Thomas C. Jenkins Department of

BIOPHYSICS

---Undergraduate Advising Manual---

I JHU Biophysics

Students Entering the Program Fall 2015
(JHU 2019 Graduating Class)
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biophysics.jhu.edu

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1. Introduction

Welcome to the Department of Biophysics!

Johns Hopkins University was one of the first institutions in the country to establish Biophysics as an independent discipline and to have a department dedicated to studying biology using the tools and approaches of physics and physical chemistry.

The Thomas C. Jenkins Department of Biophysics has a long tradition of excellence in research and teaching, and of developing leaders in the scientific community. We are proud of the role the Jenkins Department has played in advancing biophysics and we invite you to learn more about us.

1.1 What is Biophysics?

Biophysics is the application of the laws of physics to biological phenomena. Biophysics uses the languages of math and computation in seeking to describe biology in quantitative terms. As such, biophysics has been referred to as a bridge between biology and physics.

Studies in the discipline of biophysics are particularly timely and important because biology is now undergoing an incredible transformation. We live in an era in which we now know the entire DNA sequence of a person. For $99 anyone can have snippets of their genome sequence determined and their ancestry or potential illnesses predicted from this information.[1] It is now the case that a complete catalog of all molecules is being assembled, ranging from the great to the small in millions of organisms, and from all kingdoms of life. The grand intellectual challenges in biology for the 21st century will be to understand how all the molecules in a cell interact to give rise to the living state, to envision how life emerges from the interactions among a collection of inanimate molecules, and to know how life originated and how it continues to evolve.

Because the field of biology is transforming from an observational and phenomenological science into a quantitative and physical one, Johns Hopkins is fortunate to have a Biophysics department and a strong, vibrant and active community of biophysicists already focused on the study of biology from the quantitative and physical perspectives.

2. Program Mission and Objectives

The Hopkins major in biophysics has always been a rigorous and challenging major that attracts students interested in biology who are not afraid of mathematics, physics, and computation. The goal of the major is to achieve true integration between biology,

[1] 23andme.com, whole genome SNP service

chemistry, physics, mathematics and computation, and our majors are required to become competent in all five areas.

However, interdisciplinary education is not just a matter of taking courses in different departments. The strength of our major is that we integrate all these scientific areas. This is accomplished through our courses in biophysics, in our advanced laboratory course, and through our independent research requirement. Key to our goal is the fact that our courses emphasize concepts and problem solving over memorization. We train our students to become thinkers who will have the quantitative skills and technical abilities to address any biological problem at hand.

Another unique aspect of Biophysics is the close contact between majors and the faculty in the Jenkins Department. As faculty we provide our majors with individualized and personal mentorship, rivaling that available at elite, first-rate private liberal colleges in the US. All our upper-level courses are small, and the intimate contact between faculty and students both inside and outside the classroom allows us to get to know the students well and *vice versa*.

2.1 Who are the Biophysics undergraduates?

Because the major attracts outstanding students who are interested in biology and comfortable with mathematics and physics, the undergraduate biophysics major tends to be a smart and very driven student. It is not unusual for the average GPA of our graduating class to qualify for University Honors. A disproportionate number of Biophysics majors are elected to Phi Beta Kappa every year. They have a very high success rate of acceptance to medical or graduate school.

Over and above their excellent academics, our majors are generally a happy and cohesive set of students. They form study groups, and our majors help each other learn the assigned material. Teaching and working with biophysics majors is a pleasure for the faculty.

2.2 What do the Biophysics undergraduate alumni do?

Biophysics majors typically go to medical (64%) or doctoral (11%) or combined MD/PhD (6%) programs following graduation. A small fraction (2%) enter the job market without pursuing an advanced degree. Approximately 17% of new graduates decline to provide their post-graduation activities.

Medical schools that the recent graduates have attended include Albert Einstein, Columbia, Harvard, Johns Hopkins, Stanford, Univ. Chicago, Univ. Maryland, Yale.

