

BBMB Majors' Handbook 2022-23

BBMB Program Faculty & Major Advisors

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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**
- **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. Requirements & Curriculum

The Biochemistry, Biophysics, & Molecular Biology (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 years 1 & 2, provide the foundation for the major. Years 3 & 4 include 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.

A. Guidelines for First- and Second-Year students interested in BBMB:

BBMB is an interdisciplinary program in the molecular life sciences that has grown from three different areas of science – Biology, Chemistry, and Physics. BBMB requirements can be broken down into two categories: 1) the 100- and 200-level classes (up to 40 credits) taken in Biology, Chemistry, Math, and Physics that serve as prerequisites for 2) the 300- and 400-level BBMB core requirements and electives (23 credits). It is important for BBMB majors to complete the prerequisites in their first 5 semesters at Whitman or soon after transferring to Whitman.

Whatever your major may be, remember to consult the College Catalog (aka course catalog) for details on any major program, its requirements, and information on individual classes. Also, the catalog spells out all of the college's General Studies (Distribution) requirements. The College Catalog shows *everything* you need to know to complete your graduation requirements. Consult it *frequently*!

The key to completing Whitman's BBMB major in 4 years is to complete the classes listed below by the end of the fall semester of your junior year (or before you engage in off-campus study, whichever comes first).

Key prerequisites to complete by the end of your 5th semester (1st semester of junior year)

Math 124 or 125, 126, and 225 (Calculus I, II, and III)

If you had calculus in high school you may be able to start your calculus series at the 126 or 225 course level, as determined by a placement exam offered by the Math Department (see their webpage). The 124 or 125, 126 courses are co/pre-requisites for Physics 155, 156 and 225 is a pre-requisite for BBMB 324 (Biophysics).

Physics 155 and 156 (General Physics Series with labs, has a Math 124 or 125/126 pre- or co-req)

This series is a pre-requisite for Biophysics and has twice-weekly, 1.5 hr labs.

Heads up #1! This is the more advanced intro physics series. Phys145 can substitute for Phys 155, but you must take Phys 156.

Heads up #2! This series starts in the **Spring**: Phys155 is offered only in Spring, Phys156 only in Fall.

Chemistry 125 & 126; or Chemistry 140 (General Chemistry series with labs)

You will take a placement exam to determine if Chem 125 or Chem 140 is the appropriate course (see Chemistry webpage). Chem140 is a more advanced, faster-moving version of Chem 125/126.

Chemistry 245 & 246 (Organic Chemistry series with labs, has General Chemistry series pre-req)

This series is typically taken in second year. Chem 246 must be completed prior to enrolling in BBMB 325 (Biochemistry).

Biology 111 (Biological Principles with lab, has a General Chemistry pre-req; offered Fall and Spring)

This class has General Chemistry (either Chem125/135 or Chem140) as a prerequisite. Students can take this class in the Fall of the 2nd yr or Spring of the 1st yr.

Biology 205 (Genetics, has Biol 111 pre-req; Lab, Biol 206, is not required; offered Fall and Spring)

Students typically take this class in their second year. It is strongly recommended to take Genetics before Biochemistry.

***** SAMPLE 4-yr course plans are shown in Appendix A at the end of this handbook.**

B. Required courses for the BBMB major:

- 63 Credits (including all introductory chemistry and calculus credits)
- Required Courses
 - Biology 111, 205
 - Chemistry 125/135 & 126/136, or Chemistry 140; Chemistry 245, 246, 251, 252
 - Physics 145 or 155, and 156
 - Mathematics 225 (prerequisite Mathematics 124 or/125 and 126)
 - Upper level core classes: BBMB 324, 325, 326, 334, 335, 336
 - At least seven additional credits in courses numbered 200 and above from biology (excluding Biology 206), chemistry, computer science, mathematics & statistics, or physics
 - Senior year thesis and seminar classes: Three credits of BBMB, Biol, Chem, or Phys 490 (Thesis), plus one credit of BBMB 400 (Senior Seminar; spring only). December grads: you *must* enroll in BBMB 400 in your final *spring* semester at Whitman, whether or not you have completed your senior research. 490 credits should be taken during your senior year, regardless of when you do your thesis research.
 - Other notes on the major
 - Only 1 credit of Chemistry 401 or 402 or Mathematics 299 may be applied toward the major
 - Up to two credits of independent projects (BBMB or Biology 481, 482, Chemistry 390, 451, 452, Computer Science 481 and 482, or Physics 483, 484) can count toward the major
 - The P-D-F grade option is not allowed for any courses which apply to the major
 - Off campus study courses can also be used as electives to fulfill major requirements. Before enrolling in OCS programs, discuss elective possibilities with your academic advisor or the BBMB program director, providing catalog descriptions of specific courses in question, when you do so. [See section IV for information on off campus study.]

