BBMB Student Handbook 2014-15

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BBMB Program Learning Goals

Students graduating from Whitman College with a BBMB major will:

• integrate concepts from biology, chemistry, and physics to understand the structure and function of biological molecules and the interactions of these molecules in cells and organisms

• demonstrate the ability to read and critique the molecular life science literature

• perform experiments to address a research question in the molecular life sciences

• effectively communicate science orally and in writing

I. Curriculum

The BBMB major at Whitman College:

The molecular life sciences have roots in the core disciplines of biology, chemistry, and physics. Since 1991, the Whitman College curriculum has included a rigorous course of study in the molecular life sciences by offering a combined major in biology and chemistry. With the addition of biophysics to the curriculum in 2002, we crafted BBMB as a new interdisciplinary program. Introductory courses in biology, chemistry, math, and physics provide the foundation for the major. The junior and senior year includes the core courses of biochemistry, biophysics, and molecular biology, along with electives in the area of interest for each student. The major concludes with a senior seminar that explores the newest developments in this rapidly changing field and provides a forum for students to present their senior research projects to faculty and students.

Required courses for the BBMB major:

Biology: 111, 205 Mathematics 125, 126, 225

Chemistry: 125, 135, 126, 136, OR 140; 245, 251, 246, 252

Physics: 155, 156 or 165, 166

BBMB 324, 325, 326, 334, 335, 336, 400, & *three credits* of 490

PLUS: 7 credits of electives (see below)

Electives in BBMB major: at least seven additional credits taken from biology, chemistry or physics courses numbered 200 *and* above and approved by the BBMB faculty. The P-D-F grade option is not allowed for any BBMB, biology, chemistry, or physics course that can apply to the BBMB major.

Generally, advanced courses in Physics and Chemistry may count as electives for BBMB. Generally, Biology courses in the Cell/Molecular and the Organismal (Physiology/Anatomy) categories can apply to BBMB. Most courses that can count as BBMB electives are listed below. There may be other classes, too (the curriculum is always changing as we hire sabbatical replacement faculty, faculty go on family leave, develop new courses, etc). So, ***refer to the course catalog and schedule for a complete list of available courses***. Also, ***pay attention to list-serve and email announcements on new classes in Biology, Chemistry, and Physics***; some might work for BBMB.

Note that not all of the classes listed below are offered every year! ***Refer to the Whitman course schedule for info on what's available any given semester.*** You can discuss elective credit for study abroad courses with your academic advisor or the program director.

BBMB		
430	Current Topics: Infectious Diseases	Fall
481/482	Special Projects	Arr. w/ instructor
BIOL		
228	Biostatistics	Fall [not offered 2014-15]
259	Comparative Vertebrate Anatomy	Fall [not offered 2014-15]
278/9	Marine Biology + Lab	Spring [not offered 2014-15]
303/4	Cell Biology/Lab (lab separate)	Spring
305/6	Cell Physio & Signal/Lab (lab separate)	Spring [not offered 2014-15]
310	Physiology	Fall

319	Developmental Biol Seminar	Spring
320	Neurobiology	Fall
323	Neurophysiology	Spring
329	Developmental Biology	Spring [***will*** be offered in 2014-15]
330	Human Physiology	Spring [not offered 2014-15]
338	Evolutionary & Developmental Biol	Fall [not offered 2014-15]
342	Gene Discovery and Genomics	Spring
339	Microbiology & Immunology	Fall
350	Evolutionary Biology	Spring
350	Plant Physiology	Fall in 2014; usually Spring
402B	Seminar: Issues in Nutrition	Spring [not offered 2014-15]
405	Bioethics	Spring [not offered 2014-15]
472	ST: Symbiosis	Spring
472	ST: Medical Genetics/Ethics *or* Parasitology	Spring, 2cr, [one will be offered 2015]

CHEM

240	Quantitative Analysis and Chemical Equlib.	Fall
315	Marine and Freshwater Chemistry	Spring
320	Instrumental Analysis	Fall
345/46	Physical Chem I-II	Fall,Spring
360	Inorganic Chemistry	Spring
370	Adv Methods in Inorganic and Organic...	Spring and Fall
388	Environmental Chem	Spring
401/402	Chemistry Seminar	*2 cr, max
411	Org Chem of Drug Design	[not offered 2014-15]
425	Computational Biochemistry	[not offered 2014-15]
432	Capillary Electrophoresis	Fall
447	Physical Organic Chemistry	Fall
460	Bioinorganic Chemistry	Spring

MATH

247	Statistics with Applications	Fall

PHYS

245/55	20th Cent. Phys + Lab (lab separate)	Fall
246/56	Waves +Lab (lab separate)	Spring
318	Computational Physics	[Not offered, 2013-14]
325	Electricity & Magnetism	Fall
348	Optics	Spring
357	Thermal Physics	Spring

Senior year requirements: In the senior year, all BBMB majors must take a senior assessment exam containing both oral and written components. The written component consists of the GRE exam in Biochemistry, Cell and Molecular Biology. A score in the 20th percentile or higher is required to Pass. The oral exam consist of a one-hour comprehensive question exam with two or more participating faculty.

Senior BBMB majors also must complete a research project, write a research thesis describing the work (BBMB 490), and present it as a seminar to the department (BBMB 400). Research/thesis, and seminar are required capstone courses for which you receive credit.

Details on the senior exam and senior research/thesis requirements are provided below, in sections II and IV.

Course Descriptions for actual BBMB courses are listed in Appendix A, at the end of this handbook, as well as in the course catalog.

II. Research & Thesis (BBMB 490)

All BBMB students must do a research project in the molecular biosciences, or in a related area of chemisty, biology, biomedicine, or physics. Projects typically involve laboratory work, but can involve clinical or epidemiologic research, or review and critique of data from the literature in a manner that assesses a hypothesis in the molecular or biomedical sciences.

