

Appendix:
Implementation of the Undergraduate Biology Curriculum Task Force
Report on Introductory Biology
March 1, 2008

This document is intended to serve as a practical addendum to the “Report of the Undergraduate Biology Curriculum Task Force: Teaching Introductory Biology”. The recommendations made in that document will require thoughtful and careful implementation. Here we provide detailed suggestions on how to achieve the goals proposed in our report.

I. Supervision of the implementation process should be performed by a “Biology Curriculum Advisory Committee” composed of outstanding teachers with broad interests in the undergraduate teaching of biology.

It is essential this committee be led by a Chair with high standing in the Cornell community and demonstrated excellence in teaching. We anticipate that this position will require a significant time commitment and should receive a level of program support comparable to that of a department chair. The other members of the committee should also be acknowledged experts in the teaching of biology. Their expertise should cover the spectrum of knowledge that will be taught in introductory biology and the new core sequence for biology majors. We recommend that two members be appointed from each department whose only undergraduate major is biology [currently MBG, EEB, NBB, Microbiology, Plant Biology and Biomedical Sciences (Animal Physiology)], and one member from other departments that have recently added concentrations in biological sciences but maintain independent majors (currently Entomology, Nutrition, and Computational Biology). In addition, we suggest that representatives of majors closely reliant on the offerings in biology (Biology and Society, Science of Natural and Environmental Systems, etc.) collaborate with this committee as consultants. Also, we feel it would be advantageous to have a representative from the education department to integrate the latest techniques in undergraduate teaching. We acknowledge that this committee will be necessarily large and anticipate logistical challenges. The chair of this committee will ultimately decide how best to move forward, but we would suggest that subgroups of the committee meet separately to focus on the development of single courses (or other issues) and then report back to the main committee at a monthly or bi-monthly meeting. This committee should be selected by Deans Henry and Lepage, with advice from the Internal Life Science Advisory Council and the Vice Provost for Life Sciences.

The charge to this committee will be to supervise all aspects of the transition to the new plan for teaching biology at Cornell. These include (but are not limited to):

- Approval of the core concepts to be taught in the revised Introductory Biology course, the revised freshman laboratory course, and the 6 core courses to be offered for biology majors.
- Consultation and approval of course syllabus development.
- Review and approve any additional proposals for new alternative courses to fulfill one of the core biology areas.

- Supervise the development of the curriculum into the future including evaluation at regular intervals. After the initial implementation of the curriculum, we envision the primary effort of this committee to be to improve the overall quality of the curriculum. This would include the periodic evaluation of individual courses and monitoring the overall integration of the curriculum. We feel it may be advantageous to have an external review of the teaching program similar to that done for departments every five to seven years.
- This committee will not supervise the development or implementation of the new biology classes for non-scientists, which were proposed by the report of the CALS Life Sciences Distribution Requirement Task Force led by Don Viands; that Task Force should determine the process for development and selection of these courses.

II. We recommend the selection of a regular cohort of teachers to teach each of the new courses (Introductory Biology, the new Biology Core Courses, and the new first year Biology laboratory course) proposed in our plan. The cohort responsible for each course will work closely together to provide a reproducible presentation of the course from semester to semester.

Developing a consistent cohort of faculty associated with each course: To provide consistency in teaching, it is essential to define a group of faculty who will teach each course well in advance of the year it is taught. The best way to do this is to ask groups of faculty to commit to teaching a particular course one semester each year for a continuous period of 3-5 years. Once the system is running, replacement should be staggered so that at least one faculty with prior experience in the course is involved in teaching the course each year. It is recommended that a rolling 4- or 5- year teaching plan be developed for each of the introductory and core courses so that the staffing is stable for a significant time into the future, and to make clear when transitions must be budgeted. If the university can assure stability in teaching 4 years in advance (i.e., continuously maintaining a rolling 4-year plan), then we will assure the stability of our most important teaching programs.

Team-teaching vs. single professor for a semester-long course: The optimal number of teachers in each one-semester course has been an active subject of discussion. For introductory biology, the current teachers (many of whom have been teaching introductory courses for 10 years or more) feel strongly that only one professor should teach each semester, making a two-person team for the year. The major argument for this is to assure continuity in teaching style and in course expectations, which they perceive as an important element for the freshmen transition from high school into college-level learning. A counter-argument in favor of team-teaching within the semester is that the use of several instructors allows each teacher to present material from his/her specialty, and to do so with more enthusiasm for the students to identify with. We are sympathetic to both arguments and suggest that if a single teacher for each semester of introductory biology cannot be identified; then a maximum of two instructors should teach per semester.

Similar arguments can be made for the new core courses for biology majors. At least for the 100 level courses aimed at freshmen, an attempt should be made to find a

single instructor for each semester (so two instructors would alternate the two semesters of the year), or at most 2 instructors team-teaching in a single semester. For the 200- and 300- level courses, we believe that team-teaching is more likely to succeed, but we continue to recommend that the team be kept as small as possible (preferably no more than 2 per semester).

