

BBMB Majors' Handbook 2017-18

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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 their interactions in cells and organisms**
- acquire the ability to read and critique the molecular life science literature**
- perform experiments to address research questions 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. Originally, this was 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, taken in the freshman and sophomore years, 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 senior research, a required thesis, and a senior seminar that provides a forum for seniors 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, 336, 337 (or 334 & 335), 400 (in final spring semester), & a total of *three credits* of 490 (490 credits should be taken in your senior year)

PLUS: 7 credits of electives offered by Biology, Chemistry, or Physics (see below)

➤ ***Full course Descriptions for BBMB required courses are listed in Appendix A, at the end of this handbook, as well as in the course catalog.***

Electives in BBMB major: At least seven additional credits are required from biology, chemistry, physics, math, or computer science courses numbered 200 or 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 applies to the BBMB major.

Many advanced courses in Physics and Chemistry can count as electives for BBMB, and generally, Biology courses in the Cell/Molecular and the Organismal (Physiology/Anatomy) categories can apply to BBMB. Some Math, Statistics, and Computer Science courses at or above the 200-level may be accepted as BBMB electives; please consult with your BBMB Advisor or the BBMB Program Director to confirm the applicability for BBMB of courses offered by those programs. Study abroad courses can also count as electives to fulfill major requirements. Before going abroad, discuss elective possibilities with your academic advisor or the BBMB program director; provide info on specific courses when you do so. See pages 9-10 of this handbook for more information on study abroad.

Most courses that can count as BBMB electives are listed below. Note that some new classes or classes offered by visiting faculty may be missing from this list, and not all of these listed classes are offered every year. So, you should refer to the online course catalog and schedule for the most updated Biology, Physics, and Chemistry courses. Also, ***pay attention to list-serve and email announcements about new classes in Biology, Chemistry, and Physics***; many of those might be useable as electives for BBMB.

BBMB

430 Infectious Diseases

Fall

481/482 Special Projects

Arr. w/ instructor; *2 cr, max, total

BIOLOGY

228	Biostatistics	Fall [if offered]
303/4	Cell Biology/Lab (lab separate)	Spring
305/6	Cell Physiol & Signal/Lab (lab separate)	Spring
310	Physiology	Fall
315	Comparative Vertebrate Anatomy	Fall
319	Developmental Biol Seminar	Spring
320	Neurobiology	Fall
323	Neurophysiology	Spring
328,338	Evolutionary Devel. Biol.; lab (lab separate)	Fall
329	Developmental Biology	Spring
330	Human Physiology	Spring
339	Microbiology & Immunology	Fall
342	Gene Discovery & Functional Genomics	Spring
350	Evolutionary Biology	Spring
353	Plant Physiology	Spring
402	Seminar (cell or organismal biology topics)	Spring
405	Bioethics	Spring
471,472	ST classes (cell or organismal biology topics)	Fall, Spring
481/482	Special Projects	Arr. w/ instructor; *2 cr max

CHEM

240	Quantitative Analysis and Chemical Equilib.	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	Organic Chem of Drug Design	
425	Computational Biochemistry	
432	Capillary Electrophoresis	Fall
447	Physical Organic Chemistry	Fall
456	Advanced Organic Chemistry	
460	Bioinorganic Chemistry	Spring

MATH

247	Statistics with Applications	Fall
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PHYS

246/56	Waves +Lab (lab separate)	Spring
318	Computational Physics	
325	Electricity & Magnetism	Fall
348	Optics	Spring
357	Thermal Physics	Spring

Senior year requirements: BBMB majors must complete a research project, write a research

thesis describing the work and present it as a seminar to the department. Thesis and seminar are required capstone courses for which you receive credit (BBMB490, BBMB400). All BBMB seniors also must pass a senior assessment containing both oral and written components. The oral component consists of a one-hour question/answer discussion with two or more participating faculty. The written component consists of the senior thesis. More details on all of these requirements are provided below.

