Muhlenberg College

Biology Majors Handbook

2004-2005

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I. INTRODUCTION

Welcome to the Muhlenberg College Biology Department! You have chosen a major that investigates a broad area of knowledge: the theories and mechanisms that provide an understanding of life in all its beauty and complexity. It is an appreciation of these themes that has drawn the Faculty and Staff of the Department to devote their careers to education and research in the Biological Sciences. We hope to share this with you, and perhaps even infect you with some “biophilia” in the process.

The purpose of this handbook is to provide a resource for Biology majors as you proceed through your college education. The following pages identify the Faculty and Staff of the Department, describe courses, the major, research efforts, special opportunities, and provide resources for career planning. Read through this handbook, as it provides answers to frequently asked questions. It will help you devise a plan of study appropriate for your interests and goals, and call your attention to opportunities in the Department. You may also obtain additional information from the Biology Department’s website (**http://www.muhlenberg.edu/depts/biology/**).

II. DEPARTMENT FACULTY AND STAFF

This section provides you of some sense of who we are, professionally. Additional information, including quirks and hobbies, can be found on our individual web pages linked to the main Biology Department web page.

FACULTY

Dr. Mary Constant Byrne, Lecturer
Ph.D. Temple University
Room 101 x3632
Areas of expertise: physiology, anatomy, neurobiology

Prof. Chrysan Cronin, Lecturer/Microbiologist
M.S. New Mexico State University
Room 125 x3524
Areas of expertise: microbiology

Dr. Marten Edwards, Assistant Professor/Cell Biologist
Ph.D. University of Arizona
Room 226 x3252
Areas of expertise: cell biology, entomology, molecular biology

Dr. Amy Hark, Assistant Professor/Molecular Biologist
Ph.D. Princeton University
Room TBA TBA
Areas of expertise: biochemistry, genetics, plant molecular biology

Dr. Erika Iyengar, Assistant Professor/Ecologist
Ph.D. Cornell University
Room 319 x3731
Areas of expertise: ecology, marine biology, evolutionary biology

Dr. Daniel Klem, Jr., Professor/Ornithologist
Sarkis Acopian Professor of Ornithology and Conservation Biology
Ph.D. Southern Illinois University at Carbonale
Room 07 x3259
Areas of expertise: ethology, ornithology, biometrics

Dr. Elizabeth McCain, Associate Professor/Developmental Biologist
Ph.D. University of Texas
Room 225 x3255
Areas of expertise: developmental biology, electron microscopy

Dr. Paul Meier, Assistant Professor/Physiologist
Ph.D. Ohio University
Rooms 104/319 x3250
Areas of expertise: physiology, anatomy, physiological and behavioral ecology

Dr. David Much, Professor/Microbiologist
Ph.D. Jefferson Medical College
Room 224 x3256
Areas of expertise: microbiology, immunology, infectious disease

Dr. Richard Niesenbaum, Head of the Dept./Associate Professor/Ecologist
Ph.D. University of Pennsylvania
Room 305 x3258
Areas of expertise: ecology, botany, ethnobotany, conservation biology

Dr. Carl Oplinger, Professor/Ecologist
Ph.D. Cornell University
Room 312 x3257
Areas of expertise: ecology, zoology

Dr. Irvin Schmoyer, Professor/Cell Biologist
Ph.D. Purdue University
Room 126 x3802
Areas of expertise: cell biology, genetics

Dr. W. Robert Stamper, Lecturer
Ph.D. Penn State University
Room 125 x3524
Areas of expertise: invertebrate physiological ecology, human physiology, earth sciences

Dr. Jeremy Teissere, Assistant Professor/Neuroscientist
Ph.D. University of Wisconsin
Room 222 x 3617
Areas of expertise: neuropharmacology, structural biology

Prof. Yung Margaret Tsao, Lecturer
M.S. Syracuse University
Room 101 x3249
Area of expertise: bioremediation

Dr. Bruce Wightman, Associate Professor/Molecular Geneticist
Ph.D. Harvard University
Room 211 x3254
Areas of expertise: genetics, molecular biology, neuroscience, developmental biology

STAFF

Diane Dologite, Lab Manager/Chemical Hygiene Officer
Room 125 x3618

Sheila Mathieson, Lecturer and Research Technician
Room 216 x3948

Mrs. Helen Spengler, Secretary
Room 102 x3251

III. BIOLOGY COURSES

This section provides information on each of the courses offered by the Biology Department. Complete descriptions of each course are listed in the course catalogue and on the Biology web pages. Some courses may not be offered every year due to instructor sabbaticals or enrollment changes. If there is a course you are really committed to taking, you should consult the instructor to determine if it will be offered in the year you intend to take it.

BIO-100 through BIO-149 Concepts of Biology
Instructors: Cronin, Iyengar, Klem, Much, Niesenbaum, Schmoyer, Stamper, Tsao
Includes *Animal Behavior, Biology of Birds*, *Biodiversity*, *From the Bubonic Plague to AIDS*, and *Oceanography*.
These are non-majors courses.
Offered every semester.

BIO-200 Human Anatomy & Physiology I
BIO-201 Human Anatomy & Physiology II
Instructor: Byrne
Intended for students majoring in Psychology or planning careers in the allied health fields (such as Physician's Assistant and Physical Therapy). Note that this course is a non-majors course. Biology majors interested in anatomy and physiology should roster BIO-245 and BIO-250.
Offered Fall and Spring semesters, respectively, in alternate years.
Next offered in Fall 2004 and Spring 2005.

BIO-150 Principles of Biology I: Organisms and Populations
Instructors: Iyengar (2005), Niesenbaum (2004)
The first semester of the Biology core course for majors.
Offered every Fall semester.

BIO-151 Principles of Biology II: Cells and Organisms
Lecture instructors: McCain (2005) and Meier (2004)
Lab instructors: Byrne, Cronin, Tsao
The second semester of the Biology core.
Prerequisite: BIO-151
Offered every Spring semester.

BIO-152 Principles of Biology III: Molecules and Cells
Lecture instructors: Edwards (2004), Hark (2005) and Wightman (2004)
Lab instructors: Bryne, Cronin, Tsao
The third semester of the Biology core.
Prerequisite: BIO-151; CHM-103; CHM-104
Offered every Fall semester.

BIO-205 Cell Biology
Instructor: Edwards
Prerequisite: BIO-152
Offered every Fall semester.

BIO-215 Genetics
Instructor: Wightman
Prerequisite: BIO-152
Offered every Spring semester.

BIO-220 Biochemistry
Instructor: Hark
Prerequisites: BIO-152 and CHM-201 or CHM-203
Offered every Spring semester.

BIO-225 Microbiology
Instructor: Much
Prerequisite: BIO-152 or permission of instructor
Offered every Fall semester.

BIO-230 Botany
Instructor: Niesenbaum
Prerequisites: BIO-152 or permission of instructor
Not currently offered.

BIO-235 Invertebrate Zoology
Instructor: Iyengar
Prerequisite: BIO-152 or permission of instructor
Offering Spring 2005.

BIO-240 Developmental Biology
Instructor: McCain
Prerequisite: BIO-152
Offered every Fall semester.

BIO-242 Entomology
Instructor: Edwards
Prerequisite: BIO-152
Offered every Spring semester.

BIO-245 Comparative Anatomy
Instructor: Byrne
Prerequisite: BIO-152
Offered every Spring semester.

BIO-248 Neurobiology
Instructors: Teissere
Prerequisite: BIO-152
Offered every Spring semester.

BIO-250 General Physiology
Instructor: Meier
Prerequisite: BIO-152
Offered every Fall semester.

BIO-255 Ornithology
Instructor: Klem
Prerequisite: BIO-152 or permission of instructor
Offered every Fall semester.