***** Full course descriptions for BBMB required courses are listed in the college course catalog and Appendix B in this handbook.**

II. Research & Thesis

All BBMB students must do a research project that can serve as the basis for the senior thesis. Projects typically involve laboratory work, but can involve clinical or epidemiologic research, or, less commonly, a review and critique of data from the literature. All projects must assess a hypothesis or address a question in the molecular life sciences. Your research project does *not* need to be strictly biochemical or biophysical or molecular: most research in Biology or Chemistry can be used for a BBMB senior thesis. If you aren't sure about whether a research opportunity is BBMB thesis-worthy, discuss it with your BBMB major advisor.

The Whitman BBMB program is very flexible with regard to the research 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 communicate your results in your senior thesis and seminar.

Identifying a research project for your thesis

You should start thinking about finding a research project by 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 at Whitman or off campus 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. 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 are lots of ways to find a thesis project. You can find internship possibilities online, via the Summer Biomed Research Internship guide on the majors Canvas site, from announcements of our partner programs at Fred Hutch and the Mayo Clinic, the Career and Community Engagement Center, word-of-mouth or personal connections. All of these can lead to projects working with a professor at Whitman, a position at a university, hospital, government agency, or biotech company near home or during off campus study. Pay attention to the frequent notifications posted on the BBMB email list and the announcement monitor above the STEM Hub. More details are provided in Appendix C.

Finding a thesis advisor

Once you find a potential research project, it must be approved and, and will need the commitment of a thesis advisor. It's best to do this by the end of the spring semester of your junior year. However, if you run into difficulties or change projects, you can finalize thesis advisor arrangements any time before the end of add/drop period in fall of your senior year (that's the deadline for finalizing your 490 registration). Your thesis advisor need not be one of the core BBMB profs - Chemistry and Biology faculty commonly serve as BBMB thesis 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.*].

Credit for Thesis(490) and Seminar (400)

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, Biol, Chem, or Phys 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 your research prior to your senior year (e.g., during junior year, or a previous summer), you must register for 490 during your *senior year*, because technically, 490 credits are for thesis work.

Registration for a section of 490 will require consent from your thesis advisor: the 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 490. 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.

****** Hey juniors! Each Fall, BBMB faculty hold an info session on research and thesis. Go to it! Also, suggestions on where to hunt for summer research internships, and examples of recent BBMB senior research projects are provided in Appendices C & D, respectively.***

****** Near the end of your junior year, you will be asked by the BBMB program director to provide information on your plans for thesis research. If you do not identify a thesis advisor and project by August of your senior year, you will be assigned to a faculty member for your senior thesis***

****** If you arrange a good internship early enough in your junior year, you can apply for funding from the Career & Community Engagement Center. Their deadline is usually in late March.***

****** You can always discuss potential thesis projects, thesis advisors, and how to register for your senior thesis credits with your BBMB major advisor.***

III. Senior Year Requirements – Details and Timeline

Some of these requirements include forms that must be filled out by a particular deadline. Exact deadline dates can vary from year to year. Consult the Whitman Senior Handbook <https://www.whitman.edu/registrar/services-for-students-and-alumni/senior-handbook#adc> for updated info. Pay attention to announcements from BBMB during your junior and (especially) senior years. Your graduation may depend on it!

A. Graduation application

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 current Whitman Senior Handbook for the deadline.

B. Senior Assessment – Orals and Writtens

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 uploaded to the BBMB 400 Canvas site and appraised (no pass, pass, pass with distinction) by at least one other member of the BBMB faculty, chosen by your thesis advisor or the BBMB director .

***** In April of your senior year you will receive an email from the BBMB Director to upload a draft of your thesis on the BBMB Canvas site. Do this: it's how we collect theses to determine if you pass your senior written exam.**

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 the fall semester (November or early December); the remainder will take place in January and early February, starting immediately after winter break. You will be notified of the exact date at least 2 weeks before the date of your exam – but the info above is sufficient for you not to be caught off-guard.

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 what 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. Unlike written exams, there is opportunity for back-and-forth communication in these orals: you may ask for clarification of questions or simply say that you don't know. The oral exam will last ~40-45 minutes. The faculty will then discuss your exam and determine whether the exam was a pass (or a fail), and will inform you of the result. If you do not pass the exam, you'll be scheduled to take it again no sooner than 3 weeks after the first attempt.

Later in the year, faculty will consider your performance on your oral as one criterion when faculty discuss nominations for honors candidacy (see section III D).

