Rowan University

PROCESS C New Programs-Major Program Revisions-Title Changes SCC#05-06- 1 11

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Submission Deadlines: Fall - October 11, 2005 Spring - February 14, 2006

TITLE Revision of the Introductory Biology Curriculum and Biology Major

Sponsor(s) Department of Biological Sciences *e-mail: grove@rowan.edu*
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DEPARTMENT Biological Sciences
College LAS

*If **LAS**-check:* ___ *History/Humanities* ___ *Social/Behavioral Sciences*

X *Math/Science*

DESCRIBE: X ***UNDERGRADUATE*** ___ ***GRADUATE***

___ New Degree Program
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___ New Certificate of Graduat
X Major changes of degree re
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Signatures Required: representing approval before s... ...ffice of the Senate

Department Chair: Date:
Department CURRICULUM Chair: Date: 10/7/05
Academic DEAN: Date:

COLLEGE CURRICULUM COMMITTEE: Open Hearing Date: 12 NOV 2005
Approved ✓
Not Approved

Signature: College Curriculum Chair

Signature: SENATE CURRICULUM CHAIR

Date:

Comments:

Signature: Executive Vice President/Provost:

Date:

Approved:
Not Approved:

Signature: REGISTRAR

Date: 3/30/06 Course Description Received & Approved
Hegis Taxonomy & Course #

Notification Forward:

✓ SCC CHAIR
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✓ Other-

Thanks. 5-1-06

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ABSTRACT

Title: Revision of the Introductory Biology Curriculum and Biology Major

Sponsor: Department of Biological Sciences

Summary:

Faculty in the Department of Biological Sciences (and, as reported in the literature, at many other institutions) have become increasingly concerned that content knowledge and scientific skills learned in the current introductory sequence are not retained by our students into upper division courses and beyond graduation. We believe that this problem stems from a combination of factors, primarily the traditional teaching methods commonly used in the introductory sequence, but also the treatment of many basic concepts without linking them to other areas of biology. As a result, students commonly perceive their goal to be passive memorization of unrelated subsets of facts. Our objective is thus twofold: 1) to increase student learning as measured by the ability of students to appropriately apply understanding gained in the introductory sequence to more complex topics in upper division courses, and 2) to increase student engagement in science as an active, continuously self-examining process.

We will meet these objectives by a complete and systematic revision of our current two-semester introductory sequence, creating an entirely new four-semester core. The expansion will allow us to focus more heavily on the development of general skills including data interpretation, experimental design, critical thinking, and oral and written presentation. We will also be able to utilize inquiry-based activities to explore topics in ways that actively engage the students' interest and intellectual capabilities. The success of the revision should have broader impacts beyond the performance of Rowan biology majors during their academic careers. A deeper understanding by our students of science as an active process should increase their capacity for engaging in productive scientific careers following graduation.

Implementation: Fall 2006

Resources: These revisions will require an initial investment to equip 2 laboratories used to teach the new core courses (please see Appendix A). The Department's FY06 base budget is sufficient to support the new courses proposed here. Annual investments of $2,000 to purchase testing materials would be required in evaluating the success of the revisions.

DETAILS

a. Title of Proposal: Revision of the Introductory Biology Curriculum and Biology Major

b. Sponsor: Department of Biological Sciences

c. Scope and Size of Program Revision:

This revision will institute a new Biological Sciences core curriculum for the spring 2010 graduating class, including all freshmen matriculating in the fall 2006 semester or later and transfer students with junior or senior status entering in the fall 2008 semester or later. The new core for native freshmen will replace the current 2-course introductory sequence (0401.100 and 0401.101) with a sequence of four newly developed courses to be completed during the freshman and sophomore years. Additionally, the current "Advanced Science Elective" in the core will be replaced with a requirement of the Biometry course currently offered by the Department of Mathematics (1702.280). Transfer students entering with the equivalent of the traditional freshman Biology I and II sequence will be required to take a newly developed biological skills course (0401.202), the 4th course in the new introductory sequence (0401.204), and the Biometry course (1702.280) unless they receive transfer credit for a course equivalent to Statistics I (1702.260). The introductory sequence will be a prerequisite for the majority of upper-level elective courses in Biology. Proposals for the new introductory sequence and the biological skills course are attached separately, and Biometry is being offered for the first time during the spring 2006 semester.

As the new introductory sequence will provide a survey of the crucial topics in Biology, the current banking system, in which students are required to take at least one elective from 4 out of 5 banks of designated courses, will be eliminated. All Biology courses (with six exceptions) taken beyond the introductory sequence will be elective and count towards the 38 total credit hours in Biology required for the B.S. degree in Biological Sciences (unchanged from the current model). The exceptions to the electives counted towards the Biology major under the new model will be the courses in Human Biology (0401.110) and Natural Resources (0420.100) currently accepted for major credit and the non-majors Biological Systems and Applications (0401.210), General Biology: Human Focus (0401.113), General Biology: Environmental Focus (0401.112), and General Biology: Plants and People (0401:115) courses which are not accepted for major credit under the current model. A table comparing the new and old core curricula is provided in Appendix B. The model program guide illustrated in Appendix C indicates that students matriculating under the new program will be able to progress towards graduation in a timely fashion.

The distribution of general education and free elective credits will not change under this revision. As a component of the revision, however, biology majors will be required to take the Philosophy of Science course offered by the Department of Philosophy and Religion (1509.368 or 1509.369). This course will fulfill in part the 6 credit hours required in the History, Humanities, and Languages bank of the University general education requirements.

The final proposed change will be the requirement of receiving a grade of "C" or better in any Biology course to be applied towards the Biology major. Currently the Department accepts Biology courses with grades of "C-" or better for major credit.

d. Need for Program Revision

The consensus opinion of the Biological Sciences faculty is that our current introductory sequence is lacking in several ways. First, and most importantly, students do not leave these courses retaining the knowledge and abilities that are necessary for successful performance in subsequent upper-level classes and in their careers after leaving Rowan. Second, the content knowledge and abilities gained in any particular course are perceived by the students to be sufficiently relevant in isolation without any deep understanding of how individual pieces of knowledge can only truly be understood in the context of the unified discipline of biology in particular and science in general. Third, development of the skills required for success as a practicing scientist has not been incorporated into the curriculum in a systematic manner but has come as an afterthought to instruction in content. Fourth, these courses continue to be taught in very traditional ways and do not incorporate new active learning techniques shown to be effective. Finally, given the recent explosion of knowledge in core areas of biology (especially cell and molecular biology), we believe that a two-semester sequence is no longer adequate to cover key biological concepts in sufficient detail. We believe that the new introductory sequence will address all these concerns and provide a significantly stronger base of knowledge and skills for our majors.