BIO-260 Field Botany and Plant Ecology
Instructor: Niesenbaum
Prerequisite: BIO-230 or permission of instructor
Offered every Fall semester. Not offered Fall 2003.

BIO-262 Cultural and Economic Botany
Instructor: Niesenbaum
Prerequisite: BIO-152 or permission of instructor
Offered Spring semester, in alternate years. Not offered Spring 2004.

BIO-265 Ethology (W)
Instructor: TBA
Prerequisite: BIO-152 or permission of instructor
Not currently offered.

BIO-270 Ecology
Instructor: Iyengar
Prerequisite: BIO-152 or permission of instructor
Offered every Spring semester.

BIO-272 Marine Biology
Instructor: TBA
Prerequisite: BIO-152 or permission of instructor
Not currently offered.

BIO-275 Investigations in Field Biology
Prerequisite: BIO-152
May be offered every semester, by special arrangement.

BIO-305 Cell Biology II
Instructor: Edwards
Prerequisite: BIO-205
Offered in Spring semester.

BIO-326 Medical Microbiology
Instructor: Much
Prerequisite: BIO-225
Offered in Spring semester.

BIO-335 Immunology (W)
Instructor: Much
Prerequisite: BIO-152
Offered every Spring semester.

BIO-350 Applied Physiology
Instructor: Cronin
Prerequisite: BIO-250
Offered every Fall semester.

BIO-360 Histology
Instructor: McCain
Prerequisites: BIO-152, and one of the following: BIO-205, BIO-245 or BIO-250
Offered every Spring semester. May not be offered Spring 2005.

BIO-412 Molecular Biology (W)
Instructor: Wightman
Prerequisite: BIO-152 and at least one of: BIO-205, BIO-215, BIO-220 or BIO-225
Offered every Fall semester. Not offered Fall 2003.

BIO-421 Transmission Electron Microscopy (W)
Instructor: McCain
Prerequisites: BIO-152, CHM-202 and at least two 200 or 300 level biology courses
Offered in Spring semester, in alternate years. Next offered Spring 2004.

BIO-423 Scanning Electron Microscopy (W)
Instructor: McCain
Prerequisites: BIO-152, CHM-202 and at least two 200 or 300 level biology courses
Offered every Fall semester.

BIO-460 Physiological Ecology (W)
Instructor: Meier
Prerequisite: BIO-152 and two 200 level Biology courses or permission of instructor
Offered every Fall semester.

BIO-465 Conservation Biology
Instructor: Niesenbaum
Prerequisite: BIO-260 or BIO-270 or permission of instructor
Offered every Spring semester. Not offered Spring 2004.

BIO-470 Evolution (W)
Instructor: Iyengar
Prerequisite: BIO-152, additional 200 level courses desirable
Offered every Spring semester.

BIO-960 Biology Internship
Majors are eligible for internship programs with the approval of the department head.
Offered every semester.

BIO-970 Biology Independent Study
Open to qualified students with the approval of the department head.
Offered every semester.

BIO-980 Biology Research
See following section on Research.
Offered every semester.

W= Currently-designated *writing-intensive* course

SPECIAL TOPICS COURSES IN BIOLOGY

The Biology Department offers various courses under this number on a temporary or experimental basis. Some Special Topics courses *may* count toward the Biology major, but you should not assume they do. Seek guidance from your advisor or the Department Head.

IV. THE BIOLOGY MAJOR

ORGANIZATION

The purpose of the Biology Major is to introduce students to the field of Biology. Accordingly, the Biology Department emphasizes training in all areas of the discipline. You should major in Biology if your primary areas of interest lie within the breadth of modern biological sciences. The major is *not* designed to train students for a specific discipline or profession *per se* (*e.g.* physician, physical therapy, molecular biologist, ecologist). Put another way, the Biology major is *not* a "Pre-Med" major. No such major exists at Muhlenberg and students interested in careers in the Health Professions can and do major in a variety of areas, including Chemistry, Physics, Psychology, Economics, and Philosophy. Thus, the Biology major emphasizes a broad training in biology: one that will allow students to be prepared for graduate study or employment in a variety of areas.

The field of Biology is arguably the most diverse of the natural sciences. For example, Biologists study the way organisms and populations interact with the environment (ecology), the way the human respiratory system works (physiology), and the mechanism by which HIV invades human T cells (molecular biology). The Biology major emphasizes the breadth of biology, while at the same time providing opportunities for advanced study in specific areas. Thus, in the Biology Department we have organized our course of study around what we consider the *three* major areas covered by Biology. These are: population biology and ecology; organismal and developmental biology; and cell and molecular biology. In accordance with the twin goals of breadth and depth, students majoring in Biology are required to gain experience in each of the three major areas of biology, and also choose a logical progression of courses to allow a deeper understanding of a particular area of biology. Configuring your own curriculum within the Biology major is the subject of a later section.

You should also note that a Biology major is more than a collection of courses. As described in later sections, there are many opportunities to enrich your educational experience, including research in the Biology Department, internships, special field experiences and research at other institutions. Think creatively about how to configure your major given your interests and goals! Experience is an extremely valuable component of your curriculum.

COURSE REQUIREMENTS

A Biology major consists of a minimum of 14 courses: 5 cognate requirements and 9 biology courses. No Biology courses numbered in the 100's, except Biology 150-152 can be used to fulfill the Biology major requirements.

Cognate requirements: A Biology Major requires completion of five courses offered by other Departments. These courses are required so that all Biology majors gain exposure to scientific inquiry in other disciplines and from other perspectives. Note that the cognate requirements are *not* the same as prerequisites. For example, all Biology majors must take Organic Chemistry, even if they never take a Biology class that requires a knowledge of organic chemistry.

All Biology Majors should complete these courses by the end of their junior year.

CHM-103 General Chemistry I
CHM-104 General Chemistry II
CHM-201 Organic Chemistry I or CHM-203 Honors Organic Chemistry I
MTH-121 Calculus
PHY-211 General Physics

Students expecting to advance to graduate or professional study after graduation should take a full year of Organic Chemistry and General Physics.

Biology core: All Biology Majors must complete a three semester introduction to the discipline of Biology, normally in the first three semesters.

BIO-150 Principles of Biology I: Organisms and Populations
BIO-151 Principles of Biology II: Cells and Organisms
BIO-152 Principles of Biology III: Molecules and Cells

Breadth requirement: All Biology Majors must complete at least one course in each of the three major areas of Biology.

GROUP ONE
Cell and Molecular Biology

BIO-205 Cell Biology
BIO-215 Genetics
BIO-220 Biochemistry
BIO-225 Microbiology

GROUP TWO
Organismal and Developmental Biology

BIO-235 Botany
BIO-240 Developmental Biology
BIO-242 Entomology
BIO-245 Comparative Anatomy
BIO-248 Neurobiology
BIO-250 General Physiology

GROUP THREE
Ecology and Population Biology

BIO-255 Ornithology
BIO-260 Field Botany and Plant Ecology
BIO-262 Cultural and Economic Botany
BIO-265 Ethology
BIO-270 Ecology
BIO-272 Marine Biology
BIO-275 Field Investigations in Biology

Depth requirement: All Biology Majors must complete *at least* three *additional* Biology courses numbered 200 or higher (except BIO-200, BIO-201, and BIO-960). These courses should be selected according to your interests and career goals, in consultation with your advisor. The next section is dedicated to providing some guidance in configuring a curriculum that is appropriate for your interests. Note that a given course *cannot* count for both the "Breadth" requirement *and* the "Depth" requirement. Thus, all Biology Majors must complete a minimum of 6 courses numbered 200 or higher. Internships may *not* be counted as a course for completion of the Biology Major requirements. Only <u>one</u> semester of Research <u>or</u> Independent Study may be counted toward Biology Major requirements.

