

**Report of the
Undergraduate Biology Curriculum Task Force:
Teaching Introductory Biology at Cornell University**

February 6, 2008

Task Force Members:

Ronald Harris-Warrick (Chair); Neurobiology and Behavior
Kathryn Boor; Food Science
Daniel Buckley; Crop and Soil Sciences
Brian Crane; Chemistry and Chemical Biology
Laura Harrington; Entomology
George Hudler; Plant Pathology
Bruce Lewenstein; Communication; Science and Technology Studies
Dan Luo; Biological and Environmental Engineering
Lois Pollack; Applied and Engineering Physics
Jocelyn Rose; Plant Biology
Adam Siepel; Biological Statistics and Computational Biology
Jed Sparks; Ecology and Evolutionary Biology
Barbara Strupp; Nutritional Sciences, Psychology
Francisco Valero-Cuevas; Mechanical and Aerospace Engineering (left the University, Fall 2007)
Mariana Wolfner; Molecular Biology and Genetics
Stephen Zinder; Microbiology

Executive Summary

The Undergraduate Biology Curriculum Task Force was instituted by Deans Susan Henry (College of Agriculture and Life Sciences [CALS]) and Peter Lepage (College of Arts and Sciences [CAS]) in Fall 2006. This report addresses the first of our four charges, to investigate the current teaching of introductory biology, and to propose changes that would enhance the quality of our introductory courses. After consultation with members of the Cornell community and comparison with other universities, the Task Force proposes the development of separate course tracks for training in Biology for majors in the Biological Sciences, other science students, and non-scientists. We make the following major recommendations:

1. An independent one-year laboratory course, “Introduction to Investigative Biology” will be required of all Biological Sciences majors, and will be available to other non-Biological Sciences majors if deemed appropriate for the requirements of those majors. This course will emphasize a thorough introduction to the scientific method, as well as introducing specific techniques in biological research.
2. Students majoring in Biological Sciences will no longer take a one-year introductory biology course. Instead, they will be expected to take a set of five introductory courses in core areas of biology. Three of these areas (Genetics and Genomics, Biochemistry and Molecular Biology, and Evolution and Diversity) will be required of all Biological Sciences majors, while the remaining two will be chosen from the three areas of Physiology, Cell and/or Developmental Biology, and Ecology and Sustainability. These core courses will provide in-depth coverage of the full spectrum of biology. While the core courses can be taken in any order, we recommend a suggested ordering of the different core classes by developing them at freshman, sophomore, and junior levels of sophistication.
3. Students who are not Biological Sciences majors but are majoring in other scientific disciplines (e.g., Human Ecology, CALS applied science departments, physical sciences, and pre-clinical students pursuing other majors) will continue to have available an improved version of a one-year introductory biology course sequence designed to emphasize a smaller number of core concepts and analyze them in greater detail than in the present course. These courses should also have discussion sections that engage in active learning exercises. These students will also have the opportunity to take the new core courses described in Point 2, if that better suits their academic needs.
4. The Introductory Biology course provides an alternative entry into the major for Cornell students who are unsure of their major in their first year. Specifically, students who have already completed the two-semester Introductory Biology course and the first year biology laboratory course will be allowed to complete the Biological Sciences major by taking the three required core courses and one additional core course, to be chosen following consultation with the student’s academic advisor and subject to the requirements of their area of study (as well as the other normal requirements for the major).
5. Students transferring into the Biological Sciences major (from another university or another major at Cornell) will also receive partial credit for a previous course in introductory biology and only have to complete four core courses for coverage of introductory biology.

6. For non-scientists (including CALS non-science majors fulfilling a biology requirement), we recommend the development of additional courses that teach biology through a more targeted study of issues important to society. This topic has been the focus of another task force, and we are in agreement with their conclusions.
7. Pre-clinical (medical/veterinary/dental) students will have improved options over those they have had in the past.