Here is a general list of topics that are often included in oral exams

• Biol/Chem/Phys Foundations

Thermodynamics
Kinetics
Equilibria (esp. acid/base)
Bonding, structure, reaction mechanisms
Cell structure, function, & communication
Evolution, mutation, inheritance
Biophysical principles of macromolecules

• Molecular Life Science Integration

Biomolecular structure/function relationships
Catalysis
Bioenergetics & metabolism
Signal Transduction
Genome maintenance & expression
Gene regulation & relationship to biologic processes
Relationships between genes, proteins, & evolution
Experimental methods

C. How to complete Senior Research, Thesis, & Seminar

Required steps for SENIORS:

BBMB/Biol/Chem/Phys 490 Senior Thesis (Fall and/or Spring)

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 490. Even if you did your thesis research as a junior, or in a previous summer, you must register for 3 credits of 490 during your senior year when you will be writing your thesis. Registration will require consent of your thesis advisor; enroll in their section. The three credits are most commonly divided between Fall and Spring, but under certain situations all 3 *may* be taken in fall or all in spring. If you take all three credits in the Fall, you *must* complete the written, graded thesis in the Fall, so 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.

If you do your research at Whitman, your faculty research advisor will typically also serve as your thesis advisor and will consent you into their thesis section. If you do your research off-campus, then you should approach a biology, chemistry, or BBMB professor in the spring or summer before your senior year about serving as your thesis advisor. If you do not do this, you will be matched with a faculty member who will then serve as your thesis advisor and consent you into their section (the BBMB faculty meet right before the beginning of Fall semester to make thesis advising assignments based on project fit and equitable distribution of advisees. Your BBMB major advisor can address any questions on how to register for your senior thesis credits.

BBMB 400 Senior Seminar (Spring only)

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.* (i.e., 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 490 thesis advisor to organize and prepare your seminar presentation.*

***** 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 also must arrange w/ the BBMB Director to give their senior research Seminar presentation near the end of their final fall semester, if they do not present in BBMB 400 the previous spring.**

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 a few students per year earn honors in BBMB.

By early March of your senior year, oral exams should be completed and you should have made significant progress on your thesis for the BBMB faculty to determine whether you are an honors candidate. At this point, based on these criteria, the BBMB faculty, in consultation with your thesis advisor, may nominate you for honors candidacy and will inform you of this status.

Honors criteria:

- Commitment to research and excellence in the senior thesis are the chief criteria for honors in BBMB. To be considered an honors candidate, you must also achieve the grade minima and earn distinction on your oral and written senior assessments, as described below.
- Honors at Whitman requires a GPA of at least 3.3 overall and 3.5 in the major. These are college requirements that apply to honors in all departments.
- To earn honors, students must pass their senior exams with Distinction. The BBMB senior exam consists of written and oral components (see above). For honors you must get distinction on *both* of these components, as judged by all faculty involved with your oral exam and thesis appraisal. Honors candidates will be notified of their candidacy by mid-March, after all senior orals have been completed.
- *Thesis appraisal:* If you are a viable honors candidate, a penultimate draft of your thesis must be read and approved as worthy of distinction and honors caliber by one additional BBMB-associated faculty, in addition to your research advisor. By ~ April 20th you will be asked to upload your thesis to the BBMB 400 Canvas site for appraisal by your thesis advisor and a second faculty member in the BBMB, Biology, Physics, or Chemistry program. They will determine whether your thesis meets the criteria for distinction on the written component of the senior assessment and whether the research and thesis quality meet the criteria for honors. An outstanding thesis is one of the main criteria for honors in BBMB.

If so, you will receive comments from the reviewers and can discuss suggested revisions with your advisor and finalize your thesis. Complete honors theses must be submitted to the library by the last day of classes. Penrose has specific rules about honors thesis format and submission. See the [Penrose Library Honors Thesis Guidelines](#) for explicit instructions on formatting, electronic submission, and due dates 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 completed thesis to your thesis advisor and to Penrose library by the deadline. Your thesis advisor will determine the final grade at semester's end.

- Finally, you must earn an A/A- grade on your BBMB 400 senior seminar. This grade in this class is based on the quality of your research presentation and on your participation in the form of attendance, questions, and discussion

***** Most important, to qualify for honors you must do an outstanding job with your senior research, thesis, and seminar. In BBMB, honors is not just based on grades and exams: it's reserved for students who demonstrate a sustained commitment to research during their time at Whitman, and excellence in the written and oral 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.***

***** Note that earning distinction on your written exam is independent of your thesis (BBMB490) grade; it's possible for a thesis to earn an excellent BBMB490 grade while still not reaching the level of distinction and Honors caliber required for honors thesis (BBMB 498).***

IV. Off campus study

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 is possible to go abroad in either fall or spring of your junior year. What you choose to do will affect when you take your upper-level classes. To go abroad in the fall of junior year, BBMB majors should start the introductory physics sequence in spring of their first year. If you start physics in spring of your second year, you should go abroad in spring of junior year so that you are at Whitman to complete intro physics in the fall semester of junior year.

