Preparing for the Future:
A Revised Curriculum for the Life Sciences
at North Carolina State University

A report prepared by the

Taskforce on Courses and Curricula in the Life Sciences
Subcommittee for Curriculum Planning

August 2006
Summary

The Taskforce on Courses and Curricula in the Life Sciences was established in March 2006 by Dr. Ken Esbenshade, Associate Dean and Director of Academic Programs in the College of Agriculture and Life Sciences (CALS). The Taskforce was chaired by Dr. Damian Shea (Head of Biological Sciences Program) and included representatives from each of the life science departments within CALS. Spurred by earlier discussions within CALS about the impacts of organizational structure on teaching Biology, the charge of the Taskforce was to make recommendations to CALS administration about the undergraduate courses and curricula offered by the various life science departments within the college. Key issues impinging on these recommendations were how to improve the classroom-based educational experience for the rapidly increasing number of students entering Biological Sciences and other life sciences majors and how to best train students for productive careers in the increasingly sciences-oriented industries and professions of the 21st century.

A Taskforce subcommittee for curriculum planning was convened to develop recommendations directed at the development of an improved curriculum for teaching introductory level biology and ancillary courses to students within the life science disciplines. The subcommittee met throughout the spring and summer of 2006 and developed a two-year minimum “foundation” curriculum applicable to all students in the life sciences. This proposed curriculum substantially revises the existing diverse offerings and enables students to emerge as Juniors with a common and comprehensive background in the central biological concepts needed before advancing substantially into individual life science majors. Key features of the revised curriculum include the minimization of repetition between courses, increased emphasis on biological relevance of ancillary mathematics, statistics, and chemistry courses, increased emphasis on course rigor, and expectations, and greater emphasis on inquiry-driven, experimental laboratory exercises.

Rather than approach the task of curriculum revision through adjustment of content of individual existing courses, the subcommittee took a more global approach and asked, irrespective of existing departmental, college or university-level constraints, “what do we want our students to be able to do and understand and when do we want them to reach those milestones?” The answers to this question are found in the following recommendations for a “foundation” in the Life Sciences.

- Development of two 100-level courses that describe basic cellular structure and function (Biology I) and use of biodiversity and evolution themes to illustrate, at both the cellular and organism-level, how organisms address the complexities and challenges of the multi-cellular state (Biology II).
- Development/revision of courses to provide individual 200-level Anatomy & Physiology-based courses in the major divisions within the life sciences (Human, Animal, Plant and Microbial biology). Development of an equivalent course in Ecology, Ecosystems and Behavior.
• Development of required 200-level Principles of Genetics course and associated laboratory course.
• Revision of 100- and 200-level Mathematics, Statistics, and Chemistry courses to increase direct relevance to biological systems.
• Redesign of laboratory courses to include inquiry-guided modules that stress experimentation, data collection, analysis, interpretation, and reporting.

In this report the subcommittee has concentrated on developing a two-year foundation that would be required of all life science majors. The recommendations are based on a continuation of the existing organizational structure in which individual departments continue to offer individual majors. These majors may be further sub-divided into concentrations. Wherever possible, outline curricula have been provided for each of the new or revised courses within this foundation. It is important to note this foundation is also recommended as the minimum 100- and 200-level courses that should be common among the various life science curricula. This foundation would therefore not be expected to change the need for other existing (although potentially modified and repositioned) higher-level courses that are currently required in many life science curricula. It is equally important to note that a major potential benefit of the proposed curriculum revisions is a significant reduction in course material redundancy. This step, along with an accompanying overall increase in curriculum rigor, clearly provides additional opportunities for further course revisions and repositionings within individual existing majors. The final component of this report therefore examines the potential impacts of the subcommittee recommendations on selected existing or proposed curricula within the life sciences. These include (i) several potential concentrations under the current biology/zoology umbrella, (ii) a proposed Human Biology concentration within biological sciences and, (iii) proposed modifications to the existing Microbiology curriculum. We believe these examples clearly illustrate how the subcommittee recommendations could provide opportunities for close synergistic interactions among existing departments as well as increasing the relevance of individual majors through the planned development of concentrations. In combination, we believe these changes and opportunities could have far reaching positive impacts on the quality of our undergraduate education efforts within CALS and the life sciences.
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Taskforce Charge

The overall charge of the Taskforce on Courses and Curricula in the Life Sciences was to “investigate the courses and curricula offered in the life sciences in the College of Agriculture and Life Sciences and to make recommendations…..relative to the majors, minors, and concentrations …. and courses, course content, and topic flow among the life science courses.”

The Taskforce subcommittee was charged to make specific recommendations in the following areas:

- Courses, course content, and course sequence in the life sciences.
- Academic structure relative to majors, minors, and concentrations.
- Pedagogical approaches to provide instruction in the life sciences to all constituencies.

The Taskforce as a whole was asked to consider several publications during its work. These included the following:

- CALS Teaching Biology Task Force report (July, 2005).

Taskforce Members

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Background

The following section provides some background information on the key issues addressed by the current Taskforce subcommittee. This information summarizes key issues raised by earlier CALS Teaching Biology Task Force and discussions held with all or part of the current Taskforce subcommittee.

Biological Sciences: The big major on campus: The Biological Sciences major is currently the largest major offered at NCSU with ~1300 students enrolled. Annual increases in enrollment over the last decade have averaged an additional 90+ students and this trend is expected to continue and possibly accelerate over the next decade. The effective teaching of biological sciences and integrating this mission with the teaching of other life sciences represents one of the biggest educational challenges facing CALS in the immediate and near distant future. The reader is referred to the July 2005 report submitted by the Teaching Biology Task Force for an in depth discussion of the various organizational structures suggested to effectively teach this major.

Biology is a multidisciplinary but unified discipline: Life science departments often follow the naturally occurring major sub-divisions within biology. These include, among others, zoology, botany and microbiology. These departmental subdivisions may suggest to students that biology is a sectarian field of study with little overlap between subdivisions. However, a key issue in the development of a revised life sciences curriculum is that students should be exposed to the multidisciplinary nature of the discipline and should be strongly encouraged to see the unifying themes rather than dwell on the often subtle differences between subdisciplines.

At the conceptual level we would like our students to be able to synthesize materials from all biological subdivisions and ultimately be able to “see the forest despite the trees”. A revised curriculum with this aim cannot rely on this synthetic ability simply arriving (or not) at some undefined point during a student’s undergraduate career. Rather, the curriculum should be designed as a whole to consistently lead students towards synthesis. Designing such a curriculum requires a meta-level analysis of all of the current life sciences curricula, as well as coordination of future curriculum contents, pedagogical approaches, outcomes and objectives.

It should be apparent that an internally coordinated curriculum solely within the life sciences is also insufficient to meet some educational goals. The multidisciplinary nature of Biology extends far out to include other major disciplines including Mathematics, Statistics, Chemistry, Physics and Engineering. Developing a revised curriculum that stresses the multidisciplinary nature of modern biology also needs, when possible and practical, to include other disciplines in the design of course materials.

A final consideration is the appropriate administrative structure suitable for most effectively delivering a revised, interdisciplinary curriculum. In this report this issue has remained very much a secondary consideration to the curriculum content and design. A
wide range of possibilities exists ranging from succession of Life Sciences as an independent school within CALS to the formation of an Integrated Biology department to include many existing life sciences departments as well as biologically centered faculty from other disciplines such as biomathematics.

**Biology is a quantitative discipline:** Many biologists were previously attracted to this discipline because it was traditionally the least quantitative or mathematically-intensive science. However, much of biology has recently converged with mathematics and information technology. While this trend has consigned the math-averse biologist to the academic endangered species list, unfortunately much of the material that is still taught in life sciences curricula continues to minimize the mathematic component. This exclusion of mathematics from biology instruction robs the discipline of some of its greatest achievements and undoubtedly artificially constrains the horizons of the next generation of biologists that we are ostensibly training. A lack of relevant mathematics in Biology also often extends out of the lecture room and into laboratory classes. For example, Microbiology currently shies away from teaching fundamental concepts such as microbial growth curves in General Microbiology laboratory (MB 352). The reason for this deficiency is simple; the majority of students (typically juniors and seniors) have never seen or used semi-log graph paper prior to this course and are also uncomfortable if not incompetent with simple mathematical manipulations involving logarithms and exponents.

The failure of many life science curricula to sufficiently emphasize the role of mathematics in their respective disciplines is exacerbated by the fact that mathematics is often not taught to biologists in the most effective manner. Using biologically naïve mathematics and statistics Ph.D. students as TAs to teach basic mathematical concepts to biologists is unlikely to provide our students with a clear picture of how, for the majority of students, mathematics really provides tools and how these tools are useful and relevant to the life sciences. One solution to this dilemma is to revise the content of required mathematics courses (and their presentation) so this relevance can be stressed and made more apparent to students. This would need to be done without compromising course rigor and leaving the impression that the students have simply taken a watered-down “math for biologists.” At a minimum this type of revision would require close co-ordination with those already responsible for teaching mathematics to life science students. At another extreme this could involve integration of biomathematics faculty into a reconfigured broadly based biology program or department within CALS.

**Biological relevance in other ancillary courses:** If a lack of biological relevance is a criticism that can be leveled at mathematics, the same is undoubtedly true for other ancillary courses in chemistry, physics and statistics that are also required for the majority of life science students. A particularly important example is chemistry. A strong understanding of biologically relevant organic chemistry is of paramount importance to understanding the basic structure and mechanism of all biological systems. As currently taught, organic chemistry is presented mainly as a catalogue of reaction mechanisms and rules. While the chemists may feel they have “covered the material”, students are
typically left entirely to their own devices to connect the content of these classes with
their introductory biology courses. One can imagine the difference it would make if the
underlying chemistry of ester formation and hydrolysis could be tied to membrane
structure or if a discussion of saturated and unsaturated hydrocarbons could be
illustrated in terms of their impact on membrane fluidity! The impacts of biologically-
relevant revisions in organic chemistry courses could have far-reaching impacts on
many life science curricula. For example, a better organic chemistry-prepared student
body could allow a repositioning of the current memorization-based basic biochemistry
(BCH 451) course to the 200- or 300-level. This could potentially allow a redesigned
higher-level course for biochemistry majors and would also provide additional benefits
for other life science disciplines by relieving them of the need to teach elements of same
material on multiple other occasions.