Graduate schools that recent graduates have attended include New York Univ., Stanford Univ., UC Berkeley, UC San Francisco, Univ. Chicago, Washington Univ in St. Louis.

3. Resources for Students

3.1 The Jenkins Faculty

The Jenkins faculty members are the main resources for prospective majors. We are a friendly department who love what we do, and we encourage you to email any of us if you have questions about the major or about the classes we teach.

3.2 Current Biophysics Majors

In addition, our upperclassmen are always eager to share their enthusiasm for the biophysics. Freshmen have opportunities to meet upper classmen as teaching assistants in our classes or at our biophysics parties or poster sessions. We also run an informal mentoring program whereby freshmen with specific questions who want to seek the opinions of upper classmen can be put in touch with them by simply emailing the DUS to ask for Biophysics senior contact information.

3.3 Undergraduate Newsletters

Prospective majors can obtain a sense for who our majors are by reading our undergraduate newsletters. The spring versions contain "senior profiles" and highlight the graduating class each year. The newsletters can be found at the link below:

http://biophysics.jhu.edu/undergraduate_newsletter.html

3.4 Our Undergraduate Alumni

Because they love their experience here so much, our alumni are happy to serve as a resource for our current majors. This can be especially helpful for our upper classmen as they contemplate graduate or medical schools. The DUS maintains a list of undergraduate alumni who have agreed to be contacted by current students.

3.5 Social Media

3.5.1 JHU BiPhi ϕϕ Facebook Page

Current majors administrate the undergraduate Facebook page, where the Fourier transform of a cat can be viewed.

https://www.facebook.com/groups/220752411311415/

4. Departmental Advising Procedures

4.1 Faculty Advisors

Once you declare biophysics as your major, a full-time faculty member in the Jenkins Department of Biophysics will serve as your academic advisor. We are genuinely interested in your success, and we want to help you find a set of course work that meets your interests.

4.1.1 Meetings with your faculty advisor

Current majors will generally meet with their advisors at least once each semester to plan their courses for the upcoming semester and to discuss current courses. Before registration, the JHU registrar's office places a hold on all student accounts. This hold will be released by your faculty advisor upon completion of a meeting with them.

It is important that you email your faculty advisor in a timely manner to set up an appointment to meet with him or her. "Showing up" in a faculty member's office can sometimes result in a meeting, but the conversation will be much more productive if both of you have advanced notice for a meeting and can be prepared. Contact information for the faculty can be found in Section 10 or on the web site.

4.1.2 What to bring to an advisor meeting?

You will get the most out of your Hopkins experience if you learn to plan your schedule in advance. Therefore, the most important planning tool to accomplish this is to consult the degree audit for the major. Because these are now exclusively online, it is helpful if you can bring your laptop with you to your advisor meeting.

The instructions for degree audit can be found on this site:

http://www.advising.jhu.edu/degree_checklist.php

4.1.3 Obtaining a faculty advisor as a freshman

Although Johns Hopkins does not generally allow freshmen to declare a subject major, freshmen (pre-majors) interested in the major should feel free to email the Director of Undergraduate Studies (DUS) to set up a meeting to discuss their interests and current course plan and how the biophysics major can fit with their goals.

Many freshmen declare biophysics as their major during the spring of their freshman year. When this happens – usually in late April - the JHU Advising office forwards your name the Biophysics DUS, and you will be assigned one of our faculty members as your advisor. You will receive an email from the DUS with your advisor's name and email address.

Please take an opportunity to email your advisor to arrange a meeting to discuss your plans for sophomore year.

4.1.4 Switching into biophysics as an upperclassman

If you are currently an upperclassman and seek to change from your current major to biophysics, stop by the registrar's office to obtain a "change of major" form and email the biophysics DUS to set up an appointment to sign the "change of major form", discuss your goals, how your past course work will fit within the major requirements and to receive a faculty advisor assignment.