** For 2022-23 and 2023-24, when Biophysics is in transition from a Fall course (2022) to a Spring course (2024), the BBMB core course schedule recommendation for off campus study is as follows:

Abroad in Fall 22

Junior Fall 22: Abroad
Junior Spring 23: BBMB 325, 335
Senior Fall 23: BBMB 326, 336
Senior Spring 24: BBMB 324, 334

Abroad in Spring 23

Junior Fall 22:	BBMB 324, 334, 325	OR	Junior Fall 22:	BBMB 325
Junior Spring 23:	Abroad		Junior Spring 23:	Abroad
Senior Fall 23:	BBMB 326, 336		Senior Fall 23:	BBMB 326, 336
Senior Spring 24:	BBMB 335		Senior Spring 24:	BBMB 324, 334, 335

Abroad in Fall 23

Junior Fall 23:	Abroad	OR	Junior Fall 23:	Abroad
Junior Spring 24:	BBMB 325, 335, 324, 334		Junior Spring 24:	BBMB 325, 335,
Senior Fall 24:	BBMB 326, 336		Senior Fall 24:	BBMB 326, 336
			Senior Spring 25:	BBMB 324, 334

Abroad in Spring 24

Junior Fall 23: BBMB 325
Junior Spring 24: Abroad
Senior Fall 24: BBMB 326, 336
Senior Spring 25: BBMB 324, 334, 335

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; bioenergetics, and energy metabolism. Coverage of cell signal transduction is also desirable.

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; and genome organization and expression. Importantly, there should be a lot of coverage of gene regulation mechanisms. Molecular lab is also required, so the class should have an associated lab component, or you'll need to find an additional Molecular/Cell lab class. A study-abroad 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, RNA blotting, reporter gene experiments, or transcriptome analysis]. It should also include genome database use and BLAST searches. If you can't find a such a lab abroad, you'll have to take BBMB 336, Biology 206, or another suitable molecular/cellular lab after you return.

3) ****Off-campus Biophysics and Biophysics Lab****: Consult with BBMB Prof. Doug Juers if you identify classes abroad that you think might fulfill the BBMB 324 and 334 requirements.

Off campus study programs:

DIS (Danish Institute for Study Abroad) in Copenhagen, Denmark and Stockholm, Sweden 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. Other DIS core programs of interest may be: medical practice/policy, neuroscience, and public health. See <http://www.dis.dk/>

This is just **ONE OF MANY OCS** programs that offer opportunities to expand BBMB-related studies. Others include:

- **University of St Andrews** (Scotland)
- **IFSA: University of Melbourne** Partnership (Australia)
- **University of Otago** (Dunedin, New Zealand)
- **IES Queen Mary**, U London (England)
- **IES London** (England) for Health Practice and Policy
- **SIT Durban** (South Africa) for Community Health

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. SEARCHING FOR JOBS

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 searching can be done online via Indeed, BioSpace, ScienceCareers, or any institution's or company's website.

B. POST-GRADUATE FELLOWSHIPS

National Science Foundation (NSF) graduate fellowships <https://www.nsfgrfp.org>

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. Consult with your academic advisor and **Dr. Jess Hernandez, Whitman's Director of Fellowships and Grants**, 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 and Grants 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 and require advance planning.

For more information on any post-graduate fellowship, set up a visit early on with Dr. Jess Hernandez, Whitman's Director of Fellowships and Grants, Hunter 403, hernand2@whitman.edu

C. APPLYING TO GRADUATE STUDIES IN THE BIOMOLECULAR SCIENCES

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 shaped by your laboratory, your graduate advisor, and your individual accomplishments as much as the university program you are in.

Graduate Program 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. Many Whitties find short-term research tech jobs after graduation that provide them w/ valuable experience and more knowledge about what they want to do.
- **Graduate Record Examination (GRE):** Few graduate schools are requiring any GRE subject exam (the subject GRE exam for Biochemistry, Cell, and Molecular Biology was discontinued in 2016). A few universities still require that applicants take the GRE *general* test. The general tests are computer-based and are offered year round at regional centers (LaGrande, OR and Lewiston, ID are closest sites) or can be taken at home with online proctoring. Information on registration dates, costs, and test locations, are available at GRE.org.
- **Letters of support:** 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 3-4 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. Virtual interviews have been used the past two years as well.
- **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 (\$30,000+) and waive tuition. Accepted students may be expected to serve as a TA for undergraduate labs or classes.

D. APPLYING TO GRADUATE STUDIES IN THE HEALTH PROFESSIONS

If you are considering a career in the health professions - medicine, nursing, public health pharmacy, dentistry, veterinary medicine, etc., set up a visit with Kimberly Mueller, Whitman's Director of Health Professions Advising, Science 162, muellkm@whitman.edu
She will provide the specialized advice you need to meet requirements for these professional programs.

APPENDIX A: SAMPLE 4-yr plans for BBMB

Here are several SAMPLE 4-yr plans... these are just *examples of how a student could successfully complete the BBMB major in 8 semesters*. Your actual sequence will vary, depending on what math and chem courses you start in, whether you are transferring credits from another school, off campus study plans, and other course interests. Each semester you will add other classes to complete ~ 15-18 credits per semester.