The additions of the requirements for Biometry (1702.28) and Philosophy of Science (1509.368 or 1509.369) are integral to addressing these concerns. An adequate understanding of the role of statistical analysis in interpreting biological data and of the philosophical underpinnings of hypothesis testing and the nature of scientific proof are often lacking in many of our majors. The addition of these two specific courses to the requirements for a B.S. in Biology will provide our students a much deeper understanding of the fundamental ways in which science deals with variability and uncertainty in the natural world.

The Natural Resources (0420.100) and Human Biology (0401.110) courses are being removed from the list of courses accepted for major credit because they are non-laboratory courses which are, in reality, designed for a general education audience. Biology majors will be able to investigate the same topics in a variety of already existing laboratory courses (e.g. Environmental Science (0420.330) and Human Anatomy and Physiology I and II (0410.210 and 0410.212), respectively), which more directly engage the students in the scientific processes of experimentation, data collection, and data interpretation.

The change to accepting only coursework in Biology completed with a grade of "C" or better for major credit is based on our belief that this more adequately indicates an acceptable level of understanding of the subject matter. A student who completed all the required coursework in Biology with grades of "C-" would have a GPA for major courses of 1.7, a level which would warrant academic probation under current University standards.

e. Requirements for Admission and Graduation

Requirements for admission to the Biology major will be unchanged under this new model. Graduation requirements will also remain unchanged with the exception of the changes in the distribution of the major core curricula, the addition of a requirement for enrollment in Philosophy of Science, and a change in the minimum grade required for major courses to count for credit included under the current proposal.

f. Suggested time and scale

The initial offering of the new Biology 1 and 2 (0401.103 and 0401.104) courses will be in the fall 2006 and spring 2007 semesters, respectively, with the new Biology 3 and 4 (0401.203 and 0401.204) courses offered initially during the 2007-2008 academic year. Thereafter, Biology 1 and 3 will be offered each fall semester and Biology 2 and 4 offered each spring. The skills course targeted towards transfer students will first be offered in the fall 2008 semester and each fall semester thereafter, allowing the completion of Biology 4 within the first year after transfer.

g – i. Resources, library requirements, and staffing

Given that the new introductory core sequence will incorporate elements of previously existing courses, we do not anticipate the need for any additional space, computing, or library resources. The elimination of the current elective banking system will allow for the redistribution of faculty loads, with a larger number of faculty engaged in teaching the introductory sequence and fewer sections of upper level electives being offered on an every-semester or yearly basis.

These revisions will require a one-time investment to equip two laboratories to be used in teaching the new core 2 and 3 (0401.104 and 0401.203) courses. These courses will cover topics in genetics and cell biology which require a variety of specialized apparatus. While the Department currently offers upper-level courses in Genetics (0422.335) and Cell Biology (0401.430), the incorporation of these topics in much greater detail than previously existing in the introductory curriculum will significantly increase the need for equipment. We anticipate annually offering three sections each of the core 2 (0401.104) and core 3 (0401.203) courses serving a total student population of approximately 144. At a meeting with the Dean and the Associate Dean of the College of Liberal Arts and Sciences on 10/4/05, we received an oral commitment that the resources required for purchasing the equipment listed in Appendix A would be made available to us in the Fall 2006 semester.

An ongoing annual financial commitment will be required to support these revisions. The Department's FY06 base budget is sufficient to purchase consumable supplies for the core 2 and 3 courses, while $2000 would be required to purchase copies of the Educational Testing Services' Major Field Test administered to evaluate the success of these revisions (see below for more detail). We anticipate administering the test annually to approximately 80 seniors enrolled in the department's senior seminar course at cost of $25 per student.

RATIONALE

The opinion that many college students, particularly those in the sciences, lack an acceptable command of fundamental knowledge and abilities and an adequate understanding of science as a process is a growing consensus nationally. The root of this problem is a philosophical misunderstanding of the roles of both students and teachers. Traditional core courses with heavy content focus covered in isolation lead to the perception by students that a college education (and science in particular) is a superficial process of memorization and regurgitation of isolated facts, not a deep, active engagement leading to life long learning and

constant re-evaluation of knowledge and beliefs embedded in a larger scientific and social context. Students internalize the idea that the process of learning is less important than the facts learned, and that the strategies and skills necessary for acquiring new scientific knowledge themselves are not to be highly valued.

Under the traditional teaching model, biology teachers have provided students with answers to known problems, creating students poorly prepared to solve new or unknown problems with non-traditional answers. The new role of the teacher is increasingly recognized as not one of unidirectional content transfer, but more fundamentally as a developer of students' abilities to acquire the necessary content themselves in an active and self-reflective manner. There is a large body of evidence that supports the contention that learning takes place more effectively if students are actively engaged in the learning process. Once students have learned the proper application of learning processes in science, they can, in turn, learn content for themselves and apply it as needed. The new core curriculum proposed here is thus designed to train students to approach all of biology as a unified and active pursuit of knowledge subject to constant critical scrutiny.

ESSENCE OF PROGRAM REVISIONS

a. Major goals of the program in Biological Sciences

The overall goals of the program in Biological Sciences remain unchanged. As a department we have defined these goals to be:

- Intellectual rigor in our coursework
- A diverse curriculum
- Excellent advisement
- Quality education of nonmajors
- Providing role models for our students
- Promotion of diversity among the student population
- Cooperation within the Department, College and University
- Active faculty engagement in scholarship
- Providing research opportunities for students

We believe these proposed curricular changes will allow us to more adequately meet these basic goals, in particular those of intellectual rigor, diverse curriculum, and the promotion of diversity within the student body. The increased use of active learning techniques will provide opportunities for students to more fully apply their diversity of background knowledge and learning styles in a cooperative learning environment.

b. Specific objectives of the program revision:

1. improve student learning in all biology courses and across the entire curriculum
2. add active learning components to each new core course
3. coordinate the coverage of content and skills development across the introductory sequence in order to continuously reinforce and build upon student understanding

