gravitational forces from the sun, moon, and planets. Earth gains mass from the impacts of meteoroids and comets and loses mass by the escape of gases into space.

3.4 Earth's systems interact over a wide range of temporal and spatial scales. These scales range from microscopic to global in size and operate over fractions of a second to billions of years. These interactions among Earth's systems have shaped Earth's history and will determine Earth's future.

3.5 Regions where organisms actively interact with each other and their environment are called ecosystems. Ecosystems provide the goods (food, fuel, oxygen, and nutrients) and services (climate regulation, water cycling and purification, and soil development and maintenance) necessary to sustain the biosphere. Ecosystems are considered the planet's essential life-support units.

3.6 Earth's systems are dynamic; they continually react to changing influences. Components of Earth's systems may appear stable, change slowly over long periods of time, or change abruptly with significant consequences for living organisms.

3.7 Changes in part of one system can cause new changes to that system or to other systems, often in surprising and complex ways. These new changes may take the form of "feedbacks" that can increase or decrease the original changes and can be unpredictable and/or irreversible. A deep knowledge of how most feedbacks work within and between Earth's systems is still lacking.

3.8 Earth's climate is an example of how complex interactions among systems can result in relatively sudden and significant changes. The geologic record shows that interactions among tectonic events, solar inputs, planetary orbits, ocean circulation, volcanic activity, glaciers, vegetation, and human activities can cause appreciable, and in some cases rapid, changes to global and regional patterns of temperature and precipitation.

BIG IDEA 4. Earth is continuously changing.

4.1 Earth's geosphere changes through geological, hydrological, physical, chemical, and biological processes that are explained by universal laws. These changes can be small or large, continuous or sporadic, and gradual or catastrophic.

4.2 Earth, like other planets, is still cooling, though radioactive decay continuously generates internal heat. This heat flows through and out of Earth's interior largely through convection, but also through conduction and radiation. The flow of Earth's heat is like its lifeblood, driving its internal motions.

4.3 Earth's interior is in constant motion through the process of convection, with important consequences for the surface. Convection in the iron-rich liquid outer core, along with Earth's rotation around its axis, generates Earth's magnetic field. By deflecting solar wind around the planet, the magnetic field prevents the solar wind from stripping away Earth's atmosphere. Convection in the solid mantle drives the many processes of plate tectonics, including the formation and movements of the continents and oceanic crust.

4.4 Earth's tectonic plates consist of the rocky crust and uppermost mantle, and move slowly with respect to one another. New oceanic plate continuously forms at mid-ocean ridges and other spreading centers, sinking back into the mantle at ocean trenches. Tectonic plates move steadily at rates of up to 10 centimeters per year.

4.5 Many active geologic processes occur at plate boundaries. Plate interactions change the shapes, sizes, and positions of continents and ocean basins, the locations of mountain ranges and basins, the patterns of ocean circulation and climate, the locations of earthquakes and volcanoes, and the distribution of resources and living organisms.

4.6 Earth materials take many different forms as they cycle through the geosphere. Rocks form from the cooling of magma, the accumulation and consolidation of sediments, and the alteration of older rocks by heat, pressure, and fluids. These three processes form igneous, sedimentary, and metamorphic rocks.

Suspended clay particles, eroded from the Cascade Mountains of Washington State, give Lake Diablo its brilliant color. The active volcanoes of the Cascades result from the subduction of the Juan de Fuca plate beneath North America. (Courtesy of Nicole LaDue)

4.7 Landscapes result from the dynamic interplay between processes that form and uplift new crust and processes that destroy and depress the crust. This interplay is affected by gravity, density differences, plate tectonics, climate, water, the actions of living organisms, and the resistance of Earth materials to weathering and erosion.

4.8 Weathered and unstable rock materials erode from some parts of Earth's surface and are deposited in others. Under the influence of gravity, rocks fall downhill. Water, ice, and air carry eroded sediments to lower elevations, and ultimately to the ocean.

4.9 Shorelines move back and forth across continents, depositing sediments that become the surface rocks of the land. Through dynamic processes of plate tectonics and glaciation, Earth's sea level rises and falls by up to hundreds of meters. This fluctuation causes shorelines to advance and recede by hundreds of kilometers. The upper rock layers of most continents formed when rising sea levels repeatedly flooded the interiors of continents.

BIG IDEA 5. Earth is the water planet.

5.1 Water is found everywhere on Earth, from the heights of the atmosphere to the depths of the mantle. Early in Earth's history, surface water accumulated through both outgassing from its interior and the capture of some extraterrestrial ice. Water vapor in the atmosphere condensed and rained out as the planet cooled.

5.2 Water is essential for life on Earth. Earth is unique in our Solar System in that water has coexisted at Earth's surface in three phases (solid, liquid, and gas) for billions of years, allowing the development and continuous evolution of life.

5.3 Water's unique combination of physical and chemical properties are essential to the dynamics of all of Earth's systems. These properties include the manner in which water absorbs and releases heat, reflects sunlight, expands upon freezing, and dissolves other materials.

5.4 Water plays an important role in many of Earth's deep internal processes. Water allows rock to melt more easily, generating much of the magma that erupts as lava at volcanoes. Water facilitates the metamorphic alteration of rock and is integral to plate tectonic processes.

5.5 Earth's water cycles among the reservoirs of the atmosphere, streams, lakes, ocean, glaciers, groundwater, and deep interior of the planet. The total amount of water at Earth's surface has remained fairly constant over geologic time, although its distribution among reservoirs has varied.

5.6 Water shapes landscapes. Flowing water in streams strongly shapes the land surface through weathering, erosion, transport, and deposition. Water participates in both the dissolution and formation of Earth's materials.

5.7 Ice is an especially powerful agent of weathering and erosion. Water expands as it freezes, widening cracks and breaking apart rocks. Movement of massive glaciers can scour away land surfaces. The flowing ice of glaciers covers and alters vast areas of continents during Ice Ages.

5.8 Fresh water is less than 3% of the water at Earth's surface. Most of this fresh water is stored as glaciers in Antarctica and Greenland. Less than 1% of Earth's near-surface water is drinkable liquid fresh water, and about 99% of this water is in the form of groundwater in the pores and fractures within soil, sediment, and rock.

Earth's water is in constant motion. Water moves at different speeds in different places, and in different forms. Water is continuously being exchanged among Earth's surface, atmosphere, and interior. Water is essential for life and for sculpting the world around us.

BIG IDEA 6. Life evolves on a dynamic Earth and continuously modifies Earth.

6.1 Fossils are the preserved evidence of ancient life. Fossils document the presence of life early in Earth's history and the subsequent evolution of life over billions of years.

6.2 Evolution, including the origination and extinction of species, is a natural and ongoing process. Changes to Earth and its ecosystems determine which individuals, populations, and species survive. As an outcome of dynamic Earth processes, life has adapted through evolution to new, diverse, and ever-changing niches.

6.3 Biological diversity, both past and present, is vast and largely undiscovered. New species of living and fossil organisms are continually found and identified. All of this diversity is interrelated through evolution.

6.4 More complex life forms and ecosystems have arisen over the course of Earth's history. This complexity has emerged in association with adaptations to new and constantly changing habitats. But not all evolution causes greater complexity; organisms adapting to changing local environments may also become simpler.

6.5 Microorganisms dominated Earth's early biosphere and continue today to be the most widespread, abundant, and diverse group of organisms on the planet. Microbes change the chemistry of Earth's surface and play a critical role in nutrient cycling within most ecosystems.

6.6 Mass extinctions occur when global conditions change faster than species in large numbers can adapt. Mass extinctions are often followed by the origination of many new species over millions of years as surviving species evolve and fill vacated niches.

6.7 The particular life forms that exist today, including humans, are a unique result of the history of Earth's systems. Had this history been even slightly different, modern life forms might be entirely different and humans might never have evolved.

A fossil of an ammonite, an extinct ocean-living mollusk related to the modern nautilus. Ammonites evolved about 400 million years ago and were plentiful in the ocean until the occurrence of a global mass extinction > 65 million years ago that correlates with an asteroid impact.

6.8 Life changes the physical and chemical properties of Earth's geosphere, hydrosphere, and atmosphere. Living organisms produced most of the oxygen in the atmosphere through photosynthesis and provided the substance of fossil fuels and many sedimentary rocks. The fossil record provides a means for understanding the history of these changes.

6.9 Life occupies a wide range of Earth's environments, including extreme environments. Some microbes live in rocks kilometers beneath the surface, within glacial ice, and at seafloor vents where hot fluids escape from the oceanic crust. Some of these environments may be similar to the conditions under which life originated, and to environments that exist on other planets and moons.

BIG IDEA 7. Humans depend on Earth for resources.

7.1 Earth is our home; its resources mold civilizations, drive human exploration, and inspire human endeavors that include art, literature, and science. We depend upon Earth for sustenance, comfort, places to live and play, and spiritual inspiration.

7.2 Geology affects the distribution and development of human populations. Human populations have historically concentrated at sites that are geologically advantageous to commerce, food production, and other aspects of civilization.

7.3 Natural resources are limited. Earth's natural resources provide the foundation for all of human society's physical needs. Most are nonrenewable on human time scales, and many will run critically low in the near future.

7.4 Resources are distributed unevenly around the planet. Resource distribution is a result of how and where geologic processes have occurred in the past, and has extremely important social, economic, and political implications.