**Report of the
Undergraduate Biology Curriculum Task Force:
Teaching Introductory Biology at Cornell University
February 6, 2008**

Charge of the Task Force

The 21st century is likely to be the century of biology: the rapid pace of advances in knowledge and technology, combined with our need to address critical biological and environmental issues such as global warming and global epidemics, make it essential to train the next generation of scientists and citizens to understand the principles of the scientific method and the basics of biology. To that end, there has been nationwide interest in biology curriculum reform at the university/college level. Most notably, the National Research Council (NRC) report, *Bio 2010: Transforming Undergraduate Education for Future Research Biologists*, encourages a major re-conceptualization of the teaching of biology for undergraduates. In Fall 2006, Deans Susan Henry (CALs) and Peter Lepage (CAS) appointed a Task Force to study the teaching of undergraduate biology at Cornell. The Task Force was given four major charges: 1) to consider changes to the teaching of introductory biology; 2) to review the core requirements for the major in Biological Sciences; 3) to propose a strategy to best involve faculty across the life sciences in the teaching of undergraduate biology; and, 4) to discuss procedures to assure the continuing assessment and innovation of biology teaching. During the Spring and Fall 2007 semesters, we focused on the first charge, to analyze the teaching of Introductory Biology; our report on this charge is presented here.

Consultations with the Cornell Community

We began by consulting a number of groups at Cornell about how introductory biology is currently taught at Cornell, perceived problems with its teaching, and suggested solutions. Among those interviewed were representatives of the faculty who teach the current Introductory Biology courses, as well as sophomore-level biology courses that have Introductory Biology as a pre-requisite; students who have taken the various forms of Introductory Biology, and a survey of graduating seniors in 2006; the Office of Undergraduate Biology (OUB) and its director, Jeff Doyle; representatives of the Health Careers Advising Center; the Internal Life Sciences Advisory Council and the Vice Provost for Life Sciences; the Deans of CALS, CAS, Human Ecology and Veterinary Medicine; and the curriculum committees of Biological Sciences, the Engineering College, the College of Agriculture and Life Sciences, and the Educational Policy Committee of the College of Arts and Sciences. We also compared the Cornell model for Introductory Biology to that of 15 of our peer universities. After publicly disseminating a preliminary proposal for our plan, we held open meetings for students and faculty, and we solicited written comments from life science departments and individuals; these resulted in a number of changes in our proposal. Based on these consultations and our discussions, we identified a number of basic problems with the current biology curriculum.

Description of the Problems to be Resolved

- Introductory Biology is typically a freshman-level two-course sequence that is required by many different programs of study at Cornell. Currently, Introductory Biology is taught at two levels of sophistication: a course sequence primarily for non-science majors (Bio109-

110), and two-course sequences for science-oriented majors (lecture courses Bio101-104 and autotutorial courses Bio105-106) that share a similar curriculum. These introductory courses serve a wide variety of programs (e.g., biology and other life science majors, engineering, physical sciences), which have different expectations and needs for foundational instruction in biology. Members of the Cornell community recognize that having only two high enrollment introductory courses is not optimal for concurrently serving the instructional needs of many diverse Cornell students and programs.

- High enrollments in introductory courses are perceived as a problem for effective teaching and learning. The current high enrollments in Introductory Biology courses create problems for staffing and challenges to effective instruction and, thus, generally diminish learning outcomes for students. Therefore, one desired outcome of any reorganization (and a major recommendation of the NRC study) would be a reduction in individual class size.
- The field of biology has grown enormously over the past 20 years and now is much too broad for meaningful treatment in a two-semester course sequence. The current Introductory Biology courses at Cornell are outstanding courses with a long and distinguished history, but are now overburdened by the rapid growth of biological knowledge. By necessity, these courses are required to cover too much material at a rapid pace, and they run the risk of failing to treat the major concepts in enough depth to allow full comprehension. Responses from students who have taken these courses, and from professors of courses that immediately follow Introductory Biology, indicate that students have trouble retaining both detailed information and major concepts from the current Introductory Biology courses.