4. develop and/or adapt inquiry-based laboratory activities that actively engage students and expose students to science as a process
5. implement assessments to measure the effectiveness of curricular changes and to provide a mechanism for ongoing improvement.

c. Structure of the program revision

The primary proposed changes to the B.S. degree program in Biological Sciences are:

1. replacement of the current two semester introductory sequence with a newly designed four semester sequence incorporating active learning strategies, continuous reinforcement of previous acquired knowledge, and enhancement of fundamental scientific and critical thinking skills. These courses will be prerequisite to the majority of upper-level courses offered in Biology.
2. elimination of the elective banking system. All upper-level (i.e. 200-level and above) laboratory courses offered in Biology will be able to be applied towards the 38 total credit hours in Biology needed for the B.S. degree.
3. replacement of the current Advanced Science Elective with the requirement for the Biometry (1702.280) course offered in the Department of Mathematics.
4. requirement for enrollment in the Philosophy of Science course (1509.368 or 1509.369) offered in the Department of Philosophy and Religion. This course will fulfill in part the History, Humanities, and Languages bank of the University's general education requirements.
5. elimination of credit towards the major for any Biology course not completed with a grade of "C" or higher. Currently, the department accepts coursework completed with a grade of "C-" or better for major credit.

The total number of general elective courses, total number of credit hours taken in the major, and total number of free elective credit hours required for the B.S. degree in Biological Sciences will remain unchanged.

d. Identification of new courses

The new four-course introductory sequence will become the core for Biology majors and will include Biology 1: Diversity, Evolution, and Adaptation (0401.103), Biology 2: Genetics (0401.104), Biology 3: Cell Biology (0401.203), and Biology 4: Global Ecology (0401.204). Each of these courses will be a 4 credit hour laboratory course. The general content to be covered in each course is listed in Appendix D. Transfer students will take the new skills course (0401.202) and then take Biology 4: Global Ecology (0401.204).

The skills listed in Appendix D will be fully integrated as a basic component and focus of all the daily active-learning activities (for examples, see appendices E and F) and the coverage of each new content area will be guided by its relationship with topics investigated previously in the sequence. Natural selection and evolution will be the unifying theme of the whole sequence, and every subsequent topic will be examined in an evolutionary context. For example, the role of the enzyme Rubisco in photosynthesis (core 3: 0401.203) could be explored with reference to its effects on the light saturation and compensation points of plants, which can be altered by natural

selection as plant populations find themselves in altered light environments. Students can, in turn, apply this knowledge to the investigation of plant biodiversity and biogeographical patterns in the core 4 (0401.204) course.

e. Sequence of course work

The four new introductory courses are intended to be taken consecutively from the fall of the freshman year to the spring of the sophomore year, with each course serving as a prerequisite for the succeeding course (which will be able to be waived with permission of the instructor). The Biometry course can be taken at any time following the successful completion of Calculus I (1701.130), and may serve as an additional prerequisite for some upper-level Biology courses. Curriculum proposals making these prerequisite changes are being submitted separately.

f. Role of other units

The inclusion and role of courses from other disciplines in the Biology major will remain largely unchanged under this proposed revision. New courses outside of Biology to be included in the new core curriculum will be the existing Philosophy of Science (1509.368 or 1509.369) course offered by the Department of Philosophy and Religion and the Biometry (1702.280) course being offered by the Department of Mathematics for the first time during the spring 2006 semester. The proposal for this course was co-sponsored by faculty in the Mathematics and Biological Sciences departments during the fall 2004 semester. Consultations with the Department of Philosophy and Religion indicate an interest in expanding the number of sections of the Philosophy of Science course offered annually.

g. Comparison to similar program revisions

One major impetus for this current proposal was the similar example provided by the National Science Foundation-supported curriculum revisions being undertaken by the Biology Department at Hofstra University. Discussions with the Hofstra team at FIRST II meetings (a series of NSF-sponsored national meetings designed to promote inquiry-based learning in college biology programs) helped convince us of the need for and the value of incorporating student-centered learning techniques as an integral part of the introductory biology sequence. A number of biology programs at other four-year universities have also recently moved from two-semester to four-semester introductory sequences in order to adequately survey current basic biological knowledge.

h. Administration

This proposal will not require any changes in the manner in which the Department of Biological Sciences is administered.

i. Evaluation of program revisions

1) Planning evaluation: Current teaching and learning effectiveness will be assessed via a standardized survey (developed in-house) to be given at the beginning of sophomore, junior, and

senior level major courses. This survey will assess the retention of basic content we believe should have been learned during the introductory sequence. This survey will cover essential concepts and ask for applications.

2) Formative evaluation: At the end of each laboratory exercise, students will be asked to fill out an anonymous questionnaire in which they will provide feedback on whether the lab handout was helpful, the lab exercise aided the understanding of the fundamental biological principles behind it, if they valued the learning experience, and whether the background knowledge they had was sufficient for conducting the experiment. We will keep a detailed log of student participation and performance in experiments, field exploration, homework, and test results.

In the 2008-2009 academic year we will be able to compare the responses of juniors who have just completed the new core sequence with the responses of seniors who completed the old introductory sequence. This can also be done during the 2009-2010 academic year comparing the responses of "new core" seniors with those of "old core" fifth-year seniors. Similarly, we can compare the academic performance across all upper-level biology courses of the two cohorts during this two-year transitional period. We predict that the "new core" cohort should perform significantly better on both the content retention survey and in GPA averaged across the biology curriculum.

3) Summative evaluation: Starting in spring 2006 we will administer the Educational Testing Services Major Field Test in Biology to students enrolled in the Special Topics in Biological Science sections (0401.445). Students enrolled in these sections are generally seniors. The first "new core" cohort will complete the revised introductory sequence in spring 2008 and graduate in spring 2010. We will thus have test scores for 4 "old core" graduating cohorts (i.e. the 2006-2009 graduating classes) to compare with subsequent cohorts to assess improvement in content knowledge and scientific thinking skills. We will also have the in-house assessment of knowledge retention from the pre-course surveys to compare the current introductory sequence to the effectiveness of the new sequence. We will compare the number of biology majors graduating with honors and the admission success rates for students who applied to professional and graduate programs following exposure to the two different core sequences.