Note that you must complete a "writing-intensive course designated by the major" in accordance with the general academic requirements of the college. Normally, this will be one of the "W" Biology courses described in the previous section. A course *may* count for *both* W credit and either the "Breadth" or "Depth" requirements of the major.

Investigative experience: All Biology Majors must complete *at least* one 400-level course. This course is counted among the three additional Biology courses listed under "Depth" in the box above. These courses are smaller seminar-style experiences that focus on student-directed inquiry.

ELECTIVE SELECTION

You should give careful thought to the selection of upper-level (200 or higher) Biology courses as you prepare your curriculum. Your major should be specifically tailored to match your goals and interests. It should *not* be a random collection of Biology courses selected without rhyme or reason. Come up with a long-term plan of which courses you will take in each remaining semester and share it with your advisor. He or she will discuss your choices with you and help you select which courses match your specific interests and goals. If you have questions about specific courses, contact the instructor who teaches that course. He or she can discuss how that course will match your interests and support your goals.

Here are a few examples:

1. Jack is interested in studying plant ecology in graduate school. He takes three semesters of Principles of Biology during the first three semesters. During the second year, he starts an independent research project. He enrolls in Field Botany and Plant Ecology in the fall of his second year, thus fulfilling his group 3 breadth requirement and advancing his knowledge in his area of interest. In spring of his second year, he decides to fulfill his group 2 breadth requirement by taking Botany, and also takes Physiological Ecology, because this project-oriented course will expand his scientific repertoire and aid in preparation for graduate school. In the fall of his third year, Jack enrolls in both Ecology and Ornithology, as they reflect his area of interest. In the spring of his third year, Jack enrolls in Genetics, because his sophistication about the study of plant ecology will be enhanced by an understanding of genetic techniques and perspectives. In the fall of his senior year, he initiates a Biology honors project and enrolls in Evolution and Cultural and Economic Botany. In the spring he enrolls in Scanning Electron Microscopy and performs an electron microscopic study of tobacco root branching patterns. Jack has made full use of his education in Biology and configured a curriculum that makes sense!

2. Jill wants to join the fight against HIV some day. After completing Principles of Biology during her first two years, she enrolls in Biochemistry during the Spring of her second year to establish the molecular foundation necessary for her area of interest. She has also fulfilled her group 1 requirement. In the Fall of her third year, Jill enrolls in General Physiology to fulfill her group 2 requirement because this course will help her understand the physiological context in which HIV infections occur. In the Spring of her third year, Jill enrolls in Genetics and Molecular Biology, as both courses support her interests. During the summer after her junior year, Jill performs research at a medical school. In the fall of her senior year, Jill enrolls in Histology to further her training in relevant skills and initiates a senior Honors project. The following spring she completes her Biology major by enrolling in Cultural and Economic Botany, because the cultural component will help her appreciate herbal approaches to treatment of AIDS symptoms, and Immunology. Again, Jill has achieved the necessary breadth and depth in her education and will graduate as a well-trained and well-rounded individual.

3. Wolfgang decides to major in Biology, even though he's not sure what specific area interests him most. He thinks he wants to go to medical school and consults with the Health Professions office to configure his overall curriculum in accordance with that goal. He completes Principles of Biology during his first three semester. In the spring of his second year, Wolfgang enrolls in Genetics and completes his group 1 breadth requirement, choosing this particular course because of its relevance to medicine. During the next summer, Wolfgang spends two months in the Caribbean with his family exploring coral reefs and discovers his true love: he wants to become a Marine Biologist! He returns to Muhlenberg and changes his curriculum to reflect his newly-discovered passion. In the fall, Wolfgang enrolls in Ecology and Developmental Biology to establish his study of his new area of interest (and simultaneously fulfills the group 3 breadth requirement). During the Spring of his junior year, Wolfgang takes Marine Biology. Given his scientific focus, Wolfgang arranges an independent research project for his senior year, and rounds out his education by enrolling in Ethology and Conservation Biology. Wolfgang's made good use of his biology major, even with changing his area of focus midway.

4. Unlike Wolfgang, Zoe has always known she was meant to be a physician. She decides to double-major in Biology and English and consults with the Health Professions office. After completing Principles of Biology in her first three semesters, Zoe begins planning her Biology major, bearing in mind the requirements of a pre-medical curriculum and an additional major. Zoe enrolls in Biochemistry in the spring of her sophomore year, given its relevance to medicine, thus completing her group 1 breadth requirement. The following fall, she enrolls in General Physiology and Microbiology, thus completing her group 2 requirement and advancing her study in areas relevant to her goals. During the spring semester, Zoe also performs an internship at a nearby hospital. Finally, in her senior year she takes Histology to further her preparation for medical school, and Ecology to fulfill her group 3 requirement. She chooses Ecology because an understanding of the connections between organisms and environment is essential for clinical toxicology. During her last semester, she completes her Biology major by enrolling in her 400-level course, Molecular Biology. Zoe has also made good use of her Biology education, even though she has enrolled in fewer Biology courses than the other students in order to allow her double major.

You should note that the curricula of each of these fictional students are only *examples* of good ways of selecting courses in the Biology major. The courses that are appropriate for your particular goals should be determined by you and your advisor.

BIOLOGY SEMINAR SERIES

Being a Biology Major means more than sitting in a bunch of Biology classes. Among other things, it means participating in the life of the Department. One way that you can do this is by attending the Biology Seminar Series on a regular basis. Seminars are short talks on biology or medicine given by a student or visiting scientist on Tuesday or Thursday afternoons at 4:30 PM in Shankweiler 109. Look for postings and listen for announcements in your classes. The schedule is also posted on the Biology Web page. In addition to learning about things that aren't covered in your classes, you will gain insight into how science is actually performed, and maybe get a lead for an excellent internship or make a contact that will be helpful to you later on. You will also be able to enjoy cookies and juice, courtesy of the Department.

V. RESEARCH IN BIOLOGY

Your professors aren't only teachers: we're also trained scientists with particular research interests. The faculty members of the Department are committed to undergraduate research and want to engage your interest and efforts in research in Biology. A research experience is an extremely important aspect of an undergraduate curriculum. Many graduate schools require significant undergraduate research experience, and some of the best may actually expect an incoming student to have a publication already. Moreover, a research experience is extremely helpful for educational purposes as well: you will become more confident of the knowledge you learn in classes if you actually design and perform real experiments.

There are two ways to become involved in research in the Biology Department. First, you can perform research for academic credit during either academic semester. Anyone can receive 0.5 or 1.0 course unit for performing research by registering for BIO-980. Second, you can perform research on a part-time or full-time basis during the summer. In some cases, you may be paid a stipend to perform research and/or receive free housing from the college. In addition, you can earn credit for summer research by enrolling in the college's summer session.

If you are interested in performing research, you should seek out faculty members who would be appropriate mentors for your project at least a half-semester *before* you want to do research. Note that in most cases, you don't have to actually *have* a specific project in mind. A project may be suggested by your faculty mentor, or emerge through your conversations with him/her. Read the research descriptions that follow, and consult the Biology web pages to identify faculty members whose interests match yours.

BIOLOGY RESEARCH PROGRAMS

Dr. Edwards

Mosquito-borne diseases including malaria, dengue and yellow fever are among the most serious threats to worldwide human health. My research interests are focused on the molecular interactions between mosquitoes and the pathogens that they transmit. The cell and molecular biology of mosquitoes has a direct impact on how well these insects can spread diseases that kill approximately two million people each year. One approach to investigating the interface between mosquitoes and pathogens is to experimentally express foreign genes in the mosquito after she takes a blood meal from an infected host. The protein-products of these genes can target specific molecules on the surface of the pathogen. Using transgenic methods, these genes can be transferred into the mosquito genome. My students are investigating molecular aspects of mosquito reproduction and LaCrosse encephalitis virus transmission. LaCrosse virus is unusual in that it can be propagated within mosquito populations through the eggs (transovarial transmission). Three days after a blood meal, the female mosquito lays about 150 eggs. We are linking the ovary-specific promoters to a human gene (MxA), which shows extremely strong antiviral activity against LaCrosse virus. This construct will be inserted

into the mosquito genome using the Hermes transposable element. When these transgenic mosquitoes take a blood meal, they are expected to interfere with the replication of the virus in their ovaries, which would block transovarial transmission.