7.5 Water resources are essential for agriculture, manufacturing, energy production, and life. Earth scientists and engineers find and manage our fresh water resources, which are limited in supply. In many places, humans withdraw both surface water and groundwater faster than they are replenished. Once fresh water is contaminated, its quality is difficult to restore.

7.6 Soil, rocks, and minerals provide essential metals and other materials for agriculture, manufacturing, and building. Soil develops slowly from weathered rock, and the erosion of soil threatens agriculture. Minerals and metals are often concentrated in very specific ore deposits. Locating and mining these ore deposits provide the raw materials for much of our industry. Many electronic and mechanical devices have specific requirements for particular rare metals and minerals that are in short supply.

7.7 Earth scientists and engineers develop new technologies to extract resources while reducing the pollution, waste, and ecosystem degradation caused by extraction. For example, land reclamation can partially restore surface environments following surface mining.

Humans rely on petroleum for the manufacturing of plastics, fertilizers, and other goods in addition to being a major source of energy. The thoughtful use of this resource is necessary to ensure its availability.

7.8 Oil and natural gas are unique resources that are central to modern life in many different ways. They are the precursors to chemicals used to make numerous products, such as plastics, textiles, medications, and fertilizers. Petroleum sources are needed to manufacture most industrial products.

7.9 Fossil fuels and uranium currently provide most of our energy resources. Fossil fuels, such as coal, oil, and natural gas, take tens to hundreds of millions of years to form. Their abundance will make them the dominant source of energy for the near future. New sources, such as methane hydrates, are being explored.

7.10 Earth scientists help society move toward greater sustainability. Renewable energy sources, such as solar, wind, hydroelectric, and geothermal, are being developed. They will replace fossil fuels as those become scarcer, more expensive to retrieve from Earth, and undesirable due to environmental damage. Earth scientists foster global cooperation and science-informed stewardship that can help to ensure the availability of resources for future generations.

BIG IDEA 8. Natural hazards pose risks to humans.

8.1 Natural hazards result from natural Earth processes. These hazards include earthquakes, tsunamis, hurricanes, floods, droughts, landslides, volcanic eruptions, extreme weather, lightning-induced fires, sinkholes, coastal erosion, and comet and asteroid impacts.

8.2 Natural hazards shape the history of human societies. Hazardous events can significantly alter the size of human populations and drive human migrations. Risks from natural hazards increase as populations expand into vulnerable areas or concentrate in already-inhabited areas.

8.3 Human activities can contribute to the frequency and intensity of some natural hazards. These hazards include floods, landslides, droughts, forest fires, and erosion.

8.4 Hazardous events can be sudden or gradual. They range from sudden events such as earthquakes and explosive volcanic eruptions, to more gradual phenomena such as droughts, which may last decades or longer. Changes caused by continual processes such as erosion and land subsidence can also result in risks to human populations, as with the increased risk of flooding in New Orleans.

8.5 Natural hazards can be local or global in origin. Local events can have distant impacts because of the interconnectedness of both human societies and Earth's systems. For example, a volcanic eruption in the Pacific Ocean can impact climate around the globe.

8.6 Earth scientists are continually improving estimates of when and where natural hazards occur. This analysis is done through continuously monitoring Earth, increasing our understanding of the physical processes that underlie its changes, and developing scientific models that can explain hazard-related scientific observations.

8.7 Humans cannot eliminate natural hazards, but can engage in activities that reduce their impacts. Loss of life, property damage, and economic costs can be reduced by identifying high-risk locations and minimizing human habitation and societal activities in them, improving construction methods, developing warning systems, and recognizing how human behavior influences preparedness and response.

8.8 An Earth-science-literate public is essential for reducing risks from natural hazards. This literacy leads to the promotion of community awareness about natural hazards and to the development of scientifically informed policies that reduce risk.

A lava flow devours a road in Hawaii. This natural hazard creates an inconvenience; however, many natural hazards can be life threatening. The impact of natural hazards can be greatly reduced through the education of citizens about the risks in their region.

BIG IDEA 9. Humans significantly alter the Earth.

9.1 Human activities significantly change the rates of many of Earth's surface processes. Humankind has become a geological agent that must be taken into account equally with natural processes in any attempt to understand the workings of Earth's systems. As human populations and per capita consumption of natural resources increase, so do our impacts on Earth's systems.

9.2 Earth scientists use the geologic record to distinguish between natural and human influences on Earth's systems. Evidence for natural and human influences on Earth processes is found in ice cores and soils, and in lake, estuary, and ocean sediments.

9.3 Humans cause global climate change through fossil fuel combustion, land-use changes, agricultural practices, and industrial processes. Consequences of global climate change include melting glaciers and permafrost, rising sea levels, shifting precipitation patterns, increased forest fires, more extreme weather, and the disruption of global ecosystems.

Humans have significantly altered Earth's surface. The Bingham Copper Mine in Utah demonstrates that humans have moved entire mountains in a quest for resources. (Courtesy of Michael Collier)

9.4 Humans affect the quality, availability, and distribution of Earth's water through the modification of streams, lakes, and groundwater. Engineered structures such as canals, dams, and levees significantly alter water and sediment distribution. Pollution from sewage runoff, agricultural practices, and industrial processes reduce water quality. Overuse of water for electric power generation and agriculture reduces water availability for drinking.

9.5 Human activities alter the natural land surface. Humans use more than one-third of the land's surface not covered with ice to raise or grow their food. Large areas of land, including delicate ecosystems such as wetlands, are transformed by human land development. These land surface changes impact many Earth processes such as groundwater replenishment and weather patterns.

9.6 Human activities accelerate land erosion. At present, the rate of global land erosion caused by human activities exceeds all natural processes by a factor of ten. These activities include urban paving, removal of vegetation, surface mining, stream diversions, and increased rain acidity.

9.7 Human activities significantly alter the biosphere. Earth is experiencing a worldwide decline in biodiversity—a modern mass extinction—due to loss of habitat area and high rates of environmental change caused by human activities. The rates of extinctions are now comparable to the rates of mass extinctions in the geologic past.

9.8 Earth scientists document and seek to understand the impacts of humans on global change over short and long time spans. Many of these human impacts on Earth's systems are not reversible over human lifetimes, but through human cooperation their impacts on future generations can be lessened and even reversed.

9.9 An Earth-science-literate public, informed by current and accurate scientific understanding of Earth, is critical to the promotion of good stewardship, sound policy, and international cooperation. Earth science education is important for individuals of all ages, backgrounds, and nationalities.

ESLI ORGANIZING COMMITTEE

Michael Wysession, Chair (Washington University)
John Taber, Co-Chair (Incorporated Research Institutions for Seismology)
David A. Budd (University of Colorado)
Karen Campbell (National Center for Earth-surface Dynamics)
Martha Conklin (University of California, Merced)
Nicole LaDue (National Science Foundation)
Gary Lewis (Geological Society of America)
Robert Raynolds (Denver Museum of Nature & Science)
Robert Ridky (U.S. Geological Survey)
Robert Ross (Paleontological Research Institution)
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Visit www.earthscienceliteracy.org for future revisions and changes to this document, to see documentation of the process used to develop this brochure, or for an up-to-date list of partners.

The Earth Science Literacy Initiative is funded by the National Science Foundation (EAR-0832415, EAR-0832418, EAR-0832430).

Design: Johanna Adams, Geo Prose

May 2009

---------- Forwarded message ----------
From: **Van Norden, Wendy** <wvannorden@hw.com>
Date: Sat, Mar 13, 2010 at 1:52 PM
Subject: Petition
To: sylvia.hurtado@gmail.com

Dear Dr. Hurtado, March 13, 2010

Some years ago (2003-2004), the University of California eliminated the Earth Sciences from the "d" laboratory science requirements, despite the fact that the AAAS (1993) and the National Research Council (1996) had already specified national standards for 9-12 science education that included Earth and Space Sciences as a co-equal subject with Life Sciences and Physical Sciences. As a result, the teaching of Earth Science in California high schools has been significantly compromised.

Schools have either dropped Earth Science from their high school curricula or have redesigned their courses to meet the needs of students who are not college-bound. Thus at present California high schools have fewer rigorous Earth Science courses available to their students, and the Earth Science literacy of our citizens has decreased. To better understand the importance of Earth Science literacy, I recommend the attached pamphlet of the NSF-supported Earth Science Literacy Initiative. Briefly put, the Earth, Environmental, and Space Sciences (EESS) are rigorous sciences. All citizens, especially in California, benefit from EESS education if they are to make informed decisions in a century with many Earth Science related challenges, including climate change, water, energy, hazards, and non-renewable resources.

The downgrading of Earth Science in California high schools has decreased the chances that California students will study Earth Science in college.. There is a growing need for Earth Scientists, especially now that the largest segment of the Geoscience workforce is about to retire. Earth Science jobs are good jobs: salaries for entering (B.S.M.S., and Ph.D.) employees in the petroleum industry currently average approximately $83,000/year. (Please see http://www.agiweb.org/workforce/reports/2009-StatusReportSummary.pdf., and http://www.aapg.org/explorer/salarysurvey.cfm for further information)

Because of our concern about the need for increased quality and quantity of Earth Science education in California high schools, the California Science Teachers Association has circulated the following petition among educators throughout the state. At this time, we have over 450 signatures, including many from the University of California faculty. We request that the BOARS update their policy on the "d" requirement and reinstate Earth, Environmental, and Space Sciences as a specified field in the "d" requirement for laboratory science, in line with national standards and needs.

Thank-you for your consideration.