- ***Details on the senior research/thesis requirements and the senior assessment are provided below, in sections II and III.***

II. Research & Thesis (BBMB 490)

All BBMB students must do a research project in the molecular biosciences, or in a related area of chemistry, biology, or physics. Projects typically involve laboratory work, but can involve clinical or epidemiologic research, or review and critique of data from the literature, as long as it's done to ***assess a hypothesis in the molecular life sciences.***

The Whitman BBMB program is very flexible with regard to this requirement: there is no set minimum number of hours for an acceptable research project, and the projects can (hypothetically) be done at any time between the sophomore year and the end of senior year at Whitman. They can be done on- or off-campus, part-time or full-time, during a summer, or during 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 a research seminar. *Projects should be approved for use as a thesis project by a BBMB "thesis advisor"* - preferably before the end of your junior year. So, once you line up a potential project, talk to biology, chemistry, physics, or BBMB faculty who might serve as good thesis advisors, and discuss your project with them. Also, find out if they are willing to serve as your on-campus thesis advisor during your senior year.

- ***At the end of your junior year, you will be asked to provide information on your plans for thesis research.***

Thesis and seminar credit, and your thesis advisor

Students get credit for research data analysis, thesis writing, and research seminar presentation during their senior year. For this, you must register for a total of 3 credits of BBMB 490 during your senior year, and take the BBMB 400 seminar in your final spring semester at Whitman. 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, because technically, BBMB490 is for thesis work, not for the time in the laboratory.

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 work with you throughout your senior year to 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 they will provide consent for you to register for their section of 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).

- ***If you do not identify a thesis advisor and project by the beginning of senior year, you may be assigned to a Biology or BBMB faculty member for your senior thesis.***
- ***December grads must remember to take BBMB400 in their last spring semester at Whitman - even if their research and thesis won't be complete until the following fall semester.***

- *December grads should arrange w/ the BBMB Director to give their senior research presentation near the end of their final fall semester, if they do not present in BBMB400 the previous spring.*

What to do:

You should start thinking about finding a research project in the late fall of your junior year, at the latest. You can work in a lab at Whitman (or elsewhere in Walla Walla) during your senior year, 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, unpaid 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, ***BBMB is very flexible with regard to the research requirement.***

There lots of ways to find a thesis project. You can find internship possibilities online, work with a professor at Whitman, find a spot at a university, hospital, government agency, or biotech company near home, or do research during study abroad. Pay attention to the frequent notifications posted on the BBMB and Biology list-serves. Many students find opportunities at other universities through word-of-mouth or personal connections. More details are provided below, in section III.

Once you find a potential research project, you need to identify a Whitman faculty who can approve the project, and then serve as a thesis advisor. It's best to do this in spring of your junior year. However, if you run into difficulties or change projects, you can finalize advisor arrangements any time before the end of add/drop period September of your senior year (that's the deadline for finalizing your BBMB490 registration). 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; for gene regulation, it might be Prof. Vernon, *etc.*]. Then, register for your advisor's section of BBMB 490 in your senior year.

- *Steps and a timeline you should follow to fulfill senior research and thesis requirements are provided below in section III. 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. Usually organized by Prof. Vernon, it features a panel of seniors who chat about their research and how they landed their projects.*

III. Senior Year Requirements - Timeline and Details

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. Pay attention to BBMB emails and Cleo messages during your junior and (especially) senior years: many important reminders or deadlines are announced via those venues. Your graduation may depend on it.

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:

The senior thesis will serve as a written component of your senior assessment. Your thesis is supervised and graded by your thesis advisor, but an advanced draft of the thesis itself will be appraised by at least one other member of the BBMB faculty, chosen by your thesis advisor or the BBMB director.