Dr. Hark
Dr. Hark's research focuses on the molecular genetics of plant development. Contact her for more details.

Dr. Iyengar
My research interests center on the evolutionary ecology of invertebrates, particularly marine organisms. I am primarily interested in investigating the behavioral ecology of feeding, defense and competition in these animals. I have investigated the specificity of inducible defenses in bryozoans and chemical defenses of echinoderm eggs and larvae. Most recently, I am investigating the overarching question of why suspension feeding is rare in marine snails. Suspension feeding is one of the dominant feeding modes in aquatic systems and mollusks are a diverse and evolutionarily plastic group. It is puzzling that, despite originating multiple times within marine snails, suspension feeding remains a comparatively rare feeding mode in this taxon. What is preventing species radiation within suspension feeding snails? *Trichotropis cancellata* is a marine snail that is a facultative kleptoparasite, able to feed independently as a suspension feeder and to steal food from tube worms (kleptoparasitism). When parasitizing, this snail steals food literally from the mouth of its host. Through biogeographic surveys and experimental manipulations I studied the prevalence, benefits and trade-offs of suspension feeding and kleptoparasitism in *Trichotropis*, to identify potential factors promoting the shift from suspension feeding to kleptoparasitism. I plan to continue studies using this species and expand my investigations to other suspension feeding snails, such as the turritellids. In a separate research pursuit, this summer I will begin intertidal studies off the coast of Maine, investigating competitive dominance and spatial competition among marine invertebrates. At Muhlenberg, I also am interested in establishing research projects investigating interspecies interactions in freshwater systems (streams and ponds) and the impacts of human activities on riparian ecosystems. Human-mediated change in aquatic environments has escalated, often unrecorded. Increased use of public coastlines and exponentially-increasing ship effluent and pollutant run-off are some of the factors affecting the health of marine species and the interactions among those species. Increased sediment and nutrient run-off and thinner riparian zones have threatened freshwater species. Experimental studies and basic monitoring programs to establish baseline data and track changes are desperately needed, especially in temperate areas where these topics have received less attention. Although my personal research interests lie in aquatic systems, I am happy to advise students who are interested on a diverse array of questions, especially those in animal behavior, ecology or evolution.

Dr. Klem
My research interests are generally in the natural history of animals, and more specifically in the biological disciplines of biometrics, conservation biology, environmental science, ethology (biological study of behavior), ornithology, and wildlife

mortality resulting from the actions of man. Most of my studies contribute to each of these disciplines, but one common component of them all is the study of birds. I am primarily an ornithologist, and I welcome students interested in conducting research on birds in the field, in my laboratory, or in our working museum. Students do not have to be interested in a career in ornithology or field biology to be apart of investigations associated with me. Several students who are currently dentists, physicians, and veterinarians have worked on an ongoing long-term research program describing and analyzing the morphology and histology of the avian alimentary tract in my laboratory. A number of students have participated in museum curation projects; the department has an extensive ornithological collection and my work with human-associated avian mortality brings in a continuous supply of new specimens. My studies include several research questions that address the behavior, migration, and population dynamics of birds of prey and seabirds; these are active and productive areas for students having a research interest in these taxa. A valuable tool for our seabird ecology studies is a modest (6 m) research vessel, moored in Wildwood, New Jersey. Another prominent area of expertise, a topic in need of continuous investigation, and one especially relevant to avian conservation worldwide is the devastating numbers of birds that are killed and injured striking sheet glass in human structures. Research students working with me also have the option of conducting some or all of their investigation at remote sites where I have collaborative research colleagues at the Hawk Mountain Sanctuary in nearby Kempton, Pennsylvania, and The Wetlands Institute in Stone Harbor, New Jersey. Depending on future opportunities, additional research students could participate in extended studies of the birds of Armenia. Our work studying the birds of Armenia is to contribute to a conservation ethic in this former Soviet Republic, and to promote responsible land management, using birds as biological indicators, to ensure environmental health for all life, especially human.

Dr. McCain

My research interests are centered on the field of developmental biology, or the study of embryonic development, and my "subjects" are generally marine invertebrates. I've done research on clams, sea urchins, marine snails, and marine worms. Currently, I'm interested in a single species of marine worm that lives along the muddy coast of North American and can be easily collected with a scoop and a sieve. What is so remarkable about this tiny worm (it is only about a centimeter long) is that there are two unique populations which each exhibit a different form of early development. One group, which primarily lives along the east coast, bears small zygotes that develop into a larvae. The larvae, which bear little resemblance to the adults, swim around in the water until they are ready to metamorphose into the adult form; they are called indirect developers or planktotrophs. The other group, which primarily inhabits the west coast, produces large eggs that, after fertilization, develop directly into the miniature form of the adult; they are called direct developers or lecithotrophs. It is extremely rare to find any species that possess both modes of development. I am interested in documenting the developmental and cellular differences between the two embryonic forms using various techniques such as immunofluorescence, scanning and transmission electron microscopy. In the future I hope to examine differences in gene expression. My other research interests essentially follow the interests of my students, many of whom have taken the scanning

or transmission electron microscopy courses. Once they have completed either of these courses, they have been bitten by the research "bug" and can't give it up. Here are some examples of projects that I have worked on with Muhlenberg College students: the toxic effects of Streptolysin O on Feline Red Blood Cells, the morphology of mycorrhizae exposed to different soil conditions, the ultrastructure of chipmunks' small intestine and the process by which the epithelial cells are removed, *C. elegans* axonal guidance and growth, cardiac muscle development in chicken embryos, the effects of toxins on chicken development, and the process by which the mouth forms in sea urchin embryos.

Dr. Meier
My research investigates the effects of behavior and physiology on shaping the social and genetic structure of vertebrate populations. Students have worked with me on projects involving mammals, birds, and amphibians. A major focus in my lab recently is on the relative influence of migration and adaptation on local scales on the genetic structure of wood frogs, *Rana sylvatica.* The genetic structure of wood frogs is studied using microsatellite analyses. The adaptation of the frogs to local habitats is being examined by measuring the relative influence of environment and heritability on their development during the tadpole stage. The research is related to a growing and exciting area of biology that combines evolutionary and ecological theory to the understanding of development. Other recent student projects on my lab include a study on parental investment in bluebirds, *Sialia sialis*, that combines observation and radio telemetry, and scent communication in chipmunks, *Tamias striatus*.

Dr. Much
My research interests lie in the areas of infectious disease and public health. I have organized and directed a health and education outreach program for migrant farm workers. This program provided testing for tuberculosis and sexually transmitted diseases (STDs), as well as cardiovascular assessment, anti-smoking education, weight control, and practicing safe sex. My current research project involves the study of three populations: patients attending an STD clinic, a substance abuse clinic and migrant farm workers. The purpose of this study is to identify populations at greatest risk for each of these infectious diseases. With this information, medical intervention programs can more effectively use their limited resources.