Biology as an experimentally rigorous discipline: Like all major branches of science,
biology is a rigorous empirical discipline and should not be taught as advanced “nature
study” where the role of experimentation is down played. While the central point of this
statement is hopefully clear and simple, the implications are quite broad and perhaps
less obvious. One consideration is that those that teach biology should undoubtedly be
active researchers themselves. Research-active faculty can expose students to the
“bleeding edge” questions in particular fields and can also convey first-hand experience
on how these questions can and should be addressed by competent scientists. This is
perhaps the defining value-added aspect for students attending a research extensive
university like NCSU and a feature that should be preserved at all costs and increased
whenever resources permit. Another consideration is that empirical evidence should be
included in teaching in both the classroom and the laboratory. How can we expect
students to ask the next important questions in biology if they are simply asked to
memorize facts and never exposed to the questions and data that drove the
experiments that have now given rise to discipline dogma? Lecture courses therefore
should, where and when possible, enable students to see how key concepts in biology
have been developed from key experiments and data, even if it means less material
gets “covered” during a semester. For example, the Messleson and Stahl experiment
has been described as “the most beautiful experiment in biology.” Understanding of the
significance of this experiment is transformed if, rather than simply memorizing the
name and date like a bad history lesson, students are required to understand the
experimental context and approach and interpret the data and arrive at the conclusion
themselves that DNA replication is semi-conservative. By the same token, laboratory
classes should, where possible, be configured so students gain first hand experience as
researchers in inquiry-guided classes that require them to generate, analyze, interpret,
communicate and defend data. Considerable expertise already exists on this campus in
how to incorporate such open-ended approaches with other important features often
found lacking in many scientists such as writing and public speaking. In a wide-ranging
revision of a curriculum it would be an oversight and poor use of University resources if
this expertise were not used. Faculty whose research/scholarship involves educational
methodology could be a perfect complement to the research-active faculty because
students would benefit from both the bleeding-edge research experiences and
innovative and more effective teaching methodologies.
**Redundancy in course materials:** Students and faculty alike appear to be frustrated by the level of repetition of materials in the current general Life Sciences curriculum. For students there is presumed to be an educational benefit derived from repeated exposure to some fundamental concepts. However, it can also be presumed that at some point nothing more is gained from further repetition and familiarity starts to breed contempt. For life sciences faculty there is the common feeling that particular subjects (*e.g.* transcription, translation, TCA cycle) need to be revisited to ensure all students are starting at a nominally common point. However, this can lead to situations where faculty commit an inordinate amount of time teaching these materials and are then short-changed on the time available to teach discipline-specific material. Inter- and intra-curriculum course redundancy is inevitable when there is little communication or co-ordination between individual departments and their respective curricula and when no clear consensus exists on what should be expected of students at key points in their undergraduate careers.

**Prerequisites and course/curriculum rigor:** The issue of redundancy in course materials also arises because faculty are often compelled to teach remedial materials to students because they enroll in classes without the necessary prerequisite courses in hand. This represents a significant inefficiency in the teaching mission and undoubtedly has an impact on quality, rigor and completeness and relevance of individual courses. These negative impacts can also have follow-on effects throughout entire curricula as a lack of time to address a significant issue in a lower course often means the burden is then shifted to a higher course, and so on and so on. The ability to track prerequisite deficiencies has been improved by recent changes instituted by Registration and Records to electronic roll calls. However, the burden of imposing these prerequisite requirements still rests entirely with the course instructor. This can represent an enormous time commitment as it requires individualized contact and resolution for each student. For example, for a large class like General Microbiology (MB 351) up to 30% (~80 out of 280) of new enrollees have recently been deficient in either a chemistry or biology prerequisite. Furthermore, students with deficiencies are apparently often advised by their faculty advisors to ignore these prerequisites. This act alone helps perpetuate the need for remedial teaching. A potential solution to this dilemma is a university- or college-wide change (presumably administered by Registration and Records) that prevents students registering for classes without the necessary prerequisites in hand.

A final consideration concerning the rigor of life science curricula is the large variation in the number of C-walled courses for each major. Currently the most stringent life science curriculum is Biochemistry. This curriculum has 26 C-walled classes that include mathematics, chemistry, physics, as well as all of the discipline specific courses. At the other extreme lie both Biological Sciences with 3 C-walled courses apiece while Microbiology, Botany and Zoology have 20, 11 and 8, respectively. One important college level requirement that could be instituted would be to have a C-wall requirement imposed for all departmental courses taught within a major.
Specific Recommendations

Based on the discussion summarized in the Background section, the Taskforce subcommittee has made a series of recommendations that are presented in the following sections: Although the Taskforce subcommittee recognizes some of these recommendations could potentially stand alone, the Taskforce subcommittee has approached its work and this report with the view that these recommendations should be implemented as a single coherent package. An overview of the full set of recommendations is provided in diagram format in Appendix A. The reader is encouraged to refer to this material and the other specified appendices when considering each recommendation.

Recommendation #1: Development of Biology I and II courses: The Taskforce subcommittee recommends that two new courses be developed as 100-level introductory biology classes. Outlines for the proposed course content in these courses, designated Biology I and II, are provided in Appendices B and C, respectively. These courses are designed to be taken sequentially and in combination they address all of the major themes and disciplines in the life sciences. The first course (Biology I) aims to define the core properties of cells as the basic unit of all living systems. Consequently, this course addresses structure/function issues for the major classes of macromolecules, the role of enzymes in metabolism and energy generation, and the key features needed to understand the central dogma of biology. Getting away from thinking in terms of the fundamental activities of individual cells, the second course (Biology II) aims to explore the challenges and opportunities facing organisms when cellular activities become differentiated and more specialized. This second course uses the conjoined themes of evolution and biodiversity to not only survey the breadth of organisms (plant, animal and microbial) but also illustrate how multicellularity and specialization have allowed organisms to meet and overcome important selected challenges.

Recommendation #2: Development of introductory Anatomy & Physiology-type courses in each of the major life sciences disciplines (Human, Animal, Plant and Microbial biology): The Taskforce subcommittee recommends that introductory courses that discuss each of the major divisions among living organisms should be developed at the 200-level. The Taskforce also recommends that a comparable course in Ecology, Ecosystems and Behavior also be developed. It is not anticipated that life science students will be required to take all of these 200-level classes. We suggest the specific number of courses within this group required for each curriculum should be established independently for each major or concentration. However, to ensure that students obtain as broad as possible training in the biological sciences we also suggest that students be encouraged to complete as many of these courses as curriculum constraints will allow.

The common educational aim of these 200-level courses is to provide all disciplines with an equivalently-timed opportunity to expand, in a discipline-specific manner, on themes introduced in Biology I and II. Stated differently, the Biology classes, and specifically
Biology II, are expected to illustrate the diversity of living organisms but also stress the common structural, biochemical and genetic themes underlying the evolution that has given rise to that diversity. The 200-level introductory classes discussed here would be expected to reiterate these common themes but would also be expected to introduce students to the discipline-specific features and core concepts that justify the division of biology into sub disciplines. For example, a discussion of the key processes in the central dogma of biology in a 200-level Introductory Microbiology class would provide opportunities to reiterate the key role of these processes in prokaryotes but also stress the key differences between eukaryotic and prokaryotic gene structure, transcription and translation. An outline of a proposed curriculum for a 200-level Introductory Microbiology course that illustrates this specific point is provided in Appendix D.

In some instances we can expect the classroom elements of the 200-level courses being derived from existing courses. For example, the course summarized in Appendix D is a significant revision of the current General Microbiology (MB 351) course. In contrast, the proposed Animal Anatomy and Physiology course (Appendix E) and the Ecology, Ecosystems and Behavior course (Appendix F) are simply repositioned but unrevised existing courses. In all instances we anticipate each of these course outlines will require further revision when comparable curricula are available for all of these 200-level courses. We also anticipate revisions of laboratory materials will be frequently needed to provide a continuation of the experiment-based inquiry-guided format introduced in the earlier Biology I and II classes (see Recommendation #5).

Recommendation #3: Development of a required 200-level Genetics course: The Taskforce recommends that all life science students, irrespective of their major, be required to take a 200-level Principles of Genetics course. The Taskforce recognized genetics is a discipline that is common to all living organisms and felt it should be provided a prominent position within any life sciences foundation. An outline proposed curriculum for this 200-level Principles of Genetics classroom and laboratory course is provided in Appendix G.

One important argument for repositioning this course into an early rather than later point within the life science curriculum is it is an important step towards increasing the overall rigor of the life sciences curriculum. It is also important to note that this class is expected to provide students with a true genetics foundation upon which other curricula can build and illustrate exceptions and key differences. This situation is often inverted with the present position of GN411/412 in most curricula and students are often exposed to discipline specific discussions of genetics before they take this comprehensive genetics course. This current arrangement does little to encourage or facilitate the “synthesis” of genetics into the life sciences and we believe the repositioning of this course will greatly aid in meeting this educational goal.

Although the Taskforce has focused on genetics, similar arguments involving wide relevance to life sciences, course inversions and curricula rigor can also be made for certain other courses. For example, a revised or repositioned 300-level Introductory Biochemistry course could be developed to replace the current 400-level course (BCH
451). This course is not universally required among life science curricula but is frequently taken by seniors outside the Biochemistry major. Evolution and Ecology are also subjects that have wide relevance to the life sciences and could be included in this group of courses.