Sincerely,

Wendy Van Norden

Co-founder of CalESTA

TO THE ACADEMIC COUNCIL, BOARS, AND UCEP
FROM THE CALIFORNIA ASSOCIATION OF EARTH SCIENCE TEACHERS

We, the undersigned request that the UC High School "d" requirements for laboratory science be amended to include "Earth, Environmental, and Space Sciences" as a choice for admission to the UC system:

- Currently the UC High School area "d" requirement states that students shall take "**two and preferably three courses from the following sciences: biology, chemistry, and physics."**

- We, the undersigned, request that the "area d" requirements for laboratory science be amended to include "**Earth, environmental, and space sciences"** as an additional choice for admissions to the UC system. Earth, environmental, and space sciences broadly defined include content in astronomy, ecology, geology, meteorology, oceanography, Earth systems science, environmental science, planetary science, and other topics within the integrative study of all or parts of the Earth's atmosphere, hydrosphere, biosphere, and lithosphere; of the solar system, and of the cosmos. The text of the UC Area-d requirement is proposed to then read:

> **"two and preferably three courses from the following sciences: biology, chemistry, physics, and Earth, environmental, and space sciences."**

- To be considered for certification in the "d" subject area courses (in Earth, environmental, and space sciences) must meet the same requirements as biology, chemistry and physics, which is described in http://ucop.edu/a-gGuide/ag/content/Guidetoa-gReqs_2008.pdf

• *specify, at a minimum, elementary algebra as a prerequisite or co-requisite;*

• *take an approach consistent with the scientific method in relation to observing, forming hypotheses, testing hypotheses through experimentation and/or further observation, and forming objective conclusions; and*

• *include hands-on scientific activities that are directly related to and support the other classwork, and that involve inquiry, observation, analysis, and write-up. These hands-on activities should account for at least 20% of class time, and should be itemized and described in the course description.*

- We make this request in consideration of the following points

- We California educators want to teach rigorous Earth, Environmental, and Space Science content to college-bound students. However, because the UC system does not accept Earth Science as a "d" laboratory course, administrators are actively discouraging us from doing so. The removal of Earth science courses from the "d" laboratory status has encouraged schools to drop Earth science courses, or to drop the laboratory component of Earth science courses. Even if we are able to teach a rigorous Earth Science course, college-bound students are discouraged from enrolling. The addition of Earth, Environmental, and Space Science in the "d" requirements can reverse this process.

- Earth, Environmental, and Space Science classes can be taught as rigorous, problem-solving curricula that can easily fit into the "d" requirement. There are many courses already available. The Earth sciences have benefitted enormously from the explosion of online data that are available for analysis in demanding problem-solving exercises, and providing students with important 21st century skills.

- Earth, environmental and space sciences are included in several national standards recommended by several prestigious agencies (e.g., National Academy of Science/National Research Council, American Association for the Advancement of Science, Council of Scientific Society Presidents, the College Board), and those of California. UC's science admission requirements are not in compliance with either the national or the California state secondary school standards.

- Topics in the Earth, environmental, and space sciences comprise 30% of the questions on the 12th grade National Assessment of Educational Progress test (Nation's Report Card). The National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, and the Council of Scientific Society Presidents all recommend that Earth and space science classes be included a part of standard high school curricula.

- It would be difficult to find a state more in need of Earth science literacy than California. The topics of earthquakes, landslides, water supply, water quality, climate change, flood control, resource use (and depletion), air/water pollution, and plate tectonics, are extremely relevant to California residents. Unfortunately, these topics are rarely found in the curricula of biology, chemistry or physics.

- The Earth, environmental and space sciences are intrinsically interesting, and are likely to entice more students into the sciences

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BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS (BOARS)
Sylvia Hurtado, Chair
sylvia.hurtado@gmail.com

Assembly of the Academic Senate
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December 11, 2008

MARY CROUGHAN, CHAIR
ACADEMIC COUNCIL

Re: Expansion of the Area (d) Laboratory Science Admissions Requirement to Include Earth, Environmental, and Space Sciences (EESS).

Dear Mary,

In June 2008, the Davis Division of the Academic Senate requested a Universitywide review of the possible expansion of UC's Laboratory Science ('d') admissions requirement to include earth, environmental and space sciences (EESS). In July 2008, Academic Council voted unanimously to refer the issue to the Board of Admissions and Relations with Schools, with a request that BOARS deliver a report and recommendation for next steps, if any, by December 2008. For the reasons outlined below, BOARS recommends against the proposed change and against pursuing the issue further in a systemwide Senate review.

In 2005, BOARS responded to a similar request to consider the expansion of Area (d) to include EESS, and opined against the change. In 2007-08, the Science subgroup of a UC-CSU-Community College faculty Task Force convened to review the Area (c) and (d) requirements also considered the idea and discussed the EESS situation in depth. Although this intersegmental Task Force recommended some changes in the wording of Area (d), it recommended against adding EESS to the core list of laboratory science topics – biological sciences, chemistry, and physics.

The current proposal is outlined in a February 2008 memo authored by Eldridge Moores (UC Davis) and Bruce Luyendyk (UC Santa Barbara), entitled *A Request and Proposal to Modernize the UC Area d Science Entrance Requirement*, which has been endorsed by Academic Senate members from other UC campuses. Specifically, it proposes a revision of Area (d) that would require entering freshmen to have completed "…two and preferably three courses (from at least two areas) of the following sciences: 1) biology, 2) chemistry, 3) physics, and 4) Earth, environmental, and space sciences."

This document makes five key arguments:

- Earth, Environmental, and Space Sciences are included in National Science Education Standards and California Science Standards
- Given the importance of the environment, including climate change, to the planet and our lives, students need access to the content in EESS.
- Today's EESS courses are scientifically rigorous and employ modern technology in the laboratory.
- Many schools have added EESS courses, but because UC does not recognize them in area (d), students often regard them as "soft" or "not valued."
- Data from the Standardized Testing and Reporting (STAR) program indicate that adding EESS to area (d) would not reduce the numbers of students taking biology, chemistry, or physics.

When considering any change to a-g policy, BOARS carefully takes into account UC's "a-g" Guide, which describes the purpose, responsibility, and general criteria for the "a-g" requirements at the University (see www.ucop.edu/doorways/guide). The Guide states that the subject area requirements are intended to help ensure that entering students can:

- Participate fully in the first-year program at the University in a broad variety of fields of study;
- Attain the necessary preparation for courses, majors, and programs offered at the University;
- Attain a body of knowledge that will provide breadth and perspective to new, more advanced studies; and
- Attain essential critical thinking and study skills.

The "a-g" Guide says that for courses to meet the requirement, they must be academically challenging; involve substantial reading and writing; include problems and laboratory work, as appropriate; show serious attention to analytical thinking as well as factual content; and develop students' oral and listening skills.

Although BOARS has discussed this issue on a number of occasions, we reviewed the current proposal carefully. We are sympathetic to some of the proponents' arguments and concerns, particularly the importance of improving secondary education in the Sciences and the need to encourage more young people, particularly women and students from diverse backgrounds, to study Science. We agree that EESS may be an effective way to engage high school students in Science, and may appeal especially to students who are interested in issues like global warming and climate change. Given the relevance of environmental subjects to our lives and the growing potential of the subject to interest high school students (many of whom are turned off to Math and Science by high school) it is important to encourage such courses as a way to expand access to UC and diversify the Sciences. BOARS agreed to explore further how to better foster early broad interest in the Sciences, particularly among groups underrepresented in the Science fields.

The proponents also note that EESS courses are prevalent in high schools as ninth grade courses, but many are taught by teachers untrained in EESS fields. They argue that adding EESS to the (d) requirement could encourage more students to major in EESS, some of whom will go on to teach high school, which in turn, will help provide students more rigorous college preparation. Finally, the proponents note that the California Science Standards include EESS as one of four

areas in grades 9-12 – giving it clearly defined course objectives that are recognized statewide.

Again, BOARS is sympathetic to some of these points, but the Committee does not find them convincing. The primary reason is that these arguments do not align with the purposes of a-g outlined above, to ensure students can "participate fully in the first year program at the University" and "have the necessary preparation for courses, majors and programs offered at the University." The level of reasoning fostered in typical ninth grade EESS courses is different from that found in the basic tenth, eleventh, and twelfth grade sciences and is not equivalent or interchangeable with chemistry, biology, and physics in meeting the more advanced expectations of the (d) requirement. The California Science Standards reveal significant differences between ninth grade EESS and what is expected in biology, chemistry, and physics, which include far more quantitative reasoning and analysis. More importantly, UC faculty expect students to come prepared with fundamental knowledge in these subjects as building blocks for the scientific background needed as preparation for university-level courses. BOARS found evidence that Science and Engineering faculty seek this specific background three years ago, when we examined a list of basic science courses in the UC Davis catalogue that are prerequisites for Science and Engineering majors. The study indicated that EESS only rarely provides the requisite background for these introductory courses. Faculty want and need to know that all students arriving at UC have a minimum level of exposure to the basic sciences that will provide them access to college-level courses. BOARS believes the proposed change to (d) would put this access at risk.