- *In late April of your senior year you will receive an email from the BBMB Director to upload a draft of your thesis to your drop-box on the BBMB Cleo site. Do this: it's how we collect theses to determine if you pass your senior writings. Pay attention to all BBMB emails!*

2) Orals:

YOUR ORAL EXAM WILL BE SCHEDULED FOR YOU and you will be informed of the date and time. Approximately 1/2 of senior orals will be scheduled for November and December in the fall semester; the rest will take place in January and February, starting immediately after winter break. You will be notified of the exact date 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 grasp of fundamental biomolecular vocabulary and concepts covered in required courses, your ability to think on your feet, and your comfort discussing molecular life science. Questions will *not* be limited simply to material you covered in your classes; rather, they will try to address your integration of factual material and ideas in biochemistry, biophysics, and molecular biology, and their application in biological systems. Some questions will ask you to apply stuff you know to new scenarios. There is not a pre-determined set of questions for these exams - each one is different. You may be asked to look at images or draw chemical structures or cartoons on the board, to propose experiments, or interpret data. You may ask for clarification of questions or simply say that you don't know. The oral exam will last ~50 minutes. The faculty will then discuss your exam and determine whether the exam was a pass, a pass-with-distinction, or a fail, and will inform you immediately of the result. If you pass with distinction, you may qualify as an honors candidate. If so, you will be notified of that candidate status by spring break. If you do not pass the exam, you'll be scheduled to take it again.

Here is a general list of topics

- Biological, Chemical, and Physical Foundations
Thermodynamics
Kinetics
Equilibria (especially acid-base)
Bonding, structure, reaction mechanisms
Cell structure, function, and communication
Gene and genome structure, expression, and regulation
Gene and genome mutation, inheritance, and evolution
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
Relationships between genes, proteins, and evolution
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 chemistry, biology, biomedicine, or physics. This requirement is explained above in detail in section II of this handbook. The nuts and bolts of registering for research and thesis credit are described 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 each October or November. Go to that in your junior year.

What to do: You should start thinking about finding a research project in the fall of your junior year. Students can work in a lab at Whitman (or elsewhere in Walla Walla) during the academic year, 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 - paid or unpaid - are also totally acceptable*. The research *does not even need to be done in the senior year*; some students write their theses on research done in sophomore or junior summers, or during study abroad (for this you keep records of your laboratory data and methods). It is important that you have a full understanding of your project and its rationale, so projects completed prior the summer after sophomore year usually aren't acceptable. Otherwise, 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; 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.

Late fall/winter of your JUNIOR year. Start thinking about possible 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. On campus, BBMB majors may do research with any biology, chemistry, or physics professor who is willing to take them on for a project

Required steps for JUNIORS: By the end of 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 professors' 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].*

- ***Near the end of your junior year, you will be asked to provide information on your plans for thesis research. This request will be sent on the BBMB list-serve and will include instructions for what info to provide, and for uploading into your BBMB Cleo drop-box.***
- ***If you do not identify a thesis advisor and project by the beginning of senior year, you may be assigned to a Biology or BBMB faculty member for your senior thesis.***

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. Even if you did your research as a junior, or in a previous summer, you still should register for 3 credits of BBMB490 during your senior year. 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.

You must have consent from your thesis advisor to register for this required class. So, if you didn't find a thesis advisor at the end of Junior year, get one right away at start of senior year.

- ***If you do not identify a thesis advisor and project by the beginning of senior year, you may be assigned to a Biology or BBMB faculty member for your senior thesis.***

BBMB 400 Senior Seminar

This class is held each spring, typically in a MW morning time slot. 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 enroll and attend the class in spring of their junior year - even if thesis work isn't ready for presentation.*) 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. ***Work with your BBMB490 thesis advisor to organize and prepare your seminar presentation.***

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. Typically only one or two students per year earn honors in BBMB.

Honors criteria:

A. One requirement for honors at Whitman is a minimum GPA requirements, both overall (3.3) and in the major (3.5). This is a college requirement that applies to all departments.