Dr. Niesenbaum
In my lab we focus on two distinct, but related areas: plant ecology and international conservation and sustainable development. In plant ecology, we have worked on pollination and fruit set; genetics of inbreeding; mechanisms of non-random mating in plants; sex ratio variation; plant-animal interactions, and plant conservation biology. The two species that we primarily work with are *Lindera benzoin* and *Mirabilis jalapa*. Our most recent efforts in plant ecology have focused on factors that affect plant defensive chemistry and insect herbivory. In the area of international conservation and sustainable development, we are collaborating with the International Programs Department at the Rodale Institute on measuring the success of sustainable forestry and agricultural practice in northern Guatemala. In collaboration with Dr. Tammy Lewis

(Sociology) we are looking at connections between environmental policy, watershed health, and public health in Costa Rica. Dr. Lewis and I are also doing and assessment of conservation education in the US. We also work with Geographical Information Systems (GIS) and Global Positioning Systems (GPS) in our studies of ecology and conservation. Finally, a number of my students conduct research at the interface between environment and human/public health, including research on medicinal plants or ethnobotany. Students who have interest in doing research in any of these areas, and are willing to make the commitment that I expect from all of my research students are encouraged to contact me!

Dr. Oplinger
I have guided student research primarily in the areas of aquatic ecology. Students have engaged in projects ranging from plankton abundance and distribution in shallow ponds at Graver Preserve, salamander population ecology at Hawk Mountain Sanctuary to Japanese crab invasions on jetties at the Wetlands Preserve in NJ. My own scholarly work for the past decade has focused on broad-based natural history studies, first in the Poconos and most recently in the Lehigh Valley. I lead field trips to the Bermuda Biological Station where I have investigated the competitive interaction of two species of mud crabs as time permits during the field session.

Dr. Schmoyer
My lab is currently looking at the chromosome complement in Rett Syndrome cells. Rett syndrome is a rare condition found only in females, causing them to begin a neurological degeneration at approximately 18 months of age. It may be due to a translocation of the X chromosome to an autosome, causing a dosage effect. Mitochondria may also be involved.

Dr. Teissere
How are synaptic chemical signals transduced within the nervous system? How do drugs bind to and activate their receptor targets? The long-term goal of my research is to understand how the biochemical properties of a neurotransmitter receptor, the γ-aminobutyric acid Type A ($GABA_A$) receptor, underlie its functional behavior. The $GABA_A$ receptor is the major inhibitory neurotransmitter receptor in the mammalian central nervous system, and thus, $GABA_A$ receptors are powerful mediators of inhibitory tone in the brain. The $GABA_A$ receptor is also a target for many neuroactive drugs, (e.g., benzodiazepines, barbiturates, ethanol, volatile anesthetics) and neurohormones (e.g., progesterone, allopregnanolone). Although the basic functional role of this receptor is well-understood, little is known about how the structural elements of the receptor coordinate GABA binding, channel opening, and sensitivity to modulators. Additionally, a paucity of information exists about the cellular proteins that regulate $GABA_A$ receptor assembly, trafficking to the cell membrane, and downregulation. I use a multidisciplinary approach, including biochemical, molecular biological, pharmacological and physiological approaches, to examine these poorly understood properties. I am specifically interested in three lines of research: (1) resolving, at a molecular level, how neuroactive drugs interact with the $GABA_A$ receptor; (2) identifying the specific binding site for neurohormones on the $GABA_A$ receptor; and (3) identifying

novel protein associations of the $GABA_A$ receptor that contribute to assembly, trafficking, and physiology. This research has been supported by a variety of fellowships from the NIMH.

Dr. Wightman

My research interests lie in understanding how the brain gets created. During the development of most animals, a wide variety of different types of neurons are generated. Each of these neurons must make the correct circuits, and expressed the proper neurotransmitters and receptors. My lab is using a molecular genetic approach to identify and study genes in the nematode worm *Caenorhabditis elegans* that are involved in specifying unique identities of neurons during embryogenesis. We have cloned a gene called *fax-1* that is required for the proper development of certain types of neurons. The gene encodes a protein that is a member of the superfamily of nuclear hormone receptors, which function by controlling the transcription of other genes. The human version of *fax-1*, called PNR, functions in the generation of photoreceptor cells in the retina. Mutations in human PNR are a cause of inherited retinal degeneration and blindness. Because *fax-1* is a nuclear hormone receptor, it is likely to bind to DNA and regulate the transcription of other genes. Some of these "downstream" genes may be the direct mediators of neuron identity. My students are currently unraveling this and other related questions. The molecular genetic analysis of neural development in *C. elegans* offers a number of advantages for an undergraduate research program. First, the techniques can be mastered quickly. Second, the nematode's short generation time allows experiments to be done quickly, within the confines of the academic year. Finally, it allows students to be involved in an exciting, growing field that is relevant to understanding the biological basis of behavior.

VI. BIOLOGY HONORS PROGRAM

A student may work for honors by conducting research with a Biology Department faculty mentor for two semesters during the senior year. Acceptance into the honors program is selective and based on the following criteria:

1) A minimum GPA of 3.5 in Biology Department courses.
2) Approval of a proposal and application submitted to a Biology Department Faculty Member in the Spring of the Junior year. The student should work with the faculty member to develop the proposal. The proposal will be reviewed by an Honors Committee.
3) Availability of research positions with a particular faculty member.

Acceptance into the honors program does not mean that honors necessarily will be awarded. The Biology Department will grant honors at commencement to majors who have fulfilled the following conditions:

1) The candidate has met the expectations of two course units of research during the senior year or the summer prior to the senior year. These expectations will be clearly established by the faculty mentor.
2) The candidate has actively participated in the Biology Department seminar program.
3) Submission and review of a senior thesis based on the year's research. The Honors Committee will judge the candidate's thesis based both on the scientific merit of the work and the quality of writing.

In the spring of their junior year, interested students should consult with potential Biology Department faculty mentors about projects in their area of expertise. Projects are limited to field or laboratory studies conducted locally. Off-campus laboratory projects or internships are not suitable. However, this does not prohibit collaborative research that may include an off-campus component. Interested students should submit an application and a written research proposal to the Department via the faculty mentor. Applicants must have a minimum 3.50 GPA in Biology Department courses. The research proposal should be developed in conjunction with the proposed faculty mentor. The application and research proposal will be reviewed by the Biology Department Honors Committee, which is composed of Biology Department faculty members. A limited number of students will be accepted each year. Availability of particular faculty mentors may also govern whether proposals are accepted.

Accepted students (Candidates) perform their research projects over the course of the entire senior year. Candidates are encouraged to initiate their research project during the summer between their junior and senior year. Candidates will register for two full Research credits (BIO-980), entitled Honors Research, either one during the summer and one during the fall, or one each semester. Each Candidate is required to participate in the Departmental Seminar series. Candidates are expected to attend the Biology Department Seminar series regularly throughout their senior year. Each Candidate will also give a seminar, presenting his/her thesis research, most often during the spring

semester. Each Candidate is required to submit a written thesis by the last day of classes spring semester. The thesis should be a 15-30 page paper in standard scientific format. It should address a significant issue, provide background on the subject, give a complete description of the experiments performed, and a discussion of the significance of the results. The thesis will be read by the Biology Department Honors committee, which will make a determination as to whether *Honors*, *High Honors*, *Highest Honors* or no Honors will be awarded to the Candidate on the basis of the thesis. The quality of the Candidate's oral seminar is not evaluated, but participation is mandatory (see above). Students considering the Honors program should note that acceptance into the Honors program does NOT guarantee that Honors will be awarded. The level of Honors awarded to a Candidate will be indicated in the program at graduation and on the official transcript.

GUIDELINES FOR PREPARING HONORS PROPOSALS

These are the guidelines that qualified junior Biology Majors should follow when preparing an Honors Proposal. The guidelines roughly follow those for a proposal to the National Science Foundation. Consult with your research advisor and the College's Writing Center for assistance in preparing your proposal. You should make use of figures, as necessary, and provide citations throughout the body of the proposal. Number all pages consecutively.