The inclusion of three different standards documents has at times confounded and confused the discussion about EESS and the (d) requirement. Each document has different purposes. Moores and Luyendyk correctly point out that both the National Science Education Standards (National Research Council, 1996) and the California Science Standards (California Department of Education, 2000) include Standards in Grades 9-12 for Earth, Environmental, and Space Science. The purpose of the National Science Standards is to "present a vision of a scientifically literate populace." The California Science Standards (approved by the State Board of Education in 1999) identify what content should be covered at each grade level or course, and the California Standards Tests are based on these descriptions. BOARS, however, has to base its work on a third set of standards – namely, the goals and purposes of a-g, which set standards for adequate preparation for success at UC. Neither national nor State standards were designed for use in determining UC readiness. Overall, BOARS must focus on the purposes and goals of 'a-g' in evaluating such a proposal.

It is important to note that EESS courses and other science courses intended primarily for ninth grade students can be, and routinely are, approved for the College Preparatory Elective Requirement (area 'g'). Historically, most EESS courses have targeted ninth grade audiences, and in this way they are being treated on equal footing with other ninth grade science courses. When approved for area (g) EESS courses count in a-g totals and are also considered by campuses in comprehensive review. So, as has been argued in the past, this provides meaningful recognition by UC.

It is also possible for an EESS course to be approved for area (d) as long as it provides fundamental knowledge in at least one of the foundational sciences in suitable breadth and depth

and meets all area (d) course requirements. Although uncommon, BOARS did find two EESS courses that have been recognized for area (d). One is an Environmental Chemistry course designed around multiple contexts related to the environment (Global warming, ozone, pollution, etc) that builds upon a solid chemistry foundation. A second course on Environmental Technology embeds the full California Chemistry Standards inside applications in the Environmental and Earth Sciences, including both geology and atmospheric science, which provide motivation for the topics studied. The documents submitted to UC in support of approving these courses for Area (d) were carefully prepared, illustrate higher order thinking demands on students, and show how students use their math and science backgrounds in challenging ways. BOARS feels these are excellent examples of how EESS can be designed to meet area (d) and hopes that more schools can be motivated to revise the current classes to achieve this end.

EESS proponents have made other suggestions in the past to increase the laboratory science requirement from two years to three years, which would presumably help "make room" for EESS, but BOARS remains concerned that many low resource or low API schools will not be able to meet the pressures of that requirement, causing additional negative consequences for access and opportunity. There are some high schools in California, for example, that only offer two laboratory sciences, and those are usually biology and chemistry. In the current budgetary climate, it is unlikely that schools will be able to offer more courses as they face potential reductions in teaching staff.

In sum, BOARS finds that the overwhelming majority of EESS courses as currently offered at the ninth grade level are inadequate for the 'd' requirement by the criteria that define BOARS' work, as articulated in the "a-g "guide and expressed by University faculty in their prerequisites for freshman Science courses. As such, BOARS recommends against the proposed change in area (d) and against further Senate review of the issue. We are concerned that a lobbying effort for the change has been initiated irrespective of the a-g goals and criteria, and the current state of EESS courses in high schools. We note that on multiple occasions the outcomes of discussions of this issue have been the same, and we believe the repetitious nature of the request is less helpful to the EESS cause than an agenda focused on developing and promoting advanced EESS courses that would meet current area (d) criteria.

Sincerely,

Sylvia Hurtado

Sylvia Hurtado
BOARS Chair

cc: BOARS
Martha Winnacker, Senate Executive Director

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November 16, 2005

CLIFF BRUNK, CHAIR
ACADEMIC COUNCIL

RE: Request for Academic Council Action – Earth and Space Science (ESS) Eligibility Subject Requirement Proposal

Dear Cliff,

At its November 4, 2005 meeting, the Board of Admissions and Relations with Schools (BOARS) approved the enclosed request for Academic Council to endorse BOARS' position that no change to the laboratory science ('d') or elective ('g') subject requirements be made at this time. This "no change" position is in response to a proposal, considered by both BOARS and UCEP in 2003-04 and 2004-05, to add Earth and Space Science (ESS) to the subject ('a-g') requirements for UC eligibility. The committee asks that the enclosed request be included in the agenda as an action item for the November 30, 2005 Academic Council meeting.

Fiat Lux,

Michael T. Brown, Chair
BOARS

cc: John Oakley, Vice Chair, Academic Council
Maria Bertero-Barcelo, Executive Director, Academic Senate
BOARS

MTB/kp

BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS

Request for Academic Council Action: Resolution of the Proposal Regarding Earth and Space Science (ESS) Courses in Fulfillment of the University of California's Laboratory Science ('d') Requirement

REQUEST FOR ACTION: BOARS requests the Academic Council endorse BOARS' position that no change to the laboratory science ('d') or elective ('g') subject requirements be made at this time.

BACKGROUND

Laboratory Science 'd' Requirement Policy

The subject ('a-g') requirements are a set of high school courses, approved by the Academic Senate, as appropriate for fulfilling the minimum eligibility requirements for admission to the University of California. The main purpose of the 'a-g' requirements is to ensure that students are adequately prepared to succeed in the undergraduate curricula offered by UC campuses. Other purposes include providing a fair and equitable basis for guaranteeing admissions consideration and access to the University, and signaling to students and schools how college-bound students should, at a minimum, prepare for the University.

The laboratory science or 'd' requirement is set forth in Senate Regulation 424:

> (d.) Laboratory science, 2 units, two years of laboratory science providing basic knowledge in at least two of the fundamental disciplines of biology, chemistry, and/or physics.

The *University of California 'a-g' Guide*, published online at www.ucop.edu/doorways, provides more detailed information to students and schools on the criteria that science courses must meet to be approved as fulfilling the 'd' requirement. For example, the guide explains that courses in the laboratory science requirement should incorporate principles of the scientific method and scientific thinking, and it strongly recommends that students take three units, not just the required two units, of laboratory science. The guide also explains that a course can fulfill the 'd' requirement for laboratory science if it:

- Covers the core concepts in one of the fundamental disciplines of biology, chemistry, or physics; or
- Is an advanced laboratory science course that has as a prerequisite of biology, chemistry, or physics, and builds upon that knowledge and offers substantial additional new material. Such a course may include elements of another scientific discipline; or
- Is a course in the last two years of a three-year integrated science course sequence.

Earth and Space Science Proposal

Professor Emeritus Eldridge Moores (UCD) has proposed that Earth and Space Science be explicitly included in the language of the laboratory science ('d') subject requirement for UC eligibility. Two options for this modification of the language of the 'd' requirement, in order of

stated preference, have been proposed:

1. Replace "biology, chemistry, and physics" with "life science, physical science, and earth and space science."
2. Include Earth and Space Sciences among biology, chemistry, and physics as one of the "fundamental disciplines"

Proponents of the ESS proposal argue that:

1. Earth and space science (ESS) should be treated by UC in a co-equal fashion with biology, chemistry, and physics as a laboratory science because a command of ESS knowledge is an important element of scientific literacy, particularly in a seismically active state like California.
2. ESS is a distinctive field and a highly engaging one that would stimulate high school students' interest in scientific fields of study.
3. The current UC 'd' eligibility requirement: (a) is not consistent with the National Academy of Sciences K-12 science education standards for achieving the goal of science literacy; (b) does not provide enough encouragement or incentive to high schools to offer earth and space science courses; and (c) ignores a possible doorway to expanding interest in science (and in a democratic fashion).
4. A number of highly respected figures in the scientific community, including the current president of the National Academy of Sciences, support his position and argue UC's current science requirements do not promote strong science preparation in the high schools.
5. An integrative science such as Earth and Space Sciences could be an important conduit to scientific fields of study at the University, especially for women and racial/ethnic minorities.
6. The "special status" enjoyed by biology, chemistry, and physics is archaic, and is the result of historical accident.

BOARS and UCEP Responses

BOARS and UCEP considered the Earth and Space Science proposal during the 2003-04 academic year and again during the 2004-05 academic year. Both committees were unanimous in expressing value for more Earth and Space Science and other "integrated science" curricula in the high schools, but both committees also recommended that no change be made to the current 'd' eligibility requirement. The reasons behind these decisions differ in some of the particulars between BOARS and UCEP, as well as between 2003-04 and 2004-05, but include the following:

1. The central purpose of eligibility requirements is to ensure minimum preparedness for academic success at the University. It is abundantly clear that the prevailing curricular philosophy at UC holds that biology, chemistry, and physics, as appropriate, are foundational subjects for further study in any science-related field. Baccalaureate degree programs in science and science-related majors at UC overwhelmingly include introductory sequences of courses in biology, chemistry, and physics as part of their

lower-division requirements. The same is not true for ESS courses. Many of these introductory, lower-division courses specify high-school chemistry and/or physics as prerequisites. Even Geology 50 on the Davis campus, which is required for all baccalaureate degrees in Geology, specifies as its only prerequisites "high school physics and chemistry." Given this reality, it would be unwise to change the 'd' requirement in any manner that would result in lower levels of preparation in biology, chemistry, and physics among entering freshmen.

2. A change in policy is not needed because it is already possible for ESS and other integrative science courses to be approved as fulfilling the 'd' requirement, if such courses are properly designed. In particular, such courses must present at least a core set of knowledge in one or more of biology, chemistry, and physics; or must be advanced courses that have approved courses in one of these core disciplines as prerequisite. UC's approved-course database contains many examples of high school courses certified in the 'd' subject area that are not specifically in biology, chemistry, or physics. This includes courses in ESS subjects. In light of this reality, the main consequence of adopting the Moores Proposal would be the approval of ESS courses that would not be approved under the current 'd' policy (i.e., courses that neither present fundamental material in chemistry and physics, nor constitute advanced treatments that rely on such fundamental material). Such approvals would weaken, not strengthen, UC science preparedness, in the opinions of BOARS and UCEP.