4) Time evaluation: We will randomly survey biology alumni who have taken the traditional Biology I and II courses and compare their success in post-graduate education and long-life learning with those students who have taken the new biology core curriculum. The change in teaching practices for upper-division courses of faculty involved in the new core courses will also be assessed. We would expect that increased faculty and student familiarity with active learning styles will drive a broad change in our entire curriculum.

RESULTS OF CONSULTATIONS

Consultation letters are attached from the Departments of:

Chemistry and Biochemistry
Physics and Astronomy
Chemical Engineering
Mechanical Engineering
Secondary Education
Psychology
Philosophy and Religion
Computer Science

These letters uniformly indicate support for the proposed revisions.

APPENDIX A – Equipment Required for New Core Course 2 (*0401.104*) and 3 (*0401.203*) Labs

ITEM	Quantity
Microbial incubators/shakers (liquid cultures)	1
Microbial incubators (plates)	2
Water baths	2
Nucleic acid electorphoresis apparatus	10
Protein electrophoresis apparatus	10
Power sources	4
Microfuges (+ rotors)	4
Vortexes	4
Heat blocks	2
Rotators (Nutator)	2
Transfer apparatus	2
Microwaves	3
Pipettmen - set of 3 volume ranges	2
Mettler balance (>1 g range)	1
Mettler balance (< 1 g range)	1
Harvard trip balances	2
pH meters	4
PipetAid	4
Microscope for cell culture lab	1
Rotor for culture centrifuge	1

Appendix B – Comparison of Biology Major Models

OLD MODEL

Common Core (32 credit hours):

- Biology I (4 cr.) (*0401.100*)
- Biology II (4 cr.) (*0401.101*)
- Chemistry II (4 cr.) (*1906.101*)
- Organic Chemistry I (4 cr.) (*1907.200*)
- Organic Chemistry II (4 cr.) (*1907.201*)
- Physics I (4 cr.) (*1902.200 or 1902.202*)
- Physics II (4 cr.) (*1902.201 or 1902.203*)
- Advanced Science Elective: advanced science course (300-level or higher), Calculus II (*1701.131*), or Statistics I (*1702.260*) (4 cr.)

Biology Electives (total of 30 credits; no fewer than 24 credits from laboratory courses)

Students must take at least one course from a minimum of four different banks:

- Anatomy/Physiology
- Botany
- Cellular/Molecular Biology
- Ecology / Environmental Science / Evolution
- Zoology

Students may apply any Biology course towards the major with the exceptions of:

General Biology: Human Focus (0401.113)
General Biology: Environmental Focus (0401.112)
General Biology: Plants and People (0401.115)
Biological Systems and Applications (0401.210)

General Education requirements: 42 semester hours

Free Electives: 16 semester hours

NEW MODEL

Common Core (40 credit hours):

- new Biology 1: Diversity, Evolution, and Adaptation (4 cr.) (*0401.103*)
- new Biology 2: Concepts in Genetics (4 cr.) (*0401.104*)
- new Biology 3: Introduction to Cell Biology (4 cr.) (*0401.203*)
- new Biology 4: Global Ecology (4 cr.) (*0401.204*)
- Chemistry II (4 cr.)
- Organic Chemistry I (4 cr.)
- Organic Chemistry II (4 cr.)
- Physics I (4 cr.)
- Physics II (4 cr.)
- Biometry (4 cr.) (*1702.280*)

Biology Electives (total of 22 credits; no fewer than 20 credits from laboratory courses)

Students may apply any Biology course towards the major with the exceptions of:

Natural Resources (0420.100)
Human Biology (0401.110)
General Biology: Human Focus (0401.113)
General Biology: Environmental Focus (0401.112)
General Biology: Plants and People (0401.115)
Biological Systems and Applications (0401.210)

General Education requirements: 42 semester hours

Free Electives: 16 semester hours

Appendix C: Model Program Guide for the B.S. in Biology

Year 1

Fall		**Spring**	
College Composition I	3 sh	College Comp II	3
Chemistry I	4	Chemistry II	4
Biology 1: *Diversity, Evolution, and Adaptation*	4	Biology 2: *Concepts in* Genetics	4
Calculus 1	4	Biometry	4
TOTAL	***15sh***	***TOTAL***	***15sh***

Year 2

Fall		**Spring**	
Organic Chemistry I	4	Organic Chemistry II	4
Biology 3: *Introduction to Cell Biology*	4	Biology 4: *Global Ecology*	4
Physics I	4	Physics II	4
Public Speaking	3	HHL Gen Ed (LIT)	3
TOTAL	***15sh***	***TOTAL***	***15sh***

Year 3

Fall		**Spring**	
Biology Elective	4	Biology Elective	4
Biology Elective	4	Artistic and Creative Experience Gen.Ed.	3
Philosophy of Science	3	SBS Gen Ed (M/G)	3
Non-program course	3	Non-program course	3
		Free elective	3
TOTAL	***14sh***	***TOTAL***	***16sh***

Year 4

Fall		**Spring**	
Biology Elective	4	Biology Elective	4
SBS Gen Ed	3	Special Topics (WI)	3
Non-program course	3	Non-Program course	3
Free Elective	3	Free Elective	3
Free Elective	3	Free Elective	3
TOTAL	***16 sh***	***TOTAL***	***16 sh***

APPENDIX D – Topic Outline for New Introductory Courses

New Core Course	Relevant Content	Skills built
Bio 1: Diversity, Evolution, and Adaptation (*0401.103*) (fall freshman year)	Natural selection and adaptation Macro- and microevolution Homology and convergence Comparative structure and function Homeostasis Taxonomic methods	Scientific method Basic statistics Graphical presentation of data Interpretation of graphs Literature searches Writing in scientific format Use and care of microscopes and other lab equipment
Bio 2: Concepts in Genetics (*0401.104*) (spring freshman year)	Classical genetics: • Mitosis and meiosis • chromosome reproduction • Mendelian inheritance • chromosomal basis of inheritance • cell cycle Molecular genetics: • DNA structure and replication • Transcription and translation • mutation Population genetics: • Hardy-Weinberg equilibrium • allele frequencies • natural selection	Reinforce skills from core 1 Bibliographies Keeping lab notebooks Experimental design (incl. the proper use of controls) Short oral presentations
Bio 3: Introduction to Cell Biology (*0401.203*) (fall sophomore year)	Biological macromolecules Cell structure and function Membrane structure and function Prokaryotic/eukaryotic cell evolution Cell to cell signaling Regulation of gene expression Energetics: • photosynthesis (incl. C3 + C4 pathways) • respiration • enzymes	Reinforce skills from core 1+2 Longer oral presentations Reading primary literature
Bio 4: Global Ecology (*0401.204*) (spring sophomore year)	Population growth (from an energetics perspective) Global biodiversity patterns Case studies of anthropogenic impacts	Reinforce skills from core 1-3 Synthetic literature review papers Writing and re-writing