Co-ordination of the teaching cohort for course continuity: Our goal is to generate courses that are essentially the same from semester to semester, despite differences in staffing. This will require close and continual interaction between the members of the teaching cohort for a single course. Once named, the members of the cohort will work together first to develop a list of core concepts that define the content of the course. After that is approved by the Biology Curriculum Advisory Committee, they will work together to develop a syllabus and curriculum that best illustrate those core concepts. It is expected that different instructors may choose different illustrations for a core concept, but to the extent that is possible, similar examples should be used, which can be referred to across the course and if possible even between courses (see below). At least during the transition period, instructors for the course in one semester should be encouraged to attend the lectures during the alternate semester in an attempt to assure that the course is essentially the same each semester. When team-teaching during a single semester, all instructors should attend all lectures, to enhance continuity across the course. These instructors should meet regularly throughout the course to discuss the progress of the course and agree on any changes. In any team-taught course, it is essential that the two teachers work together on exam preparation throughout the semester, since one of the main objections from students to team-taught courses has been that exam expectations differ greatly between instructors (for example, how much detail is necessary, the relative importance of lecture, course handouts and text readings when they do not overlap, the type of exam given, such as essay format vs. multiple-choice, conceptual questions vs. factual questions). As an incentive to participate in the teaching cohort for these undergraduate courses, teachers who teach a half-course should be given full course teaching credit for at least the first year in their teaching rotation.

Coordination of the new core series for biology majors: A special problem arises with the presentation of introductory biology in a 5-course core sequence for biology majors instead of a single one-year course: unless strong efforts are made, these core courses may devolve into a set of completely independent courses with no effort to assure coordination or coverage of all of the major core concepts of biology. We believe that it is essential to conceive of the core series as a single extended course in introductory biology rather than a set of independent explorations of single areas. To help assure this coherence, the faculty teaching the different core courses should meet regularly and inform one another of the content of their courses. This is particularly important during the initial design of the courses, where, for example, decisions will have to be made on what material is to be taught in which course. Thus, the initial development of the syllabi and lists of core concepts for each course should be done at least in part in consultation with the teaching cohorts for the other core courses. Efforts should be made to find common concepts that can be referred to in each of the courses, demonstrating where possible the continuity of biological function. It would be particularly valuable if specific systems or examples could be chosen that could be referred to by all of the core courses, each providing its unique perspective on a common biological problem or system. The

Biology Curriculum Advisory Committee will have ultimate responsibility for supervising this interaction to coordinate the core courses into a coherent introduction to the breadth of biology.

III. Implementation of Recommendation 1: Development of the revised freshman biology laboratory course, “Introduction to Investigative Biology”

This course is designed to be the common experience for freshmen studying biology. As mentioned in the task force report, we strongly support the efforts of the current introductory biology laboratory teaching staff to move away from simple stepwise experiments and toward in-depth investigative projects that emphasize the ability of students to think critically and apply the scientific method to a real problem. To further foster this goal in the new laboratory course, the number of lab exercises should be reduced and the time spent on each exercise increased. The focus should be to make each exercise a problem-oriented thinking exercise that shows how scientists frame and then answer questions. Thus, there will need to be time to discuss the formulation of hypotheses, design of experiments to test the hypothesis (along with learning the essential role of control measurements where appropriate), analysis of the data using statistical and other methods, and interpretation of the results. We also hope that the new course will include gaining experience in literature searches, bioinformatics and scientific ethics. This problem-solving focus will allow the laboratory course to operate more independently from the core courses. Each exercise will be self contained in terms of necessary background information and will be aimed at scientific skills applicable to all of biology.

Course supervision: The implementation of this new laboratory course for freshman will be challenging and require significant effort. We anticipate that the course development be primarily implemented by the current BioGD 102-104 staff, under the direction of Kuei-Chiu Chen and Laurel Hester. However, our task force feels strongly that the staff would benefit greatly from faculty assistance. This is essential during the period of new lab exercise development and curriculum revision, and highly recommended on an indefinite basis thereafter. We propose that a tenured faculty member be assigned this oversight/supervision role as a standard teaching duty, equivalent to teaching one course.

Course logistics: As mentioned in the previous section, the new lab course will not be explicitly tied to any of the freshman-level courses (neither the modified introductory biology course nor the 4 new 100-level core courses for biology majors). Instead, efforts should be made to introduce lab exercises that are appropriate for all the core courses (and thus the breadth of introductory biology as well). Drs. Chen and Hester have recommended that an obligatory one-hour lab lecture be added each week, to allow presentation of the theoretical material that must be understood to execute the lab exercises. Such a format (with one lab lecture and one lab exercise per week) works well in other introductory course at Cornell: Chem 251, the introductory organic chemistry lab, and BioMI 291, the introductory microbiology lab. Both of these courses are offered for 2 credits, as we propose for the freshman biology lab.

It is essential that the lab sections remain small (with fewer than 20 students per section), to allow personal attention for each student by the TAs. This requires that TA allocations for this lab course remain high, and not be reduced if there are restrictions on TA availability. This may be an area where peer learning using undergraduate TAs may

be very effective. Some combination of graduate student teaching assistants (as experts in the field of biology) and senior-level undergraduate teaching assistants (as experts in the undergraduate biology learning experience at Cornell) would make an ideal team for introducing freshman to biology at Cornell.

The total enrollment for the new laboratory course will be approximately 800 students per fall semester (although see section VII below describing the level of uncertainty in this estimate), with fewer students in the spring. The introductory lab staff's estimate of their current capacity for laboratory space is approximately 810 students per semester, without adding additional sections on Saturdays (see attached enrollment and classroom availability estimates). Thus, though space will be tight, we feel that there are enough lab facilities to offer this course.