**Recommendation #4: Revision of Mathematics, Chemistry and Statistics courses:**
The Taskforce recommends that many of the ancillary courses in mathematics, chemistry and statistics should undergo revision to increase the relevancy of these required courses to students in the life science disciplines. To this end the subcommittee and individual members held several discussions with faculty members from other departments responsible for teaching these courses.

The faculty members from the Department of Mathematics who discussed the curriculum modifications with the subcommittee recognized the present two-semester calculus sequence (MA131/MA231) attracts students from a wide range of disciplines with diverse mathematical skill levels. The faculty also recognized an inherent limitation in increasing the relevance of mathematics training to life scientists is the fact class sizes are often larger than ideal. The faculty agreed that having a more biologically-oriented course sequence, taught by faculty and TAs who have strong biological interests, has the potential to provide a more relevant and engaging experience of quantitative methodology to students in the life sciences.

The revisions suggested by the mathematics faculty directed at the existing MA131 (to be renamed Calculus and Biomathematics I [See Appendix A]) were minor and mainly consisted of an increase in emphasis on using examples and applications that are more relevant to biological scientists (Appendix H). However, the second course (Calculus and Biomathematics II) was proposed to undergo a more substantial revision to place a much stronger emphasis on modeling and differential equations than the current MA231. Removing elements of MA 231 with very limited biological relevance (e.g. double integrals, infinite series) allows more time for discussion of 2D models, their behavior and analysis. Although not outlined here, similar revisions are also expected in the existing MA241 and MA242 courses.

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The subcommittee also directly discussed potential changes in statistics course (ST311) with faculty from the Department of Statistics. Notes prepared from our discussions by these faculty members are included as Appendix I. It was noted that the current offering (ST311) is often viewed as lacking rigor and applicability to life sciences. The faculty involved in these discussions suggested a revised 300-level statistics course could be made more rigorous and calculus-based and should address basic probability, point estimation, confidence interval estimation, one- and two-sample hypothesis testing, and linear models (regression and ANOVA). A note or caution was offered that the aim of including discipline-specific materials in this type of course can often be lost as a result of instructor turnover and the later use of instructors (faculty or TAs) with limited biological experience. This issue was not raised by the faculty from the Department of Mathematics as they assumed that one or more members of the “biomathematics” group would be involved in teaching or overseeing the revised offerings.
Although no direct discussions were held with chemistry faculty and the subcommittee, the subcommittee consensus was that the foundation courses should continue to include the existing CH101 and CH201 courses with some modifications in content and sequence. The introductory CH101 course involves discussions of molecular bonding, structure, and reactivity. The course stresses the principles of atomic structure, ionic and covalent bonding, reaction energetics, intermolecular forces, precipitation reactions, acid/base reactions, and oxidation/reduction processes. The course also provides introductions to organic and inorganic chemistry. The retention of CH201 was justified as this represent the most quantitative of the four chemistry classes currently required of most life science students. For example, this course stresses the quantitative aspects of solutions, solution stoichiometry, thermodynamics, chemical equilibrium, acid-base equilibria, solubility equilibria, electrochemistry, chemical kinetics, and nuclear chemistry. However, students would benefit from a more cohesive understanding of physical chemistry and its importance to biomolecules and living systems and should also gain some exposure to modern analytical chemistry. Consideration also should be given to having this “second semester” of general chemistry be taken following organic chemistry, thus allowing students to develop a foundation in organic chemistry early enough to develop direct links to introductory biology.

More significant revisions are proposed for the two currently required organic chemistry courses, CH221 and CH223. Like the mathematics sequence described earlier, the major revisions in terms of biological relevance were directed at the second course in the sequence. To reflect the increased biological relevance, the two organic classes were suggested to be renamed “Organic Chemistry for Life Sciences I and II.” The first of these courses would be expected to continue with the current CH201 emphases on structure, bonding, stereochemistry, reactivity and the synthesis of carbon compounds. Aliphatic hydrocarbons, alcohols, ethers, and alkyl halides would be discussed in detail, along with an introduction to spectral techniques. The second course would be expected to continue with the existing coverage of carbonyl compounds, aromatics and amines. However, the current emphasis on reaction mechanisms, synthetic routes and spectroscopic techniques would be reduced to favor discussions of the structure, bonding and properties of biologically relevant molecules (DNA, protein, lipids), including the chemistry of heterocyclic compounds and phosphate esters. Discussions of simple biochemical pathways (e.g. TCA cycle, fatty acid synthesis and degradation, CO₂ fixation) could be used to illustrate how the chemical behavior of more simple biomolecules is dictated by the same rules that apply to simple “textbook” non-biologically relevant chemicals. Similarly, free radical reactions, condensation reactions, displacement reactions, etc. can be taught using biochemical examples.

**Recommendation #5: Redesign of laboratory courses to include inquiry-guided modules:** As a general strategy, the subcommittee recommends that many of the laboratory classes in current or newly created or modified classes should themselves be revised to incorporate inquiry-guided modules and methods. Inquiry-guided approaches aim to increase the critical thinking skills of students and to encourage them to take increased responsibility for their own learning. In the context of a science laboratory
class this involves connecting the process of scientific discovery (e.g. observation, inference, and experimentation) with scientific knowledge gained in a classroom setting. The relationship between inquiry-guided instruction and improved learning has been well documented and approaches to inquiry-based laboratory courses have often involved multi-week modules that provide students sufficient time to fully engage in the sequential steps in the inquiry process. These steps include, among others, initial experimental design, collection of data, formulation of explanations for results based on prior understanding of concepts, communication and defense of results and conclusions. Inquiry-guided teaching can certainly be more time consuming and challenging for instructors. However, even simple steps can be taken to initiate this process. For example, laboratory exercises often direct students to exactly what data needs to be collected in an experiment by providing forms and boxes in laboratory work books. The learning experience may be slower but more meaningful if this is not prescribed and students are required to decide what data needs to be collected themselves. This simple modification highlights the difference between having students being told how to think and giving them the opportunity (and responsibility) to think for themselves. Many of the course outlines included in the Appendices have provided suggestions for inquiry-based modules for revised laboratory courses. Considerable expertise already exists on the NCSU campus in the implementation of inquiry-guided methods. This is a resource that should be used extensively in the revision of life-science laboratory classes.
Potential Ramifications

The subcommittee recognizes that full implementation of the recommendations listed above could have significant ramifications and impacts on the structure and organization of departments, curricula and courses within CALS. In this last section we have briefly examined some of these impacts. We have attempted to provide a cross section of examples rather than attempt to be comprehensive or fully inclusive. Please note, the following sections are presented based on the notion that the current organizational structure of the life sciences and its component departments remains unchanged.

One potential benefit of a substantial curriculum revision is that it also potentially allows individual departments to refocus and realign some of their teaching efforts into newly flourishing areas that have been either wholly neglected or underserved due to limited resources. This type of readjustment can potentially happen at the smaller scale (e.g. development of concentrations) or at the larger scale (e.g. substantial curriculum modification). In the following sections we provide brief examples of how various different concentrations could be created within either the existing zoology and biological sciences program. These include two concentrations (Integrative Physiology and Neurobiology and Ecology and Behavior) within the zoology curriculum and a concentration in Human Biology within the Biological Sciences program. We have also provided an example of how the recommended curriculum modifications could potentially impact an entire undergraduate curriculum (Microbiology). This section aims to demonstrate how these changes could be harnessed to expand the synergies between departments and programs and improve the college’s ability to effectively train students with career interests in the biotechnology and healthcare industries and professions.

1) **An Integrative Physiology and Neurobiology concentration within Zoology:**
The example concentration in Appendix J could be a concentration within the Zoology degree, within the BLS degree, or both. The concentration in Integrative Physiology and Neurobiology provides (a) the opportunity for students to demonstrate depth in that area for career purposes, (b) an opportunity for greater identity and interaction for students in that concentration within those large majors, and (c) a structure in which faculty in that area can take responsibility for educational improvement for students choosing that concentration, e.g., special courses, seminars, and social mixers.

2) **An Ecology and Behavior concentration within Zoology:** The example concentration in Appendix K could be a concentration within the Zoology degree, within the BLS degree, or both. It might also be appropriate for some other majors, if tailored as those faculty wished. As with other concentrations, the concentration in Ecology and Behavior provides (a) the opportunity for students to demonstrate depth in that area for career purposes, (b) an opportunity for greater identity and interaction for students in that concentration within those
large majors, and (c) a structure in which faculty in that area can take responsibility for educational improvement for students choosing that concentration, e.g., special courses, seminars, and social mixers. Alternative titles encompassing this general area could be (i) Ecology, Evolution, and Behavior, (ii) Ecology and Conservation Biology, or (iii) simply, Ecology. Many other attractive conceptual variations and titles are possible, and the present title and mock-up are a starting point from which involved faculty can start.

3) **A Human Biology concentration within Biological Sciences:** A Human Biology Concentration would provide students with a rich education in the scientific and humanist disciplines that underlie modern health sciences. The concentration would serve as an excellent preparation for entrance into health related professional careers including medicine, dentistry, pharmacy, genetic counseling, and many others. It would also provide a strong foundation for careers in science and biomedical research. The concentration is designed as a broad based, interdisciplinary program which integrates biology, physical and social sciences and humanities. The concentration focuses on an understanding of molecular biology, genomics, anatomy and physiology to an understanding of human health and disease. In addition, the breadth of the program would give students interested in the above professions a well-rounded appreciation of the cultural and psychological influences on human biology and health.

Appendix L provides a proposed 8 semester Human Biology Concentration layout, which reflects the Biology Teaching Task Force recommendations for a rigorous life sciences core curriculum. The human biology concentration, begins with this integrated sequence of foundational courses in biology, chemistry, and mathematics. The freshman core requirements are expanded during the subsequent years to provide students with a breadth of coursework designed to best prepare them for graduate work in a healthcare curriculum (medical, dental, optometry, etc.) as well as science and biomedical research. The recommended coursework includes not only courses within the life sciences but also a requests to CHASS and other departments for an allotment of biology restricted seats in specific “health biology related” courses. Key components of this broad based 8 semester layout are designed to below:

1. Adding required courses that develop a comprehensive understanding of the functioning of the human body and related science disciplines
2. Preparing students for graduate admissions tests in a timely manner (end of fall semester junior year)
3. Include coursework exploring foundations in medical writing and medical economics as well as CHASS and other university courses relevant to human biology.