The Whitman BBMB program is very flexible with regard to this requirement: there is no predetermined minimum number of hours for an acceptable research project, and the projects can (hypothetically) be done at any time during a student's 2-3 years at Whitman, on- or off-campus, during summer or the academic year. The important thing is to take part in a supervised research project for which you obtain and/or analyze data, and then to communicate your results in a senior thesis and research seminar. Projects do need to be approved in advance by a BBMB advisor, for use as a thesis project.

Students get credit for research data analysis, thesis work, and research seminar presentation during their senior year. For this, you must register for three credits of BBMB 490 during your senior year, and take the BBMB 400 seminar. The 490 credits can be split between fall and spring, or they can all be taken in the spring of senior year. Even if you do thesis research prior to your senior year (e.g., during junior year, or a previous summer), you must register for BBMB 490 during your senior year. Registration for a section of BBMB 490 will require consent from your thesis advisor: a Whitman BBMB, Chemistry, Biology, or Physics faculty member who has agreed to serve that role. They will guide you through your thesis writing and your senior seminar presentation. For thesis credit, your research advisor must approve your research project and agree to serve as advisor for it, and then, when the time comes, they must provide consent for you to register for BBMB490. After that, you'll work with them to prepare your senior seminar (to be presented in BBMB 400 in spring of your senior year), and to complete your thesis (due on the last day of classes of your senior year).

The Drill:

You should start thinking about finding a research project in the late fall of your junior year, at the latest. Students can work in a lab at Whitman (or elsewhere in Walla Walla) during the semester, or do a summer research internship on or off campus, such as at a university, research institute, hospital, biotech company, or government laboratory. Many summer positions carry stipends and involve 8 - 10 weeks of full-time work. But shorter internships or part-time laboratory projects are also totally acceptable. And the research need not be done in the senior year; some students write their theses on research done in sophomore or junior summers, or during study abroad (this can be done if you keep records of all of your laboratory data and methods). As stated above, we are flexible with regard to the research requirement.

Once you find a potential research project, you need to identify a Whitman faculty who can approve

the project, and then serve as a research advisor. It's best to do this by pre-registration period in spring of your junior year, or at least sometime in spring of your junior year. However, if you run into difficulties or change projects, you can finalize advisor arrangements any time before September of your senior year. Your research advisor need not be one of the core BBMB profs - Chemistry and Biology faculty commonly serve as BBMB research advisors. Talk to faculty or look at their course offerings and web pages, and contact the professor(s) who have research expertise most closely related to your research project. [For example, if you do research in protein structure, Prof. Juers might be the best advisor; if you work in neurobiology it might be Prof. Withers or Knight; for gene expression or genomics, it might be Prof. Vernon *etc.*]. Then, register for your advisor's section of BBMB 490 in your senior year.

***Steps you need to take to fulfill senior research and thesis requirements are provided below in section IV*.** **That section also includes information on honors criteria.**

Suggestions on where to hunt for summer research internships, and a list of recent BBMB senior research projects are provided in Appendix B, at the end of this handbook. Also, talk to BBMB and Biology seniors about what they've done. And attend the *annual Bio/BBMB thesis information session* given each fall; this usually features Prof. Vernon as well as a panel of seniors who discuss their research and how they landed their projects.

III . Study Abroad

Thinking of study abroad?...

BBMB faculty recommend *against* study abroad for BBMB majors *unless* all calculus, introductory physics, organic chemistry, and genetics requirements are completed by the end of sophomore year.

Consider the info below to substitute abroad courses for core BBMB classes. Also, note that it's easier to find suitable electives than substitutes for core (required) courses. So it's best to go abroad in fall junior year, and take the BBMB 324-325-326 series here, after you get back.

1) **Off-campus biochemistry** : If you are looking for an off-campus (domestic or abroad) course to be the equivalent of BBMB325, it must include content on protein structure/function; enzyme kinetics and mechanisms of action; signal transduction; and bioenergetics and energy metabolism.

An off-campus biochemistry lab (for BBMB335 equivalency) must include techniques for the purification and characterization of proteins.

2) **Off-campus molecular biology**: If you are looking for an off-campus (domestic or abroad) course to be the equivalent of BBMB326, it must include content on DNA/RNA structure/chemistry; molecular research techniques; gene structure, evolution, and expression. Importantly, there should be a lot of coverage of gene regulation and some coverage of genomics. Molecular lab is also required, so the class should have an associated lab component, or you'll need to find an additional lab course.

An off-campus molecular biology lab (for BBMB336 equivalency) must include some standard techniques of DNA manipulation, detection, and analysis [e.g. plasmid isolation, restriction digestion, PCR, agarose gel electrophoresis, cloning; reverse-transcription; DNA or RNA blotting]. It should also contain some computer DNA sequence analysis/comparison and accession of genome databases.

3)**Off-campus biophysics**: Consult with Prof. Doug Juers in the Whitman Physics department if you identify classes abroad that might fulfill this requirement.

DIS (Danish Institute for Study Abroad) in Copenhagen, Denmark has a core program and courses in Biotechnology & Biomedicine. This program is designed for students exploring career opportunities within biotech research and/or biotech business development. The core course and study tours offer you insight into biotechnology-based methods for diagnosis and treatment of disease; an understanding of the dynamics of drug discovery and development; and an interdisciplinary perspective on how biotech research and biotech business work together. See http://www.dis.dk/

IV. Senior Year Requirements

Note that some of these requirements include forms that MUST be filled out by a particular deadline. That deadline can vary from year to year. Consult the registrar (or their web page) for info.

A. Degree candidacy declaration

This form comes from the Registrar's office and must be completed by *all seniors* who wish to graduate. It is typically due in early November. Consult the registrar's office for the exact due date for your senior year.