IV. Implementation of Recommendation 2: development of the new core course series intended primarily (but not exclusively) for majors in Biological Science.

The major innovation in our report is to suggest that most students majoring in Biological Sciences take a 5-semester sequence of core courses that replace the current 2-semester introductory biology plus 3 core courses. With the exception mentioned below, all of the core courses should be offered each semester, like the current core courses in biochemistry, genetics and evolution. As described above, successful implementation of this aim will require coordination within and between the teaching cohorts of all the core courses, to assure that all versions of a single course are substantially interchangeable and there is continuity across the core course sequence.

Course direction and basis: We feel strongly that each core course should be developed by a single "lead department" that has primary responsibility for its success and whose Chair is responsible for staffing the course. These courses are typically derived from existing courses, which will need to be revised for the appropriate level of presentation. Details of lead department and course evolution are as follows:

- Evolution and Diversity: EEB; derived from BioEE 278, redesigned to 100 level
- Ecology and Sustainability: EEB; derived from BioEE 261, redesigned to 100 level
- Cell and Developmental Biology: MBG. We propose offering two different courses for this core area. One will be derived from BioBM432 and will emphasize cell biology with some developmental biology. The other will be derived from BioGD 385 and will emphasize developmental biology with some cell biology. Both courses will be redesigned for the 100 level. Each will be offered once a year on alternating semesters.
- Physiology: Biomedical Sciences, derived from BioAP 311, redesigned to the 100 level. We feel that this course should include some plant physiology, so faculty from Plant Biology may participate. In addition, faculty from NBB may help with teaching of neurophysiology.
- Genetics and Genomics; MBG, derived from BioG281, focused at the 200 level
- Biochemistry and Molecular Biology: MBG, derived from BioBM 330 and 331-332, focused at the 300 level since it requires organic chemistry as a prerequisite. We feel strongly that there should be a one-semester lecture course covering this material, which should be similar in content to the autotutorial course, BioBM330 and the summer course, BioBM333, and

offered for 4 credits per semester. In addition, we encourage the maintenance of BioBM330, the autotutorial version of this material. The current two-semester lecture series, BioBM 331-332, is an outstanding course much loved by a subset of students; it should be maintained as an “Honors Biochemistry” sequence for those wanting a more detailed introduction to biochemistry and molecular biology.

Development of syllabi for new core courses: As mentioned above, the first core course in each of the core areas should be developed within the designated “lead department”, but its content and syllabus must be approved by the Biology Curriculum Advisory Committee. The following steps need to be taken for each new course:

- The Chair of the lead department is responsible for naming the cohort of faculty to teach the courses each semester.
- The teaching cohort will be responsible for developing a list of essential core concepts to be taught each semester. This will be approved by the Biology Curriculum Advisory Committee. This list will be kept as the essential definition of the course material, available to other departments if they wish to develop alternative core courses in this area (see below).
- The cohort will then develop a syllabus, choosing books and readings, and designing the lecture schedule to cover the key concepts. This syllabus must take into consideration the level of the course (especially if redesigned for first year students)
- This will be reviewed and approved by the departmental curriculum committee before submission to the Biology Curriculum Advisory Committee, and then the Biology and college curriculum committees for eventual adoption.
- This initial syllabus will be considered provisional and will be reconsidered after the first year to make adjustments based on the first year experience of teaching the material.

Evolution and revision of core courses over time: The task force feels strongly that the content and syllabi of the core courses should not become fixed in stone over time, but should evolve to reflect the increase in knowledge and change in emphasis of core concepts that reflect new research in each area. While this is an obvious trajectory for any course, it is not always universally practiced. Evolution of courses over time is to be strongly encouraged. One possible way is to require the cohort teaching a core course to review and amend the document of essential core concepts at a regular interval (perhaps every 5 years), and to submit the revised list to the Biology Curriculum Advisory Committee, or its successor committee, for review and approval. The curriculum would then have to be revised at regular intervals to reflect these changes. It will be essential to continue the interaction between the different core courses as they evolve, to adjust the topics covered, continue the development of common examples across courses, and avoid unnecessary overlap.

Addition of new courses as alternatives within each core area: While the first priority of the Biology Curriculum Advisory Committee will be to oversee the design of a single course option in each of the 6 core areas, we foresee the advantages of having more than one course that would fill the requirements for a single core area. An example is already given above for biochemistry and molecular biology. Having alternative courses for a core will decrease class size and enhance the choices available to our students. It allows

different “flavors” of a core course to be offered, which may better suit the different needs of our diverse student body. We make the following recommendations on this issue:

- There should be a limited set of alternatives for each core area. We recommend that no more than 3 courses be accepted to serve each core area. This limit could be revisited in the future if more than three excellent alternative courses are identified after the transition.
- Since these courses provide the core information for majors in the Biological Sciences, they should be offered by departments directly associated with the major in Biological Sciences: these are defined as departments supervising a program of study (concentration) within the major.
- Faculty considering the development of a new core course will have access to the document outlining the core concepts that define each core area. The new course must demonstrably cover all these core concepts, although it is free to use different examples (for example, from their own department’s research area) to demonstrate these core concepts.
- Any new course must be approved by the department curriculum committee, the Biology Curriculum Advisory Committee or its successor, and then by the Biology and College curriculum committees.
- Each new course will be offered provisionally for one year. After its first year, the course will be re-evaluated by the teachers of the course and the Biology Curriculum Advisory Committee or its successor before final acceptance as a core course for the major.
- While we recommend that the initial core courses be offered each semester, new additional core courses need not be offered each semester. If the limit of 3 alternative courses is reached for a core, the two additional courses should be offered on alternating semesters to maximize student choices.