This concentration is recommended for students seeking future acceptance to human biology related graduate and professional programs as well as into competitive R&D fields. In light of this, we ask for consideration of a more
stringent “C” bar standard for certain courses within this concentration. We propose increasing the number of “C” bar courses from the current 3 within the BLS program to up to 15 for continuation in this concentration into junior tier coursework (including the 100 and 200 level math, chemistry, biology, English and physics courses).

These recommendations have been developed in conjunction with information obtained through consultation with numerous NC graduate programs including UNC, Duke and Wake Forest as well as the evaluation of over 20 similar Human Biology programs across the US.

**Structure Points:**

- Utilizes the Task Force recommendation for changes within the Life Sciences which integrates scientific concepts and their application across science disciplines (math, chemistry, biology, etc) in freshman courses
- 2 semesters of basic human anatomy sequence emphasizing both microscopic and macroscopic anatomy to the understanding of the structure and function of human anatomy
- An earlier exposure to 200 and 300 level exploratory genetics and biochemistry courses, allowing students to develop stronger foundation in these science concepts.
- Interpersonal communication/public speaking, scientific writing and medical economics course requirements
- Electives and required courses targeted at enhancing understanding of human biology while integrating interdisciplinary concepts of human psychology, anthropology, toxicology, nutrition, etc.
- Course flow is structured to maximize exposure to critical knowledge components needed to excel on graduate admissions exams by the completion of these by end of the 5th semester of study for testing during the spring of their junior year. This also allows three additional full semesters of course options to enhance specific interest areas

4) **Revision of the Microbiology undergraduate curriculum:** The modifications made to the Microbiology curriculum have stayed consistent with the subcommittee’s objectives of removing redundancy among curricula, developing a coherent, well-planned sequence of courses and emphasizing scientific rigor in the curriculum. The major features of the potential modifications to the undergraduate Microbiology curriculum are as follows (see Appendix M):

i) **Development of 200-level Introductory Microbiology course:** The content of this course will be derived from one of several current versions of the existing General Microbiology (MB351). The major feature of the development of a 200-level course will be to reduce the molecular content (e.g. basic chemistry and biochemistry, enzymology, gene structure and regulation) of the existing 300-
level course (see Appendix D). These revisions would allow the course to concentrate on basic microbiology (pure cultures, isolation and characterization techniques, microbial diversity) and allow increased emphasis on two “tracks” within the MB curriculum; the Applied/Industrial and the Health Professions tracks. As suggested by their names, these tracks are aimed at preparing students for careers in the biotechnology and health-related fields, respectively. This 200-level course would continue to be offered with an associated, but not required, laboratory class. The laboratory class itself would be based on the existing and popular MB352 It would also incorporate several of the inquiry-guided modules and approaches developed in the Honors version of this course (MB352H).

ii) Development of new course (MB 3XX Microbial Molecular Biology): A major revision to the MB curriculum would be the development of a new required lecture and laboratory course that would focus exclusively on microbial molecular biology. The reallocation and expansion of the molecular materials that have been perennially compromised in the existing MB 351 course would enable Microbiology to provide a much needed coherent training in the theoretical and practical aspects of molecular biology. This is turn would relieve other higher-level courses of teaching remedial molecular concepts and techniques. These courses include, among others, MB411/12 (Medical Microbiology) or a derivative of this course, MB414 (Metabolic Regulation) and MB451 (Microbial Diversity). This course would also be expected to be a significant benefit to students interested in participating in research projects in faculty laboratories as well as those with future interests in careers in the biotechnology arena. An outline of the curriculum of this proposed course is shown in Appendix N.

iii) Expansion of Health Professions “track”: The Department of Microbiology currently has two main research emphases: Molecular Microbial Physiology and Cell Biology/Immunology/ Virology. The main emphasis among the physiologists is applied and environmental bacteriology. The courses taught by faculty in these areas provide a solid “track” within the curriculum that effectively prepares students for careers in the applied areas of microbiology. In contrast, despite the enormous significance of microbiology to human health, the MB curriculum currently does not provide an equally comprehensive series of courses for students interested in health-related careers. The proposed revisions to the life sciences foundation and the other modification discussed above potentially provide Microbiology with an opportunity to expand the existing course offerings to complete this Health Professions track. The additional major revisions in the Microbiology curriculum would include a discontinuation of the current Medical Microbiology (MB411/412) and subdivision and expansion of this course into two new courses. These new courses would include one that more thoroughly and broadly addresses Human Infectious Diseases (e.g. mechanisms of pathogenesis, public health microbiology, epidemiology) while the other lecture and lab course would address the practical features of Diagnostic Microbiology. This second course would expand the laboratory work that is currently quickly
covered in Medical Microbiology lab (MB412) to include practical features of immunology and virology addressed in the other two already existing lecture-based courses (Introductory Virology [MB461] and Immunology [MB441]) in the proposed Health Professions track

**Benefits:** As we anticipate will be the case for other majors, a realignment and revision of the foundation curriculum for the life sciences provides room for Microbiology to improve its existing introductory course for both majors and non-majors. These revisions will also potentially allow Microbiology to further adjust the content, scope, and number of higher-level courses in the MB curriculum. These later modifications would allow Microbiology to better serve the needs of existing and future students to become competitive and effective graduate students, local biotechnology industry employees or health care professionals. The full development of these tracks within the MB curriculum would also potentially allow them to be made available as specific minors for students with main interests in other areas. Looking to the future, the presence of clearly defined health-related degrees in the Biological Sciences (Human Biology concentration) and in Microbiology could allow for considerable synergies between the two programs and could help attract additional high quality undergraduates to these programs. Likewise, the formal establishment of an Applied/Industrial track could foster equally important synergies with other CALS-sponsored initiatives such as the BTEC facility, the local biotechnology industry and the Master’s of Microbial Biotechnology (MMB) program already offered by the Department of Microbiology (see Appendix M).

**Resource Requirements:** The teaching of the modified 200-level Introductory Microbiology would be expected to fall to the existing faculty who currently teach MB351. We further anticipate the current laboratory (MB352) course would continue to be associated with this new 200-level course. These changes therefore do not require significant additional resources. In contrast, the proposed new 300-level Microbial Molecular Biology course would require an additional faculty member to teach the course and 2 TA positions to support the lab sections. The course would also require the initial and recurring costs for suitable equipment and consumables. The size of this class would initially be expected to be comparable to other lecture/lab courses offered by Microbiology for our majors (*e.g.* MB 411/2 and MB451). Both of these courses cater to ~70 students per year. An important consideration is this new course would provide hands on experience in modern molecular techniques. It could be envisioned that an intensive and modern molecular biology-based course offered by a CALS department could be an attractive substitute for courses currently offered by COE through the Biotechnology program. In this case the size of the class could increase significantly and would undoubtedly require additional resource support.

The resources required for the full development of the Health Professions track are similar to the cost outlined above for the 300-level Microbial Molecular Biology course. For example, discontinuation of MB411/12 would release the
faculty resources needed to teach either of the two new proposed courses (Human Infectious Disease or Diagnostic Microbiology). However, an additional faculty member would be required to teach the other course. The TA support currently assigned to MB412 (Medical Microbiology lab) could be used to support the laboratory component of the proposed Diagnostic Microbiology course.
APPENDIX A

Revised Core and Selective Course Content Considerations for Biology/Life Sciences

Year 1:

Biological/Life Sciences
- A) Biology I
- &
- B) Biology II

Chemistry
- A) General Chemistry – (CH101)
- &
- B) Organic Chemistry for Life Sciences I

Math
- A) Calculus and Biomathmatics I
- &
- B) Calculus and Biomathmatics II

Year 2:

Biological/Life Sciences
- C) Ecology, Ecosystems, & Behavior
- D1 & D2) Human A & P (2 Semesters)
- E) Plant A & P
- F) Animal - Environmental A & P
- G) Introductory Microbiology A & P

2 semesters of course work depending on major &/or concentration recommendations

Chemistry
- C) Organic Chemistry for Life Sciences II
- &
- D) Inorganic Chemistry (CH201)

Math
- E) Bio Statistics (1st Semester)

Genetics
- A) Principles of Genetics (+/-lab) (2nd Semester)

Required for life science major ? prereqs
* To Include Hardy Weinberg/Evolution/Natural Selection
APPENDIX A

Years 2, 3 & 4
Advanced Course Selections

A) ? 300 level Biochemistry - first sem. jr. year?

B) Advanced Biochemistry (451, 453, etc)

C) 351 Microbiology

D) Medical Microbiology

E) Immunology

F) Neurobiology

G1, G2) Nutrition & Human Nutrition

H) Biotechnology

I) Animal Development

J1, J2, J3) “Adv.” Genetics Courses

K) Plant Development

L) Pharmacology & Toxicology

M) Cell Biology

N) Adv. Anatomy

O) Health & Disease Physiology

P) Exercise Phys/Kines.

Q) Specialty Lecture Series

R) Advanced Evolution

S) Animal Behavior

T) Advanced Ecology

U) Other specialty courses

V) Physics I & II

W) EMT Basic Cert/CNA

X) Research – learning experience – 492/493

Y) Major – Concentration Specific Courses

Z) Research – learning experience – 492/493

W) EMT Basic Cert/CNA

X) Research – learning experience – 492/493

Y) Major – Concentration Specific Courses
APPENDIX B

Biology I – Introductory Biology
Molecular/Cellular Development

Goal/Objective – for students to gain an understanding of how cells function, communicate, control and regulate their activities as well as the effects of malfunctions of these activities.