3. There is no agreement among UC faculty that ESS is "co-equal" with biology, chemistry, and physics. There is agreement that ESS courses that would not be approved under the current 'd' requirement are NOT "co-equal" with UC-approved biology, chemistry, and physics courses.

4. Expanding the list from "biology, chemistry, and physics" to include ESS is not defensible from the stand-point of other "integrative sciences" (e.g. anthropology, engineering, psychology) or other science-related subject areas (e.g., computer science, geography). How could a decision to elevate ESS and not many other subject areas be rationalized?

5. The "national standards" to which Professor Moores refers are contained in a major 1996 report from the National Academy of Sciences. This report sets forth a blueprint for K-12 educational reform, with the goal of promoting scientific literacy in society as a whole. It adopts the broad categories "life science," "physical science," and "earth and space science" for its own purposes, and this categorization appears to be the basis of Professor Moore's claims that UC is "out of step with national standards." The NAS report does not address university admissions in any way. The goal of a more scientific literacy among the general population is a worthy one, but is different from the fundamental intent of UC's eligibility requirements.

6. Increasing the 'd' requirement to a mandatory three years, or increasing the current 'g' elective requirement to two years, would not, by itself, address the concerns raised by Professor Moores. Adding to the existing 'g' requirement is not necessary: students can take an approved Earth and Space Sciences class NOW under the existing 'g' requirement. Further, restricting an additional 'g' unit to ESS would be impossible: what about other integrative sciences, or indeed other fields altogether?

7. Adding a unit to the ‘d’ or ‘g’ requirement would be irresponsible, given what we current know about the ability (and inability) of schools to offer the current requirements in a quality way. Adding to the ‘d’ or ‘g’ requirement would exacerbate schooling inequities, especially in these tight budgetary times for California: students attending poorly resourced schools are rendered ineligible (and do not appear in campus applicant pools), not as a function of personal decision-making or lack of ability, but because they simply attended a school that either does not offer the requirements, offers them infrequently, or offers them on a restricted basis (“tracking”). At present, there are 34 high schools in California that do not offer a complete complement of approved ‘a-g’ courses.
8. Changing or adding to the ‘d’ or ‘g’ requirement would increase alignment tensions between CSU and UC admissions requirements. We have been working to close the gap: UC requires the 2 units of laboratory science to be in biology, chemistry, or physics; CSU also requires 2 units of laboratory science, but one of these units must be in biology. The present lack of alignment causes difficulties for students preparing for both UC and CSU.

BOARS considered every possible way of incorporating the assumed value of the Earth and Space Sciences proposal, but these eight concerns spoke compellingly against a change. For all of these reasons, it was judged to be bad policy to go forward with either (1) expanded options for fulfilling the current ‘d’ requirement, (2) an increased ‘d’ requirement restricted to Earth and Space (or even “integrated”) sciences, or (3) an expanded ‘g’ requirement.

BOARS POSITION: BOARS does not find the arguments offered to date to be compelling or persuasive, and therefore recommends no change to the laboratory science (‘d’) or elective (‘g’) subject requirements.

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print Guide to "a-g" Requirements [PDF]

Purpose, responsibility, and general criteria for the "a-g" requirements

The purposes of the "a-g" subject area requirements are to ensure that entering students

- Can participate fully in the first year program at the University in a broad variety of fields of study;
- Have attained the necessary preparation for courses, majors and programs offered at the University;
- Have attained a body of knowledge that will provide breadth and perspective to new, more advanced studies; and
- Have attained essential critical thinking and study skills.

The following general criteria must be satisfied for courses to meet the requirement:

- Be academically challenging;
- Involve substantial reading and writing;
- Include problems and laboratory work, as appropriate;
- Show serious attention to analytical thinking as well as factual content; and
- Develop students' oral and listening skills.

The Board of Admissions and Relations with Schools (BOARS) establishes the subject areas and pattern of courses required for minimum eligibility for freshman admission to the University of California. BOARS is a committee of the University's Academic Senate and includes faculty representatives from each campus of the University. The Academic Senate has been given the responsibility from the UC Regents to set the conditions for admission, subject to final approval of the Board of Regents.

The California State University system has agreed to accept courses certified by the University of California to meet its subject area requirements.

(d) LABORATORY SCIENCE

Two units (equivalent to two one-year courses) of laboratory science are required; three units are strongly recommended.

The intent of the laboratory science requirement is to ensure that entering freshmen have a minimum of one year of preparation in each of at least two of the areas of Physics, Chemistry, and Biology/Life Science. This requirement can be satisfied by taking two courses from among these specific subject areas, but courses from across the broad spectrum of scientific subjects are potentially acceptable, provided they conform to the Course Requirements specified below.

Goals of the Laboratory Science Requirement

The overarching goal of the subject requirement in Laboratory Science is to ensure that freshmen are adequately prepared to undertake university-level study in any scientific or science-related discipline. The term "laboratory" is intended to signify an empirical basis of the subject matter, as well as inclusion of a substantial experimental and/or observational activity in the course design. The requirement emphasizes Biology/Life Sciences, Chemistry, and Physics, because these subjects are preparatory to university-level study in all scientific and science-related disciplines. However, coverage of these foundational subjects in suitable breadth and depth can potentially be found in a wide range of science courses, provided the courses conform to the criteria described under the Course Requirements below.

All courses certified in the Laboratory Science subject area should be designed with the explicit intention of developing and encouraging these scientific habits of mind:

1. Students should develop a perception of science as a way of understanding the world around them, not as a collection of theories and definitions to be memorized.

2. Students should emerge from high school embracing an ease in using their scientific knowledge to perceive patterns and regularity, make predictions, and test those predictions against evidence and reason.

3. Students should recognize that abstraction and generalization are important sources of the power of science.

4. Students should understand that scientific models are useful as representations of phenomena in the physical world. They should appreciate that models and theories are valuable only when vigorously tested against observation.

5. Students should understand that assertions require justification based on evidence and logic, and should develop an ability to supply appropriate justifications for their assertions. They should habitually ask "why?" and "how do I know?"

6. Students should develop and maintain an openness to using technological tools appropriately, including graphing calculators and computers, in gathering and analyzing

data. They should be aware of the limitations of these tools, and should be capable of effectively using them while making sound judgments about when such tools are and are not useful.

7. Students should recognize that measurements and observations are subject to variability and error, and that these must be accounted for in a quantitative way when assessing the relationship between observation and theory.

Course Requirements

Regardless of the scientific subject, all approved courses are expected to satisfy these criteria:

1. Courses should be consistent with the Goals described above.

2. Courses must explain the relevant phenomena on the basis of the underlying biological, chemical, and/or physical principles, as appropriate. They should provide rigorous, in-depth treatments of the conceptual foundations of the scientific subject studied.

3. Courses should afford students opportunities to participate in all phases of the scientific process, including formulation of well-posed scientific questions and hypotheses, design of experiments and/or data collection strategies, analysis of data, and drawing of conclusions. They should also require students to discuss scientific ideas with other students and to write clearly and coherently on scientific topics.

4. Courses must specify, at a minimum, elementary algebra as a prerequisite or co-requisite, and should employ quantitative reasoning and methods wherever appropriate.

5. Courses must take an overall approach that is consistent with the scientific method in relation to observing, forming hypotheses, testing hypotheses through experimentation and/or further observation, and forming objective conclusions.

6. Courses must include hands-on scientific activities that are directly related to and support the other class work, and that involve inquiry, observation, analysis, and write-up. These hands-on activities should account for at least 20% of class time, and should be itemized and described in the course description.

7. The California Content Standards for Grades 9 – 12 in Physics, Chemistry, and Biology/Life Sciences delineate the topical breadth considered appropriate in these three subjects. While these Standards can be a useful guide, coverage of all items in the Standards is not necessary. Likewise, simple coverage of all standards is not enough to assure course approval. Success at the university level requires that secondary students assimilate the major ideas and principles that encompass the Standards. More important than the topics covered, or even than the skills directly used directly in class, are the more general abilities and attitudes gained through the effort of mastering the course content. These general abilities and attitudes are described in the Goals section above.

Notes

1. There is no preferred order to the sequence of courses that cover the foundational subject areas.

2. Students who have successfully completed an approved three-year integrated-science sequence will have met the two-year "d" requirement as well as the one-year "g" elective requirement. Students electing to enroll in an integrated-science program (ISP) are strongly advised to complete the entire three-year sequence. In most cases, the first year of an integrated-science sequence fulfills only the "g" elective requirement; the second and third years of the sequence then fulfill the two-year "d" laboratory science requirement.

3. Online courses may be approved for credit toward the "d" requirement if they meet all the guidelines outlined above, including a supervised hands-on laboratory component comprising at least 20% of the course (e.g., UCCP courses).

Background on Science Standards

1. The California State Board of Education Adopted the Science Content Standards for California Public Schools in 1998. They were developed by the Standards Commission for all students, not as college preparatory standards. These standards can be accessed at http://www.cde.ca.gov/be/st/ss/. The science standards are developed by grade level in grades K-8 with a focus on Earth Science in grade 6, a focus on Life Science in grade 7 and a focus on Physical Science in grade 8. At grades 9 through 12 the standards are broken into four subjects: Physics, Chemistry, Biology/Life Sciences, and Earth Sciences.