General Findings of the Task Force

- We strongly believe that Cornell should continue to offer a general major in Biological Sciences, with a common set of core courses for all students in the major, and a selection of concentrations in different fields for advanced coursework.
- A strong laboratory experience is the core of Introductory Biology teaching, and should be required for all students majoring in Biological Sciences.
- Class sizes in the introductory-level courses should be reduced as much as possible to allow students more personal interactions with teachers and teaching assistants (TAs).
- Smaller class size may be accomplished by increasing the number of tracks of courses that introduce basic biology, each tailored to the needs of a different constituency. After much consideration, we propose three tracks, each optimized for (though certainly not limited to) a particular group of students:
 - Majors in Biological Sciences (including pre-med students who are Biology majors).
 - Other science majors who need an introduction to biology. This includes CALS and Human Ecology students majoring in applied life sciences, but not in Biological Sciences *per se* (e.g., Food Science, Entomology, Nutrition, Animal Science, etc.), and pre-med/vet/dental students who are not Biological Sciences majors. Students served by this track also include physical science students, such as engineers, physicists, chemists, and mathematicians, with an interest in learning biology.
 - Non-scientists with an interest in biology or who are fulfilling a CAS breadth requirement or the CALS biology requirement.

- A common freshman experience is desirable as a foundation to the major in Biological Sciences. A freshman experience should include an environment for bonding among freshmen, an introduction to the scientific method, and experience in the analysis and writing up of data.
- All courses should emphasize active learning, both in the lecture and in discussion sections.
- Core concepts of biology should be identified and taught, using selected examples from the spectrum of the discipline, rather than attempting to cover all the areas of biology (i.e., cover fewer topics in greater depth). The inclusion of discussion sections will also allow time to discuss social, legal, and ethical issues related to the scientific material, and prepare our students to become more informed members of society.
- We should optimize the use of our outstanding and diverse faculty at Cornell through development of incentives for participation in introductory-level teaching.
- Preparation of students for medical, veterinary, dental, and graduate schools will not be impacted by the proposed changes. In many cases, success of these students may be enhanced by the proposed revisions.

Recommendations for Implementation

To address the issues outlined above and to produce an adaptable and effective undergraduate biology curriculum for majors in Biological Sciences, the Task Force recommends moving from a linear curriculum that originates from a single Introductory Biology course sequence, towards a set of freestanding courses representing the core areas of biology. This will simultaneously provide a balanced in-depth introduction and allow our undergraduate majors considerable flexibility. The Task Force feels that the costs of repetition of some introductory material across the core will be significantly outweighed by the benefit of enhanced retention of knowledge by students. For scientists who are not Biological Sciences majors, we recommend the retention of an introductory biology course that is more focused on fewer core concepts and covers those in-depth. For non-scientists, we agree with the conclusions of the CALS Life Sciences Distribution Requirements Task Force, and recommend the development of courses that teach the critical basic concepts of biology within a social context of interest to the students. We present detailed aspects of this plan below.

- 1. An independent one-year laboratory course, “Introduction to Investigative Biology”, will be required of all Biological Sciences majors and will be available to other students if deemed appropriate for the requirements of their major or required for pre-clinical training.**

This course, modeled on the successful Bio103-104 lab course, will be independent of all biology lecture courses. It will provide both basic laboratory skills and a thorough introduction to the scientific method. It is expected that a significant portion of the course (perhaps as much as 50%) will be spent on out-of-lab exercises such as hypothesis generation, experimental design, quantitative analysis, and scientific writing. Additional time may be spent learning how to do database searches, how to read the scientific literature, introductory bioinformatic analysis, and scientific ethics. There will be a weekly laboratory lecture to provide intellectual continuity to the course. As is currently the case in Bio103-104, lab sections will be small. These will be led by TAs trained by the highly-skilled

current leadership of Bio103-104. Comprehensive oversight by a tenured faculty member or by a committee of faculty will be necessary for this course. The year-long course sequence will be offered for 2 credits each semester. Although envisioned primarily for first-year students, the course could also serve as an effective introduction to biology teaching at Cornell for transfer students.