B. Comprehensive Major Exam Requirements

1) Written (GRE):

You should take the exam in fall semester of your senior year. Starting in 2014, the exams will be offered in September and October. ***YOU MUST MAKE YOUR OWN ARRANGEMENTS TO TAKE THE GRE***. Exam dates and registration deadlines are provided at the website. They change each year. Registration deadlines are usually ~6 weeks before the exam date : the registraton deadline for the September exam is in August, and the October exam in early September. So g***et on this right away in your senior year!*** Registration should be done online, at --> http://www.ets.org/gre/subject/register. When you register, be sure to ***designate that your scores be released to Whitman College***.

The GRE is also offered in April. However, ***putting the exam off until spring is strongly discouraged,*** because it could potentially ***delay your diploma.*** The registrar will not give you a diploma unless senior exam results are received by their deadline in early May. If GRE results are not received by the registrar's deadline, you can still walk in Commencement, but you won't receive your actual diploma until the following September. Therefore, except for students who put off taking Biochemistry until their senior spring semester, it is unwise to put off the senior exam until April.

The written exam consists of the GRE subject exam in Biochemistry, Cell, and Molecular Biology.

GRE scores will be evaluated as follows:

70 %ile or above	pass written component of the senior exam with distinction
20 %ile or above	pass writtens
below 20 %ile	no pass, must retake written exam.

A score below the 20th percentile will require either that you re-register and take the GRE again, or take an in-house exam in the spring.

2) Orals:

YOUR ORAL EXAM WILL BE SCHEDULED FOR YOU and you will be informed of the date and time. Approximately 1/3 - 1/2 of senior orals will be scheduled for late in the fall semester; the rest will take place in January and February, starting immediately after winter break. You will be notified at least 2 weeks before the date of your exam.

Your oral exam will be conducted with 2 faculty members from the BBMB program. The purpose of the exam to gauge your overall grasp of fundamental biomolecular concepts that you covered in required courses, and your ability to think on your feet and to discuss molecular life science using the vocabulary of the field. Questions will *not* be limited simply to material you covered in your classes; rather, they will try to address your integration and synthesis of concepts and models in biochemistry, biophysics, and molecular biology. Some questions will ask you to apply stuff you know to new scenarios. There is *not* a pre-determined set of questions for any exam - each exam is different. You may be asked to look at images or draw structures or cartoons on the board. You may ask for clarification of questions or simply say that you don't know. The oral exam will last ~ 50 minutes. The committee will then discuss your exam and vote on a pass with distinction/ pass/ no-pass basis, and will inform you immediately of the result.

Here is a general list of topics

• Biological, Chemical, and Physical Foundations
Thermodynamics
Kinetics
Equilbria (especially acid-base)
Bonding, structure, reaction mechanisms
Cell structure, function, and communication
Gene and genome structure, expression, and regulation
Evolution, mutation, inheritance
Development or physiology of cells or multicellular organisms

• Molecular Life Science Integration
Biomolecular Structure/Function Relationships
Catalysis
Bioenergetics and Metabolism
Signal Transduction
Genome Maintenance and Expression
Gene regulation and relationship to biological processes
Experimental methods

C. Senior Research, Thesis and Seminar: steps for Juniors and Seniors

All BBMB students must do a research project in the molecular biosciences, or in a related area of chemisty, biology, biomedicine, or physics. This requirement is described above in detail in section II of this handbook. The nuts and bolts of registering for research and thesis credit are described again below, organized according to when you should do the various steps. Also, there is a senior research information session for both BBMB and Biology juniors, held in October or Novermber. Go to that.

Late fall/winter of your JUNIOR year. Start looking into research projects. It is especially important to get an early start if you are interested in finding an off-campus summer research internship. Many deadlines are in mid-winter.

Required steps for JUNIORS: In spring of your junior year, you should find a research advisor for your senior research project (see section II of this handbook). These projects may involve laboratory work, clinical research, epidemiologic research, or review/critique of published work. Biological field research may also be suitable, if it has a physiological, evolutionary, or molecular component.

If you plan to do a summer research internship for your senior thesis, you must discuss the project with a Whitman faculty professor who can serve as your research advisor. Approach as many Whitman profs as you need to to find the advisor who would be the best fit. Check out faculty websites to see what their areas of expertise are.

If seeking off-campus opportunities, it's best to apply to several, and then seek approval from a research advisor later, once you get summer internship offers/ acceptances. We encourage you to find an off-campus research gig, and don't want faculty approval to be a hindrance to the process. So apply first, and nail down a thesis advisor later. Note: *If* you wish to nab a grant from Whitman's Summer Internship Grant program, you need to find a potential research gig by late March. [See Appdx B and consult the Student Engagement Office for more info on the Summer Internship Grant program].

Required steps for SENIORS: You must register for a total of 3 credits of senior research/ thesis in either the Fall OR Spring semester of your senior year. You get credit for thesis work by registering for BBMB 490. Registration will require consent of your research advisor; enroll in his/her section. The three credits *may* be taken all in fall, all in spring, or divided up between Fall and Spring semesters. If you take all three credits in the Fall, you *must* complete the written, graded thesis in the Fall. Only do this if you are graduating in Dec. or are *certain* you will finish the thesis by the last day of classes in December. Recommended: 1 credit of 490 in the fall, and 2 in the spring, when you do most of your thesis writing.

BBMB 400 Senior Seminar

This class is held each spring, typically at 10M, W11. It's *required* for all BBMB seniors, or for juniors planning to graduate the following December. ***You must register for this class in your final spring semester at Whitman***. (*ie*, December graduates graduating a semester early must take the class in spring of their junior year.) The course is mainly devoted to student seminars describing senior research projects; literature presentations on recent research breakthroughs may be included as the schedule permits.

Your seminar date will be scheduled for you by the BBMB 400 instructor**,** and you will be informed of the date at least two weeks in advance. Students who completed their research over the summer will usually be scheduled earlier and those continuing the project during the spring semester will likely be scheduled later in the semester. Information on the length of the talks and grades will be provided on the BBMB 400 class syllabus.