The typical majors from which Biophysics receives transfers include Molecular & Cellular Biology, Chemical & Biomolecular Engineering, Chemistry or Physics. The typical time frame for transferring into the biophysics major is during the sophomore year, although transfers are still possible in the junior year depending on the prior major and completed course work.

5. Examples of Paths for Completion of the Major

The following two sections (5.1 and 5.2) show examples for completion of the biophysics major for incoming students that do not enter with any AP credits.

Section 5.3 lists Biophysics courses that are appropriate for freshmen entering with AP credits who want to get started on additional major requirements.

5.1 For the Biophysics Major with the Goal of pursuing Graduate School

Freshman Year Fall		
030.101	Intro Chemistry I	3
030.105	Intro Chemistry I Lab	1
110.108	Calculus I	4
171.101	General Physics I	4
173.111	General Physics I Lab	1
H/S Elective		3
	Semester Credits	**16**
	Cumulative Credits	*16*

Freshman Year Spring		
030.102	Intro Chemistry II	3
030.106	Intro Chemistry II Lab	1
110.109	Calculus II	4
171.102	General Physics II	4
173.112	General Physics II Lab	1
250.131	Freshman Seminar in Biophysics	1
H/S Elective		3
	Semester Credits	**17**
	Cumulative Credits	*33*

Sophomore Year Fall		
030.205	Organic Chemistry I	4
110.202	Calculus III	4
250.253	Prot Eng & Biochem Lab[1]	3
250.345	Cell & Mol Physiology	3
H/S Elective		3
	Semester Credits	**17**
	Cumulative Credits	*50*

Sophomore Year Spring		
030.206	Organic Chemistry II	4
110.201	Linear Algebra	4
250.205	Intro Scientific Comp[1]	3
250.265	Bioinformatics[3]	3
H/S Elective		3
	Semester Credits	**17**
	Cumulative Credits	*67*

Junior Year Fall		
250.315	Biochemistry I	4
250.353	Comp Biology[3]	3
250.372	Biophysical Chemistry	3
250.521	Research Problems	3
	Semester Credits	**13**
	Cumulative Credits	*80*

Junior Year Spring		
250.316	Biochemistry II	3
250.383	Mol Biophysics Lab[2]	3
250.522	Research Problems	3
H/S Elective		3
171.309	Wave Phenomena[3]	3
	Semester Credits	**15**
	Cumulative Credits	*95*

Senior Year Fall		
171.310	Biological Physics	4
List 1 Elective	One of the following is recommended:	3
250.401	Adv Sem Structural & Physical Virology[2]	
Or 250.403	Bioenergetics[2]	
Open	Open Elective	3
H/S Elective		3
	Semester Credits	**13**
	Cumulative Credits	*108*

Senior Year Spring		
250.381	Spectroscopy	3
List 1 Elective	One of the following is recommended:	3
250.411	Adv Sem Structural Biology of Chromatin[2]	3
Or 250.401	Adv Sem Memb Protein Struct, Func & Pharm[2]	
Open	Open Elective	3
	Semester Credits	**12**
	Cumulative Credits	*120*

Footnotes:

(1) Can be taken in either order; (2) Counts as Writing credits; (3) List 1 or List 2 elective. Any indicated courses are recommended choices.

5.2 For the Biophysics Major with the Goal of pursuing Medical School

Freshman Year Fall		
030.101	Intro Chemistry I	3
030.105	Intro Chemistry I Lab	1
110.108	Calculus I	4
171.101	General Physics I	4
173.111	General Physics I Lab	1
H/S Elective		3
	Semester Credits	**16**
	Cumulative Credits	*16*

Freshman Year Spring		
030.102	Intro Chemistry II	3
030.106	Intro Chemistry II Lab	1
110.109	Calculus II	4
171.102	General Physics II	4
173.112	General Physics II Lab	1
250.131	Fresh Sem in Biophys	1
H/S Elective		3
	Semester Credits	**17**
	Cumulative Credits	*33*