- 2. For students majoring in Biological Sciences, a new core series of courses will be developed. This core sequence will expand the material covered in the current Introductory Biology lecture courses, providing in-depth coverage of the full spectrum of biology over a five semester period.**

The current requirement of a year of Introductory Biology plus three core courses (Biochemistry, Genetics, Evolution) will be replaced by an expanded core of five courses, three of which will be modified versions of the current core courses and will be required of all Biological Sciences majors. This set of core courses will cover the full spectrum of biology currently covered in Bio101-102, but in considerably more depth and over a five semester period to enhance comprehension and retention of basic concepts of biology. Students will be required to choose five one-semester core courses from a list of six areas:

All students will take courses in the following three core areas:

- 1) Evolution and Diversity
- 2) Genetics and Genomics
- 3) Biochemistry and Molecular Biology (Organic Chemistry pre-requisite)

Each student will choose two courses from the following three core areas:

- 4) Physiology: A Systems Approach to the Organism
 - 5) Cell and/or Developmental Biology
 - 6) Ecology and Sustainability
- In an effort to decrease the numbers of students in each course and, thus, increase faculty-student interactions, at least one course in each of the core areas will be taught every semester. This follows the current successful models of Genetics, Biochemistry, and Evolution. This will require a modest increase in the number of professors dedicated to introductory teaching. To assist students in planning their academic careers, we propose that all courses in the core areas be offered during the summer session, as well as during the academic year.
 - Each core course will be offered for at least 3 credits, though some will be offered for 4 or more credits, as is currently the case for the core Biochemistry and Genetics courses. We encourage (but do not require) the instructors of these courses to consider adding a discussion section or a laboratory section to enhance in-depth understanding of the material. Discussion sections will emphasize “active learning” strategies such as group consideration of case studies, solving problem sets, and discussion of key papers from the primary literature. Completing this five-course sequence will not exceed the CAS limits on the course requirements for students majoring in Biological Sciences.

- The exact order in which the core courses are to be taken by each student will not be fixed so that students can immediately begin to pursue their own interests and have access to upper division courses in their area of specialization earlier in their academic careers. However, we do recommend a general order for taking the courses. This will simplify interactions between courses and provide a more uniform biology training. Thus, courses will be primarily oriented towards freshmen (100 level courses), sophomores (200 level) or juniors (300 level). The proposed levels are:
 - 100: Evolution and Diversity; Ecology and Sustainability; Cell Biology and/or Developmental Biology; Physiology
 - 200: Genetics and Genomics
 - 300: Biochemistry and Molecular Biology
- All majors in Biological Sciences will be strongly urged to complete the core five-course sequence no later than the end of the first semester of their junior year.
- Students entering Cornell with advanced placement credits in Biology (AP Bio) will not be allowed to use these credits to fulfill a course requirement in the Biological Sciences major; these students will still be required to take five core courses if they wish to major in Biological Sciences. However, they may use their AP Bio credits towards other non-major graduation requirements.
- We endorse the continuation of the Programs of Study (“concentrations”) in their current form. Individual Programs of Study may choose to require a specific subset of the core courses if they are viewed as essential to training in their area. The new core courses are expected to provide a more detailed entry into some of the concentrations. We acknowledge that the upper division course offerings in some Programs of Study may require some adjustments under the new curriculum.
- Although the first step will be to modify existing courses to generate the appropriate introductory core courses above, in the future, more than one course may be acceptable to fulfill a particular core area. Suggestions for additional courses must be approved by the Biology Curriculum Transition Committee (described below) as well as by the Biological Sciences, CALS, and CAS College Curriculum Committees.
- Students who began their studies at Cornell before the inauguration of this plan will be allowed to complete the Biological Sciences major according to the requirements in place at the time of their matriculation. The new core courses in the areas of Evolution and Diversity, Biochemistry and Molecular Biology, and Genetics and Genomics will substitute for the old core courses in these areas.
- The Colleges will provide appropriate additional TA support. We strongly support the use of highly-qualified undergraduates to serve as TAs in the core courses, as is already the case in two autotutorial Biological Sciences courses; this has been beneficial for students in these courses. Because serving as an undergraduate teaching assistant is a highly-instructive and rigorous endeavor, and requires the undergraduate TAs to learn the material in much greater depth than other students, we feel it is entirely appropriate for undergraduate TAs to receive academic credit for this work.