APPENDIX E - Example inquiry-based laboratory exercise

Termite Behavior Lab

Note: *these instructions are for the instructor only. No instructions should be given to the students prior to this laboratory.*

Purpose & approach

The main purpose of this lab is for students to learn the scientific method through a hands-on, inquiry-based lab. No lecture or preparatory discussion is necessary; however, you will have discussions with your class as you go through the exercise, asking them to do the next step in the scientific method. At the end, you can show them how they have in fact proceeded through all the steps, and relate it to science in general. It's better to leave the real discussion until the end. Don't tell them too much about why they're doing what they're doing during the lab... they'll be interested enough in the termites to let the "why" part slide by initially. But you'll want to end up there before ending the lab.

Materials

- Live termites
- 8 ½ " x 11" paper (multiple sheets per student)
- Pens (multiple colors and types, making sure there are at least some ball-point pens in the mix. Types can include Sharpies, gel pens, and felt-tipped pens. **The key is to include a PaperMate ballpoint pen, either blue or black, as this brand consistently elicits a response.**
- Large Post-it Note paper. (Sold at Office Max & Staples – it's poster board size, around 2 ft. x 3 ft., and it has adhesive on one end that allows you to hang it on the wall)
- Large Sharpie pens (for writing on the large paper so everyone can see)
- Small paint brushes (for brushing the termites to keep them on the paper)

Methods

Observations

- Have students work in groups of 2-3.
- Give each group several pieces of paper and pens, and make sure they know they can use any other groups' pens if they want to.
- Ask the students to take a pen and draw 2 silver dollar-sized circles on their paper (no more instructions are necessary, and they can do this however they want to, wherever on the paper they want to).
- Tell the students you're going to give them live termites, and they can use the brushes to keep them on the paper.
- Give each group a few termites. Drop them onto the students' paper with the circle drawn on it, anywhere on the paper.
- The termites follow ball-point pen ink, presumably because of a chemical compound in the ink that is similar to the one they really use to follow trails in the field. You can research this point if you want to know more.

- Allow the students to "play" with the termites for several minutes. *Hopefully they will not need suggestion or encouragement to experiment* with the termites by drawing other lines and shapes to see what the termites do.

Design hypotheses

- After enough time has passed and you feel the students have experimented and observed enough termite behavior, go around the room and collect all the termites again.
- Ask each group to come up with 3 hypotheses they would like to formally test to learn more about termite behavior. They should write these hypotheses in large, clear letters on the large Post-it Notes.
- When every group is done, have them put their Post-it Notes up on the wall so that the whole class can see them.
- Go around the room and ask each group to share their hypotheses and the reasoning behind them. You probably won't need to go through all groups; after a few groups have spoken, you may find a lot of overlap. At some point you may want to ask the remaining groups to add hypotheses or information if they are beyond what has already been discussed.
- This period is also a chance for students to share what they've observed with the class. Some groups may learn new things that would impact the hypothesis they want to test, or the way they'd conduct an experiment.

Design the experiments

- Ask each group to now discuss how they're going to test their hypotheses. Can they design an experiment that will adequately test each hypothesis, eliminating other possible explanations for the termite behavior they've observed?
- You can either have the students write their designs on their Post-it Notes, or you can go back around the classroom and just ask each group to share their plans to test each hypothesis. You could do this by allowing other groups to chime in if they came up with similar or different ways of testing the same hypothesis, rather than going systematically around the room.
- Provide comments and suggestions on their experimental designs. Make sure they've thought through other possible explanations, so they can reasonably trust their results.

Testing the hypotheses

- Ask the students to test at least 1 of their hypotheses (you can do more if you like, but one gets the point across).
- Tell the students they can start with fresh pieces of paper.
- Go around the room again and deliver several termites to each group.
- Give them time to test their hypothesis.

Analyzing the results and comparing to the hypothesis

- At the end, collect the termites again and ask the students to discuss with their group their results and what they mean in terms of their hypothesis.
- Have the students write on the Post-it Notes their experimental results.

- Go around the classroom and ask each group to present their results and to describe what they mean in terms of their hypothesis.

Final discussion and writing assignment

- This part is up to your discretion.
- A good way to end the lab would be to have a discussion on the scientific method, pointing out to students that they have in fact gone through these steps on a totally (we assume) novel organism and behavior.
- A possible way to assess this exercise would be to have the students do a short write-up, both on what they did in the lab (and their reasoning), as well as how the exercise demonstrated the scientific method. You might see if they can extrapolate this exercise to something else they might want to study, to see if they can transfer this knowledge to another system.
- You could, also, have them do this write-up as a group, if you can get them to really work on it together. The rationale behind this would be to get them to discuss the lab even further with a peer.

APPENDIX F - Example inquiry-based laboratory exercise

ENVIRONMENTAL CORRELATES OF STOMATA DENSITY

(adapted from an exercise by Bruce Grant and Itzick Vatinick, Widener University)

Introduction (written for students):

Leaf stomata are the principal means of gas exchange in vascular plants. Stomata are small pores, typically on the undersides of leaves, which are opened or closed under the control of a pair of banana-shaped cells called guard cells. When open, stomata allow CO_2 to enter the leaf for synthesis of glucose, and also allow for water, H_2O, and free oxygen, O_2, to escape. In addition to opening and closing the stomata (stomata behavior), plants may exert control over their gas exchange rates by varying stomata density in new leaves when they are produced (such as in the spring or summer). The more stomata per unit area (stomata density) the more CO_2 can be taken up, and the more water can be released. Thus, higher stomata density can greatly amplify the potential for behavioral control over water loss rate and CO_2 uptake.

But why, you might ask, might it be adaptive for a plant to control its rates of water loss and CO_2 uptake? One answer can be found in the sun. Generally, plant photosynthetic apparati are only designed to function well over a rather narrow range of temperatures. When heated, cytochromes, pigments, and membranes critical to phosphorylation and carbon fixation rapidly denature (i.e., they cook). To avoid this, an individual plant may open its stomata and evaporate water which will lower the leaf temperature. Thus, one may hypothesize that leaves in the sun should have higher stomata density than do leaves in the shade - all else being equal.