Course Topics:
- **Scientific Method**
- **Chemistry of Life:**
  - Basic Building Blocks, Atomic structure, molecules, and chemical bonds
  - formation, importance, effects
- **The Role of Water**
- **Cellular structure, organization:**
  - Organelle function, cytoskeletal components (microtubules, intermediate filaments), extracellular matrix
- **Biological Membrane**
  - Structure, function, transport, channel types, endo/exocytosis
- **Organic Basics**
  - Carbon Chemistry, functional groups, reactions
- **Macromolecules**
  - Structures, functions, importance (proteins, amino acids, etc)
- **Enzymes**
  - Structure/function/importance
- **Energy I**
  - Photosynthesis – light/dark cycles, Calvin Benson
- **Energy II**
  - Cellular metabolism, Glycolysis, TCA, ETC – (Carbs, proteins, fats)
  - Aerobic Metabolism
- **DNA/Chromosome structure**
  - Cell cycle and controls, cell interactions
- **Mitosis and Meiosis** (malfuction/tumors/cancer controls)
- **Mendel and Basic Genetics** (gene structure, DNA and mapping)
- **DNA replication**
  - Bacterial
  - Prokaryotic vs Eukaryotic
- **Gene Transcription and Translation/Protein Synthesis** – promoters, polymerases, splicing/editing,
  - Prokaryotes – transcription and regulation
  - Eukaryotes – transcription and regulation (transcription factors, processing, splicing and processing)
- **Control of the Genome** – Molecular biology: DNA technology/genomics
- **Human Genetics/Genetic Engineering**
APPENDIX B

- Embryology and Development
- Natural selection and population genetics

Possible class problem sets:
1) basic chemistry review
2) basic biochemistry/organic review problem sets
3) enzymes
4) macromolecules
5) cellular organelles – tracing products through a cell
6) photosynthesis and aerobic respiration problem set
7) mitosis vs meiosis worksheet
8) genetics problem sets
9) karyotyping experiment
10) tree of life/history of life

Lab suggestions:

Concept Goals - By end of semester – would like for students to:
- be able use compound microscope,
- convert units,
- develop simple experiments,
- capture and report data,
- draw conclusions
- describe structure of atom
- describe chemical bonds
- understand pH and acids and bases
- understand components and differences between macromolecules
- understand differences between prokaryotic and eukaryotic cells – function of organelles, integrated function of cellular organelles (and normal versus cancer cells) – cell/cell communication
- understand membrane transport and reactions to stress, and enzyme function
- understand mitosis vs meiosis and basics of Mendelian genetics
- understand DNA and RNA transcription, protein synthesis
- understand extraction of energy – photosynthesis and aerobic respiration
- basic evolution/natural selection

Equipment and techniques – microscope, chromatography, electrophoresis, spectrophotometric analysis, PCR, pipetting,

- Recommend 1 (or possibly two) full or half course continued experiments to develop recording and reporting techniques – ie. Part one – planned experiment with observations and reporting then Part two – add on variation based on first results
APPENDIX B

- LABS

- Scientific method and scientific writing
- The microscope – study of sample (ie. Pond water, simple histology, etc)
- pH and buffers
- Marcomolecules
- Cells intra and extracellular matrix and components
- Diffusion and osmosis
- Enzymes, membranes, cell response to stress
- Cellular respiration/photosynthesis
- Genetics/Mendelian inheritance
- Chromosomes and Cell division/molecular genetics
- Protein synthesis
- Population genetics
Goal/Objective – This second course in the introductory biology series would expand on the concepts of MCD through the evaluation of the basic principles of evolution and ecology while surveying the diversity of life on earth. **In surveying life on earth, the course will focus on the challenges organisms and lineages have faced in surviving.**

Course Topics:

**Section 1 (short introductory section) – Closest kin, Evolutionary history of humans and other primates, what it means to be us and not microbes**

- **Origin of Life/Evolutionary Concepts**
  - National Genographic samples of students to trace their haplotype histories. Through these histories study human evolution and prehistory.
- Systematics and classification (using primates as an example)
- Sections ends by scaling back out to a broader evolutionary context to see where we are on the evolutionary tree and what the major branches are.

- **Comparison of microbes and human. Use this comparison to frame the new challenges that face organisms with each major evolutionary transition.**

- Lead into the story of the origin of life.

- **Regional focus: Congo and megatransect across it.**

**Section 2 – The majority of life, microorganisms, diversity, lives and consequences (Chemical challenges and responses) (3500 mya - today)**

- Evolution and development of life
  - Making Organic Compounds: The Stanley Miller Experiment

- Living without oxygen
- Learning to eat sunlight
  - Introduce story of serial endosymbiosis and Lynn Margules

- Archea
- Eubacteria
- Eukaryotes and Protists
APPENDIX C

- Viruses
  - Basic ecological concepts: food webs, predation, mutualisms using microbes as a case study.
  
  - Regional focus: Forest soils, students (as ecoregions including discussion of gut microbes and antibiotic resistance), and dorm rooms.

Section 2 Tinkering with altruism, multicellularity and the challenges of cooperation (1500 - 600 mya)

- Evolution of multicellularity (Sponges)
  - The Cambrian explosion and possible body plans (framed around S.J. Gould).
    - The challenges of movement
    - The challenges of cooperation

- Animal Symmetry (Cnidarians)
- Body Cavity Search, Protostomes, Lophotrochozoa, Platyhelminthes (story of Janine Caira and shark tapeworms)
- Lophophorates
- Annelids
- Molluscs: chitens, gastropods, bivalves, cephalopods

  - Regional focus: The North Carolina sea and shore

Section 3 The sun eaters, the evolution of plants and the challenges of dispersal, transport and mating (430 mya to today)

- The challenges of colonizing land
- Plant diversity and classification
- Seedless and Seed plants – Bryophytes,
- Anatomy of plants/plant transport
- Plant Growth and Development/Reproductive challenges out of water (dispersal, pollination)
- Fossil fuels, the carboniferous and why the planet is green
- Domestication of plants. What do we eat and why does that matter?
- Plant animal interactions and a who's who of bizarre plants. Orchids, Proteas, Carnivores and Mistletoes

  - Neither here nor there, the fungi, evolution, reproduction, consumption.

  - Regional Focus: Plants of North Carolina, pitcher plants to pines.
APPENDIX C

Section 4 – Invertebrates take over the land, the boneless majority (420mya to today) and the challenges of walking

- Convergence between plants and invertebrates in response to the move to land
- Invertebrates cheat by carrying microbes (symbioses with microbes as a repeated response to major challenges).
- Major transitions in terrestrial invertebrates
- Species diversity and terrestrial invertebrates
- Ecdysozoa: Nematoda: Arthropods: Chelicerate
- Additional topics covered here, Biogeography, phylogeography, and climate change.

- Regional focus: North Carolina forests and the All Taxa Biodiversity Inventory.

Section 5 – Return to the vertebrates, the bony minority and the challenges of complexity

- The beginning of our kind, Dueterostomes.
- Tissues, organs, and organ systems – structure and function
  - Major transitions in vertebrate form and function
  - Fish-Amphibians-Reptiles-Birds
  - Mammals

- Complexity and the fallacy of progress. Why our branch isn’t stronger and alligators aren’t ancient.

- Did smoking really kill the dinosaurs? Mass extinctions, the current extinction and their role in innovation.

- Evolutionary imperfections and constraints and challenges due to complexity—Why we walk funny and whales have legs

- Return to the story of primate evolution. Here the focus is on details of primate evolution and what is unique about our clade. A return to the comparison of primates and microbes.

- Regional Focus: North America at large scale.

Concept Goals for Semester and Approaches –

- This class would provide a basic introduction to the origin and diversity of life. Evolution is a unifying theme with emphasis placed on presenting organismal diversity within a phylogenetic framework
- Each section would be framed around major challenges associated with important evolutionary transitions (e.g. the transitions to land).
APPENDIX C

- Students should finish class with a profound sense of the magnitude of the diversity of life on earth, and the breadth of that diversity.
- Where possible, the course will focus on North Carolina, where much of the phyletic diversity on earth is represented. More often than not, one doesn’t need to leave the dorms to find a louse, a mite, and a tapeworm, for example.
- To increase the interest in the course material and to give the class an appreciation for who does science and how they do it, each week will be at least partially framed around the story of discovery by a particular scientist. Examples include, Lynn Margules and the serial endosymbiont theory, Janine Caira and the study of shark tapeworms, Terry Erwin and estimates of the number of species/beetles on earth, etc… (Bring in one or two of these people to give talks?)
- Nearly all of the example stories will focus in detail on key experiments (or methods more generally, if not experiments) so that students have a chance to walk through (and even in some cases perform) those experiments.

Lab:

- Recommend 1-2 semester long experiments with time to further develop report writing skills. Additional reading (a popular science book on evolution?) associated with lab?)
- One experiment consists of a biodiversity survey and manipulation across campus, dorm rooms and apartments. Couple with a bioblitz on Centennial campus.
- Second experiment would emphasize evolution. Could involve a selection experiment of some kind on a short lived organism. Good to get the students to see evolution in the flesh.
APPENDIX D

Introductory Microbiology – 200-level

Goals: The aim is to provide students with a broad overview of Microbiology. The course would initially aim to illustrate the central concepts in Microbiology and show how these were developed and continue today (Section #1). The course would stress the diversity of prokaryotes and illustrate how this arises primarily from metabolic diversity (Section #2). The remainder of the course would reflect the two concentrations in the Microbiology curriculum, the Applied/Industrial (Section #3) and the Medical professions Microbiology (Section #4). Much of the molecular material in the existing MB 351 would be eliminated from this new course and moved to a new course (MB 3XX/L Microbial Molecular Biology). The proposed course would retain the accompanying laboratory course currently numbered as MB 352.