Sample plan # 1: 100- and 200- level BBMB prerequisites completed in 4 semesters

Fall yr 1:

GenS 145	Complex questions	(4)
Chem 125*	Gen Chem	(3)
Chem 135*	Gen Chem Lab	(1)
Math 124 or 125	Calculus I	(3)

Spring yr 1:

GenS 146	Powerful arguments	(4)
Chem 126*	Gen Chem	(3)
Chem 136*	Gen Chem Lab	(1)
Math 126	Calculus II	(3)
Phys 155	Gen Physics	(4)

Fall yr 2:

Chem 245	Organic Chem	(3)
Chem 251	Org Chem Lab	(1)
Phys 156	Gen Physics	(4)
Biol 111	Biological Prin	(4)

Spring yr 2:

Chem 246	Organic Chem	(3)
Chem 252	Organic Lab	(1)
Biol 205	Genetics	(3)
Math 225	Calculus III	(3)

Fall yr 3:

BBMB 325	Biochemistry	(3)
elective		

OR

Spring yr 3:

BBMB 325	Biochemistry	(3)
BBMB 335	Biochemistry Lab	(1)
BBMB 324^	Biophysics	(3)
BBMB 334^	Biophysics Lab	(1)

Fall yr 4:

BBMB 326	Molecular Biology	(3)
BBMB 336	Molecular Biology Lab	(1)
BBMB 490	Senior Thesis	(1-3)#
elective		

Spring yr 4:

BBMB 400	Senior Seminar	(1)
BBMB 490	Senior Thesis	(1-3)#
elective		

Sample plan # 2: 100- and 200- level BBMB prerequisites completed in 5 semesters

Fall yr 1:

GenS 145	Complex questions	(4)
Chem 125*	Gen Chem	(3)
Chem 135*	Gen Chem Lab	(1)
Math 124 or 125	Calculus I	(3)

Spring yr 1:

GenS 146	Powerful arguments	(4)
Chem 126*	Gen Chem	(3)
Chem 136*	Gen Chem Lab	(1)
Biol 111	Biological Prin	(4)

Fall yr 2:

Chem 245	Organic Chem	(3)
Chem 251	Org Chem Lab	(1)
Biol 205	Genetics	(3)
Math 126	Calculus II	(3)

Spring yr 2:

Chem 246	Organic Chem	(3)
Chem 252	Organic Lab	(1)
Phys 155	Gen Physics	(4)
elective		

Fall yr 3:

Phys 156	Gen Physics	(4)
Math 225	Calculus III	(3)
BBMB 325	Biochemistry	(3)
elective		

OR

Spring yr 3:

BBMB 324^	Biophysics	(3)
BBMB 334^	Biophysics Lab	(1)
BBMB 325	Biochemistry	(3)
BBMB 335	Biochemistry Lab	(1)

Fall yr 4:

BBMB 326	Molecular Biology	(3)
BBMB 336	Molecular Biology Lab	(1)
BBMB 490	Senior Thesis	(1-3)#

Spring yr 4:

BBMB 400	Senior Seminar	(1)
BBMB 490	Senior Thesis	(1-3)#
elective		

Sample plan # 3: Placement into Chem 140 and Math 126**Fall yr 1:**

GenS 145	Complex questions	(4)
Chem 140*	Gen Chem	(3)
Math 126	Calculus II	(3)

Fall yr 2:

Chem 245	Organic Chem	(3)
Chem 251	Org Chem Lab	(1)
Phys 156	Gen Physics	(4)
Math 225	Calculus III	(3)

Fall yr 3:

BBMB 325 elective	Biochemistry	(3)
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Fall yr 4:

BBMB 326	Molecular Biology	(3)
BBMB 336	Molecular Biology Lab	(1)
BBMB 490 elective	Senior Thesis	(1-3)#

Spring yr 1:

GenS 146	Powerful arguments	(4)
Biol 111	Biological Prin	(4)
Phys 155	Gen Physics	(4)

Spring yr 2:

Chem 246	Organic Chem	(3)
Chem 252	Organic Lab	(1)
Biol 205	Genetics	(3)

Spring yr 3:

BBMB 325	Biochemistry	(3)
BBMB 335	Biochemistry Lab	(1)
BBMB 324^	Biophysics	(3)
BBMB 334^	Biophysics Lab	(1)

Spring yr 4:

BBMB 400	Senior Seminar	(1)
BBMB 490 elective	Senior Thesis	(1-3)#

Sample plan # 4: Off-campus study during 6th semester**Fall yr 1:**

GenS 145	Complex questions	(4)
Chem 140*	Gen Chem	(3)
Math 126	Calculus II	(3)