But, on the other hand, if water is not available, such as under drought conditions, excessive evaporation might lead to desiccation and an equally severe disruption of photosynthetic function. Thus, one might expect plant leaves exposed to drought conditions to have fewer stomata in sunlit environments.

The above discussion illustrates a very important concept in experimental biology - there are often alternative hypotheses to explain variation in nature. In this case, stomata density may increase or decrease in response to environmental variation in sunlight and water availability. Note that since you will not be measuring sunlight or water availability you should use caution in how you word your acceptance or rejection of your hypothesis for your plants.

Overview of Data Collection and Analysis Methods.

Week 1.

Envision an environmental difference that might affect stomata density and formulate an hypothesis about which way you would expect stomata density to vary and WHY. Discuss these in detail with your lab instructor PRIOR to taking any data. Next, decide on a place anywhere within about 10 minutes walking time where you intend to collect leaf samples in the environmental types of interest, and go and get them. Bring your leaf samples back to lab and count their stomata densities. Lastly, submit your co-authored research proposal with your partner. This document should fit on one page.

Week 2.

Next week, bring all of your data to class, finish counting stomata (if you have not already have done so), and your instructor will help you with the statistical analyses, and computer graphics generation of your stomata data to test your hypothesis. In addition, you should begin to produce your oral and written reports which are due the following week.

Week 3.

The entire lab period this week will be devoted to a symposium of presentations of your research results to your peers. You and your research partner will make a 12 minute oral report to your peers using visual aids (such as an overhead projector and/or video projector for a PowerPoint presentation). Also on this date, your co-authored written report is due as well as your disk copy of your data. Your individually written critical review of this multiweek lab activity is due the following week.

Methods for Obtaining Stomata Impressions.

1. Obtain the leaf upon which you wish to census stomata.

2. On the side you wish to census stomata (typically the leaf underside) paint a rather thick swath of clear nail polish.

3. After the nail polish has dried (several minutes), obtain a square of VERY CLEAR tape (such as package sealing tape, but do NOT use scotch tape). Stick your tape piece to the area that contains the dried nail polish swath.

4. GENTLY, peel your nail polish swath from the leaf completely. You will see a cloudy impression of the leaf surface now attached to your tape piece (hereafter referred to as your "leaf impression").

5. Tape your leaf impression to a VERY CLEAN slide and use scissors to cut off the excess tape.

6. Use a pen and write some sort of ID code signifying the treatment group name (e.g. leaf from sun) and other info (e.g. leaf #3) directly on the slide.

7. Focus your leaf impression under at least 400x power and observe the stomata.

8. Search around on your impression to find an area that subjectively appears to have a high density of stomata. That is, move the slide around until the field of view is away from the edge of the impression and so that there are no dirt blobs, no thumbprints, no damaged areas, and no big leaf vein impressions in view.

9. Count all stomata you see and record the number neatly on a clearly labeled data sheet. (Note that you should design a data sheet on which to record your stomata counts that clearly indicates which data correspond to which leaf and treatment group. You will be separately assessed on how neatly you accomplish this part of the task.)

10. Repeat the previous two steps three times, and the highest number of the three will be your one datum from this impression.

11. Repeat all steps above for at least 12 different leaf impressions in each treatment group.

Mike,

I have been reviewing the proposals for the biology core revision.

I'm impressed with the careful rethinking of your entire program that the department has undertaken. In COE we know a good deal about the work involved in a major restructuring of a curriculum! The active learning assignments and activities, the engagement with the professional literature, the deep holistic understanding of the field that you're striving for—these are elements that will strengthen student engagement with biology.

While our department curriculum committee hasn't had an opportunity to look at all the proposals in the detail they merit, I am venturing to suggest a couple of relatively small changes

1. The Course Evaluation section of the Biology 1 proposal needs more specific methods. Perhaps you should refer to the core curriculum proposal where these methods are described.
2. I note with approval that you're requiring Bio 1 students to use primary literature. However, you say that library resources are adequate. Are you sure about that? Will students have access to the databases and research articles they will need? I know that you're asking for a chunk of money to supply the laboratories needed for the new courses and you probably want to avoid asking for library resources in addition. However, you do need to have Greg Potter complete the library resources form for each of these course proposals and the core curriculum proposal. You're expected to at least list the resources available to you currently.

Initially, it appears that K-12 Subject Matter Teaching students will not be affected negatively by the change as the total number of credit hours will not change. The sequencing of the courses may need to be carefully worked out in future years for those students who are dual majors with K-12 Subject Matter-Biology. The special course to integrate transfer students is an excellent idea, and perhaps a model that other departments should emulate.

The inquiry-based methods you're proposing for your new curriculum might dovetail well with the Inquiry and Discovery course that elementary education majors are required to take in the new program. Just a thought!

After our SE/FE curriculum committee reviews your proposals, I will write a more formal letter. However, I believe that you can use this e-mail as evidence that you have consulted with us.

By the way, was your NSF CCLI proposal funded?

Holly Willett
Chair
SE/FE

The Chemical Engineering program has reviewed your curriculum proposal and we are supportive of the proposed changes to the Biological Science Curriculum.

==========

Robert P. Hesketh
Professor and Chair
Chemical Engineering
Rowan University
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Glassboro, NJ 08028-1701

Phone: (856) 256-5313
Fax: (856) 256-5242
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http://users.rowan.edu/~hesketh

Rowan University

Memorandum

Mechanical Engineering

To: Dr. Michael Grove, Department of Biological Sciences

From: John Chen, Associate Professor and Chairperson

Date: 5 October 2005

Re: Letter of consultation for proposed revision of the introductory biology curriculum

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This letter is in support of the proposal entitled, "Revision of the Introductory Biology Curriculum and Biology Major," prepared and sponsored by the Department of Biological Sciences. My program supports the proposed revision and the new structure of the introductory biology sequence. These changes will not adversely affect Mechanical Engineering students.

Please contact me if there are further questions or concerns. Thank you.