All California public schools are required to adopt instructional materials that align with the standards. The State Board of Education formally adopts a textbook list at grades K-8 that schools must select from, however at grades 9-12 schools may choose freely from what is available on the market provided they assert they meet the standards.

The Standards also provide the content upon which that the California Standards Tests (CST) are based. There are four discipline based end-of-course CST exams for high school in Biology, Chemistry, Earth Science and Physics. There are also four integrated tests, Integrated I, II, III, IV. More information and results of these tests can be found at http://www.cde.ca.gov/ta/tg/sr/.

2. The National Research Council published National Science Education Standards in 1996 (National Academy Press, 262 pages). This document includes: Teaching Standards, Professional Development Standards, Assessment Standards, Content Standards, Education Program Standards, and Education System Standards.

The content standards for grades 9-12 in this document (p 173-207) deal with seven domains: Science as Inquiry, Physical Science, Life Science, Earth and Space Science, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science.

The purpose of the National Science Standards is to "present a vision of a scientifically literate populace," and provide recommendations only. They are not recognized by the State Board of Education in California and were not designed to be College Preparatory Standards.

3. In 1986, the Academic Senates of the California Community Colleges, California State University and the University of California approved a Statement of Preparation in Natural Science Expected of Entering Freshmen. It recommended "all college bound students receive instruction in physics, chemistry and biology regardless of their major and that laboratory instruction be an integral part of these courses." The document then discusses content of the courses in these three subjects in detail. This document has not been updated since 1986. (Math was updated in 1997 and is currently under revision, English was last updated in 2002.)

Background on Earth Environmental and Space Science Courses in California High Schools

Science Courses, Schools, Enrollment Numbers

Information about the enrollment levels of California public high school courses can be found at the California Department of Education Website, www.cde.ca.gov, following the links to DataQuest. This information is based upon the California Basic Education Data (CBED.) The entire chart, which has more information, is not reproduced here. Instead, information about main introductory offerings in the basic sciences are summarized.

Subject	# schools	# students	# courses	#a-g
Astronomy	54	2,561	88	66
Biology	1,425	443,554	14,712	13,661
Chemistry	1,066	241,956	7,979	7,778
Physics	926	85,614	3,067	2,980
Earth Science	975	171,339	5,832	2,695
Geology	65	7,928	260	227
Physical Science	997	187,374	6,457	1,531
General Science	926	431,769	14,373	373
Life Science	979	160,586	5,630	388
Environmental Studies	246	15,775	572	413
Oceanography	147	13,957	460	412

Notes:
1. The CBED is not known to be extremely accurate, but it is useful for understanding general trends.

2. The information stored by CDE does not tell us which courses are area 'd' and which are area 'g.' Almost surely, the Biology, Chemistry, and Physics courses are area d, while the remaining courses are nearly all area g (although not all).

3. The large numbers of Physical, General, and Life Science courses that do not meet area g do not qualify because for the most part they are intended to satisfy a graduation requirement only, which is not allowed for area g. Some may not qualify due to a failure to meet a laboratory or field requirement. Usually when this is the case, schools do not apply for a-g. Others may qualify for g, but the schools did not apply. Presumably the same reasons apply to Earth Science courses where only about 46% of the courses meet area g.

4. Exactly how many students enroll in these courses depending upon grade level is not available in this data set, however a good idea of the distribution can be gleaned from the California Standards test data.

The California Standards Tests

High Schools Students may take four Standards Tests during high school. These tests are based upon the California Science Standards in Biology/Life Sciences, Chemistry, Earth Science, and Physics. This data is available from the CDE website and the full data is included as an appendix.

It is important to note that these tests do not necessarily correspond to courses with the same title, and not all students take these tests, as 12th grade students are not tested. But they do give an indication of the numbers of students enrolling in these classes and how well they do. Here is a short version of the 2008 STAR data in high school science.

SUBJECT	Ninth Grade	Tenth Grade	Eleventh	Total
CST Biology/Life Sciences				
Students Tested	178,125	250,181	97,026	525,332
% Proficient or above	52%	35%	39%	42%
CST Chemistry				
Students Tested	4,085	102,231	126,190	232,506
% Proficient or above	44%	41%	25%	32%
CST Earth Science				
Students Tested	152,393	32,497	39,983	224,873
% Proficient or above	31%	23%	28%	28%
CST Physics				
Students Tested	11,853	7,894	44,452	64,199
% Proficient or above	30%	36%	47%	43%

Notes:
1. The table shows that Biology, Chemistry, and Physics are largely tenth, eleventh, and twelfth grade courses, although a significant number of ninth grade students enroll in Biology (and in fact do quite well on the test).

2. Most students tested in Earth Science are at the ninth grade level, which coincides with the level of the course.

3. Most of the ninth (and tenth) grade students tested in physics take a conceptual physics or general physical science course that may meet area g, but not likely area d.

4. In Biology, Chemistry, and Physics the CBEDs show more students enrolled in these courses than take the tests. In contrast, more students take the CST in Earth Science than the CBED indicates are in the course. Many 9th grade students take Physical Science courses that are largely based upon Earth Science so they take that test. Reportedly, these courses are not taught as Earth Science Courses because of the difficulty of finding credentialed teachers (for example, approximately 60% of ninth grade students in Sacramento County are in such a course).

Credential Requirements.

Science teachers in California High Schools are typically credentialed in one of three categories: Single Subject Credentials (service in that subject area K-12), Standard Secondary Credentials (service in grades 7-12) and Standard Elementary Credentials in (service in grades K-9).

A chart is appended showing specific requirements, but basically it works as follows. To teach in Biology, Chemistry, Earth Science, or Physics, a single subject credential must specify that subject area, and those who hold a Standard Secondary of Elementary credential must have a major or a minor in that area.

However, any holder of a single subject teaching credential in any of the four science areas may teach introductory general science, introductory life science, or introductory physical science (these courses may qualify for area g) and this is, for the most part how they are staffed.

Data on UC Applicants

This data is from the 2007 CPEC Eligibility Study. This data does not come from UC applicant files.

CPEC ELIGIBILITY STUDY 2007
COUNTS OF UC APPLICANTS, ADMITS, ENROLLEES TAKING SCIENCE COURSES
NOTE: All Data From CA Public High Schools

	Counts			Percent of Total		
	Applicants	Admits	Enrolls	Applicants	Admits	Enrolls
CPEC Study Weighted Counts	52,362	46,402	25,704	100.0%	100.0%	100.0%
Science Subject Areas						
Biology	50,289	44,601	24,853	96.0%	96.1%	96.7%
Chemistry	48,679	43,293	24,001	93.0%	93.3%	93.4%
Physics	30,743	27,983	15,844	58.7%	60.3%	61.6%
Earth Science (Environmental Science)	10,435	9,385	5,095	19.9%	20.2%	19.8%
Miscellaneous Science - NOT D requirement	9,602	8,216	4,402	18.3%	17.7%	17.1%

Appendix 1. California Standards Test Data for 2008

SUBJECT	Ninth Grade	Tenth Grade	Eleventh	Total
CST Biology/Life Sciences				
Students Tested	178,125	250,181	97,026	525,332
% of Enrollment	34.10%	50.40%	20.80%	
Students with Scores	177,800	249,527	96,722	524,049
Mean Scale Score	353.2	331.5	337.9	340.1
% Advanced	22%	11%	16%	16%
% Proficient	30%	24%	23%	26%
% Basic	29%	36%	31%	33%
% Below Basic	9%	14%	13%	13%
% Far Below Basic	9%	14%	16%	13%
CST Chemistry				
Students Tested	4,085	102,231	126,190	232,506
% of Enrollment	0.80%	20.60%	27.10%	
Students with Scores	4,078	102,161	125,979	232,218
Mean Scale Score	341.2	341.9	320.9	330.5
% Advanced	19%	16%	9%	12%
% Proficient	25%	25%	16%	20%
% Basic	30%	38%	38%	38%
% Below Basic	9%	10%	16%	13%
% Far Below Basic	17%	11%	21%	17%
CST Earth Science				
Students Tested	152,393	32,497	39,983	224,873
% of Enrollment	29.20%	6.60%	8.60%	
Students with Scores	151,970	32,374	39,811	224,155
Mean Scale Score	326.1	313.6	319.7	323.1
% Advanced	9%	6%	8%	8%
% Proficient	22%	17%	20%	20%
% Basic	38%	35%	35%	37%
% Below Basic	15%	18%	16%	16%
% Far Below Basic	16%	25%	22%	18%
CST Physics				
Students Tested	11,853	7,894	44,452	64,199
% of Enrollment	2.30%	1.60%	9.50%	
Students with Scores	11,832	7,877	44,372	64,081
Mean Scale Score	325.6	332.4	346.7	341.1
% Advanced	9%	13%	18%	16%
% Proficient	21%	23%	29%	27%
% Basic	37%	34%	32%	33%
% Below Basic	18%	16%	12%	13%
% Far Below Basic	15%	14%	9%	10%

Science Admissions Requirements at the UC Comparison Universities and the Greenes Guide "Public Ivies"

The information below was obtained from campus admissions websites. Most campuses specified definite requirements for admission, however many privates do not have a specific program (Harvard for example) and they only have recommended courses. These distinctions are indicated. The wording about level of specificity of the courses at each institution is copied from the websites. Some schools specify specific subjects while some do not.

I. UC comparison institutions

Harvard University Recommended: four years of science: biology, chemistry, physics, and an advanced course.

Massachusetts Institute of Technology Recommended: One year of high school physics, One year of high school chemistry, One year of high school biology

Stanford University Recommended**:** three or more years of laboratory science (including biology, chemistry and physics).