D. Honors in Major Study

In BBMB, honors is not something you have to think about or apply for. Nobody is to actively seek honors; honors will be awarded to students who meet the criteria listed below. Your job is to excel as a student, both with course work and (especially) research endeavors. Generally, only one or two students per year earn honors in BBMB.

Honors criteria:

A. To qualify for honors at Whitman, seniors must meet the college's minimum GPA requirements, both overall (3.3) and in the major (3.5).

B. To qualify for honors, students also must pass their senior exams with Distinction. The senor exam

consists of written and oral components (see Section B, above). To qualify for honors you must get distinction on both: your score on the subject GRE must be in the 70th %tile or higher, and your oral exam must be considered worthy of distinction by all faculty on the examination committee. Senior exam results are typically available by late February of your senior year.

C. *Most important*, to qualify for honors you must do an outstanding job with your senior research, thesis and seminar. Honors is not just based on grades and exams: it's reserved for students who demonstrate a commitment to research and communication thereof.

Your thesis advisor should discuss your candidacy for honors with you during your senior year. By late February of your senior year, you will know if you meet the GPA, GRE, and oral exam criteria for honors candidacy. If so, you may be considered an honors candidate. To earn honors, you must complete a research project of suitable scope according to criteria set by your thesis advisor, and excel throughout the year in the thesis process, according to your advisor's expectations. Ultimately you must earn a final grade of A on your thesis.

Special rules for honors thesis: If you are a viable honors candidate, your completed thesis must be read by one additional BBMB-associated faculty, in addition to your research advisor. By about April 25th, you and your thesis advisor should distribute the penultimate draft of your thesis to a second faculty reader in the BBMB, Biology, Physics, or Chemistry program. After you get comments back from the 2nd reader, discuss suggested revisions with your advisor and finalize your thesis.

Complete honors theses must be submitted to the library. The college has specific rules about honors thesis format and submission. Sometime in your final semester, ***check with Penrose about paper requirements, special formatting, electronic submission, and the exact due date for honors theses***. Also, be sure to *fill out the electronic submission/distribution form and get your thesis advisor's signature on it*. Submit your properly formatted thesis to your thesis advisor and to Penrose library ***by the last day of classes.*** Your thesis advisor will determine the final grade.

V. Post – Graduation Plans

Immediately after graduation, BBMB majors choose many different paths to future careers: immediate employment in academic, governmental, or biotech labs; assignments in the Peace Corps, Teach for America, Americorps or other volunteer/service organizations; post-graduate fellowships or internships; and graduate or professional education.

A. JOB SEARCHING

For positions in academic research labs or biotech companies, you may find positions via direct inquiry to the institution or company (either specific lab/dept or to the HR dept). Also, job placement ads are available in professional journals, such as *Science, Chemical and Engineering News*, *Physics Today.*

B. APPLYING TO GRADUATE SCHOOLS

Graduate school focuses on research. Students interested in pursuing graduate study in the molecular and cellular life sciences or related fields should plan to submit applications by ~Dec. 1 for admission the following Fall. Refer to info on each individual grad program for exact due dates. A number of resources are available to help you with selecting and getting accepted into a graduate program. Early in the process you should talk with your adviser or another faculty member about your plans. This conversation can help sort out your interests and identify the types of program you may wish to consider. Talk with at least one faculty member whose expertise is in that area; he or she will be able to help you identify graduate programs that are strong in your area of interest and often can

supplement written sources with personal knowledge about institutions and individual researchers. Faculty members also may be acquainted with the experiences of recent Whitman graduates at institutions you are considering.

There are several valuable references available on graduate programs. Keep in mind, however, that your graduate school experience is more a function of your laboratory, your graduate advisor, and your individual accomplishments, rather than the university program you are in.

• *Peterson's Guide to Graduate Programs* is issued in several volumes. All are available on-line at http://www.petersons.com/GradChannel/code/search.asp?path=gr.fas.grad. You can use it even if your name isn't Peterson.

Each two-page listing describes such things as programs of study, facilities, costs, financial aid, community, application procedure, and faculty. Departments offering only a masters degree are included.

• The *ACS Directory of Graduate Research* is published every two years by the American Chemical Society. Ph.D.-granting departments in the U.S. and Canada are listed in sections on chemistry, biochemistry, medicinal chemistry, and pharmacology. For each department, there is a list of the faculty, their research interests, and their publications during the last two years. The directory is available online at http://dgr.rints.com/

• Each year we receives numerous flyers and pamphlets and some catalogs from graduate programs. This information is posted outside of the BBMB lab (S-317), Jim Russo's office (S-336), and in the filing cabinet on the 2nd floor of the Science atrium (northwest corner).

• And of course direct online searching of programs.

Application requirements:
Research experience

• Grad school is research training, and you aren't going to get into a graduate program w/o prior research experience. Luckily, as a Whitman BBMB major you're required to do a senior thesis. So thanks to our rigorous BBMB major requirements, you'll have this covered, unless you do a literature-based thesis.

• Graduate Record Examination (GRE)
Some graduate schools and most fellowship programs require that applicants take BOTH GRE general and subject tests. For many programs, only the general test is required. The general tests are computer-based and offered year round at regional centers (not in Walla Walla). The subject test is the same exam you are required to take for your BBMB senior assessment, so whether or not it's required, you've got that covered.

• Letters of evaluation:
Usually three evaluations will be required for each application from faculty members or research mentors who know your work well and, if possible, have taught you in recent or upper level courses. Many programs have evaluators submit letters electronically. Writing good Evaluations is a demanding task. Consequently you should give those persons who will write on your behalf as much lead time as possible, but at LEAST 2-3 weeks for the first letter.

• Visit to the school:
Most programs which invite you to interview will pay for your entire visit (airfare, lodging, meals). But scheduling visits during the academic year can be challenging, but it's important.

• Financial considerations:
Most doctoral programs in the molecular life sciences will provide a stipend ($25,000+) and waive tuition.