Course Topics: The course would be subdivided into 4 sections as follows:

Section #1: Key Microbiology Concepts
What is Microbiology and how does it impact your life?
History and the core concepts (disease, biogeochemical, industrial)
The core laboratory techniques (plating, microscopy)
How to grow and kill microorganisms and how to measure these processes
Diversity of microorganisms
Structure and function (bacteria, archaea, fungi, viruses, eukaryotes)

Section #2: Introductory Microbial Physiology and Molecular Biology:
Integration of metabolism (catabolism and anabolism)
Basic thermodynamics of life
Electron donors and electron acceptors (reduction and oxidation)
Electron donor diversity: Impacts on physiology
Electron acceptor diversity: Impacts on physiology
Heterotrophs, autotrophs and phototrophs
Key differences in molecular biology (gene structure, transcription, translation)

Section #3: Applied and Environmental Microbiology:
Industrial Microbiology
Food Microbiology-Food safety
Agricultural Microbiology
Biogeochemical cycles
Symbiosis
Wastewater treatment/Bioremediation
Bioterrorism

Section #4: Medical Microbiology:
How to be a good bacterial pathogen
How to be a good viral pathogen (introductory virology)
How does your body beat pathogens (introductory immunology)
How can we help your body (chemotherapeutics).
Zoology 250 - Animal Anatomy and Physiology

Lectures: MWF (1:30-2:20, 50 minutes), Bostian 3712
Laboratory: 1 per week (3 hours)
Credit hours: 4
Prerequisites: ZO 150 & ZO 160 or BIO 125 & ZO 150

Web-site: www.cals.ncsu.edu/course/zo250/zo250.htm (note that there is no “l” here)

Instructor:  John Godwin
246 David Clark Laboratories
ph: 513-2936
e-mail: John_Godwin@ncsu.edu

Office hours: Monday from 2:30-3:30 and Wednesday 10:00-11:00
Please note: if these times do not work, please contact me to make an appointment to meet.

Course Description
This course will use a problem-based approach in focusing on fundamental principles of animal function. These principles will be illustrated by selected examples from both vertebrates and invertebrates. Emphases will be on biotic and abiotic environmental challenges to animal functioning, how animal structure and function are adapted to the physical and chemical laws that govern the rest of the world, and the way in which the solutions animals “arrive at” reflect both evolutionary adaptation and phylogenetic influences.

The laboratory portion of the course will be more “hands-on”. This will involve some inspection/dissection of specimens, but primarily be based on physiologically-based “wet” and computer labs demonstrating animal function.

General Lecture Topics
Symmetry, Form and Life Style: Why are most motile animals bilaterally symmetrical? What determines animal size?

Support and Movement: The generation of muscular force; Skeletal types; Locomotion; Other skeletal functions - mineral storage, protection, blood formation

Animal Nutrition: Physical and chemical packaging of nutrients; Digestive processes; Absorption: roles of surface area and diffusion; feeding adaptations

Gas Exchange: Physical and chemical constraints on gas exchange; Respiratory pigments; Water and ion loss in gas exchange; Becoming terrestrial

Internal Transport: Open vs. Closed systems - phylogenetic distribution & attributes of each. Vertebrate Circulatory Systems; The lymphatic system

Immunity: The need for an immune system and the components of this, the generation of immunity, HIV and AIDS

Regulation of internal body fluids and homeostasis: Homeostasis: Osmoregulation; Nitrogenous wastes; Thermoregulation-ectothermy, endothermy, and mixtures of the two

Reproduction: Sex determination and development; The regulation of reproduction; Sex hormone effects on the brain and behavior

Endocrine systems and hormonal integration: Why an Endocrine System? Endocrine Glands and Hormones in Invertebrates and Vertebrates; Master glands; Hormone Receptors and signal transduction; Regulation of hormonal secretion and actions

Nervous systems and neural integration: Why a nervous system?; Excitable cells and ion channels; Signal propagation in neurons; Neuron communication; Neuromotor systems; Neural Systems and Behavior
Receptors and Sense Organs: Sensory transduction; Sensory modalities; Intensity coding; Mechanoreception/Hearing; Photoreception; Chemoreception, Electoreception

Grading

Grades will be on the ABCDF scale with +/- grades. The letter grade will be based on in-class exams, and a comprehensive final exam for the lecture portion of the course (75% of total course grade, individual components listed below) and on quizzes and reports for the laboratory portion of the course (6.25% for quizzes, 13.75% for written reports, 2.5% for oral presentation of a project proposal and the results of your project, and 2.5% for participation, clean-up, completion of worksheets for a lab subtotal of 25% of the course grade). In-class exams will consist of a variety of types of questions drawn from material covered since the previous exam (see syllabus) while the final exam will be comprehensive.

Letter Grades for this course will be assigned according to the scale below:

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<thead>
<tr>
<th>Grade</th>
<th>Percentage Range</th>
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<tbody>
<tr>
<td>A-</td>
<td>89.5-92.5%</td>
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<tr>
<td>A</td>
<td>92.6-97.0%</td>
</tr>
<tr>
<td>A+</td>
<td>97.1-100%</td>
</tr>
<tr>
<td>B-</td>
<td>79.5-82.5%</td>
</tr>
<tr>
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<tr>
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<td>59.6-64.5%</td>
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<tr>
<td>D+</td>
<td>64.6-69.4%</td>
</tr>
<tr>
<td>F</td>
<td>below 54.5%</td>
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</table>

Important Note: These grade cutoffs may be lowered, but will not be raised.

Calculation of Final Grade

<table>
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<tr>
<th>Component</th>
<th>% of total</th>
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<tbody>
<tr>
<td>Lecture Grade:</td>
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<tr>
<td>Lecture Exams: best 3 of 4 at 16.67% each*</td>
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<tr>
<td>Final Exam*</td>
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<td>Lecture Subtotal</td>
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<tr>
<td>Lab Grade:</td>
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<tr>
<td>Total:</td>
<td>100%</td>
</tr>
</tbody>
</table>

* note that these four are the three in-class exams during the semester and the non-comprehensive portion of the final exam that will be based on the last quarter of the material.

Calculation of lecture portion of grade: The lecture portion of your grade will be determined as follows. There will be three in-class exams worth 16.67% each during the course of the semester. The final exam will be a split: part of the credit will be based on material covered since the last in-class exam and the other part will be comprehensive and cover the whole semester. We will take the best three grades from your in-class exams and the non-comprehensive portion of your final (i.e., the portion covering material since the last lecture exam) for the final grade calculation. Since these are worth 16.67% each, these exams therefore are worth a total of 50% of your course grade (3 X 16.67 = 50). The comprehensive portion of the final exam will be worth 25% of your final course grade. The comprehensive portion of the final exam will be used for all grade calculations.

Policy on Attendance

Students are expected to attend both the lecture and their scheduled laboratory. Borderline grading cases will be affected by attendance in lecture: students with one or no unexcused absences will be assigned the next highest grade if they are within two
percentage points of the cutoff point (e.g., a ‘B-’ would become a ‘B’ if within 2% of the
grade cutoff). Students with two or more unexcused absences will not be given this increase. Students missing either lecture exams or laboratory exercises and quizzes will receive no credit for these exercises. Opportunities to make up lecture exams will be allowed only if students can provide a university-sanctioned excuse and supporting documentation. Any make up exams will be in primarily or completely essay format.

Laboratory quiz and exercise grades will be “pro-rated” (i.e., the average calculated based on the other quizzes/exercises) if and only if a university sanctioned excuse for missing the quiz or exercise is provided. If no legal excuse is provided, a grade of zero will be given for the quiz/exercise and entered for the final grade calculation.

Policy on Academic Integrity
Please refer to the University’s policy on academic integrity for information regarding expectations of honesty and academic integrity in this and other courses. Students are expected to adhere to the NCSU student Honor Pledge and a student’s signature on a test or assignment will be taken as an acknowledgement that they have done so. The integrity policy and honor pledge can be found at: http://www.ncsu.edu/provost/academic_policies/integrity/reg.htm. This policy is also described in the NCSU undergraduate catalog. Sharing or obtaining information from other students or reference to pre-recorded information during examinations are violations of this policy and may result in an automatic NC for this course as well as more severe disciplinary penalties.

E. LIST OF TEXTBOOKS:
The text for this course will be Biology by Campbell, Reece and Mitchell (6th edition, 1999). Note that this edition is very similar to the 5th edition by Campbell and it is therefore unnecessary to buy the 6th edition if you already have the 5th edition. The text will cover much, but not all, of what we discuss in lecture. There will also be supplementary readings available on reserve as reprints from American Scientist. In addition to the text, lecture outlines will be available from the bookstore for this course for approximately $8.00. These are not required, but should prove handy. Please note that these outlines will not cover everything we discuss either and some other material is likely to be added over the course of the semester.

For the laboratory portion of the course, you will need to purchase the Zoology 250 Laboratory manual by John Godwin (approximate price: $6.00).
<table>
<thead>
<tr>
<th>Date</th>
<th>Lecture Topic</th>
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<td>Animal Nutrition</td>
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<td>Support and Movement</td>
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<td>Gas Exchange</td>
<td>886-897</td>
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<td>900-922</td>
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<td>Regulation of the Internal Environment</td>
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<td>922-939</td>
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<td>Exam II: covers 9/16-10/14</td>
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<td>Endocrine Systems/Hormonal Integration</td>
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<td>Reproduction</td>
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<td>Nervous Systems and Neural Integration</td>
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<td>Receptors and Sense Organs</td>
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<td>Circadian Rhythms - Bora Zivkovic</td>
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<td>December</td>
<td>Last Day of Classes</td>
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<td></td>
<td>Final Exam: 1-4 PM, Bostian 3712</td>
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Important Dates

August 23 Tuesday  Last day to add a course without permission of instructor.
TRACS closes for adds at 5:00 pm.