B. To qualify for honors, students also must pass their senior exams with Distinction. The senior exam consists of written and oral components (see section B above). To qualify for honors you must get distinction on both components, as judged by all faculty involved with your oral exam and research/thesis appraisal. You'll know your oral exam results by March 1st. For distinction on your written exam, you will need to submit a complete, excellent-quality draft of your thesis for appraisal in mid/late April. At that point your thesis advisor, along with a 2nd faculty reader, will determine whether your research, thesis progress, and thesis quality meet the criteria for honors. Generally, you must earn a final grade of A or A+ on your thesis to earn honors.

C. Support of your thesis advisor. *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. 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 writing process, according to the expectations of your advisor and other faculty involved in appraising your thesis progress and the thesis itself.

If your thesis advisor considers your thesis progress of honors caliber, s/he may discuss the possibility of honors with you during your senior year, and will more formally notify you of honors candidacy after your oral exam is passed with distinction.

➤ ***Commitment to research and excellence in the senior thesis are the chief criteria for honors in BBMB. If you are a candidate honors, you must have a high-quality draft of your thesis completed in time for appraisal by BBMB faculty, in mid/late April.***

D. In addition to excelling in your thesis work, you must get an A or A+ grade in the BBMB 400 senior seminar course. This class is graded based on the quality of your thesis research presentation, as well as participation in the form of attendance, questions, and contributions to discussion.

By about March 1st of your senior year, you will know your oral exam outcomes and should have made significant progress on your thesis for your advisor to determine whether you are an honors candidate. At this point, based on these criteria, your thesis advisor may nominate you for honors candidacy and will inform you, the program director, and other BBMB faculty of this status.

Thesis appraisal: Special rules for honors thesis: If you are a viable honors candidate, a penultimate draft of your thesis must be read and approved as honors caliber by one additional BBMB-associated faculty, in addition to your research advisor. In late April you may be asked to distribute your thesis to a second faculty reader (“appraiser”) in the BBMB, Biology, Physics, or Chemistry program. Alternatively, the thesis you submit for the written exam in late April will be distributed to a second faculty reader (see IIIB-1, above). At this point your draft thesis will be appraised to determine if it

meets the criteria for honors - so if you have been nominated for honors, you should submit a complete and excellent draft at this step. After you get comments back, 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.

IV. Study Abroad

Thinking of study abroad?... BBMB majors can go for study abroad in the junior year, *if* all calculus, introductory physics, and organic chemistry requirements are completed before the semester abroad. When making plans to study abroad, note that it's easier to find suitable electives than substitutes for core required upper-level courses and labs. It's best to take Biochemistry, Biophysics, and Molecular Biology here, with their associated labs. Usually, the BBMB 337 lab (or the 334 335 labs) are only offered in spring, and BBMB 326 and 336 in the fall, so it's usually best to go abroad in fall junior year and take the BBMB 324, 325, and 326 classes and the 336 and 334, 335, or 337 labs, after you get back. However, depending on where you go for study abroad, it may be possible to find a class that can substitute for one of these upper-level core classes. Here's what to look for:

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 molecular/cell biology lab course.

An off-campus molecular biology lab (for BBMB336 equivalency) must include some standard techniques of DNA manipulation and analysis [e.g. DNA isolation, PCR, agarose gel electrophoresis, molecular cloning] and some analysis of gene expression [e.g., RT-PCR, cDNA analysis, RNA blotting, transcriptome analysis]. 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/>

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 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.

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. Thanks to our rigorous BBMB thesis requirement, you'll have this covered - at least to a minimum level. More prestigious programs may prefer applicants with more prior research experience than is required for a Whitman thesis.

- **Graduate Record Examination (GRE)**
Most graduate schools require that applicants take the GRE general test, and some (but not as many) require the Biochemistry subject test. The general tests are computer-based and offered year round at regional centers, but not in Walla Walla. The subject exams are given in September/October and April. Since many graduate programs do not require the subject exam, you should check on the requirements of programs you are interested in. Information on registration dates, costs, and test locations, are available at GRE.org. Note that registration deadlines are often ~4-6 weeks before the exam date. So plan ahead.
- **Letters of Reference:**
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; 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). Scheduling visits during the academic year can be challenging, but it's important.
- **Financial considerations:**
In graduate school, you are expected to do research full time, and most doctoral programs in the molecular life sciences will provide a stipend (\$25,000+) and waive tuition. Accepted students may be expected to serve as a TA for undergraduate labs or classes.