Sophomore Year Fall		
030.205	Organic Chemistry I	4
030.225	Intro Organic Chem Lab	3
110.202	Calculus III	4
250.253	Prot Eng & Biochem Lab[1]	3
250.345	Cell & Mol Physiology	3
	Semester Credits	**17**
	Cumulative Credits	*50*

Sophomore Year Spring		
030.206	Organic Chemistry II	4
110.201	Linear Algebra	4
250.205	Intro Scientific Comp[1]	3
250.265	Bioinformatics[3]	3
H/S Elective		
	Semester Credits	**17**
	Cumulative Credits	*67*

Junior Year Fall		
250.315	Biochemistry I	4
250.353	Comp Biology[3]	3
250.372	Biophysical Chemistry	3
250.521	Research Problems	3
	Semester Credits	**13**
	Cumulative Credits	*80*

Junior Year Spring		
250.316	Biochemistry II	3
250.383	Mol Biophysics Lab[2]	3
250.522	Research Problems	3
H/S Elective		3
Open	Open Elective	3
	Semester Credits	**15**
	Cumulative Credits	*95*

Senior Year Fall		
171.310	Biological Physics	4
List 1 Elective	One of the following is recommended:	3
250.401	Adv Sem Structural & Physical Virology[2]	
Or 250.403	Bioenergetics[2]	
550.311	Probability & Statistics for Biological Sciences	3
H/S Elective		3
	Semester Credits	**13**
	Cumulative Credits	*108*

Senior Year Spring		
250.381	Spectroscopy	3
List 1 Elective	One of the following is recommended:	3
250.411	Adv Sem Structural Biology of Chromatin[2]	3
Or 250.401	Adv Sem Memb Protein Struct, Func & Pharm[2]	
H/S Elective		3
	Semester Credits	**12**
	Cumulative Credits	*120*

Footnotes:

(1) Can be taken in either order; (2) Counts as Writing credits; (3) List 1 or List 2 elective. Any indicated courses for Lists 1 or 2 are recommended choices.

5.3 Courses suitable for freshmen with AP credits who intend to major in biophysics

The main JHU Advising office maintains policies about acceptance and equivalencies of AP credits for incoming freshmen. The Jenkins Biophysics department follows their guidelines and accepts their recommendations regarding AP credits for required courses.

The following biophysics courses are suitable for freshmen with AP credits and will allow those students to get started on completing the requirements for the major.

AS.250.205 Introduction to Computing (Fall or Spring)
AS.250.253 Protein Engineering and Biochemistry Lab (Fall or Spring)
AS.250.345 Cellular and Molecular Physiology (Fall)
AS.250.265 Bioinformatics (Spring)

None of these courses have pre-requisites, and no special permission is required for freshmen to take these courses.

6. Degree Checklists

The JHU Advising web site maintains Degree Audit website for all majors and minors. These can be found here:

http://www.advising.jhu.edu/degree_checklist.php

7. Degree Requirements

7.1 Curriculum

The degree requirements are outlined below.

7.1.1 Required Chemistry Courses

The biophysics major requires 6 courses in chemistry.

1. AS.030.101 Introductory Chemistry I
2. AS.030.102 Introductory Chemistry II
3. AS.030.105 Introductory Chemistry Laboratory I
4. AS.030.106 Introductory Chemistry Laboratory II
5. AS.030.205 Organic Chemistry I
6. AS.030.206 Organic Chemistry II with Biochemistry (Preferred choice)
   or
   AS.030.212 Advanced Organic Chemistry

7.1.2 Required Physics Courses

The biophysics major requires 5 courses in physics:

1 first year physics series (2 courses);
1 first year physics lab series (2 courses); and
1 upper level physics course (Biological Physics).

For the first year physics series, there are 4 options. All of these are accepted by the Biophysics major, however the preferred series is Option 1 (lecture style) or Option 2 (studio-style) below:

First Year Physics Option 1:

1. AS.171.101 General Physics: Physical Science Major I
   and
2. AS.171.102 General Physics: Physical Science Major II

First Year Physics Option 2:

1. AS.171.107 General Physics for Physical Science Majors I (AL)
   and
2. AS.171.108 General Physics for Physical Science Majors II (AL)

In lieu of the 101/102 or 107/108 physics series, the biophysics major also accepts one of the following series. No permissions or waivers are required to take these other options.