August 30 (Tuesday)  Last day to register (includes payment of tuition and fees) or to add a course. Last day to drop a course, or change from credit to audit with tuition reduction. Last day for undergraduate students to drop below 12 hours

September 28 (Wed)  Last day to withdraw or drop a course without a grade, change from credit to audit or credit only at the 400 level or below. Last day to submit Request for Course Repeat Without Penalty.
TRACS closes for drops at 5:00pm.

December 12, 1–4 PM  Final Exam in Bostian 3712
# BRIEF SYLLABUS

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<td>F-8/19</td>
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<td>3. Adaptation to Aquatic and Terrestrial Environments</td>
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<td>W-8/24</td>
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<td>5. Adaptation to Life in Varying Environments</td>
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<td>M-8/29</td>
<td>6. Life Histories and Evolutionary Fitness</td>
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<td>W-8/31</td>
<td>7. Sex and Evolution</td>
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<td>F-9/2</td>
<td>8. Family, Society, and Evolution</td>
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<td>M-9/12</td>
<td>10. Population Growth and Regulation I</td>
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<td>11. Population Growth and Regulation II</td>
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<td>12. Temporal and Spatial Dynamics of Populations</td>
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<td>13. Population Genetics and Evolution I</td>
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<td>15. Predation and Herbivory</td>
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<td>16. Dynamics of Predation I</td>
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<td>17. Dynamics of Predation II</td>
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<td>18. Competition</td>
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<td>F-10/21</td>
<td>25. History and Biogeography</td>
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<td>26. The Physical Environment I</td>
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<td>28. Variations in the Physical Environment I</td>
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<td>30. Biological Communities: The Biome Concept</td>
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<td>31. Terrestrial Biomes</td>
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<td>W-11/9</td>
<td>32. Aquatic Biomes</td>
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<td>33. Energy in the Ecosystem I</td>
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<td>M-11/14</td>
<td>34. Energy in the Ecosystem II</td>
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<td>W-11/16</td>
<td>35. Pathways of Elements in the Ecosystem I</td>
<td>7</td>
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<tr>
<td>F-11/18</td>
<td>36. Pathways of Elements in the Ecosystem II</td>
<td>7</td>
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<tr>
<td>M-11/21</td>
<td>37. Nutrient Regeneration in Terrestrial and Aquatic Ecosystems</td>
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<td>M-11/28</td>
<td>38. Extinction and Conservation</td>
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<td>F-12/2</td>
<td>40. Review</td>
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Topics for Proposed 200-level Principles of Genetics Course

June 2006 Draft

- Mendelian Genetics
- Chromosome Basis of Inheritance, Sex Determination and Sex Linkage
- Pedigrees
- Extensions of Mendelian Genetic Analysis
- Linkage, Crossing-Over, and Gene Mapping in Eukaryotes
- Genetic Recombination in Bacteria and Bacteriophages
- Quantitative Genetics
- Population Genetics
- The Beginnings of Molecular Genetics: Gene Function
- The Structure of Genetic Material
- The Organization of DNA in Chromosomes
- DNA Replication and Recombination
- Transcription
- RNA Molecules and RNA Processing
- The Genetic Code and the Translation of the Genetic Message
- Recombinant DNA Technology and the Manipulation of DNA
- Regulation of Gene Expression in Bacteria and Bacteriophages
- Regulation of Gene Expression and Development in Eukaryotes
- Gene Mutations
- Chromosomal Mutations
- Transposable Genetic Elements, Tumor Viruses, and Oncogenes
- Organization and Genetics of Extranuclear Genomes
Review of Basic Knowledge (Mitosis, Meiosis, Mendel - perhaps coupling this with a lab that allows the students to try crossing some plants)

Intro to Basic Lab equipment (microscope use, pipetter use, sterile techniques) (Maybe this could couple with a model organism lab to observe various model organisms in Genetics - at least worms and flies and using the scopes with them)

Linkage with fruit flies

Population Genetics with fruit flies and computer simulation

Cytogenetics - either using a karyotype lab (if this is the only undergrad GN lab, I would still use this) or a polytene chromosome lab with flies

Ligation and Transformation

Plasmid DNA isolation

Electrophoresis

Southern Blot

PCR
Calculus and Modeling in the Biological Sciences

Goals: Proposed topics/syllabus for a more biologically oriented and relevant two semester calculus sequence for biology students

First Semester (Based on current MA 131)

Overview: Single variable calculus, emphasizing its relevance in biological applications. Particular attention will be paid to the interpretation of graphs in biological settings. Less emphasis will be placed on mathematical minutiae, proofs of results will be omitted.

Topics

Straight lines, gradient as a rate of change.
Average and instantaneous rates of change (chords and tangent lines).
The derivative as a rate of change.
Formal definition of the derivative (introduce concepts of limits, continuity, differentiability), including an example of differentiation from first principles.
Rules for differentiating simple functions (e.g. $x^n$, sums and constant multiples).
Tangent line approximation to a function. Use of the derivative to produce error estimates.
The second derivative.
First and second derivative rules, relationships between graphs of $f(x)$, $f'(x)$ and $f''(x)$.
Sketching graphs.
Optimization.
Product, quotient and chain rules. Emphasize biological quantities that can be calculated as products, quotients or composite functions.
Exponential and logarithmic functions, and their derivatives.
Exponential growth and decay models. Representation in terms of a differential equation. Appropriate graphical depiction of exponential growth and decay. Discuss inadequacies of exponential growth model.
Integration: antiderivatives and indefinite integrals. Antiderivatives of simple functions.
The integral as the area under a curve, Riemann sum and approximations for areas under curves.
Fundamental theorem of calculus and definite integrals.
Calculation of area under curve or area between curves. Biological examples (e.g. area under birth rate curve gives number of births, interpretation of area between birth and death rate curves in terms of population change).
Integration techniques (substitution and parts).
Improper integrals, convergence and divergence.
APPENDIX H

Second Semester (Loosely based on current MA 231)

Overview

Modeling in biology (difference and differential equation models). Introduction to multivariate calculus.

Topics

Difference equations (first order linear), for instance as models for population change.
Solution techniques: numerical, algebraic, graphical/qualitative. Stress advantages and disadvantages of each.
Criticism of models: discuss assumptions and limitations.
Differential equations (one dimensional). Recap exponential growth, and extend to exponential growth/decay towards an asymptote. Examples drawn from a range of biological settings.
Slope field and numerical solution of ODEs (brief discussion).
Solution of differential equations by separation of variables.
Qualitative theory of ODEs, graphical techniques for solution. Long-term behavior, equilibria and (local) stability.
Logistic growth equation.
Functions of several variables, partial derivatives.
Maxima and minima. Least squares as an example.
Double integrals?
Taylor polynomials?
Infinite series?
Coupled ODEs. Interacting populations. Examples from biochemistry, population dynamics, etc. Nullcline analysis.
The syllabus for the first semester seems quite clear-cut to me. Taught with an appropriate biological emphasis, the present MA 131 is, for the most part, a satisfactory course.

The proposed second semester places a much stronger emphasis on modeling and differential equations than does our current MA 231. The material currently taught in MA 231 on double integrals and infinite series seems less useful and has little biological motivation. Removing this material might allow more time for discussion of coupled ODEs (2D models), their behavior and analysis.

(Thinking along similar lines, there is almost certainly a fair bit of material in MA 241 and MA 242 that is of marginal usefulness to biologically-oriented students.)

For many areas of modeling, the next most useful topic to know would be linear algebra. This would open up the main analysis techniques of two and higher dimensional differential equation models. A course providing a combination of linear algebra and two-dimensional models, together with some additional topics, might make a natural third semester for students who want to take modeling further.

The math department’s present two-semester calculus sequence (MA131/MA231, Calculus for Life and Management Sciences) attracts students from a wide range of disciplines (such as biology, business, textiles) and with diverse mathematical skill levels. Many of the sections are taught by faculty and TAs who have little experience of using mathematics in biological settings. Class sizes are (at least for MA 131) often larger than the corresponding sections of MA 141.

Having a more biologically-oriented sequence, taught by faculty and TA who have strong biological interests has the potential to provide a more relevant and engaging experience of quantitative methodology to students in the life sciences.
APPENDIX I

Notes from a discussion of a possible revised intro stat class with a biological emphasis

**Background:** Students currently take ST311, a non-calculus based, one semester introduction statistics class that includes some elementary probability. ST311 is typically taught by ST grad students under the supervision of a course coordinator, who in recent years has been one of Statistics’ teaching faculty. Student feedback suggests that the course is currently too easy, and that the students have difficulty applying what they learn in ST311 to other courses.

**Proposal on the table:** In response to this feedback, a revised introductory statistics class geared towards biology undergrads is being considered. The class would differ from ST311 in the following two important ways:

- **Level of difficulty:** The proposed biology / life sciences curriculum places this intro stat class after two semesters of calculus. Therefore, the new biostat class could be calculus based. Even if the class were not calculus based, the difficulty could be increased by expanding coverage.

- **Application to biology** From a pedagogical perspective, the ideas that one tries to convey in an intro stat class can be taught equally well with example data sets from a variety of disciplines. However, it may be that undergraduates do not appreciate the generality of statistical methodology, and would be more motivated to learn if presented with examples specific to their major. Consequently, focusing on biological examples may increase student motivation, and by so doing increase learning as well.

**Content:** The content of a 300-level, one-semester intro prob and stat class is fairly consistent: basic probability, point estimation, confidence interval estimation, one- and two-sample hypothesis testing, and (time permitting) linear models (regression and anova). Although it may seem disappointing not to cover more advanced methodology (e.g., multiple regression, nonparametrics), basic statistical concepts are sufficiently elusive that they need to be introduced and mastered in the simplest settings. Doing so usually leaves little time for more advanced methods.