Fall yr 2:

Chem 245	Organic Chem	(3)
Chem 251	Org Chem Lab	(1)
Phys 156	Gen Physics	(4)
Math 225	Calculus III	(3)

Fall yr 3:

BBMB 325 elective	Biochemistry	(3)
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Fall yr 4:

BBMB 326	Molecular Biology	(3)
BBMB 336	Molecular Biology Lab	(1)
BBMB 490 elective	Senior Thesis	(1-3)#

Spring yr 1:

GenS 146	Powerful arguments	(4)
Biol 111	Biological Prin	(4)
Phys 155	Gen Physics	(4)

Spring yr 2:

Chem 246	Organic Chem	(3)
Chem 252	Organic Lab	(1)
Biol 205	Genetics	(3)

Spring yr 3:

OFF CAMPUS STUDY

Spring yr 4:

BBMB 324^	Biophysics	(3)
BBMB 334^	Biophysics Lab	(1)
BBMB 335	Biochemistry Lab	(1)
BBMB 490	Senior Thesis	(1-3)#

* Chem 140 can be substituted for Chem 125,135,126,136

a total of 3 credits of Senior Thesis are required

^ BBMB 324/334 will be offered Fall 2022, then next in Spring 2024 as it moves to the Spring semester

Electives: any course 200-level and above in BBMB, Biol, Chem, Phys, Math/Statistics, Comp Sci

APPENDIX B: BBMB course descriptions

[Check the current issue of the course catalog for recent updates on pre-requisites and scheduling]

324 Biophysics

Fall Juers 3 credits ****NOTE: In 2023-24, Biophysics will move to the Spring semester. Check updated scheduling information online for subsequent years.****

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. May be elected as Physics 324. *Prerequisites:* Physics 156 and Mathematics 225.

325 Biochemistry

Fall and Spring Moss/Russo 3 credits

This course provides students with 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; and integration of metabolism and disease. Students will actively participate in group problem-solving, and gain experience reading and critiquing scientific journal articles. Applies to the Molecular/Cell requirement for the Biology major.

Prerequisites: Biology 111 and Chemistry 246.

326 Molecular Biology

Fall Vernon 3 credits

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 aspects of genomics. Required for BBMB majors. Applies to the Molecular/Cell requirement for Biology majors. *Prerequisite:* Biology 205. *Pre- or corequisite:* BBMB 325. Open to non-BBMB majors only with consent of instructor.

334 Biophysics Laboratory

Fall Juers 1 credit ****NOTE: In 2023-24, Biophysics Lab will move to the Spring semester. Check updated scheduling information online for subsequent years.**

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. May be elected as Physics 334. *Corequisite:* BBMB 324. Open to non-BBMB majors only with consent of instructor.

335 Biochemistry Laboratory

Spring Russo 1 credit

A semester-long team project introducing students to the core laboratory techniques and methods in protein biochemistry for characterizing a catalytic protein. Students will engage in biochemical reagent preparation, enzyme isolation and purification, enzyme and protein assays, gel electrophoresis, and immunodetection methods. Applies to the Molecular/Cell requirement for the Biology major. *Prerequisites:* Biology 111 and Chemistry 136 or 140. *Pre- or corequisite:* BBMB 325. Open to non-BBMB majors only with consent of instructor.

336 Molecular Biology Laboratory

Fall Vernon 1 credit

Laboratory exercises in nucleic acid biochemistry, including molecular cloning, PCR, and DNA and RNA isolation and analysis techniques. One three-hour laboratory per week. Applies to the Molecular/Cell requirement for the Biology major. *Corequisite:* BBMB 326. Open to non-BBMB majors only with consent of instructor.

360-363 Special Topics in BBMB 1-4 credits

See updated Whitman course information online to see if any BBMB ST classes are available.

400 Senior Seminar**Spring Juers, Moss, Russo, Vernon 1 credit**

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 from his or her peers. Open to non-BBMB majors only with consent of instructors.

430 Infectious Disease**Fall Russo 3 credits**

This course will use the practices of public health to explore the role of infectious disease on human mortality and morbidity from biomedical, social, and economic perspectives. Readings, discussion, and journal writing will focus on: epidemiology and burden of disease, the immune system and the host response to viruses, bacteria, and parasites; antimicrobial agents and drug resistance; and vaccine development and policy. Each student will work in a team to present a week-long Case Study on a disease of global importance such as COVID, influenza, dengue, HIV, malaria, or tuberculosis. *Prerequisite:* consent of instructor.

481, 482 Special Projects**Fall, Spring Staff 1-2 credits**

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 Thesis**Fall, Spring Staff 1-3 credits**

Each student will take part in a research project involving the collection and analysis of data, and write a thesis on that research in accepted scientific style. One or more drafts of the thesis will be required before the final version is due in the last week of classes. Each student also will publicly present his/her research results in the BBMB 400 Senior Seminar or a similar presentation venue. A total of three credits are required in the senior year; credits may be taken in the Fall and/or Spring. *Prerequisite:* consent of thesis advisor.