C. POST-GRADUATE FELLOWHIPS

National Science Foundation (NSF) graduate fellowships

NSF fellowships provide full support for three years of graduate study at any U.S. university. At the time of application, you must designate your first choice institution, but you are obligated to attend that institution. These are very prestigious, and therefore competitive awards. Between 2004-2007, 3 BBMB students have been awarded NSF fellowships (9 Whitman science grads overall). Consult with your academic advisor early in your senior year.

Postbaccalaureate Intramural Research Training Award (IRTA)

http://www.training.nih.gov/student/pre-irta/previewpostbac.asp

The IRTA program and the National Cancer Institute's Cancer Research Training Award (CRTA) provide opportunities for recent college graduates to spend a year engaged in biomedical research at the National Institutes of Health (NIH). Trainees work side-by-side with some of the leading scientists in the world in an environment devoted exclusively to biomedical research. Fellowships are available in the more than 1250 intramural laboratories of the National Institutes of Health (NIH), which are located on the main NIH campus in Bethesda, MD as well as in Baltimore and Frederick, MD; Research Triangle Park, NC; Phoenix, AZ; Hamilton, MT; and Detroit, MI.

Fellowships for International Study

Most fellowship programs for graduate study abroad require that applicants be nominated by their undergraduate institution. These include the Churchill, Fulbright, Marshall, Rhodes and Watson Fellowships. Generally these programs carry certain restrictions such as location of study and career goals. Further details may be obtained from the Post-graduate Fellowships and Grants Office in RCC.

D. APPLYING TO HEALTH PROFESSIONS SCHOOLS

If you are considering a career in the health professions (medicine, nursing, public health pharmacy, dentistry, veterinary medicine, etc…), contact Jim Russo, Health Professions Advisor, early in your junior year. russo@whitman.edu

Appendix A: BBMB course descriptions

324 Biophysics x, 3 Juers
The application of concepts and approaches from physics (e.g. mechanics, thermodynamics and electromagnetism) to deepen understanding of molecular and cell biology. We will focus on simplified models that capture the salient features of biological systems. Example topics include diffusion, hydrodynamics and cellular locomotion, free energy transduction, ligand binding, entropic forces, enzyme kinetics, molecular motors, macromolecular conformation, and signal propagation in neurons. Three one-hour lectures per week; weekly problem sets; exams. *Prerequisites:* Physics 155 and Mathematics 225. *Corequisite: Physics 156.*

325 Biochemistry 3, 3 Fall: Belchik; Spring: Rokhsana, Russo
A detailed examination of protein structure and function, focusing on the role of proteins in molecular recognition and catalysis. Topics include: techniques used to characterize proteins; enzyme kinetics and mechanisms; signal transduction across membranes; bioenergetics; catabolism of proteins, fats, and carbohydrates; integration of metabolism and disease. Three lectures per week. Fulfills the Molecular/Cell Biology requirement for the Biology major. *Prerequisites:* Biology 111, Chemistry 246.

326 Molecular Biology 3, x Vernon
A detailed examination of nucleic acid structure and function, focusing on gene expression and mechanisms of gene regulation. Other topics include molecular biology of viruses, mobile genetic elements, the genetic basis of cancer, and principles of genomics. Three lectures per week. Required for BBMB majors. Fulfills the Molecular/Cell requirement for the Biology major. *Prerequisites*: Biology 205 and BBMB 325; consent of instructor required for non-BBMB majors.

334 Biophysics Laboratory x, 1 Juers
Laboratory exercises on a range of biophysical top-ics. Experimental testing of models developed in BBMB 324. Study of macromolecules using techniques that may include absorption spectroscopy, fluorescence spectroscopy, circular dichroism, nmr, crystallization and structure determination via X-ray diffraction. One three- to four- hour laboratory per week. *Corequisite:* BBMB 324. Open to other students only with consent of instructor.

335 Biochemistry Laboratory x, 1 Russo
Laboratory exercises in protein biochemistry, which will include biochemical reagent preparation, enzyme isolation and purification, enzyme and protein assays, and gel electrophoresis. One three- to four-hour laboratory per week. Fulfills the Molecular/Cell Biology requirement for the Biology major. *Prerequisites:* Biology 111 and Chemistry 136 or 140; *Corequisite:* BBMB 325. Chemistry 240 is strongly recommended. Open to other students only with consent of instructor.

336 Molecular Biology Laboratory 1, x Vernon
Laboratory exercises in nucleic acid biochemistry, including molecular cloning, PCR, and DNA and RNA isolation and analysis techniques. One three-hour laboratory per week. Fulfills the Molecular/Cell Biology requirement for the Biology major. *Prerequisite*: BBMB 335; *Corequisite*: BBMB 326; consent required for non-BBMB majors.

400 Senior Seminar x, 1 Juers and Vernon
The senior seminar will serve as the capstone of the major by providing a forum for all seniors to make

a full-length oral presentation. Each student will describe the background, methodologies, and experimental results of the senior research project and respond to questions and critiques of his or her peers. Open to other students with consent of instructors.

430 Current Topics in Biochemistry: Infectious Disease 3, x Russo
The role of infectious disease in human mortality and morbidity. Discussion topics include: epidemiology and etiology of disease, cellular targets of microbial infection, immune responses, design and mechanism of action of antibiotic drugs, drug resistance, the development of vaccines for disease prevention, and the ethical dilemmas and social consequences of infectious disease. Case studies may include polio, influenza, malaria, tuberculosis, Hepatitis B, and HIV. *Prerequisite:* consent of instructor.

481, 482 Special Projects 1-2, 1-2 Staff
Research projects or independent studies arranged with individual students. The students must consult with a faculty member prior to the semester of the anticipated project to determine if the project is suitable, and the project must be done with the supervision of a Whitman faculty member. *Prerequisite:* consent of instructor.