Yale University No specific recommendations in science on website.

State University of New York, Buffalo Recommended: Three years of college-preparatory science

University of Illinois, Urbana Required: 2 years lab science, 4 years recommended.

University of Michigan, Ann Arbor Required: 3 science courses, at least two are laboratory

University of Virginia, Charlottesville No specific recommendations in science on website.

University of Illinois, Urbana: Required: 2 years lab science required, 4 years recommended.

University of Virginia Required Science: from among biology, chemistry and physics 2 units**.** 3 units, including chemistry and physics are required if applying to the School of Engineering and Applied Science.

II. “The Public Ivies” from Greenes’ Guide 2001 list

Eastern

College of William and Mary Required: 4 units of science, 3 laboratory

Pennsylvania State University Required: Three units of science

Rutgers University Required: 2 years of science, the courses depends upon school

SUNY Binghamton Recommended: Three years of college-preparatory science

University of Connecticut Required: 2 years of laboratory science

University of Delaware Required: 3 years of science (2 must include a lab)

University of North Carolina Required: three units in science, including at least one unit in a life or biological science and at least one unit in a physical science, and including at least one laboratory course

University of Pittsburgh Required: 3 Units Laboratory Science - Biology I, II, Chem. I, II, Physics, Gen. Science, etc.

University of Virginia Required Science: from among biology, chemistry and physics 2 units**.** 3 units, including chemistry and physics, if applying to the School of Engineering and Applied Science.

Western

University of Arizona Required: one unit from any three of the following: biology, chemistry, physics, earth science, integrated lab science (may include advanced study in one area)

University of Colorado Required: 3 units Natural science (includes 2 of lab science, 1 of which must be either chemistry or physics)

University of Washington Required: Two years of science. Applicants must complete one full year- both semesters in the same field-of the basic principles of biology, chemistry, or physics, with a laboratory experience. The second year of science may be completed in any course that satisfies your high school's graduation requirement in science. Two years of agricultural science are equivalent to one year of science.

Great Lakes & Midwest

University of Indiana Required: 2 semesters of natural science (biology, chemistry, physics)

Miami University (Oxford Ohio) Required: 3 units in natural science, including both a physical and biological science

Michigan State University "Admission to Michigan State University is competitive, but there are no minimum requirements."

Ohio State University Required: 2 units of college prep science

University of Illinois Required: 2 years lab science, 4 years recommended.

University of Iowa Required: 3 years, students must take one full-year course each from two of these areas: biology, chemistry, or physics. The third course can be from any area including others not listed, such as general science, physical science, environmental science, and anatomy and physiology, etc. Integrated science courses are evaluated for this requirement based on course content.

University of Michigan, Ann Arbor Required: 3 science courses, at least two are laboratory

University of Minnesota Required: 3 years of science, including one year each of biological and physical science, and including a laboratory experience

University of Wisconsin Required: 3 science units minimum, 4 units typical for applicants

Southern

Georgia Institute of Technology Required: 3 units of science

New College of the University of South Florida Required: 3 units of science

University of Florida Required: 3 units Natural Sciences (two units must include laboratory)

University of Georgia Required: 3 units Science -life science with lab -physical science with lab -one science elective * For students who will graduate from high school in 2012 or later, 4 units of science are required. The courses must include two courses with a laboratory component. Overall, students must complete; at least one unit in Biology, one unit of physical science or physics, one unit of chemistry, earth science or environmental science, and one additional science unit.

University of Texas
2 units (3 recommended) of laboratory science. Recommended courses include physical science, biology, chemistry, physics, physiology and anatomy, geology, meteorology, marine science, or astronomy.

UNIVERSITY OF CALIFORNIA

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BOARD OF ADMISSIONS AND RELATIONS WITH SCHOOLS (BOARS)
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March 19, 2009

MARY CROUGHAN, CHAIR
ACADEMIC COUNCIL

Re: Proposed Survey of Departments Offering Introductory Courses in Science and Engineering

Dear Mary,

The Board of Admissions and Relations with Schools (BOARS) continues to discuss the pending systemwide Senate review of the question of expanding UC's laboratory science ('d') admissions requirement to include earth, environmental and space sciences (EESS), along with what information should be part of the review materials sent to campuses to help them make informed decisions.

Three years ago, BOARS examined a list of basic science courses in the UC Davis catalogue that are prerequisites for science and engineering majors there. We found evidence that science and engineering faculty at Davis seek specific background in biology, chemistry, and physics, and that EESS courses only rarely provide the requisite background for entry-level courses.

In light of the imminent systemwide review, we believe it would be useful to get a more complete UC-wide picture of faculty expectations for high school student preparation in the sciences and mathematics. The Higher Education Research Institute at UCLA, which I direct, is willing to administer the attached web-based survey to all UC campus departments that offer introductory courses in science and engineering fields.

We request the approval of the Academic Council to put the Senate's imprimatur on this effort. I am appending the survey below. Thank you for your consideration.

Sincerely,

Sylvia Hurtado

Sylvia Hurtado
BOARS Chair

cc: BOARS
Martha Winnacker, Senate Executive Director

Encl: 1

University of California Academic Senate
Survey of Departments Offering Introductory Courses in Mathematics, Science, and Engineering

Administered by the Higher Education Research Institute, UCLA

Email:

Dear Senate Colleague:

The purpose of this short survey is to review faculty expectations for high school student preparation. The Academic Senate is charged with establishing and maintaining policies regarding high school course prerequisites for success at the University of California. High school approvals are conducted by the Office of the President according to the Senate policy. To assist us, we request your help in completing this brief survey about the expectations you have for student preparation in your entry-level courses.

You may wish to base your responses to some questions on information in your catalogue about high school prerequisites for these courses, but we note that answers to question 6 may require the best thinking of the experienced faculty in your department who teach these courses, based on their observations of student preparation. Please consult with these faculty as needed to answer this survey. All responses remain confidential and results will be used to inform the work of the Board of Admissions and Relations with Schools to help ensure information can be focused on student preparation for UC work.

Thank you for your time and assistance in helping the Academic Senate construct policies that ensure the preparation of high school students for UC. This 15 minute, 8 question survey can help all of us make a difference in California's education.

Sincerely,

Mary Croughan, Chair
Academic Senate

Sylvia Hurtado, Chair
Board of Admissions and Relations with Schools

ONLINE SURVEY BEGINS

Please answer the following questions:

1. Indicate your UC campus: (drop down)

2. Indicate your Department/Discipline: (drop down)

3. Indicate your title: (drop down)

4. List the introductory math/science/engineering courses in your department (those without prerequisite courses from your department) available to all students: (List)

5. Are high school prerequisites or co-requisites for these introductory courses stated in your campus course catalogue? (yes/no/comment)

6. Please indicate the high school preparation your faculty feels is necessary for students to succeed in these introductory courses (these need not have been spelled out in the course catalogue). In your response, you should assume high school science courses include **laboratory experiences** aligned with the content. With the exception of calculus, these courses are basic courses for college bound students, not the AP versions.

    a. List the specific introductory course (type in)

    b. Rate the importance of each of the subjects offered in CA high schools to this introductory course. (1 = not important, 2 = somewhat important but not necessary, 3 = very important, preferred, 4 = essential, required or should be required)

        i. Mathematics at the level of:
            Algebra II
            Math Analysis or Pre-Calculus
            Calculus

        ii. High School science courses (with a laboratory/direct observation component):
            Biology
            Chemistry
            Environmental Studies
            Earth Science/Geology
            Marine science/Oceanography
            Physics

    Note: Students may take approved science courses without a laboratory to meet an elective requirement for UC.

c. List a second specific introductory course (type in)

d. Rate the importance of each of the subjects offered in CA high schools to this introductory course. (1 = not important, 2 = somewhat important but not necessary, 3 = very important, preferred, 4 = essential, required or should be required)

i. Mathematics at the level of:
Algebra II
Math Analysis or Pre-Calculus
Calculus

ii. High School science courses (with a laboratory/direct observation component):
Biology
Chemistry
Environmental Studies
Earth Science/Geology
Marine science/Oceanography
Physics

7. What subject tests or AP exams do you recommend for students to take that would place them out of this introductory coursework? (None, drop down list of tests).

8. Offer comments about high school preparation of students entering UC in these fields of study:

University of California Academic Senate Survey of Departments Offering Introductory Courses in Mathematics, Science, and Engineering Fields

In Spring 2009, Academic Senate Chair Mary Croughan and BOARS Chair Sylvia Hurtado sent an email invitation to participate in a web-based survey to 130 department chairs or deans that were identified on campus websites. These included department heads in the biological sciences (45), chemistry (9), earth,space, and environmental science (13), engineering (42), mathematics or statistics(14) and physics (7). The web survey was developed in consultation with BOARS, and the Academic Council also reviewed and approved the survey before it was launched. The web survey was tested and administered by postdoctoral scholar, Kevin Eagan, Higher Education Research Institute at UCLA and an undergraduate student assistant supported on a national study of undergraduates in science. Each respondent was issued a unique logon ID for the survey to ensure single responses and to protect the confidentiality of respondents. A total of 50 department chairs responded after three reminders to non-respondents and a final request to forward the survey to the current department chair in Fall 2009.