C. POST-GRADUATE FELLOWSHIPS

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 Whitman's Health Professions Advisor* as early as you can (preferably by early in your junior year). They will provide the specialized advice you need to meet requirements for these various professional programs.

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 or Spring: Moss, Rokhsana, or 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:* Biol111, Chemistry 246.

326 Molecular Biology 3, x Vernon or Moss

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 [not offered when BBMB337 is offered]

Laboratory exercises on a range of biophysical topics. 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 or Moss [not offered when BBMB337 is offered]

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 or Moss

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.

337 Techniques in Biochemistry and Biophysics x, 1 Juers, and Moss or Russo

Laboratory exercises emphasizing protein structure and function. Methods may include reagent preparation; protein isolation, purification, and identification; enzyme and protein assays; structure

determination via X-ray diffraction; spectroscopic analysis of protein folding and ligand binding; and models of thermal motion via particle tracking. One three hour laboratory per week. Counts towards the Molecular/Cell requirement for the Biology major. Prerequisites: Biology 111 and Chemistry 136 or 140; Corequisite: BBMB 324 or 325. Open to non-BBMB majors only with consent of instructor.

400 Senior Seminar x, 1 Vernon, Juers, Moss

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 in 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>

Center for Infectious Diseases Research <http://www.cidresearch.org/>

Pacific Northwest Diabetes Research Institute <http://www.pnri.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>

AmpliPhi Biosciences Corp: <http://www.ampliphio.com>

CTI BioPharma Corp: <http://www.ctibiopharma.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. REUs are full-time, paid summer research internships found at many universities. Though funded by the NSF, REU programs are run independently by different universities: each REU program has its own focus and its own application process and deadlines. You can get info on REU opportunities from individual university departments (such as biochemistry, cell biology, or microbiology department websites), *or* you can go directly to this NSF website to get more info:

http://www.nsf.gov/crssprgm/reu/reu_search.cfm You can search that site for opportunities by geographic location or research topic. There are REU programs 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. Helpful advice: don't just focus on REU programs at super-prestigious universities. There's a *lot* of cutting edge science done at scores of universities all over the country.

2. NIH Summer Research Program (any of the National Institutes of Health)

<http://www.training.nih.gov/programs/sip>

3. HHMI

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. <https://www.janelia.org/you-janelia/students-postdocs/undergraduate-scholars-program/application-details>

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/scientific-careers/summer-internship>.

5. Other institutions

By looking at posters around the building, or searching Summer Undergraduate Research, you can identify many universities and institutions with summer research programs that pay approximately \$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. New programs may not be advertised until December or January, so if you start to look in the fall semester, check again periodically for announcements of new programs.

Examples of Sr. Research Projects *(Note the variety of projects, locations, and advisors)*
2016-17

R. Eguia	Evolution of Monkeyflower anthocyanin pigmentation	Whitman (Advisor: A. Cooley, Biology)
C. Amundson	Stem cell/immunology research	Fred Hutchinson Cancer Center
M Palmer	Organic synthesis for proteasome inhibitor drug design	Whitman (Advisor: M. Gotz, Chemistry)
A Oken	X-ray crystallography of enzyme structure	Univ. of Oklahoma (Advisor, D. Juers)
Q Wang	Studies on protein crystallization	Whitman (Advisor: D. Juers, Physics)
M Hirano	B-catenin phosphorylation: effects on zebrafish embryos	Univ. of Washington (D. Vernon, Biol.)
N Lifshaz	Organic chemistry: removing bioactive pollutants from water	Samford University, Alabama
B Hernried	Engineering a plant hormone response pathway in yeast	Whitman (Advisor: B. Moss)