490 Senior Research and Thesis 1-3, 1-3 Staff
Each student will collect data and write a thesis on his or her research in accepted scientific style. One or more initial drafts of the thesis will be required before the final version is due in the last week of classes. Each student also will present his/her research results in a public forum, typically BBMB 400 Senior Seminar. May be repeated for a maximum of three credits; a total of three credits are required in the senior year (Fall and/or Spring). Prerequisite: consent of the research adviser.

Appendix B: Research Internships- Information and Examples

A. Projects at Whitman...

Many professors in BBMB, biology, and chemistry provide student research opportunities in their laboratories. Some secure funds from research grants to support students during the summer as well as during the school year. There is also a Whitman Internship Program that provides stipends to students for summer work, on a competitive basis. Unfortunately, starting in 2014, this program may not support students doing work on campus. Still, you can contact them and inquire.

Feel free to approach any faculty in BBMB, Biology, or Chemistry to inquire about possibilities in their labs!

B. Projects the Northwest...

You may be able to land a paid summer internship, or get paid with a Whitman Internship Grant, for research you do off campus (contact the Student Engagement Center for info on that program; deadline is in late March). Having funding from the Internship Program may make it easier to find an off-campus lab willing to take you for the summer.

National Science Foundation REU programs (see C-1., below; some are located in the Northwest) .
http://www.nsf.gov/crssprgm/reu/reu_search.cfm

Private research institutes in the Puget Sound Area
* Fred Hutchinson Cancer Research Center

http://www.fhcrc.org/science/education/undergraduates/
* Infectious Disease Research Institute http://www.idri.org
Seattle Biomedical Research Institute http://www.sbri.org
Pacific Northwest Research Institute http://www.pnwi.org
PATH (Program for Appropriate Technology in Health) http://www.path.org
Institute for Systems Biology http://www.systemsbiology.org

* Whitman College has grants to support 2 students each summer at these research institutions. Calls for applications will be posted in November.

Universities and other agencies
UW (many depts. including Biochemistry, Structural Biology)
OHSU (many depts. including Cancer Center, CROET, Stroke Center, Vollum Institute)
WSU (many depts. incl Health Sciences in Spokane; SURF program in Pharm/Toxicology in Pullman)
U. Idaho
Boise State University
Oregon State University
U. of Oregon
Walla Walla Health Dept.
USDA extension offices or research programs
PNNL

Biotech & Pharmaceutical companies
Amgen http://www.amgen.com
Targeted Genetics http://www.targen.com
Cell Therapeutics http://www.cticseattle.com
Zymogenetics http://www.zymogenetics.com

C. Other U.S. programs

1. **National Science Foundation** The biggest and most diverse collection of undergraduate research opportunities in the U.S. is the NSF's REU (Research Experience for Undergraduates) program. REU internships are full-time, paid summer research internships at numerous universities. You can get info on REUs opportunities from individual universities (or university departments that host REU students), *or* go directly to the NSF website to get more info:
http://www.nsf.gov/crssprgm/reu/reu_search.cfm You can search for opportunities by geographic location, research topic, etc. There are REU programs are all over the U.S., including the Northwest. NSF REU programs are very competitive- but they offer diverse opportunities and pay well, and are worth looking into.

2. **NIH Summer Research Program** (any of the National Institutes of Health)
http://www.training.nih.gov/student/internship/internship.asp

3. HHMI
a. Janelia Farm
The HHMI Janelia Farm Research Campus is one of the most prestigious, multi-disciplinary biomedical science research centers. It is located in northern Virginia and was founded to provide a research setting for innovative ideas and scientists w/o the need to compete for continual research funding. The labs work on fundamental issues in molecular/cell/neuro biology; imaging and other

molecular/cellular technologies; gene expression and regulation.

Janelia Undergraduate Scholars This program gives undergraduates an opportunity to spend 10 weeks during the summer working as an intern in the lab of a mentor at Janelia Farm. The scholars are encouraged to attend weekly seminars and other events at Janelia. At the end of the session, each scholar will present his or her work at a symposium. Housing is provided. There is also an allowance of $4,500 for the 10-week period. The program also supports the most economical travel to and from Janelia.
http://www.hhmi.org/janelia/undergrad.html

b. International Research Opportunities for Undergraduates

HHMI facilitates the placement of undergraduates from HHMI grantee institutions (Whitman is a grantee) into the laboratories of HHMI International Research Scholars. Although they do not offer any financial assistance, the International Scholars are a highly vetted group of scientists, who publish in English, and whose laboratories can provide experiences in high quality science.

Whitman is asked to nominate students to apply, and students can choose up to five scientists from among the list of 104 Scholars on the HHMI Web site (http://www.hhmi.org/cgi-bin/scientist_search/search.pl?it=INTERNATIONAL&x=34&y=12).

They express a preference for students who have previously engaged in independent research, are beyond their freshman year, and are majoring in a life science, chemistry, or physics.
If wish to participate next summer, you should notify Jim Russo, Whitman's HHMI Program Director, by Oct 1, 2010.

4. **Pasteur Institute**
Located in the heart of Paris, the Institut Pasteur is one of the world's leading biomedical research organizations devoted to basic scientific research primarily in the area of infectious disease. The Pasteur Foundation Summer Internship Program provides U.S. undergraduates with the rare opportunity to conduct summer research at the Institut Pasteur. The foundation's goal is to encourage students in the pursuit of a scientific career and to expose them to an international laboratory experience.

Each year, four laboratories at the Institut Pasteur are chosen to host U.S. undergraduates. During the internships, interns will carry out research supervised by a lab mentor. Applicants should be eager to engage with a different culture, and self-sufficient enough to arrange travel and secure housing in Paris. Depending on availability, affordable housing in a residence on campus may be possible. Interns will receive a living allowance of $400 per week for a maximum of $4,000. Travel/housing are not paid by this program, but a $500 subsidy is provided and intended to defray costs of travel and requisite insurance.
http://www.pasteurfoundation.org/internships.shtml

5. Other institutions
By looking at posters around the building, or searching Summer Undergraduate Research, you can identify many universities and institutions with formal programs for the summer that pay approx $3000-4000 for 8-10 weeks.