John C. Chen
Associate Professor and Chairperson

Tel: 856.256.5345; Fax: 856.256.5241
Email: jchen@rowan.edu

Michael,

The Computer Science Department supports your proposed changes in the Biology sequence. Since our majors are required to take 3 semesters of lab science, and they often opt for Biology I and II, we are pleased to note the emphasis on Genetics and Evolution. This will help prepare our students for further study in Bio-informatics in graduate school.

Seth D. Bergmann Interim Department Chair
Computer Science bergmann@rowan.edu
Rowan University 856-256-4500 ext. 3197
Glassboro, NJ 08028 Fax: 856-256-4741
USA cs.rowan.edu/~bergmann

The Department of Chemistry and Biochemistry fully supports the efforts of your department to reinvent your core courses. It is admirable that you engage in this level of effort to recreate the beginnings of your field and especially to include the broader concepts of science. We are very interested in your inclusion of active teaching methods and will watch this change carefully. We are also intrigued by the lab changes you propose that will result in the adoption of more inquiry based experiences.

We appreciate the many discussions we have had to fine tune the curriculum our biochemistry majors should follow under this new scheme.

Robert Newland, Ph.D.
Chair, Chemistry & Biochemistry
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newland@rowan.edu

Rowan University

Department of Physics and Astronomy

Date: October 10, 2005
To: Dr. Michael Grove
From: Jeff Hettinger, Chair, Department of Physics and Astronomy
Re: Curriculum Proposal

This memo provides the support of the Department of Physics and Astronomy for the reconfiguration of the introductory courses in the Biology program. We feel that this is an excellent idea/plan.

Students in our Physical Science program who are currently required to take either Biology I or II can be accommodated by your new Biology I course since it will remain in the Math/Science General Education Bank and the content description seems practical for this group.

These modifications may impact decisions our department makes in the future. Our department has been considering the possibility of enhancing our Physics program to include some Biophysics content in the form of a concentration or minor. Your response to Dr. Newland with regard to his Biochemistry program suggesting that it would be possible to take Biology II and III as well as upper level courses in Biology if the skills developed in Biology I and IV were accounted for in other courses ensures us that we can work out a solution to this issue when it arises.

To: Mike Grove, Biological Sciences
From: Keiko Stoeckig, chairperson, Psychology Department
Date: October 6, 2005
RE: proposed changes to current Introductory Biology curriculum and Biology major

The Psychology Department has reviewed the proposed revisions to the Biology major and the Introductory Biology courses, and we would like to commend Mike Grove and the Biology Department for crafting such a thoughtful proposal. The overall revision to the Biology major, of course, is best evaluated by the Biology Department, and it will have little immediate effect for the Psychology Department. However, the restructuring of the Introductory Biology courses could have a substantial impact on the General Education courses required for Psychology majors.

Currently, Psychology majors are required to complete one of the following to fulfill the lab science General Education requirement: General Biology: Human Focus, Biology I, Biology II, or Anatomy & Physiology I. The Psychology Department has no objection to the restructuring of content as proposed for the new Biology 1 and Biology 2 courses, so long as these courses will be offered as General Education courses (as has been indicated in the course proposals). In fact, the content described in the proposed Biology 1 course appears to better fit the needs for a Psychology major than the content of the current Biology I course. (However, General Biology: Human Focus remains the course that best meets our needs, and thus will remain the recommended course for Psychology majors.)

There is some concern that the content of the proposed Biology 2 course might be too narrowly focused to satisfy the needs of our majors, so it might be the case that the Psychology Department would not permit Biology 2 to be used to fulfill the Biology lab science requirement. This could become problematic for transfer students, if the General Biology course taken at a community college were to be accepted as equivalent to the proposed Biology 2 course rather than the proposed Biology 1 course. However, in the event that this should happen, the Psychology Department might be willing to allow transfer student to complete another Biology course (such as Human Biology) to fulfill our Biology requirement. Nevertheless, attention to the transfer equivalence of the proposed Biology 1 and Biology 2 courses would be an important consideration for the Psychology Department.

Although, as stated earlier, the revision of the Biology major has little immediate impact on the Psychology Department, this revision might have a longer-term effect on the structure of a future neuroscience major (a joint program, in the early stages of development, to be proposed by the Psychology and Biology Departments). The increased flexibility afforded by the proposed changes to the Biology major would appear to allow for an easier integration of Biology courses into the neuroscience program, so from that standpoint, as well, the Psychology Department is supportive of the proposed revisions.

In summary, the Psychology Department offers its full support for this proposal. Although it is possible that, as a result of this revision, some initial minor difficulties might occur, the Psychology Department is certain that any such issues can be resolved. Thus, we believe that this well-conceived program proposal deserves the University's full support.

Thank you for the opportunity to review your program proposal. If you require additional information, please feel free to contact me at x4821 or stoeckig@rowan.edu.

Keiko Stoeckig

October 3, 2005

Dr. Michael Grove
Department of Biology
Dear Mike,

Thanks for sending me the copy of the biology department's proposed revision of its core curriculum and general education requirements. This looks like a well considered and quite exciting change, which promises to provide an even better biology training than the already very good one that Rowan's bio majors receive.

Our department has discussed your proposal to require Philosophy of Science of all your majors, and we are unanimous in supporting it. We deeply appreciate the interdisciplinary relationships our department has with so many others on campus, not least with the sciences, all of which will now require their students to take this course. We believe (as you obviously do) that taking the course will make your majors more thoughtful and theoretically alert scientists. The benefits are mutual; Matt Lund, who teaches the course, is excited about the prospect of having more scientists in his class, and when our major is finally approved and comes on line, our students will benefit by taking it with science majors.

There is no avoiding the fact that this requirement will have significant staffing implications for our department. You graduate between 70 and 80 majors each year, and that number is rising. Philosophy of Science, a writing intensive course, is capped at 25. That means we must add at least three new sections a year, more likely four, in order to meet the needs of your department. Chemistry and Biochemistry has just added Philosophy of Science to their requirements; and while Physics already requires it, they have begun allowing substitutions because the class is in such high demand. The unmet demand from these two majors will mean at least one additional section of the course.

So we must also ask for your support. Please join with your colleagues in the other sciences to tell the Dean and the Provost that the Biology department and the other sciences need two-thirds of a new line *in Philosophy and Religion* in order to implement your new core curriculum. We will ask for a full line for this purpose, and use the remaining third to reduce our dependence on adjuncts or to diversify our offerings in the philosophy of the sciences and technology.