V. Alterations to the requirements for the Programs of Study (concentrations) within the Biological Sciences major.

We fully support the continuation of the requirement for all majors in Biological Sciences to complete a Program of Study (concentration) along with the core courses, to provide advanced knowledge in one area of biology. Requirements for each Program of Study are, and should remain, under the purview of the individual departments offering the programmatic area. The following are likely decisions a Program of Study may make given the suggested changes proposed to the core biology requirements:

- It may decide that one of the core courses represents the entry-level course for that concentration, and thus require that students pursuing that concentration take that core course.
- It may choose to retain the upper division courses from which the new core courses are derived, in which case those courses will need to be revised to reflect the knowledge gained from the core course.
- One possible benefit of the core system (especially if certain upper division courses are retained) may be the development of middle tier courses in some areas, rather than the more common jump that undergraduates currently make directly to advanced courses from a single entry-level course. However, this will

be under the direct control of individual departments and decisions they make about the distribution of course offering.

- We believe that development of the core course series can be accomplished while keeping the overall credit requirement for the major just below the limit of 70 credits required by CAS. However, if the new core courses are offered for more credits than we currently expect (and only in this case), the limit to credits in the concentration areas may need to be revised to keep the requirements for the major within the limit.

VI. Implementation of recommendation 3: Revision of a two-semester lecture course in introductory biology

As described in the task force report, we recommend the continuation of the teaching of an introductory biology course, covering the central core concepts of biology in two semesters. This course will continue to be essential for a number of students, including:

- First year students who are uncertain about their major but have interests in biology (see point IX below for more on this path to the major).
- Students majoring in applied biology departments in CALS
- Pre-clinical (medical, veterinary, and dental) students who are not Biological Sciences majors
- Students in Human Ecology who need a quantitative introduction to Biology
- Other scientists with an interest in biology (engineers, physicists, chemists, mathematicians, etc.)

As described in our task force report, we propose that the introductory biology course continue to focus on the essential core concepts of biology, but should cover them in more depth than at present. This will require a reduction of the breadth of coverage of all of biology, but with the benefit of greater comprehension and retention of the core concepts by students. We suggest the following recommendations for this course: Teaching cohort: Since this course is aimed at students not majoring in the Biological Sciences, we feel that it can be taught by faculty from both the departments whose major is Biological Sciences and by faculty from applied biology departments in CALS and the Veterinary College. The critical decision of the faculty to teach this course will be initially made by the Biology Curriculum Advisory Committee together with the Director of the Office of Undergraduate Biology. The selection criteria must, of course, be demonstrated excellence in undergraduate teaching, a willingness to commit to teach one semester a year for a set period (3-5 years), and breadth of knowledge in the core concepts of basic biology. As stated above, we recommend that, if possible, each semester be taught by a single professor and, at most, two professors working very closely together.

Syllabus: The syllabus will be developed in a similar manner to that of the core courses. The cohort of faculty teaching the course will design the syllabi with input and approval of the Biology Curriculum Advisory Committee and the Biology and College Curriculum Committees. Introductory Biology should be a basic biology course, covering the fundamentals of biology, rather than focusing on applications in agriculture or industry, although these topics could be included as examples to provide enrichment and motivation for learning the material. We recommend that the essential concepts from the

six new core courses for biology majors be used as a starting point for developing the major concepts to be taught in introductory biology. However, given the time restrictions of a 2-semester course, the teaching cohort will have to be very selective about which concepts to include, to ensure adequate time to develop the ideas in some depth, and the students to absorb them. Attention should be made to assure that the core concepts tested by the MCAT and GRE Biology exams are fully covered.

Incentives for teaching introductory biology: Over the past five years, there has been great difficulty in attracting professors to teach introductory biology. BioG 101-102 has been taught by a different professor each semester, and this, despite the very best efforts of outstanding teachers, has resulted in difficulty in teaching the course in a consistent style. Thus, it is a very high priority to develop a cohort of outstanding teachers who are willing to commit to a prolonged period of teaching introductory biology (3-5 years). Once the cohort is established, turnover should be staggered so that there is at least one experienced professor each year. Given our recent history, we expect that incentives will be necessary, at least at the beginning, to attract these professors. Members of the initial cohort that develop the list of core concepts and develop the syllabus for the modified course should be given a month of summer salary to help in course development, and a month of summer salary after the first year of the new course to work on modifications based on the experience of the first year. Other possible incentives could include a full year teaching credit for one semester of teaching introductory biology, and access to the TAs from the course for the professor's department. If we are successful in developing a committed cohort of interested teachers, these incentives may then not be necessary. An alternative we have considered is to use fundraising to endow faculty Chairs for the teaching of introductory biology, and allow faculty to compete for this honor.