Thanksgiving break or Winter break is a great time to start thinking about possible summer

opportunities. Many of the programs have deadlines ranging from mid- January to Mar 1.

Examples of Sr. Research Projects (location and advisor)

2013-14

Shunei Asao
Algae Switching in Forked Tube Lichen
BBMB & Biology, Whitman College **(Advisor: Suzanne Alterman)**

Jay Barlow
Role of Microbial Biosurfactants in the Athabasca Oil Sands
U. of Calgary; BBMB, Whitman College **(Advisor: Sara Belchik)**

Ryan Calvert
Nutritional Counseling for Patients with Cardiovascular Disease
BBMB & Biology, Whitman College **(Advisor: Kendra Golden)**

Andres Crane
Role of Astroglia Contact in Neurogenesis
BBMB & Biology, Whitman College **(Advisor: Ginger Withers)**

Daniel Ellis
Biomimetic Models for Mo-containing CO Dehydrogenase
BBMB & Chemistry Whitman College **(Advisor: Dalia Rokhsana)**

Forrest Epstein
Adenovirus-Derived Junction Opener
Dept. of Medical Genetics, U. of Washington, Seattle **(Advisor: Arielle Cooley)**

Kayla Erspamer
Alpha-TEA-lysine salt induction of autophagy in breast cancer
BBMB & Biology, Whitman College **(Advisor: Ginger Withers)**

Patrick Finnegan
GIRL genes in *Vitis vinafera*
BBMB & Biology, Whitman College **(Advisor: Dan Vernon)**

Kendell Gilmore
PIRL-9 gene overexpression in transgenic *Arabidopsis thaliana*
BBMB & Biology, Whitman College **(Advisor: Dan Vernon)**

Gabriela Kaus
Role of c-di-GMP responsive circuits in biofilms of *Vibrio*
Dept. of Microbiology, U. of Iowa, Iowa City, IA **(Advisor: Sara Belchik)**

Sam Kirsch
Neuron Polarization on Nanotextured Growth Surfaces
BBMB & Biology, Whitman College **(Advisor: Ginger Withers)**

John Lee
Atlas for Mouse Brain Vasculature
Allen Institute for Brain Sciences, Seattle **(Advisor: Ginger Withers)**

Liz Leong
PIRL-9 gene expression in roots of *Arabidopsis thaliana*
BBMB & Biology, Whitman College **(Advisor: Dan Vernon)**

Amanda Lu
Biochemical pharmacology of IRAP inhibition
Dept. of Physiology, Monash University, Australia **(Advisor: Jim Russo)**

Joshua Melander
Experience-dependent Neuroplasticity
BBMB & Biology, Whitman College **(Advisor: Chris Wallace)**

McKenzie Momany
RNA isolation from Foreskin and Rectum in HIV vaccine trial
Fred Hutchinson Cancer Research Center, Seattle **(Advisor: Dan Vernon)**

Carol Pengshung
Tuberculosis Antigen Discovery
Infectious Disease Research Institute, Seattle **(Advisor: Jim Russo)**

Chris Perkins
Betaine in Mice
BBMB & Biology, Whitman College **(Advisors: Leena Knight and Paul Yancey)**

Corinne Pingul
Evaluation of Physical Fitness and Nutrition Programs in WWPS
Walla Walla Public Schools **(Advisor: Jim Russo)**

Nathan Radakovich
Diversity of CD8 Tcell responses to HY antigens in GVHD
Fred Hutchinson Cancer Research Center, Seattle **(Advisor: Dan Vernon)**

Alexandra Roston
Allosteric control KCNQ1 Ion-channel in Cardiac tissue
Cardiovascular Research Group, U. of British Columbia, Vancouver **(Advisor: Leena Knight)**

Jeremy Schofield
Model Complexes to probe substrate specificity of pcpA enzyme
BBMB & Chemistry Whitman College **(Advisor: Tim Machonkin)**

Reid Shaw
Intracompartmental Pressure Measurement
Mirador Biomedical, Seattle **(Advisor: Leena Knight)**

Hallie Swan
PIRL-6 gene expression using protoplasts in *Arabidopsis thaliana*
BBMB & Biology, Whitman College **(Advisor: Dan Vernon)**

Ivana Vukovic
Molecular cloning of XylE Catechol 2,3 Dioxygenase
BBMB & Chemistry Whitman College **(Advisor: Tim Machonkin)**

Forrest Watkins
Pentamidine binding to DNA in Myotonic Dystrophy
Institute of Molecular Biology, U. of Oregon, Eugene **(Advisor: Arielle Cooley)**

Katie Zajicek
Chromatophore cell based biosensors
Oregon State University **(Advisor: Paul Yancey)**

2012-13

Kiran Aujla	Whitman College	**(Advisor: Chris Wallace)**
Tiluck Bhatt	Whitman College	
Molly Blust	Infectious Disease Research Institute	**(Advisor: Jim Russo)**
Geoff Burks	Whitman College	**(Advisor: Doug Juers)**
Emmy Coleman	Albert Einstein	**(Advisor: Ginger Withers)**
Rose Cotter	Whitman College	**(Advisor: Doug Juers)**
Taylor Folt	Infectious Disease Research Institute	**(Advisor: Kendra Golden)**
Whitney Griggs	Whitman College	**(Advisor: Tom Knight)**
Alexis Guy	Whitman College	**(Advisor: Allison Calhoun)**
Tom Haffner	Fred Hutchinson Cancer Research Center	**(Advisor: Tom Knight)**
Jack Hardiman	U California – San Francisco	**(Advisor: Ginger Withers)**
Dandi Huang	Fred Hutchinson CRC	**(Advisor: Kendra Golden)**
Kendra Klag	Whitman College	**(Advisor: Dan Vernon)**
Spencer May		**(Advisor: Jim Russo)**
Taylor Mesojednik	Swedish Heart Institute	**(Advisor: Leena Knight)**
Trevor Miller	Whitman College	**(Advisor: Chris Wallace)**
Ryan Nesbit	Whitman College	
Dannie Nguyen	Whitman College	**(Advisor: Kendra Golden)**
Vince Peterson	Whitman College	**(Advisor: Marion Gotz)**
Andrew Roehrig	Whitman College	**(Advisor: Kendra Golden)**
Woody Sorey	Walla Walla Health Dept	**(Advisor: Jim Russo)**
Will Stark	Walla Walla University	
Andrew Terrell	University of Washington	**(Advisor: Leena Knight)**
Olivia Ware	Whitman College	**(Advisor: Doug Juers)**