The survey focused on assessing expectations of UC faculty in terms of high school preparation in science and mathematics for introductory courses in their department/discipline. Respondents were asked to identify two introductory courses in their department and assess the relative importance of specific high school preparation. Respondents rated the importance of high school mathematics courses (algebra ll, math analysis/pre-calculus, calculus) and high school science courses in biology, chemistry, earth sciences/geology, environmental studies, marine science/oceanography, and physics taken from high school enrollments lists of the California Department of Education.

Limitations of the Study

There exists no central list of department chairs, and Council also did not have a ready way to identify heads of all departments. This resulted in identifying all department chairs on campus websites, and in the case where no department chair was identified, the Deans of Science and Engineering were sent the survey (in particular, the Merced campus does not list department chairs on the website). A second limitation was the response rate of 50 out of 130 department chairs. (Two respondents also chose not to answer all questions on the survey). Math and physics professors responded at a higher rate relative to their representation in the sample. Despite larger numbers, engineers and computer scientists responded at lower rates than their representation in the sample. Results reported by aggregated field help reviewers take into account specific field preferences for high school course preparation.

Aggregated Fields	Original Sample (N=130)	Respondents (N=50)
Biological Sciences	32%	30%
Chemistry	7%	6%
Computer Sci/Engineering	35%	28%
Earth, Space, Envir. Science	10%	10%
Mathematics/Statistics	11%	16%
Physics	5%	10%

Reviewing Results

Most respondents identified one course and rated the different high school science and math courses, fewer typically responded to desired prerequisites for a second course in their department. Departments were combined for adequate cell sizes and to protect the confidentiality of particular individuals. High percentages typically reflect small cell sizes, overall results are more reliable but reflect fields with many more established departments on campuses.

Percent of Dept. Chairs Responding "Very Important" or "Essential" by Academic Department

High school Courses	Biology/ Chemistry	Computer Science/ Engineering	Earth Science/ Environmental Studies	Physics/ Math	Total
Earth Science					
Intro Course 1	5.6	7.7	40.0	0.0	10.4
Intro Course 2	0.0	14.3	75.0	0.0	11.2
Calculus					
Intro Course 1	0.0	77.6	25.0	16.7	29.2
Intro Course 2	7.7	88.8	33.3	40.0	40
Biology					
Intro Course 1	50.0	30.8	40.0	8.3	33.4
Intro Course 2	50.0	25.0	75.0	0.0	32.3
Physics					
Intro Course 1	22.0	85.7	80.0	30.8	48
Intro Course 2	20.4	66.7	75.0	41.7	43.6
Chemistry					
Intro Course 1	61.1	61.6	100.0	8.3	52.1
Intro Course 2	57.1	62.5	100.0	8.3	47.4
Environmental Studies					
Intro Course 1	11.1	15.4	40.0	0.0	12.5
Intro Course 2	7.1	16.7	50.0	0.0	11.4
Marine Science/Oceanography					
Intro Course 1	0.0	7.7	20.0	0.0	4.2
Intro Course 2	0.0	14.2	50.0	0.0	8.4

Importance of HS Earth science/Geology Credit for Introductory Course 1 by Department (N=48)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	**Total**
1 Not Applicable	16.7	23.1	0.0	58.3	27.1
2 Not Important	33.3	30.8	0.0	33.3	29.2
3 Somewhat Important but not necessary	44.4	38.5	40.0	8.3	33.3
4 Very Important/ Preferred	0.0	0.0	20.0	0.0	2.1
5 Essential, Required, or Should be Required	5.6	7.7	40.0	0.0	8.3

Importance of HS Earth science/Geology Credit for Introductory Course 2 by Department (N=36)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	21.4	28.6	0.0	63.6	33.3
2 Not Important	50.0	14.3	0.0	36.4	33.3
3 Somewhat Important but not necessary	28.6	42.9	25.0	0.0	22.2
4 Very Important/ Preferred	0.0	0.0	50.0	0.0	5.6
5 Essential, Required, or Should be Required	0.0	14.3	25.0	0.0	5.6

Importance of HS Calculus Credit for Introductory Course 1 by Department (N=48)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	22.2	0.0	0.0	16.7	12.5
2 Not Important	44.4	0.0	50.0	33.3	29.2
3 Somewhat Important but not necessary	33.3	21.4	25.0	33.3	29.2
4 Very Important/ Preferred	0.0	35.7	25.0	16.7	16.7
5 Essential, Required, or Should be Required	0.0	42.9	0.0	0.0	12.5

Importance of HS Calculus Credit for Introductory Course 2 by Department (N=35)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	7.7	0.0	0.0	10.0	5.7
2 Not Important	46.2	0.0	66.7	10.0	25.7
3 Somewhat Important but not necessary	38.5	11.1	0.0	40.0	28.6
4 Very Important/ Preferred	7.7	44.4	33.3	30.0	25.7
5 Essential, Required, or Should be Required	0.0	44.4	0.0	10.0	14.3

Importance of HS Biology Credit for Introductory Course 1 by Department (N=48)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	11.1	15.4	0.0	58.3	22.9
2 Not Important	0.0	23.1	20.0	25.0	14.6
3 Somewhat Important but not necessary	38.9	30.8	40.0	8.3	29.2
4 Very Important/ Preferred	16.7	23.1	20.0	8.3	16.7
5 Essential, Required, or Should be Required	33.3	7.7	20.0	0.0	16.7

Importance of HS Biology Credit for Introductory Course 2 by Department (N=37)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	14.3	25.0	0.0	63.6	29.7
2 Not Important	7.1	12.5	0.0	36.4	16.2
3 Somewhat Important but not necessary	28.6	37.5	25.0	0.0	21.6
4 Very Important/ Preferred	42.9	12.5	50.0	0.0	24.3
5 Essential, Required, or Should be Required	7.1	12.5	25.0	0.0	8.1

Importance of HS Physics Credit for Introductory Course 1 by Department (N=50)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	11.1	7.1	0.0	23.1	12.0
2 Not Important	33.3	7.1	20.0	23.1	22.0
3 Somewhat Important but not necessary	33.3	0.0	0.0	23.1	18.0
4 Very Important/ Preferred	5.6	35.7	40.0	15.4	20.0
5 Essential, Required, or Should be Required	16.7	50.0	40.0	15.4	28.0

Importance of HS Physics Credit for Introductory Course 2 by Department (N=39)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	14.3	11.1	0.0	25.0	15.4
2 Not Important	42.9	0.0	0.0	25.0	23.1
3 Somewhat Important but not necessary	21.4	22.2	25.0	8.3	17.9
4 Very Important/ Preferred	14.3	33.3	25.0	25.0	23.1
5 Essential, Required, or Should be Required	7.1	33.3	50.0	16.7	20.5

Importance of HS Chemistry Credit for Introductory Course 1 by Department (N=48)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	5.6	7.7	0.0	58.3	18.8
2 Not Important	16.7	23.1	0.0	25.0	18.8
3 Somewhat Important but not necessary	16.7	7.7	0.0	8.3	10.4
4 Very Important/ Preferred	33.3	30.8	40.0	0.0	25.0
5 Essential, Required, or Should be Required	27.8	30.8	60.0	8.3	27.1

Importance of HS Chemistry Credit for Introductory Course 2 by Department (N=38)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	7.1	12.5	0.0	58.3	23.7
2 Not Important	14.3	12.5	0.0	25.0	15.8
3 Somewhat Important but not necessary	21.4	12.5	0.0	8.3	13.2
4 Very Important/ Preferred	35.7	12.5	75.0	0.0	23.7
5 Essential, Required, or Should be Required	21.4	50.0	25.0	8.3	23.7

Importance of HS Environmental Science Credit for Introductory Course 1 by Department (N=48)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	16.7	23.1	0.0	58.3	27.1
2 Not Important	11.1	30.8	0.0	33.3	20.8
3 Somewhat Important but not necessary	61.1	30.8	60.0	8.3	39.6
4 Very Important/ Preferred	11.1	7.7	40.0	0.0	10.4
5 Essential, Required, or Should be Required	0.0	7.7	0.0	0.0	2.1

Importance of HS Environmental Science Credit for Introductory Course 2 by Department (N=35)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	14.3	33.3	0.0	63.6	31.4
2 Not Important	35.7	16.7	0.0	36.4	28.6
3 Somewhat Important but not necessary	42.9	33.3	50.0	0.0	28.6
4 Very Important/ Preferred	7.1	0.0	25.0	0.0	5.7
5 Essential, Required, or Should be Required	0.0	16.7	25.0	0.0	5.7

HS Marine Science/Oceanography Credit for Introductory Course 1 by Department (N=48)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	16.7	30.7	0.0	58.3	29.2
2 Not Important	38.9	38.5	0.0	33.3	33.3
3 Somewhat Important but not necessary	44.4	23.1	80.0	8.3	33.3
4 Very Important/ Preferred	0.0	0.0	20.0	0.0	2.1
5 Essential, Required, or Should be Required	0.0	7.7	0.0	0.0	2.1

HS Marine Science/Oceanography Credit for Introductory Course 2 by Department (N=36)

	Biology/ Chemistry	Computer Science/ Engineering	Earth Science & Environmental Studies	Physics/ Math	Total
1 Not Applicable	21.4	28.6	0.0	63.4	33.3
2 Not Important	50.0	28.6	0.0	36.4	36.1
3 Somewhat Important but not necessary	28.6	28.6	50.0	0.0	22.2
4 Very Important/ Preferred	0.0	0.0	50.0	0.0	5.6
5 Essential, Required, or Should be Required	0.0	14.2	0.0	0.0	2.8