- Although these core courses are designed to offer a complete coverage of biology for majors in Biological Sciences, they will also be available to students in other majors who wish to take them.

3. To serve students in majors other than Biological Sciences who require an introduction to core concepts in biology, and to serve other scientists seeking an in-depth introduction to biology, two new one-year Introductory Biology course sequences will be developed.

- The courses will not attempt to cover “all of biology”, but will focus, in-depth, on selected topics that best illustrate the core concepts of biology. Thus, they will sacrifice some breadth for depth, with the aim of increased retention of the core concepts.
- Each course will have its own integrated discussion section, allowing “active learning” exercises such as case studies to be solved as a group, problem sets for hands-on learning, and group interpretation of classic papers from biology, as well as scientific ethics. This will require a significant increase in the number of TAs, because the current Bio101-102 does not currently have graduate lecture TAs or discussion sections.
- Each of these courses will be offered for 3 credit hours per semester (up from the current 2 credit hours per semester) to reflect the addition of a discussion section to supplement the current two lectures per week. Although the Task Force believes that three lectures a week would be desirable, we feel that the benefits of including a discussion section, with its active learning component, outweigh those of a third lecture.
- Enrollment in the one-year Introductory Biology course sequence is expected to be reduced as a result of the changes in curriculum for Biological Sciences majors. This decrease in enrollment should make it easier to attract faculty to teach in the course and improve the learning atmosphere of the course.

4. The Introductory Biology course provides an alternative entry into the Biological Sciences major.

Cornell students who are unsure of their major in their first year may choose to take the two-semester Introductory Biology course (with the Introductory Biology lab) to familiarize themselves with the breadth of areas for study in biology. If they then decide at the end of their freshman year to major in Biological Sciences, they will have one core course waived for the core course requirement and, thus, will have to complete only four of the core courses for the major. The three required core courses must be among these four courses. The choice of which core course to waive will be decided in consultation with the academic advisor and subject to the requirements of the student’s Program of Study. This constitutes an acceptable, though not preferred, alternative entry into the major, with a cost to the student of one extra 3-credit course. Students who have taken only one semester of Introductory Biology will not be granted the one-course waiver; they will still be required to take the five-core course sequence.

5. Students transferring into the Biological Sciences major from another university will be able to enter the major through the alternative option described in Section 4.

For students who have completed two semesters of Introductory Biology at another university, one core course will be waived, so only four additional core courses will be required. The three required core courses must be among these four core courses. Students can still receive college credit for the other semester of Introductory Biology, but it will not be applicable to any requirements in the Biological Sciences major. Students who have only completed one semester of Introductory Biology will not be granted this waiver. Given the unique aspects of the new laboratory course, “Introduction to Investigative Biology”, we recommend (but do not require) that it be taken by all transfer students who previously had an Introductory Biology lab course, and require it for those without Introductory Biology lab experience. Additional advanced courses taken elsewhere may be used to satisfy core requirements upon submission of appropriate documentation and approval by the Office of Undergraduate Biology.

6. For non-scientists (including CALS non-science majors fulfilling a biology requirement), we recommend the development of additional courses that teach biology through a more targeted study of issues important to society.

- This topic is the subject of a report recently completed by the CALS Life Sciences Distribution Requirements Task Force. Their report provides considerable detail about the implementation of new biology courses for non-scientists in CALS, and we support their conclusions.
- New courses will be developed that address the biology of major social issues. These would teach core concepts of biology within a more focused context, with examples such as the following:
 - “Global Warming”: Ecology, Evolution, Physiology, Behavior
 - “Genetic Engineering”: Genetics, Molecular Biology, Medicine, Plant Biology, Ecology
 - “Global Epidemics”: Microbiology, Epidemiology, Ecology, Physiology, Medicine
 - “Cognitive Neuroscience”: Neuroscience, Physiology, Genetics, Biochemistry, Psychology
 - “Invasive Species and Environmental Change”: Ecology, Physiology, Climatology, Population Biology, Conservation
- Bio109-110 should be phased out as the new courses become available. Students wishing a more panoramic coverage of biology will be free to take the new Introductory Biology course described in Point 3 above, since this course will no longer be aimed at biology majors.