APPENDIX C: Research Internships- Information and Examples

BBMB's research and thesis requirements add a whole hands-on dimension to your Whitman education - one that complements all the book-learning' you do for your classes here and gives you a different perspective on science. *Don't be too picky* about where you do your thesis research or even what the research subject is: your senior thesis research does *not* need to be closely related to your current career goals. At this stage of your career, almost any research experience will prove valuable.

A. Projects at Whitman...

Many professors in BBMB, biology, and chemistry provide student research opportunities in their laboratories. Some have research grants to support students during the summer as well as during the school year. There is also a Whitman Internship Grant (WIG) program run through Whitman's Career and Community Engagement Center that provides stipends to students for summer work, on a competitive basis. This program is primarily for research done off-campus. Feel free to approach any faculty in BBMB, Biology, or Chemistry to inquire about possibilities in their labs!

B. Off-Campus Projects

Many Whitties land summer research gigs at universities, hospitals, government agencies, or companies in their hometowns (many in the Northwest). Some of these internships are offered as part of a university-run summer program to which students must apply. Some examples (such as National Science Foundation-REU programs) are listed below on the next 2 pages. But many students find great summer research opportunities simply by contacting professors, clinicians, or scientists at any university or biotech company and just *asking*. Doing this, you may be able to land a paid summer internship, *or* you can secure your own pay by applying for a Whitman Internship Grant (contact Whitman's Career and Community Engagement Center for info on the WIG program; the application deadline is usually in late March). Having access to the Whitman Internship Grant program might make it easier for you to find an internship, because an off-campus lab may be eager to take you on if they are not obligated to pay you.

Whitman Partnerships

Whitman College has grants to support 2 students each summer at the Fred Hutch Cancer Research Center in Seattle and the Mayo Clinic in Rochester, MN, Jacksonville, FL, or Phoenix, AZ

See <https://www.whitman.edu/academics/research> for more info on these internships.

Calls for applications will be made in November and applications are due early January. Contact Profs. Russo or Moss for more details.

National Science Foundation The largest/most diverse collection of undergraduate research opportunities in the U.S. is the NSF's REU (Research Experience for Undergraduates) program

http://www.nsf.gov/crssprgm/reu/reu_search.cfm

REUs are full-time, paid summer research internships found at many universities. There are REU programs all over the U.S., including the Northwest. 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 excellent 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. NSF REU programs are usually very competitive - but they offer diverse opportunities, they 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. In recent years Whitties have had great (sometimes career- shaping) research experiences in universities in places near and far....such as Iowa, Oklahoma, and Alabama.

NIH Summer Research Program (any of the National Institutes of Health)
<http://www.training.nih.gov/programs/sip>

Private research institutes in the Puget Sound Area

- Seattle Children's Research comprises several diverse biomedical research centers
<https://www.seattlechildrens.org/research/centers-programs/>
- Center for Infectious Diseases Research <http://www.cidresearch.org/>
- Pacific Northwest Research Institute <http://www.pnri.org/>
- PATH (Prog. for Appropriate Technology in Health) <http://www.path.org>
- Institute for Systems Biology: <http://www.systemsbiology.org>
- Allen Brain Institute <https://alleninstitute.org>

Universities and other agencies in the Northwest

- WSU (health sciences in Spokane, Vet Sciences/Global health in Pullman)
- UW (many depts. including Biochemistry, Structural Biology, Molecular Cell Biology)
- OHSU (many depts. including Cancer Center, CROET, Stroke Center, Vollum Institute)
- U. Idaho; Boise State University; Idaho State University
- Oregon State University; U. of Oregon
- Walla Walla County Dept. of Community Health OR WA State Dept. of Health
- USDA extension offices or research
- PNNL in Richland,WA

Biotech & Pharmaceutical companies....e.g. in Seattle

Amgen	Biorad	Bristol Myers Squibb	
Gilead	Novo Nordisk	Omeros	SeaGen

Other Universities, Biotech Companies, Research Institutes, and Hospitals

Sometimes the most effective way to find a research opportunity is to email, phone, or just drop in on labs at universities or biotech companies in your hometown, or at other places where you might have a personal connection. Lots of Whitties have found internships by simply cold-calling professors or labs this way. If you aren't asking for pay, they may be very happy to take you on for a for a summer. If you do this early enough in the year, you can apply for Whitman Internship Grant .