**Cautionary note:** The history of discipline-specific, 300-level stat classes is uneven. It is not atypical for these courses to revert back to generic intro stat classes because of instructor turnover (while retaining unique designations in the course catalog that mask similarities with other offerings). It may be worth considering alternative strategies that work within the framework of the current course offerings, instead of designing a new course.
# APPENDIX J

**Curriculum:** Biological Sciences   **Concentration:** Integrative Physiology and Neurobiology (IPN)

**Degree earned:** Bachelor of Science in Biological Sciences – IPN Concentration

## FRESHMAN YEAR

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<th>Fall Semester</th>
<th>Credit</th>
<th>Spring Semester</th>
<th>Credit</th>
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<tr>
<td>ALS 103 Intro. Agri. &amp; Life Sciences</td>
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<td>BIO *** - Biology I</td>
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<td>BIO*** - Biology I</td>
<td>4</td>
<td>CH 221 Organic Chemistry for the Life Sciences I</td>
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<td>CH101 Chemistry – A Molecular Sci</td>
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<td>Humanities/Social Science Elective¹</td>
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<td>CH 102 General Chemistry Lab</td>
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<td>ENG 101 Academic Writing &amp; Research</td>
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<td>Physical Education Elective²</td>
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### Credits
15-16

## SOPHOMORE YEAR

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### Credits
15

## JUNIOR YEAR

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### Credits
16-18

## SENIOR YEAR

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### Credits
15-16

**Minimum Credit Hours Required for Graduation:** 128
### APPENDIX K

**Curriculum: Biological Sciences  Concentration: Ecology and Behavior (EB)**  
Degree earned: Bachelor of Science in Biological Sciences – EB Concentration

#### FRESHMAN YEAR

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<th>Fall Semester</th>
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<th>Credit</th>
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<td>ALS 103 Intro. Agri. &amp; Life Sciences</td>
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<td>BIO *** - Biology II</td>
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<td>BIO*** - Biology I</td>
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<td>CH 221 Organic Chemistry for Life</td>
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<td>CH101 Chemistry – A Molecular Sci</td>
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<td>Humanities/Social Science Elective¹</td>
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<td>CH 102 General Chemistry Lab</td>
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<td>231B Calculus and Biomathematics II</td>
<td>3-4</td>
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<tr>
<td>ENG 101 Academic Writing &amp; Research</td>
<td>4</td>
<td>Or MA 241</td>
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<td>131B Calculus and BioMathematics I</td>
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15-16

#### SOPHOMORE YEAR

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<tr>
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<td>Genetics 2**</td>
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<td>CH 223L Organic Chemistry for Life</td>
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<td>Sciences II</td>
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<td>CH 201 Chemistry – A Quantitative Sci</td>
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<td>BioStats or Stats 311 or MA 242</td>
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<td>Humanities/Soc. Sci. Elec.</td>
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<td>COM 110 or 112 or 211 – Public Speaking or Interpersonal Communication or Argumentation/Advocacy</td>
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15

#### JUNIOR YEAR

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<tr>
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<td>PY 212 College Physics II (or PY 208)</td>
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16-18

#### SENIOR YEAR

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<th>Credit</th>
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<tr>
<td>Restricted Elective</td>
<td>3</td>
<td>Free/Restricted Electives⁴</td>
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<tr>
<td>Ecology/Behavior Elective</td>
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<td>Humanities/Social Sci. Elective¹</td>
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<td>Humanities/Social Sci. Electives</td>
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<td>Free Elective⁵</td>
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15-16

Minimum Credit Hours Required for Graduation: 128
APPENDIX L
Human Biology Concentration Proposal

Core Curriculum

- * Possibly Required for Concentration
- ** Recommended

Followed by course options with the following recommendations to select “?” hours of restricted “pre-healthcare/research electives” PLUS other concentrated health humanities:

- * Toxicology/Pharmacology
- * Medical Economics
- **Health and Disease
- Advanced Physiology
- Advanced Genetics
- Immunology
- * Micro A & P followed by Medical Micro
- * Scientific Writing
- ** Medical Terminology
- Ecology & Evolution
- Histology
- Advanced Anatomy
- Human
- Nutrition & Disease
- * Required Research
- Medicinal Plants
- Advanced Biochemistry
- Neurobiology
- Biotechnology
# APPENDIX L

Curriculum: Biological Sciences  **Concentration:** Human Biology  
Degree earned: Bachelor of Science in Biological Sciences – Human Biology Concentration

## FRESHMAN YEAR

<table>
<thead>
<tr>
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<th>Credit</th>
<th>Spring Semester</th>
<th>Credit</th>
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<tbody>
<tr>
<td>ALS 103 Intro. Agri. &amp; Life Sciences</td>
<td>1</td>
<td>BIO *** - Biology II</td>
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<tr>
<td>BIO*** - Biology I</td>
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<td>CH 221L Organic Chemistry for Life</td>
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<td>CH101 Chemistry – A Molecular Sci</td>
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<td>Sciences I</td>
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<td>CH 102 General Chemistry Lab</td>
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<td>ENG 101 Academic Writing &amp; Research</td>
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## SOPHOMORE YEAR

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<tbody>
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<td>Bio 2** - Human A &amp; P I with lab</td>
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<td>Bio 2** - Human A &amp; P II with lab</td>
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<tr>
<td>CH 223L Organic Chemistry for Life Sciences II</td>
<td>4</td>
<td>CH 201 Chemistry – A Quantitative Sci</td>
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<td>BioStats or Stats 311</td>
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<td>Genetics 2** - without lab</td>
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## JUNIOR YEAR

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<td>PY 212 College Physics II (or PY 208)</td>
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<td>MB 412 – Medical Micro Lab</td>
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<td>MB 2**Microbiology A &amp; P - 200</td>
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<td>ALS 498H or BIO 492 or BIO 493</td>
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<td>NTR 419 Human Nutrition &amp; Disease</td>
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## SENIOR YEAR

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<tr>
<td>TOX Pharmacology/Toxicology</td>
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<td>Free/Restricted Electives^4</td>
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<td>Free Elective^4</td>
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<td>15-16</td>
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</tr>
</tbody>
</table>

Minimum Credit Hours Required for Graduation:  **128**
APPENDIX L

Footnotes:

Foreign Language proficiency at the FL-102 level required for graduation.

1. Students must select Humanities and Social Science courses from the university approved GER list. One course must focus on a non-English speaking culture. – Students should select Humanities and Social Science courses from the recommended list of healthcare recommended selections (see attached) -

2. One completed credit must be a 100 level PE class.

3. Public speaking/Communication Course (COM 110 or 112) and Scientific Writing (ENG 333) – strongly recommended

4. Students are strongly encouraged to select courses from the healthcare electives recommendations – (see attached) – 11 hours of Free electives/12 Restricted
Potential Microbiology Synergies/interactions

Microbiology Major

Core Curriculum (with Micro A & P MB 251)

Applied/Industrial Track

Food Microbiology Lecture + Lab (FS [MB] 405/06)

Industrial Microbiology Lecture (BAE [MB] 425)

Microbial Biotechnology Lecture (MB 455)

Metabolic Regulation Lecture (MB 414)

Microbial Diversity Lecture + Lab (MB 451)

Seminar in Microbiology Lecture (MB 490)

Medical Professions Track

Microbial Molecular Biology Lecture + Lab (MB 3XX)

Human Infectious Diseases Lecture (MB 4XX)

Immunology Lecture (MB 441)

Molecular Virology Lecture (MB 461)

Diagnostic Microbiology Lecture & Lab (MB 4XX)

Human Biology Concentration

Microbial Molecular Biology MB XXX

Human Infectious Disease MB 4XX

Immunology MB 441

Molecular Virology MB 461

Diagnostic Microbiology MB 4XX

Master’s of Microbial Biotechnology MMB/MBA Program

BTEC Facility Activities
Appendix N

MB 3XX Microbial Molecular Biology

Goals: Course will address the important role of molecular biology (broadly defined) in modern microbiology and its impacts on other biological sciences. The lecture course will relieve existing MB 351 of currently compromised coverage of these important issues. Laboratory class will provide students in MB major important exposure to theory and practice in molecular biology. This is expected to have further benefits for higher-level MB classes and impact preparation of MB students for research experiences as Juniors and Seniors.

Course Topics:

- The role of microbes in the development of molecular biology
  - Overview of molecular biology
  - Importance of microbes to the development of molecular biology

- Fundamentals of microbial molecular biology
  - Information flow from gene to protein
  - Microbial DNA structure
  - Microbial processes of replication, transcription, and translation

- Microbial mechanisms of gene expression control
  - Role of sigma factors
  - Role of transcription factors, repressors, and activators
  - Role of regulatory RNA
  - Role of post-transcriptional control mechanisms

- Microbial genetics
  - Mutagenesis and recombination
  - Methods of genetic exchange in microbes

- Microbial genomics
  - Organization of microbial genomes
  - Bioinformatic analyses of microbial genomes
  - Experimental evaluation of gene function and regulation
    - Microarray analysis
    - Proteomic analysis

- Microbial-based genetic engineering
  - Techniques of genetic engineering
  - Practical applications for genetic engineering
Appendix N

MB 3XXL Microbial Molecular Biology Laboratory

**Goals:** The aim of the laboratory class will be to provide students with hands-on experience in a number of mini-experiments broken into 2-3 week modules. These modules will reinforce the major concepts in microbial molecular biology including gene structure, regulation and transfer mechanisms. Students will also gain hands on experience with modern molecular approaches such as RT-PCR, cloning strategies and analytical methods such as SDS-PAGE and other forms of gel electrophoresis. Students that successfully complete this course will be well prepared for other MB courses with strong practical molecular emphases (MB 411/412 Medical Microbiology and MB 451 Microbial Diversity) as well as research projects in faculty laboratories.

**Laboratory Course Content:**

- **Module 1:** Analysis of microbial gene expression using a regulated *lacZ* fusion
- **Module 2:** Dissemination of antibiotic resistance to experimentally demonstrate microbial genetic exchange
- **Module 3:** Use of Real-time PCR analysis to monitor changes in gene expression
- **Module 4:** Cloning and expression of recombinant thermostable enzymes