Appendix C: GRE information

THE GRE SUBJECT EXAM IN: BIOCHEMISTRY, CELL AND MOLECULAR BIOLOGY

The test contains about 180 multiple-choice questions, a number of which are grouped in sets toward the end of the test and based on descriptions of laboratory situations, diagrams, or experimental results.

The content of the test is organized into three major areas: biochemistry, cell biology, and molecular biology and genetics. In addition to the total score, a subscore in each of these subfield areas is reported. Because these three disciplines are basic to the study of all organisms, test questions encompass both eukaryotes and prokaryotes. Throughout the test, there is an emphasis on questions requiring problem-solving skills (including mathematical calculations that do not require the use of a calculator) as well as a content knowledge. While only two content areas in the following outline specifically mention

methodology, questions on methodology and data interpretation are included in all sections.

In developing questions for the test, the committee that develops the test keeps in mind both the content of typical courses taken by undergraduates and the knowledge and abilities required for graduate work in the fields related to the test. Because of the diversity of undergraduate curricula, few examinees will have encountered all of the topics in the content outline. Consequently, no examinee should expect to be able to answer all questions on the edition of the test he or she takes. The committee is aware that the three content areas are interrelated. Because of these interrelationships, individual questions or sets of questions may test more than one content area. Therefore, the relative emphases of the three areas in the following outline should not be considered definitive. Likewise, the topics listed are not intended to be all-inclusive but, rather, representative of the typical undergraduate experience.

I. BIOCHEMISTRY 36%

A. Chemical and Physical Foundations
Thermodynamics and kinetics
Redox states
Water, pH, acid-base reactions, and buffers
Solutions and equilibria
Solute-solvent interactions
Chemical interactions and bonding
Chemical reaction mechanisms

B. Biomolecules: Structure, Assembly, Organization, and Dynamics
Small molecules
Macromolecules (for example, nucleic acids, polysaccharides, proteins, and complex Lipids)
Supramolecular complexes (for example, membranes, ribosomes, and multienzyme complexes)

C. Catalysis and Binding
Enzyme reaction mechanisms and kinetics
Ligand-protein interaction (for example, hormone receptors, substrates and effectors, transport proteins, and antigen-antibody interactions)

D. Major Metabolic Pathways
Carbon, nitrogen, and sulfur assimilation
Anabolism
Catabolism
Synthesis and degradation of macromolecules

E. Bioenergetics (including respiration and photosynthesis)
Energy transformations at the substrate level
Electron transport
Proton and chemical gradients
Energy coupling (phosphorylation and transport)

F. Regulation and Integration of Metabolism
Covalent modification of enzymes
Allosteric regulation
Compartmentation
Hormones

G. Methodology
Spectroscopy
Isotopes
Separation techniques (for example, centrifugation, chromatography, and electrophoresis)
Immunotechniques

II. CELL BIOLOGY 28%

A. Cellular Compartments of Prokaryotes and Eukaryotes: Organization, Dynamics, and Functions
Cellular membrane systems (structure and transport)
Nucleus (envelope and matrix)
Mitochondria and chloroplasts (including biogenesis and evolution)

B. Cell Surface and Communication
Extracellular matrix (including cell walls)
Cell adhesion and junctions
Signal transduction
Receptor function
Excitable membrane systems

C. Cytoskeleton, Motility, and Shape
Actin-based systems (including muscle contraction)
Microtubule-based systems
Intermediate filaments
Prokaryotic systems

D. Protein Synthesis and Processing
Regulation or translation
Posttranslational modification
Intracellular trafficking
Secretion and endocytosis

E. Cell Division, Differentiation, and Development
Bacterial division
Meiosis and gametogenesis
Eukaryotic cell cycles, mitosis, and cytokinesis
Fertilization and early embryonic development (including positional information, homeotic genes, tissue-specific expression, nuclear and cytoplasmic interactions, growth factors and induction, environment, and polarity)

III. MOLECULAR BIOLOGY AND GENETICS 36%
A. Genetic Foundations
Mendelian and non-Mendalian inheritance
Transformation, transduction, and conjugation
Recombination and complementation
Mutational analysis
Genetic mapping and linkage analysis

B. Chromatin and Chromosomes
Karyotypes
Translocations, inversions, deletions, and duplications
Aneuploidy and polyploidy
Structure

C. Genomics
Genome structure
Physical mapping
Repeated DNA and gene families
Gene identification
Transposable elements

D. Genome Maintenance
DNA replication
DNA damage and repair
DNA modification
DNA recombination and gene conversion

E. Gene Expression
The genetic code
Transcription
RNA processing
Translation

F. Gene Regulation in Prokaryotes
Positive and negative control of the operon
Promoter recognition by RNA polymerases
Attenuation and antitermination

G. Gene Regulation in Eukaryotes
Cis -acting regulatory elements
Trans -acting regulatory factors
Gene rearrangements and amplifications

H. Bacteriophages and Animal and Plant Viruses
Genome replication and regulation
Virus assembly
Virus-host interactions

I. Methodology
Restriction maps
Nucleic acid blotting and hybridization
DNA cloning in prokaryotes and eukaryotes
Sequencing and analysis
Protein-nucleic acid interaction