- **Cover Sheet:** Includes 1) your name, 2) home and campus address and phone numbers, 3) your Honors Research Advisor's name, 4) signed Academic Behavior Code [1 page].
- **Project Summary:** Provide a brief statement of objectives, methods and significance of the proposed research [1 page MAXIMUM].
- **Project Description**
  - **Background/Prior Results:** review the relevant literature and present any preliminary or prior results [1-3 pages].
  - **Research Plan/Methodology:** describe the study system and specific approaches to testing hypotheses. We recommend breaking this section down by individual research question and provide a description of the methodology for each [1-3 pages].
  - **Significance of Proposed Research:** describe how this study will contribute to general knowledge of biological systems and processes. You may also include a brief statement describing how this research fits with your overall plan of study and career goals [1-2 pages].
  - **Budget:** List major equipment and supplies that must be acquired for the project and approximate costs [1 page].
- **References:** Consult *Writing Papers in the Biological Sciences*, by Victoria E. McMillan for proper format for citations.

GUIDELINES FOR THE MUHLENBERG COLLEGE BIOLOGY HONORS THESIS

General Format:

- All text is double-spaced with the exception of each reference in the Literature Cited and the legends for the figures and tables. The font is 12 point Times Roman
- The top, bottom, and right margins are one inch while the left margin is one and a half inches.
- All headings (i.e. Dedication, Table of Contents, Introduction, etc.) are centered and fully capitalized. Each of these sections begins at the top of a new page.
- Page numbers are centered and a half an inch from the bottom margin. *All pages previous to the first page of the Introduction are lowercase Roman numerals (i, ii, iii, iv, v, etc.); therefore, the first page of the manuscript, the signature page, is considered page i and the first page of the Introduction is page 1. The page numbers, however, are not printed on the pages until after the title page.

Organization:

The sections or separate pages are placed in the following order:

- Signature page*

The signature page has the title, centered and UPPERCASE, and lines for the signatures of the thesis advisor and the Honors Committee members. The latter are right justified.

- Dedication*
- Title page*

The title page contains the title, the author's name, and the following statement: "This thesis was presented to Muhlenberg College in partial fulfillment for the Biology Honors Degree." This is then followed by "Muhlenberg College" and, finally, the month and year of graduation. Each of these five points is appropriately capitalized, centered, and separated by five to ten lines.

- Acknowledgments*
- Abstract*
- Table of Contents*
- List of Figures (with page numbers)*
- List of Tables (with page numbers)*
- Introduction
- Materials and Methods
- Results (with Figures and Tables)

The Figures and Tables are placed within the results section and each requires a separate page. Each Figure is on a right page while the facing page (the back of the previous *blank* page) contains the figure legend. All pages have page numbers, are placed in consecutive order, and positioned nearest to the first point of referral in the Results.

- Discussion
- Literature Cited

See McMillan's *Writing Papers in the Biological Sciences* for the correct format.

An example of the format for each page is available in the Department Office

VII. SPECIAL OPPORTUNITIES IN BIOLOGY

INTERDISCIPLINARY EXPLORATIONS IN COSTA RICA

In this interdisciplinary program, students explore real solutions to the delicate problem of environmental and cultural conservation, using Costa Rica as a model. Students meet regularly during the spring semester to develop projects and prepare for the two week intensive program in Costa Rica at the end of the semester. In Costa Rica, students explore the varied environments of this tropical country, live in and interact with members of a small community, work with conservation professionals, and conduct independent research projects. This program stems from a partnership between Muhlenberg College and the town of Las Juntas (Abangares) in Costa Rica. For more information, contact **Dr. Niesenbaum** or **Dr. Tammy Lewis** (Sociology).

MARINE BIOLOGY IN MAINE

Possible future sites include Washington, Baja California and Bermuda.
Come immerse yourself (literally and figuratively) in marine biology! This course is conducted at the Shoals Marine Laboratory, located on an island off the southern coast of Maine. This intensive field course takes advantage of the diversity of microhabitats in this region, utilizing the abundant intertidal areas to compare rocky outcrops and tidepools to protected areas and shell hash, students snorkel to observe the ecology of shallow water areas, and we perform plankton tows, dredges and trawls to investigate the the water column and seafloor. The course emphasizes the ecology of the invertebrates and algae of this area, through fieldwork, laboratory investigations, and lectures. Topics discussed include zonation, competition, life history strategies and larval ecology. Students gain experience in experimental design, which culminates in their conducting a small experiment of their own. Students are housed in dormitories and scrumptious food is provided through the Marine Labs. The course is conducted over 10-12 days, usually in August and rarely in May. Interested students should contact Dr. Iyengar for more information.

SCIENCE DAY

Science Day is an annual event organized by **Prof. Cronin** in which Muhlenberg students go to a local elementary school and participate in hands-on science activities with the children for an entire school day. Each year, over 100 Muhlenberg students volunteer their time to promote their passion for science by doing fun activities with the children such as DNA extractions, dissection of owl pellets, and making paper and Slime. Other activities involve science investigation and experimentation. The goal is to reach children at an early age when they may not be exposed to hands-on science. Typically, Science Day occurs the week prior to Easter recess. While the majority of students come from the biology department, all students are welcomed to participate in

this popular activity.

STUDENT CONSERVATION ASSOCIATION

This organization operates an extensive Resource Assistance Program throughout the year. These positions are primarily voluntary in that they typically provide room and board and transportation costs to and from the assignment, but no stipend. Assignments range from exotic field sites studying animals like Bald Eagles and Mountain Lions to people-oriented experiences at state and national parks, museums, and visitor centers. Several Muhlenberg students have worked in this program, studying organisms such as the Northern Spotted Owl and the Gray Wolf. For more information, contact **Dr. Klem**.

HAWK MOUNTAIN SANCTUARY ASSOCIATION INTERNSHIPS

Education and research internships are available at this local and prestigious site. Several Muhlenberg students have enjoyed this experience working along side international interns in field research and national and traditional class room settings. For more information, contact **Dr. Klem**.

CLINICAL INTERNSHIPS

Many students with career plans in the Health Professions chose to do internships with area health care-providers such as Lehigh Valley Hospital. The Health Professions Office has information about how to arrange physician-shadowing and other internship experiences relevant to clinical practice.

VIII. CAREERS IN BIOLOGY

This section includes brief descriptions of a few selected careers in biology and medicine, and how they relate to the Biology major at Muhlenberg. We have included some suggested courses for each career goal to help you think about how to organize your curriculum around your goals.

BIOMEDICAL RESEARCH/CANCER RESEARCH/CELL AND MOLECULAR BIOLOGY/GENETICS/ DEVELOPMENTAL BIOLOGY

There are currently abundant opportunities in academic institutions, medical schools, the government, and pharmaceutical industry for individuals with training in modern biotechnology. You can work in these settings with a Bachelor's or Master's degree as a technician, or as a scientist with a Ph.D. Many students may work for one or two years following graduation in one of these settings with only their B.S. from Muhlenberg. A lifetime career in one of these areas generally requires a Ph.D., although there now exist some specialized M.S. programs that are designed to prepare students for a technical career in the biotechnology industry. Currently, individuals with an M.D. are working in these areas, but this is likely to decrease in the future, given changes in the American medical establishment. If you are interested in working in one of these areas, even for a relatively short period of time, you should plan to take: **Biochemistry, Cell Biology, Developmental Biology, Genetics, Immunology, Microbiology,** and **Molecular Biology**. You should also take two years of **Chemistry**, a year of **Physics, Calculus,** and perhaps **Physical Chemistry**, particularly if you are interested in a biochemically-oriented position (*e.g.,* working in a pharmaceutical setting). Laboratory research experience is generally required for admission to graduate programs.

NEUROSCIENCE

The expectations for graduate study and a career in Neuroscience are similar to the above section, with additional emphasis on Psychology. Students interested in a career in Neuroscience should take the usual two years of **Chemistry**, and one year each of **Physics** and **Calculus**. Upper level Biology courses that you should take include: **Biochemistry, Cell Biology, Comparative Anatomy, Development Biology, General Physiology, Histology, Molecular Biology, Neuroscience** and **Transmission Electron Microscopy.** Courses in other Departments include: **Introductory Psychology, Cognitive Processes, Physiological Psychology, Sensation and Perception, Psychological Statistics**, and **Philosophy of the Mind.** Once again, laboratory research experience is an expectation of graduate programs in this area.