VII. Staffing numbers for the new program

TA requirements: Attached is a spreadsheet indicating our best estimates of the numbers of students in the new courses, and estimates of the numbers of TAs that will be needed to adequately staff the proposed laboratory and discussion sections. Despite our efforts, the estimates of future student enrollments are imprecise. It is essential that more reliable estimates be obtained before we finalize planning for TA allocation under the new plan. An immediate priority is to get a professional survey of student interests in order to firm up our estimates; this could be accomplished, for example, with assistance from the Department of Education. This survey would be aimed at students who are currently participating in the introductory biology courses, asking them what they think they would take under the new plan. It is also essential to determine any changes in College course requirements for non-scientists (for example, in CALS and Human Ecology). Such a survey will help to address a number of uncertainties in what courses the students will take when the new plan is implemented. Our major concern is with the number of students who will take the first year biology laboratory course. These concerns include:

- Our proposal argues that students with AP Biology in high school should not be allowed to use those AP credits to fulfill a requirement in the major of Biological Sciences. It appears that at present ~60% of students with AP Biology Credit already take introductory biology with the lab. This suggests about 60 more students will take the lab course (i.e., a 60 student increase over those who currently take the present lab course).

- We do not know how many of the students currently taking Bio 109-110 will decide to take the new introductory biology lecture and lab courses. Bio 109-110 is currently dominated by non-science majors who would likely take one of the new CALS Life Sciences Distribution Requirements (see below). However, we have no firm information about the likely choices of students. A survey of the current students in this course would help with this estimate.
- At present, our proposal encourages students transferring to Cornell from another university to take the first year biology lab, even if they took a college biology lab at another university. This would likely add ~60-115 students per year to the introductory lab course. If transfer students did not take the introductory laboratory course, it would significantly shrink the size of the lab course. If TA allocations or lab space become severely limiting resources under the new plan, this may be a viable, if not perfect solution.
- The College of Human Ecology is considering changing the one-year introductory biology requirement for their students. We do not know whether they will allow their students to take our new courses for non-scientists (see below), or continue to require a one-year introduction to biology. This could significantly influence the introductory biology lecture and lab courses. Our understanding is that many of these students already take Bio 101-104 (and are therefore already incorporated into the estimates in the attached file), but we need better estimates of what Human Ecology students currently taking Bio109-110 would likely take under the new curriculum.
- There are multiple options for the future of the autotutorial introductory biology course, BioG 105-106 (see below) and depending on how this highly successful lecture/lab course is used (as part of the new biology core or in support of the two-semester introductory biology course) there are likely ramifications for other courses. The effect on the enrollment in the lecture courses (either the new biology core courses or the two-semester introductory sequence) is easily absorbed and accounted for in the attached estimates of TA allocation. However, if all of the students currently enrolled in BioG 105-106, switch to the freshman year lab courses, it would add 80-120 students per semester.

In summary, these uncertainties could lead to a maximum increase of 200-500 students to the first year biology lab course and this is something that is highly uncertain in the attached document. In contrast, although there is uncertainty as to the distribution of student enrollment across the core lecture courses (i.e., the possibility exists for over- or under-enrollment in any particular core course), our enrollment estimates in the attached document are based on total enrollment of the current courses and, therefore, can accommodate all students currently taking introductory biology courses. If the students do not distribute themselves evenly among the new core courses, it would be possible to cap semester enrollment in the more popular core courses, thereby spreading students across multiple core offerings. However, the issue of enrollment in the freshman laboratory course is more problematic. If the freshman laboratory course is critically over-subscribed we will need to do one or more of the following: 1) increase the TA allocation; this is a desirable solution, but challenging given the cost associated with a large increase in TAs; 2) discourage (or not require) transfer students who major in

Biological Sciences from taking the course; this may be reasonable if most transfer students have taken a prior biology laboratory course; or 3) restrict enrollment to biology majors and non-biology pre-clinical students who require a biology lab; a reasonable solution for our biology majors and pre-clinical students, but sub-optimal for other groups of students. This would be our lowest priority solution.

Possible solutions to the potential need for additional TAs to staff the new courses: The Task Force has operated under the assumption that all of our suggestions must be made against a backdrop of a limited ability to increase the number of teaching assistantships. We have avoided solutions that require large increases in TAs. However, dependent upon several variables outlined in this report, a small increase of 6 full-year TAs is likely under the new curriculum. If the colleges are unable to reallocate TAs from other courses to staff the new curriculum, we have discussed several favorable solutions:

- Fundraising efforts aimed at increasing the number of graduate TAs available for course staffing. We are aware that this is difficult.
- Use undergraduates to serve as discussion section leaders. Undergraduates are already highly successful in two autotutorial biology courses (BioBM 330 and BioG 105-106), and several other courses in CALS and the Hotel School. In these courses, undergraduate TAs are selected from students who performed well in the course and are highly motivated to master the material and help other students. In our experience, they have made outstanding TAs. Peer learning is a powerful and effective way to teach biology. We are not suggesting that an undergraduate would have the same level of knowledge as a graduate student, but this deficit would be significantly offset by an undergraduate's knowledge of biology education at Cornell. We feel strongly that a combination of graduate and undergraduate TAs could provide the optimal learning environment in many of our core courses. Because they need to master the material in detail in order to teach it, these undergraduate TAs should receive academic credit for their TAs.
- Ask entering Assistant Professors (if they are not otherwise teaching) to participate in courses at a level lower than primary instructor. For example, an Assistant Professor could take the lead in organizing the discussion sections as well as leading some discussion sections themselves. This would serve to integrate our young faculty into teaching without overburdening them during the time they are initiating their research programs. It would also prepare and perhaps motivate our young faculty to participate in introductory teaching later in their career.
- Institute a program of teaching postdoctoral fellowships. These postdocs would gain much needed teaching experience by serving as TAs one semester of the year. The university would pay the stipend for this part of their job (for example, 25% of salary and fringes), while grant support would, as usual, provide the rest. This would be less expensive than funding graduate TAs since it avoids having to pay graduate tuition. We note here that training in teaching is severely lacking in the modern postdoctoral position and a desire for teaching experience exists among many current postdoctoral scholars at our university, in order to help them secure a faculty position. This program could provide a major innovative

feature of postdoctoral training at Cornell, and could help us attract the best postdoctoral fellows to our institution.

- Hire lecturers to run discussion or laboratory sections. If a lecturer worked full time only on this, they could teach many more sections than a graduate student, at a much lower cost.

If none of the solutions outlined above are possible, it may become necessary to abandon discussion sections in the revised Introductory Biology two-semester sequence. This would maintain the status quo, where there is no discussion section associated with BioGD 101-102. Loss of these discussion sections would significantly reduce the numbers of TAs needed, but would also reduce the active learning opportunities for students taking this course. We feel this is our least attractive solution.

Faculty teaching requirements: We do not believe that it will be necessary to hire new faculty to implement the new curriculum. We have experts available to teach each of the proposed courses. However, a potential consequence of having instructors moving into introductory teaching is a modest reduction in the number of upper division courses offered to our students. To estimate the magnitude of this shift, we make the following assumptions:

1) Each of the new core courses is offered both semesters each year, and one professor teaches the course each semester. 2) One professor each semester takes a supervisory role for the first year biology lab. 3) The introductory biology lecture course is taught by two professors each year. With these assumptions, eight one-semester teaching slots would have to be converted to teaching the introductory and core biology courses. Given the very large number of upper division courses, and the fact that these eight positions are spread over several departments, we feel that this represents an acceptable reduction in upper-division offerings. This estimate does not include the staffing of the new courses for non-scientists, which are the subject of the Viands report.

VIII. Teaching of introductory and core courses during the summer

To assist students in planning their coursework, and to help transfer students to graduate on time, we recommend that all the introductory biology and new core courses for biology majors be offered during the summer session. This is not a major addition, since introductory biology and laboratory, evolution, genetics, biochemistry, cell biology and ecology are already offered in the summer. Thus, the only new summer course that would need to be developed would be physiology. The curricula of these courses should roughly follow the semester courses, and in all cases will teach the core concepts developed for each course. Such summer courses can provide financial support to the departments, which should serve as an incentive for their development.

IX. Implementation of recommendations 4 and 5: alternative track to the Biological Sciences major through introductory biology.

Students may enter Cornell with no idea about which of the many choices is best for them to declare as a major. For example, a student who plans to go to medical school (and thus needs to fulfill the pre-med requirements) may not know whether to major in Biological Sciences or in a different field. The five-course core sequence poses a

significant challenge for them. We estimate that a minimum of 4 core courses (Biochemistry, Genetics, Cell/Developmental Biology, Physiology) will be necessary for a student to fully prepare for the MCAT exams. If a student takes two of the core courses in the first year, but then decides to major in a different field, they will have only partial knowledge of the breadth of biology, and will have to either complete the core sequence or take introductory biology. This would be a significant burden on the uncertain student. To get around this problem, we propose a hybrid solution. We recommend that students who are completely uncertain about their future major take the introductory biology course with the first year lab. At the end of that year, if they decide to transfer into the Biological Sciences major, there will be a minimal penalty in that they will only have to complete 4 additional core courses (including the three required ones). The student will confer with their academic advisor and the DUS of the Area of Study to make sure that the core course that is “skipped” is not essential for the concentration.

A similar problem arises for students transferring to Cornell from another institution, having already taken an introductory biology course. We propose the same solution for these students, to avoid too large a course penalty for them to complete the major. Of course, any courses beyond introductory biology that transfer students took at another institution will be considered for fulfillment of the core course requirements.

Finally, a student who is unsure of his/her major may choose to start taking the core courses for the Biological Sciences major. If they then change to another major, they are of course free to complete the core course series to have an in-depth coverage of basic biology.

X. Implementation of recommendation 6: teaching of biology courses for non-scientists

We support the findings of the CALS Life Sciences Distribution Requirement Task Force. Their major recommendation is to initiate a set of courses teaching biological principles within the context of socially important issues, such as global warming and cognitive science. While we agree that the Viands Task Force provide leadership on this issue, we have the following suggestions:

- These courses should emphasize science and not politics or social science. The courses should emphasize how important it is to understand how science is performed, and how it differs from other explanations (political, religious, etc.). This requires developing a deep understanding of the scientific method as a path towards explanation, and understanding how the scientific method is used should be the major goal of the courses. These courses should also show how essential it is for the lay public to understand the basic concepts in biology to address many of the major problems facing society today.
- These classes should be small if possible, to enhance active learning and closer interaction with the faculty.
- To achieve this, each biologically related department in CALS should offer at least one course for non-scientists (i.e., a course with no scientific prerequisites, and which fits the requirements defined by the CALS Life Sciences Distribution Requirement Task Force). This would add up to a minimum of 15 courses. Many departments already offer courses for non-scientists, and these courses could

easily be adapted to the requirements of the CALS Life Sciences Distribution Requirement Task Force report.