7. Pre-medical/veterinary/dental students will have the same or improved options compared to what they have had in the past.

Most medical, veterinary, and dental schools require one year of general biology. Students pursuing these career directions will now have three options to obtain basic biology training. First, they can major in Biological Sciences, taking the five-semester core sequence and the Introductory Biology lab; this will provide a more detailed coverage of Introductory Biology than the current courses do, and will fulfill the current requirements for one year of general biology for medical, veterinary or dental school. Second, students can major in another field, in which case their medical/veterinary/dental school biology requirement can be met by taking the one-year Introductory Biology course, which will also cover the essential topics which are needed in preparation for MCATs. Finally, students can take the one-year Introductory Biology course and then transfer into the Biological Sciences major and complete the three required core courses and one additional core, as described under Section 4. This plan has met with approval of the Admissions Office at Weill Cornell Medical College, and we are seeking approval from a large number of other medical schools. Students planning to apply to medical/veterinary/dental school cannot fulfill their general biology requirement with the non-scientist courses listed in Section 6.

8. General principles for implementation of the plan.

This document is aimed at presenting the general outline of a new plan for the teaching of biology at Cornell. Details of its implementation will have to be worked out in the future. However, several general points can be made at this time:

- This plan should not be implemented until the new courses are thoroughly designed and approved, and preparations are complete. The earliest possible date for implementation would be Fall 2009, but it is more likely that we should aim for Fall 2010.
- A “Biology Curriculum Transition Committee” should be constituted by the Deans to supervise the implementation of the plan. This committee will be made up of distinguished teachers from the departments that direct concentrations for the major in Biological Sciences. It will supervise the development of the new courses, consider proposed modifications of existing courses, and decide on proposals for new additional core courses. Eventually, all new or modified courses will have to be approved by the Biology and CALS Curriculum Committees, and the Educational Policy Committee of CAS.
- The steps toward implementation should include the following:
 - Selection of faculty to teach the new or modified courses, overseen by the departments named by the Deans to take responsibility for each course. Since the new biology core courses will be offered each semester, the faculty teaching the same core course in different semesters will need to coordinate their teaching to ensure that those offerings cover all the same basic concepts and are taught at the same level of sophistication.
 - Design of new or modified syllabi for the courses by the selected faculty, with advice from the departmental curriculum committees, will require review and approval by the Biology Curriculum Transition Committee.

- Development of interactions between the new core course areas for Biological Sciences majors to assure that they refer to one another and form a unified approach to basic biology, rather than a set of independent courses. Regular meetings of the faculty teaching different core courses will be required to facilitate a unified curriculum.
- The OUB will work to prepare detailed advising guidelines about the new curriculum and its alternatives, both for incoming students, and for faculty and staff who serve as academic advisors. This information should be available both in the Cornell course catalog and online in a dedicated website to assist students and advisors. It is essential that the advising guidelines be prepared carefully, and approved by the Biology Curriculum Transition Committee, to minimize confusion during the transition to the new plan.
- We recognize the unique status of first-year students who need to adjust to learning at the university level. We strongly urge the continuation of the current enrichment activities to help first-year students, including those currently offered by the faculty of Introductory Biology. The modified first-year lab course, “Introduction to Investigative Biology”, will be the central focus of this effort. The lecture courses can also offer enrichment activities. These include special tutoring and advising opportunities, discussions over dinner, and others. We strongly urge the development of “00”-level courses for all of the new core courses for biology majors, especially those offered at the 100 level, to help students who are experiencing difficulties in adapting to the demands of university courses.
- A plan should be developed by the Biology Curriculum Transition Committee to determine the metrics to judge the success of this new plan. These metrics could include GRE and MCAT scores, admission statistics for graduate and medical school, teaching faculty and faculty advisor input, and alumni reports regarding the success of their training in biology as it relates to their career. The metrics should be determined as soon as possible in order to be able to collect them from graduates for the next several years (until students begin to graduate under the new plan). This would provide a baseline for comparison with students studying under the new plan. These metrics should be assessed annually.