First Year Physics Option 3:

1. AS.171.103 General Physics I for Biological Science Majors
   and
2. AS.171.104 General Physics II for Biological Science Majors

OR

First Year Physics Option 4:

Generally, only students seeking to double major in both physics and biophysics will choose this fourth series.

1. AS.171.105 Classical Mechanics I
   and
2. AS.171.106 Electricity and Magnetism

For the first year of physics labs, two series are available.
A student choosing Options 1, 2 or 3 above will normally take the Option 1, the 111/112 series below.

First Year Physics Lab Option 1:

1. AS.173.111 General Physics Laboratory I
   and
2. AS.173.112 General Physics Laboratory II

OR

First Year Physics Lab Option 2:

Generally, only students seeking to double major in both physics and biophysics will choose this series.

1. AS.173.115 Classical Mechanics Laboratory
   and
2. AS.173.116 Electricity and Magnetism Laboratory

One upper level physics course is required

1. AS.171.310 Biological Physics

7.1.3 Required Biophysics Courses

The biophysics major requires 8 courses in biophysics.

1. AS.250.205 Introduction to Computing
2. AS.250.253 Protein Engineering and Biochemistry Lab
3. AS.250.315 Biochemistry I
4. AS.250.316 Biochemistry II
5. AS.250.345 Cellular and Molecular Physiology
6. AS.250.372 Biophysical Chemistry
7. AS.250.381 Spectroscopy and its Application in Biophysical Reactions
8. AS.250.383 Molecular Biophysics Laboratory

7.1.4 Required Math Courses

The biophysics major requires 4 courses of mathematics.

1. AS.110.108 Calculus I
2. AS.110.109 Calculus II (for Physical Sciences and Engineering)
3. AS.110.202 Calculus III
4. AS.110.201 Linear Algebra

Because some students matriculate with advanced mathematics skills, the following substitutions are accepted. No special permissions are required from Biophysics to take the following courses.

In lieu of AS.110.202 Calculus III the biophysics major accepts

AS.110.211 Honors Multivariable Calculus

In lieu of AS.110.201 Linear Algebra, the biophysics major accepts

AS.110.212 Honors Linear Algebra
OR
EN.550.291 Lin Alg & Diff Equations

7.1.5 Required Research Experience

The biophysics major requires 2 semesters (6 credits) of independent research. These will normally be fulfilled by the following courses:

1. AS.250.521 Research Problems (fall)
2. AS.250.522 Research Problems (spring)

It is also possible to obtain research for credit towards the major in the summer using the following course:

AS.250.597 Research Problems (summer)

A full description of the research requirements and how to find a research experience can be found in Section 12: Appendix A.

Two important things about the research requirement to keep in mind:

Intersession research (250.574) can be conducted for a grade but does not count towards the major.

The Registrar's academic year starts with the summer session, and only 6 credits of research can be earned within any one academic year. In other words, the Registrar does not allow 3 credits to be earned in the summer and 3 credits to be earned in the following fall and 3 credits to be earned in the following spring within any one academic year.

7.2 Required Natural Science Electives

Four natural science electives are required.
Two of these must be selected from List #1.
Two additional courses must be selected from either List #1 or List #2.