Sincerely,

David Clowney
Chair, Department of Philosophy and Religion

Rowan University

November 7, 2005

Dr. Michael Grove
Biology Department
Science Hall
Rowan University
Glassboro, NJ 08028

Dear Mike,

Thank you for the opportunity to review the proposed changes in the biology core curriculum and the five proposed courses required to implement the curriculum. I apologize for this very tardy letter of consultation.

The Secondary Education/Foundations of Education departmental curriculum committee has reviewed the proposals and supports them. We do not believe they will affect adversely our students, though we will need to be careful in scheduling our science methods courses. As we are consulting with the academic content major departments as we start scheduling our new courses, we do not view this as a difficult or onerous task. We are pleased to note the particular care you took to accommodate transfer students.

Personally, I think the proposals are a creative way of meeting changing perspectives in educating the next generation of biologists. My compliments to the committee.

Cordially,

Holly G. Willett
Associate Professor
Chair, SE/FE

Department of Secondary Education/
Foundations of Education
College of Education
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856-256-4755
856-256-4918 fax

To Whom It May Concern:

This email is intended to confirm not just my endorsement of the five new Biology Core courses and additional changes to the major, but also an endorsement from the Department as a whole. The entire Department has been consulted at every step in the development of these curricular proposals, and it has always met with unanimous support.

These changes will bring our Department to a level similar to comparable institutions. The emphasis in the new Core will be not just on knowledge content, but also on the skill content. We anticipate that the Core revisions will have a profound impact on the sophistication of our upper-level courses and on the marketable skills of our graduates. The commitment of our faculty to these changes is illustrated by their attendance at weekly core curriculum development meetings. The additional changes to our degree requirements directly address Department objectives and will enrich the qualifications and skill sets of our majors.

These new courses and the overall curricular changes have my strong, enthusiastic support, and I am happy to confirm that the Department is eager to implement them.

Sincerely,

Gregory B. Hecht, Ph.D.
Interim Chairperson
Associate Professor of Microbiology
& Molecular Biology
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Rowan University

Curriculum Proposal- LIBRARY RESOURCE FORM

SCC#05-06- 121

This form ***MUST BE COMPLETED FOR NEW COURSE or PROGRAM PROPOSALS, and EXTENSIVE CHANGES TO A COURSE or PROGRAM.***

The purpose of this form is to provide a channel of communication between the Campbell Librarians and faculty when submitting new course or program proposals, or making extensive changes to existing courses or programs. The information will be used to assess the resources available in the library, and to identify resources the library should acquire to support the new courses/programs, or extensive changes to same. The information will also provide the rationale for institutional support for library acquisitions. This form should be completed in a coordinated effort between the course sponsor(s) and the academic department liaison librarian.

Note: Sponsor(s) complete parts A & B
If assistance is required to complete, please notify the librarian liaison.
Forward this form to the librarian who will complete parts C, D & E

When form is completed, attach to the original curriculum proposal before submitting to the Senate office.

A. ***College:*** LAS	***Department:*** Biological Sciences
Proposed by: Biological Sciences	Date: 10/7/2005

COURSE TITLE: Revision of the Introductory Biology Curriculum and Biology Major

Anticipated Date for Course/Program Offering: Fall 2006

B. ***List specific resources that should be acquired to support this course.***

We anticipate that current library resources are sufficient for this change in the major.

C. ***Describe the resources available in the library to support this course/program, including reference, monographic, electronic databases, audio-visual materials, etc. A summary statement is sufficient.***

The Campbell Library has a strong biological sciences collection and also subscribes to a variety of electronic databases supporting this field.

D. ***List key periodicals available in the library to support this course/program.***

Our print subscriptions include key periodicals such as *Cell*, *Nature*, *Science*, and a variety of more specialized journals.

E. ***Librarian comments & recommendations:***

The library can support the new curriculum with our current resources.

LIBRARIAN LIAISON: Denise Brush Signature: Denise A Brush

eld/05

Rowan University

February 21, 2006

To Whom It May Concern:

This office supports the curriculum proposals SCC-05-06-806, *Philosophy of Science Requirement for Biochemistry Majors*, SCC-05-06-807, *Philosophy of Science Requirement for Chemistry Majors* and SCC-05-06-821, *Revision of the Introductory Biology Curriculum and Biology Major*, which also includes the addition of Philosophy of Science as a requirement.

I have targeted the Philosophy and Religion department for growth in the coming years. I will be requesting a new line to cover the significant increase in offerings of Philosophy of Science. It will be a high priority for the college.

Sincerely,

J.A. Harper
Dean

JAH/jds

Office of the Dean
College of Liberal Arts & Sciences
Bosshart Hall
201 Mullica Hill Road
Glassboro, NJ 08028-1701
856-256-4850
856-256-4921 fax

Mosto, Patricia

From: Wang, Jin
Sent: Thursday, February 23, 2006 3:01 PM
To: Mosto, Patricia
Subject: FW: curriculum proposal SCC-05-06-821

Hi Pat:

How have you been?

We did give the Department of Biological Science an oral commitment to supporting "Revision of the Introductory Biology Curriculum and Biology Major" and we continue to keep it as one of our high priority needs.

If this email is not sufficient to meet your expectation, please let me know. If I should address this commitment to Christy, please also advise. Thanks.

Jin

From: Harper, Jay A.
Sent: Tuesday, February 21, 2006 10:48 AM
To: Wang, Jin
Subject: FW: curriculum proposal SCC-05-06-821

From: Mosto, Patricia
Sent: Tuesday, February 21, 2006 10:44 AM
To: Hecht, Gregory B.; Grove, Michael W.
Cc: Mosto, Patricia; Faison, Christy; Milou, Eric; Harper, Jay A.; Clowney, David
Subject: curriculum proposal SCC-05-06-821

Greg and Mike:
I am in the process of revising the curriculum proposal "Revision of the introductory Biology Curriculum and Biology major" from your department.

In page 4 you said: ".... we received oral commitment that the resources required for purchasing equipment will be available Fall 2006". We need a letter from the Dean stating that commitment. Also, you are proposing "Philosophy of Science" as a required HHL course. Although you have consulted with David Clowney, Chair of Philosophy and Religion, there will be an impact on that department. We need a letter from the Dean that there is a commitment from LAS to support another line for the P&R department

Please submit both letter so the Provost can approved the revisions to the Biology Curriculum and the Biology major

Thanks

Pat