2015-16

B Walund	Virus evolution: Sequencing and comparing HIV variants	Center for Infectious Disease Research, Seattle
C Phalen	High-throughput enzyme inhibition screening	Infec. Disease Research Inst., Seattle
S Curtis	Testing antibody-drug conjugates for AML therapy	Seattle Genetics (company)
S Anderson	DNA replication protein FNACD2 interactions w/ CtIP.	University of Minnesota
J Jurich	Thermal expansion in solutions of cryoprotective agents	Whitman (Advisor: Juers)
R Fenoli	PRMT-1 protein and how it's affected by dimerization	Utah State University
A Hulse	Disease resistance to stem rust fungus, in wild barley	U. Minnesota (Advisor: Cooley)
J O'Connor	Computational modeling of the CODH enzyme active site	Whitman (Advisor: D. Rokhsana)
K Beebe	Sex differences in mice-circuit mapping in mouse brain	UW Dept. Pharmacology (T.Knight)
B Sheppard	Effects of PIRL9 overexpression on plant development	Whitman (Advisor: Vernon)
W Wood	PIRL6-GFP fusion constructs for protein localization	Whitman (Advisor: Vernon)
J Hart	Lifetime and turnover time of taste buds	U. Colorado-Denver
R Waraich	Synapse formation in rat brains during development	Whitman (Advisor: Withers)

2013-14

Shunei Asao	Algae Switching in Forked Tube Lichen, Whitman College	(Advisor: Suzanne Alterman)
Jay Barlow	Role of Microbial Biosurfactants in the Athabasca Oil Sands, U. of Calgary	(Advisor: Sara Belchik)
Andres Crane	Astroglia Contact in Neurogenesis, Whitman College	(Advisor: Ginger Withers)
Daniel Ellis	Biomimetic Models for Mo-containing CO Dehydrogenase	Whitman College (Advisor: Dalia Rokhsana)
Kayla Erspamer	Alpha-TEA-lysine salt induction of autophagy in breast cancer	(Advisor: Ginger Withers)
Patrick Finnegan	Identification of the PIRL LRR gene family in <i>Vitis vinifera</i>	Whitman College (Advisor: Dan Vernon)
Gabriela Kaus	c-di-GMP responsive circuits in biofilms of <i>Vibrio</i>	Dept. of Microbiology, U. of Iowa, (Advisor: S.Belchik)
Sam Kirsch	Neuron Polarization in Cell Culture on Nanotextured Surfaces,	Whitman College (Advisor: Ginger Withers)
John Lee	Imaging for the Atlas for Mouse Brain Vasculature,	Allen Institute for Brain Sciences, Seattle (Ginger Withers)
Amanda Lu	Biochemical pharmacology of IRAP inhibition.	Dept. of Physiology, Monash U., Australia (Jim Russo)
Joshua Melander	Experience-dependent Neuroplasticity,	Whitman College (Advisor: Chris Wallace)
M. Momany	RNA isolation from patient samples for HIV vaccine trial,	Fred Hutchinson CRC, Seattle (Dan Vernon)
Carol Pengshung	Tuberculosis Antigen Discovery	Infectious Disease Research Institute, Seattle (Advisor: Jim Russo)
Alexandra Roston	Allosteric control KCNQ1 Ion-channel in Cardiac tissue.	U. of British Columbia, Vancouver (L.Knight)
Jeremy Schofield	Model Complexes to probe substrate specificity of pcpA enzyme.	Whitman College (Tim Machonkin)
Reid Shaw	Intracompartamental Pressure Measurement on animal limbs.	Mirador Biomedical, Seattle (L. Knight)
Hallie Swan	PIRL6-GFP protein localization in <i>Arabidopsis</i> protoplasts.	Whitman College (D. Vernon)
Ivana Vukovic	Molecular cloning of Xyle Catechol 2,3 Dioxygenase,	Whitman College (Advisor: Tim Machonkin)
Forrest Watkins	Pentamidine binding to DNA in Myotonic Dystrophy,	U. of Oregon (Advisor: Arielle Cooley)