7.2.1 "List #1" Electives

A minimum of two "List #1" electives must be taken. The following courses are the "List #1" electives

250.265	Bioinformatics
250.301	Laboratory in Molecular Evolution
250.302	Models and Algorithms in Biophysics
250.310	Exploring Protein Biophysics using nuclear Magnetic Resonance (NMR) Spectroscopy
250.313	Molecular and Cellular Systems Biology
250.320	Macromolecular Binding
250.353	Computational Biology
250.401	Advanced Seminar in Structural & Physical Virology
250.403	Bioenergetics: Origins, Evolution and Logic of Living Systems
250.411	Advanced Seminar in Structural Biology of Chromatin
250.421	Advanced Seminar in Membrane Protein Structure, Function & Pharmacology
171.202	Modern Physics
171.309	Wave Phenomena with Biophysical Applications
or	
171.201	Special Relativity and Waves

7.2.2 "List 2" Electives

The following courses are the "List #2" electives

020.306	Cell Biology
020.330	Genetics
020.344	Virology
020.346	Immunology
020.363	Developmental Biology
020.380	Eukaryotic Molecular Biology
550.211	Probability and Statistics for the Life Sciences
or	
550.311	Probability and Statistics for the Biological Sciences and Engineering

Any 3-credit or higher 300-level or higher course in any of the following departments:

Biology, Biophysics, Chemistry, Math or Physics

7.3 Students entering JHU with AP Credits

The main JHU Advising office maintains policies about acceptance and equivalencies of AP credits for incoming freshmen. The Jenkins Biophysics department follows their guidelines and accepts their recommendations regarding AP credits for required courses.

7.4 Transfer credits

The majority of transfer credit requests in the Jenkins Biophysics department concern courses in chemistry, physics, mathematics and biology. We do not normally make any decisions about the appropriateness of any transfer courses in those subject areas. Rather, we defer to those departments for all decisions about whether courses taken elsewhere are equivalent to the respective JHU courses.

Prior to taking any courses outside of Hopkins, students desiring to take courses at other institutions and bring credits back to JHU should seek approval from the JHU Advising office as well as the DUS in the department in which the course is offered. Often the DUS in that department will require a syllabus and course description for consideration.

If the other department accepts the courses as equivalent to their own courses, the biophysics department will accept the equivalency.

7.5 Study Abroad

Biophysics majors can participate in study abroad programs. Because of our upper level requirements, it is usually easiest for our majors to use the summer term for study abroad. Spending a semester abroad is also possible but requires advanced planning. If you are interested in studying abroad, discuss this possibility with your faculty advisor early in your sophomore year to create a plan that enables you to meet the major requirements without overloading your schedule.

7.6 KSAS Requirements

The Jenkins Department of Biophysics is within the Krieger School of Arts & Sciences and follows their general degree guidelines. Therefore, in addition to the major course requirements, an undergraduate degree in biophysics requires:

- Minimum of 120 credits total (this includes credits in the major)
- 9 credits of humanities courses
- 9 credits of social science courses
- 12 credits of writing courses

7.6.1 Writing Course Requirements

The Krieger School of Arts & Sciences requires 12 credits total of courses with a "Writing" (or "W") designation. Although many humanities and social science courses have a writing designation, biophysics majors are also able to fulfill writing credits by taking the courses within the major, which will give them exposure to scientific writing:

250.320	Macromolecular Binding
250.383	Molecular Biophysics Laboratory
250.401	Advanced Seminar in Structural & Physical Virology
250.403	Bioenergetics: Origins, Evolution and Logic of Living Systems
250.411	Advanced Seminar in Structural Biology of Chromatin
250.412	Advanced Seminar in Membrane Protein Structure, Function & Pharmacology

Fulfilling the writing credits solely with these biophysics courses requires advanced planning because not all of these courses are offered every year.

7.6.2 Humanities and Social Science Requirements

It is generally recommended that students spread these courses out over the course of their eight semesters.

7.7 Academic Performance Rules

7.7.1 Minimum Grade Requirements

The biophysics major requires that students earn a grade of "C" or greater for all courses required in the major. A student who earns a grade of "C-" or below must repeat the course and earn a better grade.

The KSAS guidelines on minimum grade requirements apply to all other courses.

7.7.2 Repetition of Course Content

Students earning a grade of C- or less in a course required for the major must repeat the course.

7.7.3 Courses Taken Pass/Fail

KSAS has a policy of allowing students to take courses Pass/Fail if those courses are outside a student's major.