ECOLOGY AND EVOLUTIONARY BIOLOGY

Students interested in careers as a professional ecologist or evolutionary biologist should prepare for graduate school. Individuals work in these fields with Bachelors', Masters', and Ph.D. degrees. If you are interested in a career in these areas you should take **Ecology, Evolution, Field Botany and Plant Ecology,** and **Genetics**. You will also need to take **Statistics**, and a year of **Physics**, **Calculus**, and **Chemistry**. Significant field research experience is also a must. You may also want to enroll in **Botany, Comparative Anatomy, Ethology**, **General Physiology, Molecular Biology, Ornithology, Physiological Ecology, Plant Evolutionary Biology, Zoology,** the special field experience trips to Costa Rica and/or Bermuda, and **Advanced Statistics.**

APPLIED ECOLOGY, ENVIRONMENTAL MANAGEMENT AND FORESTRY

Students majoring in Biology may seek employment or graduate education in applied ecology and related fields. If you are interested in one of these areas plan on taking **Ecology, Field Botany and Plant Ecology, Genetics,** and **Conservation and Restoration Ecology** (to be added to the curriculum soon). You should also enroll in **Statistics, Microeconomics,** and complete a year of **Physics, Calculus,** and **Chemistry.** Other courses you should consider are: **Botany, Ethology, General Physiology, Physiological Ecology, Plant Evolutionary Biology, Ornithology, Invertebrate Zoology,** the special field experiences in **Costa Rica** and **Maine**, and **Advanced Statistics.** Significant field research experience is of paramount importance.

PEACE CORPS

Biology students may wish to apply their science background and obtain real world experience by volunteering for the Peace Corps enroute to various careers. Recent Muhlenberg Biology Graduates are working on forestry in Honduras, fisheries in Zambia, and on environmental education in South East Asia. A number of graduate programs are linked to the Peace Corps. The application process should begin early in the fall of your senior year. For more information contact one of the Peace Corps Liaisons: **Dr. Lisa Perfetti** in Foreign Languages or **Dr. Niesenbaum**.

CLINICAL MEDICINE, DENTISTRY, PODIATRY, OPTOMETRY AND VETERINARY MEDICINE

If you plan to apply to a health professional school, you should follow the curriculum recommended by the Health Professions office. Consult with that office as soon as possible, preferably by your Sophomore year. Most medical schools require one year of **English**, two years of **Chemistry**, one year of **Biology**, one year of **Physics**, and at least one semester of **Calculus**. Some programs require a semester of **Biochemistry** and/or a semester of **Psychology**. Students who are interested in Optometry school are

encouraged, and in some cases may be required, to take **Calculus, Statistics** and **Microbiology**. Within the Biology major, we strongly recommend that students interested in medical school enroll in **Biochemistry, Genetics,** and **General Physiology** before the end of the junior year. Taking these courses will help you prepare for the MCAT or other standardized test. Other courses that might help you once you enroll in your chosen professional school include: **Cell Biology, Comparative Anatomy, Developmental Biology, Histology, Immunology, Microbiology,** and **Molecular Biology.**

GENETIC COUNSELING

Genetic Counselors provide counseling on matters relating to genetics and health to individuals in a clinical setting. A career in this field generally requires a graduate degree (usually a Master's) from an accredited institution. These programs generally require course work in: **Biochemistry, Genetics,** and **Molecular Biology**. Course work in **Statistics** and **Psychology** is also frequently required. Biology Majors interested in careers as Genetic Counselors should also consider taking **Cell Biology, Developmental Biology,** and **General Physiology**. Laboratory research experience is a significant asset.

PHYSICIAN'S ASSISTANT (PA)

In recent years there has been some interest in careers as Physician's Assistants from Biology Majors. Most physician assistant programs require applicants to have previous health care experience and some college education. The typical applicant has a bachelor's degree and over 4 years of health care experience. Nurses, EMTs, and paramedics frequently apply to PA programs. This career is not for those who could not obtain admission to medical school. In addition to the standard two years of **Chemistry** students interested in careers as a PA should take: **Biochemistry, Comparative Anatomy, Developmental Biology, Genetics,** and **General Physiology**. Many PA programs may also require **Human Anatomy and Physiology**, however this course is not part of the Biology major. Some programs expect **Molecular Biology, Microbiology** and/or a year of **Physics**. Students should be aware that most programs require *significant* health-related practical experience. Consult with the Health Professions Office for more information, as soon as possible.

PHYSICAL THERAPY (PT)

Some Biology Majors may be interested in pursuing careers in Physical Therapy. The minimum educational requirement is a 4-year college degree in Physical Therapy from an accredited program. Muhlenberg College, like most liberal arts colleges, does not have a PT program. However, many programs now offer a Master's Degree in PT and after 2002, graduate degrees will be required to work in the field. Most PT programs require **Human Anatomy and Physiology**, however this course is not part of the Biology major. Most also require course work in **Psychology**, **Chemistry**, **Physics** and **Statistics**. Biology majors interested in Physical Therapy should consider taking **Biochemistry, Comparative Anatomy** and **General Physiology**. Significant preparation outside of course work, such as performing internships, is also expected. Consult with the Health Professions Office, as soon as possible.

GRADUATE SCHOOL IN BIOLOGY

For many careers in Biology, graduate study is advisable, and even required in some cases. For some careers (see above) you may be able to do independent research with a Masters' degree. In others, a Ph.D. is required, and many programs may not even offer a Masters' degree. Talk to the faculty members with expertise in your area of interest (see section II) *as soon* as you have decided that graduate study might be for you. They will be your best resources for guidance in what courses to take, what type of research to do, where to do it, and so on. Note that undergraduate research experience is not an asset for many programs, it is a *requirement*.

Should you go to graduate school? The decision to go to graduate school is appropriate if you desire a career in scientific research, industry, or education. *Never* go to graduate school because you "do not know what else to do." In this case, you will be better served by seeking employment and delaying enrollment in graduate school until you have a plan.

How do you apply to graduate school? The application process is similar to that for other educational ventures. However, students usually apply to a *specific* program, or even to work with a specific *individual scientist*, rather than to an institution at large. Most programs have application deadlines in November, December, or January for admission the following Fall.

How much does graduate school cost? Frequently nothing, in fact they may pay *you*. Most graduate programs pay for your tuition and most will offer teaching or research fellowships that will provide you with a modest income while you are in graduate school. If you have a strong academic record and have done undergraduate research, you should apply for a National Science Foundation Graduate Fellowship. These prestigious awards provide full tuition and approximately $20,000/year stipend. Consult the Science Graduate Awards advisor, **Dr. Wightman**, for more information.

To which graduate programs should you apply? This will vary from one field to another. A famous institution might have a few very weak graduate programs in addition to many strong ones. Discuss this issue with an appropriate faculty member from the Department. For graduate study in the broadly-defined area of cell and molecular biology, make sure that the program has an NIH-training grant in place. These grants provide funding for your tuition and a stipend for living expenses. Lack of an NIH-training grant is evidence of a weak graduate program. For graduate study in all areas, you should *never* restrict yourself geographically, unless you have a compelling reason. Applying only to graduate programs in the immediate area is one of the most common mistakes students make. Your future employability is significantly shaped by the reputation and quality of the graduate program you attend!