- After the full set of non-scientist courses are developed, it will no longer be necessary to teach Bio 109-110. Students desiring a survey of biology for non-majors can take the revised introductory biology lecture course and the first year lab course.

XI. Implementation of recommendation 7: Courses for pre-clinical students (medicine, veterinary medicine, dentistry)

The new curriculum plan outlined in our report provides several excellent paths to fulfill the requirements for applying to medical, veterinary, and dental school. First, students can major in the biological sciences and complete the 5-semester core series in introductory biology. This will provide more depth than the current curriculum and will fully prepare the students for the MCAT exams, etc. and their future academic careers. Second, students can major in another area while completing the revised introductory biology course with the first year biology laboratory, as well as the other pre-clinical requirements; the introductory biology courses will be improved over their current versions to enhance comprehension and retention, and this should also improve student preparation for clinical studies. Third, students who are unclear about their choice of major can take the introductory biology lecture course and first year biology laboratory course, and then switch into the Biological Sciences major; in this case they fulfill the basic biology requirements by only taking 4 additional core courses, as well as completing a concentration. This results in one additional 3-credit course over starting immediately with the core series, which should not prevent the students from graduating on time, and again will prepare the students for clinical studies. There are also other options for students desiring additional training. For example, a non-biology major pre-clinical student who had taken the two-semester introductory biology sequence could take additional core courses if they desired a more in depth coverage of a particular topic (e.g., Cell Biology). A student majoring in another field could even complete the entire core series for biology majors, if they wanted an in-depth understanding of biology.

It is essential that appropriate advising guidelines be developed in coordination with the Health Careers Advisory Board, to guide pre-clinical students in these choices.

XII. The special situation of first year students: enhancing biology through “Freshman Enrichment”

The faculty who currently teach introductory biology have strongly urged our Task Force to recognize that first year students are different from upper division students, and the courses taught need to be designed with this in mind. We agree with this assessment. First year students are just learning how to study at the university level, and adjusting from a situation where they were the top students in their classes (and thus may not have had to work hard in their classes to earn top grades) to being average among our students (and need to work very hard on their coursework). Additional services, which are currently offered in conjunction with introductory biology, should continue to be made available to help the first year students in both introductory biology and in the core biology courses in this transition. We make the following recommendations:

- 100-level core courses for biology majors need to be designed with consideration to the specific learning issues of first year students. The courses should start more slowly and emphasize training in how to study and how to prepare for discussion sections and exams. Advice from the current introductory biology professors should be sought while these courses are being designed.
- Optional non-credit classes (00-level) that offer additional tutoring should continue to be offered for introductory biology, and should be developed for all the 100-level core biology courses (and possibly the upper division core courses as well). These can be taught by lecturers or teaching postdoctoral fellows, as described above.
- If the 100 level courses attract a significant number of upper class students, discussion sections specifically for first year students should be developed such that the first year students are not in competition with the upper class students.
- A number of enrichment activities are performed by the introductory biology faculty and should be adopted by faculty teaching the 100 level core courses as well. This includes additional office hours, additional tutorial opportunities, and enrichment opportunities outside of class such as a weekly dinner discussion on biology.
- The “Explorations” program, allowing first year students to visit a research biology lab, is outstanding and we recommend very strongly that it be continued. The logical way to do this would be to link it to the first year biology laboratory course, so all students taking the course participate in one “Exploration” each semester.
- As described in our report, we feel that the first year biology lab course can provide a common and enriching experience for entering students. This course should also offer enrichment as appropriate for the first year students.

XIII. Future of BioGD 105-106, the autotutorial introductory biology course

BioGD 105-106 is very highly regarded by its students and provides abundant opportunities for one-on-one learning (primarily through the use of undergraduate TAs). Thus, we are eager to continue offering this course. However, the course director, Darlene Campbell, is concerned that if majors in the Biological Sciences take the core course sequence instead of Introductory Biology, the participation in this course would drop significantly. We feel that this is not certain (see discussion in Section VII). Thus, one option is to continue this course in its present format as an alternative to the introductory biology course. We strongly support this option.

A second alternative is to convert this course into an alternative version of one of the core courses, such as physiology. This would provide an equivalent to the current autotutorial version of biochemistry (BioBM330), and would further reduce course size for the majors in biological sciences. However, we feel that the gains for the core courses in terms of class size are outweighed by the anticipated increase in the enrollment of the lecture two-semester introductory biology sequence.

XIV. “Grandfathering” of current students

When this plan for a new biology curriculum is initiated, there will be sophomores, juniors and seniors who started their training in biology under the current set

of requirements. We recommend that these students be allowed to complete their major using the old requirements. Specifically, for majors in Biological Sciences, any new core courses (for example in Evolution and Diversity, Genetics and Genomics, and Biochemistry and Molecular Biology) should be accepted as fulfilling the current requirements for core courses in these areas. There should be no effect of the new plan on currently enrolled students.