APPENDIX D: Recent examples of BBMB Thesis Projects

(Note the variety of topics and locations)

2021-22

O. Andersen	Effects of sugar/fat/ethanol on fatty liver disease	BBMB, Whitman (Russo Lab)
E. Anderson	Rate motifs of maize auxin repressors	BBMB, Whitman (Moss Lab)
C. Arroyo	Structural studies on BrXo phage resistance protein	Fred Hutch, Seattle
A. Chiles	Biosensors as auxin reporter in maize	BBMB, Whitman (Moss Lab)
L. Farr	Computational model for Sulfite Oxidase active site	Chemistry, Whitman (Biswas Lab)
P. Hwang	Kinetic analysis of PnpC1C2 via site-directed mutagen	Chemistry, Whitman (Machonkin Lab)
A. Salvino	Molecular dynamics of hinge-motion in Thermolysin	BBMB, Whitman (Juers Lab)
K. Tate	Evolution of SARS CoV-2 variants in England 2020-21	BBMB, Whitman (Russo)

2020-21

J. Bent	NMR for substrate specificity of benzoate dioxygenase	Chemistry, Whitman (Collins Lab)
D. Conkin & N. Ganjooloo	Computational Studies of Ring-Cleaving dioxygenases	Chemistry, Whitman (Machonkin Lab)
M. Hatten-Beck	COVID-19 Testing: Early pandemic response in US	BBMB, Whitman (Russo)
M. Meyer	COVID-19 Related Myocarditis	BBMB, Whitman (Russo)
A. Mueller-Immergluck	Disc herniation, multifidus muscle, & stem cells	UC-San Francisco
B. Preskensis	Sports-Related Concussion & Antisaccade Gaze Shift	Biology, Whitman (T, Knight Lab)
M. Saleh	Efficacy of Novel HSP90 Inhibitors in Synovial Sarcoma	Biosciences, Idaho State Univ,
S. Thaman	PIRL9 expression in <i>Arabidopsis</i> : reporter gene studies	BBMB, Whitman (Vernon Lab)
N. Tran	Sex differences mitochondrial genes CVB3 myocarditis	Mayo Clinic

2019-20

J. Bachtold	FI tests for Colorectal Cancer Screen - Rural Oregon	OHSU, OR Rural Research Network
A. Cooper	Thermolysin Protein Crystal in Neutral Ionic Salts	BBMB, Whitman (Juers Lab)
A. Hung	Sex-Specific Mitochondrial Dynamics in Exercise & Rest	Biology, Whitman (Coronado Lab)
M. Kanagy	Expression and function of PIRL7 gene	BBMB, Whitman (Vernon Lab)
L. Mortimer	Maternal Cortisol & Fetal Brain Development	Vanderbilt Univ., Nashville
B. Ward-Dubois	<i>E. coli</i> OM Protein A & Host Kinase Phosphorylation	Biology, Whitman (Danka Lab)
K. Wanke	Permissive mutations & fitness in influenza mutations	Fred Hutch, Seattle
J. Williams	Fructose & Fat in Non-Alcoholic Fatty Liver Disease	BBMB, Whitman (Russo Lab)
A. Yoshida	Integrin clustering & cytokine expression in dendritic cells	Benaroya Research Institute, Seattle

2018-19

Y. Buckley	Auxin hormone signaling in maize	BBMB, Whitman (Moss Lab)
B. Cosgrove	Programming to design online genomics analysis tools	NSF REU, University of Missouri
M. Duncan	Bioenzymatic organic synthesis	Chemistry, Whitman (Collins Lab)
C. Finkbeiner	Regulation of cell identity in mouse knockout mutants	U. Washington (Stone Lab)
M. Maker	Enzyme expression and kinetic analysis	Chemistry, Whitman (Machonkin Lab)
A. Person	Evolution of flower pigmentation in Monkey Flowers	Biology, Whitman (Cooley Lab)
E. Peterson	Cancer cell biology: CAR T cell therapy	Fred Hutchinson Cancer Research Ctr.
R. Price	Organic synthesis of a proteasome inhibitor	Chemistry, Whitman (Gotz lab)

2017-18

K. Chang	Mechanism of tissue regeneration in <i>Acomys</i>	Majesky Lab, Seattle Children's Res. Inst.
K. Daly-Jensen	Auxin hormone signaling pathway in <i>Zea maize</i>	BBMB, Whitman (Moss lab)
E. Gladhill	Modeling of carbon monoxide dehydrogenase active site	Chemistry Dept., Whitman (Rokhsana lab)
K. Harrison	Warming and cooling curves of protein crystals	Physics Dept., Whitman (Juers lab)
N Horst	Mouse mitochondrial physiology	Biology Dept, Whitman (Coronado lab)
A. Mercer	Antibiotic resistance in pathogenic bacteria	Los Alamos National Lab
E. Minus	Hybridization and evolutionary diversity in monkeyflower	Biology Dept, Whitman (Cooley lab)
T. Salaguinto	Bee foraging behavior in Greece	NSF REU, U. Central Oklahoma
S. Zewdie	HIV infection/vaccine research	Fred Hutchinson Cancer Res. Center, Seattle