M.S. or Ph.D.? Think about your long term goals before committing to a particular degree program. In some fields, such as molecular biology, obtaining a Masters' degree may actually make you *less* competitive for subsequent application to Doctoral programs. Many of the best programs in biomedical research no longer offer M.S. degrees. However, if you want to work in a technical capacity only, you may be more *employable* with a Masters' degree than with a Doctoral degree. In other fields, such as many field-oriented disciplines, getting an M.S. is a common step along the way to earning an eventual Ph.D.

How long will graduate study take? Most Masters' programs take 2-3 years to complete and may involve significant course work. In contrast, Doctoral programs take 5-8 years (sometimes even more!) and generally involve less course work or more independent research. Keep in mind that graduate study is *very* different than undergraduate study. You will spend much less time in classes and studying, and much more time working on independent research. Thus, much of the time spent in graduate school will feel more like a job than like school. Except it's a *really fun* job!

IX. GETTING RECOMMENDATIONS FROM FACULTY

Chances are, whether you are headed into the job force or onto graduate study, you will need recommendations from a faculty member. This is part of our job, and we enjoy being able to support our students, so you shouldn't feel hesitant about approaching us. You may want to consider the following suggestions and guidelines for asking faculty members for a recommendation.

- Choose recommenders that know you the best. Faculty who know you only from a very large introductory course are less likely to have much useful to say about you than those who have taught in a more intimate setting or served as a research advisor.
- Give your recommender plenty of time. Four weeks is usually a good rule of thumb, but if you're in a jam, don't hesitate to ask us if the deadline is sooner.
- Ask your recommender about any particular requirements they may have.
- Provide your recommender with written details regarding the recommendation. What is this for? Is there anything in particular you would like us to highlight? Where do we send the recommendation? In general, unless a recommendation *must* go back to you, we will prefer to send the recommendation directly to the school or employer.
- A pre-addressed envelope is nice.
- Make *certain* that you waive your right to see the recommendation. If you do not waive your right to review the recommendation, the school or employer may not take what we write seriously.

X. EMPLOYMENT IN THE BIOLOGY DEPARTMENT

The Biology Department employs students to provide various tasks. You do not necessarily need to be eligible for work-study for some of these positions. Student workers perform routine laboratory and greenhouse maintenance, prepare laboratory reagents, maintain safety records, serve as building Night Supervisors, and assist in introductory laboratories. The Department is always in need of dependable students. Contact **Mrs. Spengler** in the Biology office if you are interested in a job in the Department

XI. SHANKWEILER BUILDING POLICY

The Biology Department wants students to use the Shankweiler Building for study and research. At times when classes or meetings are not scheduled, the Vaughan Room is available to students for group and individual study. Monday through Friday, the building is open to students all day and during restricted evening hours. Students engaged in research projects or employed by the Department can obtain access to the building at other times by adhering strictly to Departmental policy. The building schedule is as follows:

Monday – Friday, 7 AM – 7 PM

Building is unlocked and all students are allowed to work in the building

Monday – Thursday, 7 PM – 11 PM; and Friday, 7 PM – 9 PM

Building is unlocked and all students are allowed to work in the building, but ALL students **must sign the Building Log** located in the Vaughan Reading Room. The Night Supervisor, a student employee, is responsible for overseeing building policy during these times.

Monday – Thursday, 11 PM – 7 AM; and Friday, 9 PM – Monday, 7 AM

The building is locked and the **only** students allowed in the building are those that have received safety training and have the explicit permission of the Department to be in the building. These students **must sign the Building Log** when they enter the building. In general, the only students given late night and weekend permission are those who are employed to perform specific tasks or are performing research projects. The mechanism for gaining access to the building is provided to these students.

XII. LABORATORY SAFETY

The Department of Biology is committed to providing students with a safe laboratory environment and the knowledge of safe laboratory practices. A safe laboratory is the result of prudent practices, good housekeeping and good common sense. The following Guidelines list prudent practices that can apply to any laboratory or field experience. These are not all-inclusive. Laboratory instructors will provide additional safety practices.

COMMON LABORATORY PROTOCOL

1. NEVER EAT, DRINK, SMOKE, HANDLE CONTACT LENSES OR APPLY COSMETICS IN THE LABORATORY.
2. Before working in any area, locate all safety equipment such as the fire extinguisher, chemical shower, eyewash, first aid kit, and chemical spill cleanup kits. Know the proper use of the equipment.
3. Do not work alone in the laboratory.
4. IGNORANCE IS DANGEROUS. Come to laboratory prepared. Read and understand the laboratory procedures before beginning any work. This will increase not only safety but also the reliability of your data and your understanding of the material.
5. Wear sensible clothing to laboratory. No sandals or bare feet, loose sleeves or dangling jewelry. Long hair should be tied back.
6. NEVER MOUTH PIPETTE
7. Safety goggles must be worn when handling chemicals, microorganisms, heating glass or dissecting animal specimen.
8. When working in the laboratory, be sure the work area is not cluttered with personal belonging. Coats, bookbags, etc. should be placed in designated areas.
9. Special care is needed in using any heat source. Never leave a heat source unattended. Always use special caution when near a heat source and use appropriate apparatus when handling hot glassware.
10. Do not handle broken glass by hand. Use a broom and dustpan. Broken and disposable glass should only be placed in the glass containers, never in the general trash.
11. Do not operate any equipment without instruction in its use. Some equipment can pose a hazard if used improperly.
12. Report any chemical spills or accidents to the Instructor.
13. Always clean up your work area before leaving.
14. Wash hands before leaving the laboratory.
15. Care should always be used when working with dissecting tools.
16. Animal specimen should never be put in the sink or trash. The Instructor will provide waste disposal containers.
17. Notify your instructor immediately if you are pregnant, color blind, allergic to any plants or insects or latex or have any other medical condition that may require special precautionary measures in the laboratory.

HANDLING CHEMICALS

1. When working with chemicals assume that all chemicals are poisonous.
2. NEVER MOUTH PIPETTE.
3. Know the nature of the chemicals you are using. Be aware of the toxicity, flammability and combustibility of all chemicals that you are working with. Read the labels and the MSDS reports. MSDS reports can be found at the end of the hall on the 2nd floor between rooms 205 and 206.
4. Wear safety goggles. A lab coat and gloves are also recommended.
5. Keep flammable chemicals away from heat sources.
6. Use care when carrying reagents around the room.
7. Never put chemicals in the trash or down the sink. Instructors will provide disposal instructions.
8. Know the procedures if a chemical spill occurs.
9. Always stopper reagents when not in use. Never return a reagent to their original containers unless instructed.
10. When preparing reagents be sure that the bottles are properly labeled with the name of the chemical, any associated toxicity and the nature of the chemical, such as flammability, combustibility, and incompatibilities. Consult MSDS reports for details.
11. Use a fume hood when so directed and when using volatile chemicals.
12. Students participating in research and work-study in the department must read and understand the College Chemical Hygiene Compliance Manual, which can be found in the Vaughan Reading Room.

WORKING WITH BIOHAZARDS

1. Before starting work scrub down the top of the lab bench. This will remove any organisms left from the previous lab and reduce contamination in your experiments.
2. A lab coat or apron should be worn at all times in the laboratory. Safety goggles should also be worn when heating samples and handling chemical reagents.
3. Observe strict sanitary procedures when pipetting. NEVER MOUTH PIPETTE. Avoid spraying any microorganisms when pipetting. Place contaminated pipettes in the appropriate containers for autoclaving.
4. Use care in handling cultures. Keep cultures covered when observing and carrying. Avoid breathing in the spores from spore-forming bacteria and fungi.
5. Place old cultures and any contaminated labware in the appropriate receptacles and areas for autoclaving.
6. Do not bring equipment from other labs. Do not remove cultures, or other materials from the laboratory without specific permission from the Instructor.
7. Before leaving the laboratory scrub the top of the lab bench with disinfectant.
8. After cleaning up remove your lab coat and other personal protection equipment and wash your hands with soap and water before leaving the laboratory.