XV. Advising for the new curriculum

It is essential that new guidelines for advising be developed and available well in advance of the initiation of the new curriculum. Separate documents should be developed for students and advisors (professors, lectures, staff advisors, etc.). We recommend the following:

- Student guidelines should be developed both for the “Courses of Study” and for web access. A single document can be developed for the web, but with pointers scattered widely through the many sites a student may access to get this information.
- Advisor guidelines should be sent individually by email to all interested parties, as well as available online. Training sessions should be offered to help advisors learn the details of the new plan.
- It should be made clear that there are two possible paths to a major in Biological Sciences. The preferred path is to take the first year lab course and immediately start taking core courses in the first year. This is certainly appropriate for all students who are relatively certain about their choice of major. However, an acceptable alternative is for students to take the introductory biology lecture course followed by a choice of 4 core courses, as described in point IX above. This alternative is good for students who are initially uncertain about their choice of major but have interests in Biology. This second alternative results in one additional 3-credit course over the core course option, but provides more flexibility, for example, for pre-meds who need to know basic biology but are unsure of their major. It should be noted that this level of flexibility is rare in most other majors. For example, there are much more serious ramifications for a student who eventually decides to major in Engineering, but does not take the prescribed introductory courses as freshman.
- The advising guidelines should emphasize that the modified introductory biology sequence is not a less rigorous version of the current BioGD 101-102. In fact, quite the opposite, we fully anticipate the course will maintain its current high level of rigor and become even more effective because of decreased class size and increased depth of coverage of core concepts.
- We believe that the staff of the OUB, in conjunction with the Health Careers Advisory Board, are the most qualified to write these advising guidelines. The documents should be approved by the Biology Curriculum Advisory Committee to assure accuracy and appropriate editorial emphasis.

XVI. Evaluation of the success of the new plan

One of the major frustrations encountered by the Task Force in their deliberations is the paucity of metrics that measure the success of our current program. Any evaluation

of the future program will be extremely difficult without the ability to compare it to our current program. Therefore, it is essential to develop a set of metrics that can be collected starting immediately, to measure the success of our current program for comparison to the future curriculum. As with any change, we anticipate an initial decrease in these metrics during the years of transition. However, if after this initial equilibration the new plan shows significant decrements in these metrics, we could then make revisions or even return to the current system. This would not be difficult, since introductory biology is being retained and improved. It is essential that professional guidance be obtained on how to acquire, analyze, and interpret the metrics for success, and we urge that such professional guidance be sought immediately. It would be optimal to collect a full set of metrics starting with this year's graduating class; this would then generate several years of baseline data before anyone graduates under the new plan, to allow quantitative comparison of the two plans. The Biology Curriculum Advisory Committee, or its successor, would be appropriate to judge these analyses and make decisions on future evolution of the teaching in biology.

We consider the following metrics as relevant, but freely admit that we are not experts in the evaluation of curricula:

- MCAT scores for pre-medical students, separated by Biological Science majors and majors in other fields. We understand that average MCAT scores for Cornell students are in fact available.
- GRE scores for graduating Biological Sciences students planning to go to graduate school.
- Percent of majors in Biological Sciences planning to attend medical/veterinary/dental school, and success rates for each area.
- Percent of majors in Biological Sciences planning to attend graduate school, and success rates for each area
- Alumni satisfaction with the training they obtained for their careers, collected at 5- and 10- year intervals after graduation
- Instructor evaluations of student preparation for upper division biology courses.

XVII. Suggested timeline for implementation of the curriculum plan

The suggested timeline below reflects our estimate of when major goals should be reached if the transition to the new plan is aimed for Fall 2009. We are aware that these are difficult, complicated goals, and an implementation of Fall 2010 may become a preferred implementation deadline. We feel strongly that having adequate time for preparation far outweighs any benefit an earlier implementation and this should drive all decisions.

- Spring 2008: Select Chair and membership of the Biology Curriculum Advisory Committee
- Spring 2008: Hire professionals to generate and analyze questionnaires on student preferences of course attendance under the new plan and to develop better estimates of the course sizes and TA needs under the new plan
- Spring 2008: Hire professionals to determine metrics and ways to obtain them from graduating seniors, to develop a database of success of the curriculum and to

compare with the success of the new plan; collect these metrics from graduating seniors

- Spring, 2008: Inform Chairs of “Lead Departments” of need to develop new courses
- Spring-Summer, 2008: Chairs select teaching cohorts for courses.
- Fall, 2008-Spring 2009: Teaching cohorts meet to develop lists of core concepts for each course; Biology Curriculum Advisory Committee reviews and approves these lists.
- Spring-Summer, 2009: Teaching cohorts develop syllabi, book choices, etc. for the new courses, have these choices approved by their department Curriculum Committees and the Biology Curriculum Advisory Committee, and curriculum committees in Biology and the two Colleges.
- Spring-Summer, 2009: Cohorts teaching the different biology core courses meet as a group to compare their courses, and decide on strategies to make the core courses into a single continuous introduction to biology rather than 6 independent courses.
- Fall, 2009: first teaching of new courses.
- Summer 2010: Evaluation of success of new courses, redesign of curricula if needed.