7.7.4 Double Counting Policy

For the purposes of double majoring (or minoring), Johns Hopkins allows students to "double count" the same course. The Jenkins Biophysics department follows this policy.

7.7.5 Departmental Honors Program

The Jenkins Biophysics department offers outstanding students the opportunity to earn departmental honors in Biophysics. This honors distinction appears on the student's transcript upon graduation. If the honors requirements are approved prior to April 1, an "Honors" distinction will additionally appear in the commencement program.

The requirements for departmental honors in biophysics are two-fold:

- The student must maintain an overall GPA of 3.5 or greater
- The student must write and receive approval of an Honors paper that is based on their 6 credits of required research. Details on the honors procedures and the format of the Honors paper can be found in Section 13: Appendix B.

7.7.5.1 Honors Deadlines

May Commencement:
Generally the honors paper must be submitted no later than March 1 of the senior year to meet the May commencement deadline.

December Commencement:
Generally the honors paper must be submitted no later than November 15 of the senior year to meet the December commencement deadline.

7.7.6 Ethics in Learning

The Jenkins Biophysics department follows the Johns Hopkins guides for ethics in learning. Violations of academic integrity will not be tolerated and will be handled in accordance with the guidelines established by the Krieger School of Arts and Sciences.

8. 5th Year BA/MA Program in Biophysics

The TC Jenkins Department of Biophysics offers outstanding undergraduate biophysics majors the opportunity to advance their education through a combined, 5-year B.A., M.A. program. Candidates for this program must be current biophysics undergraduates with a departmental GPA of 3.5 or greater and a strong research history. All bachelors' requirements must be completed before matriculating into the master's program.

If you are interested in pursuing the 5th year BA/MA program, discuss this with your Jenkins advisor.

9. Minor in Biophysics

The Jenkins Department of Biophysics does not offer a minor in biophysics.

10. Undergraduate Planning for Professional Schools

10.1 Graduate School Requirements

The biophysics major at Johns Hopkins is an excellent preparation for doctoral studies in a wide variety of fields including pharmacology, computational biology, structural biology, immunology, and of course, biophysics. Section 4.1 shows a typical path to completion of the biophysics major that provides a general preparation for advanced quantitative study. Undergraduates with well-defined graduate interests in specific areas are encouraged to discuss their plans with their faculty advisors to choose the appropriate electives.

10.1.1 Waves

The biophysics faculty and our biophysics alumni in graduate programs both highly recommend that the following "List 1" elective physics course be taken.

AS.171.309 Wave Phenomena

10.1.2 Computational Electives

Computational skills are increasingly important for advanced scientific study. In addition to our required Introduction to Computing course, students are encouraged to take more than one of our upper level "List 1" electives that develop computing skills.

250.302 Models and Algorithms in Biophysics
250.313 Molecular and Cellular Systems Biology
250.353 Computational Biology

10.1.3 Research Experience

The undergraduate research experience is a key aspect that prepares students for graduate studies. Although only 6 research credits are required, this should be viewed as an absolute minimum research effort for the student interested in graduate school. Rather, undergraduates should seek to "join" a lab for 2 years or more to enable them to pursue a scientific problem in a significant manner.

10.2 Considerations for Completion of the Pre-Medical Requirements

The biophysics major fulfills all of the requirements for medical school with the one exception of (030.225) Organic Chemistry Laboratory. Section 4.2 shows a typical path to completion of the biophysics major that takes into account the following needs of the pre-medical student. There is plenty of room in the academic schedule of a biophysics major to easily meet the pre-medical requirements.

10.2.1 Organic Chemistry Lab

There are several semesters in which "Open" electives must be taken to meet the 12-credit minimum for full-time student status. Pre-medical students are therefore advised to consider Organic Chemistry Laboratory as one of these electives.

10.2.2 College level "biology" course

General Biology is not required for the Biophysics major, does not count towards any of the requirements or electives for the biophysics major, and it is not literally required for medical school. In some cases students with no biology background may be advised by the JHU Advising office to take the General Biology course, but this is not necessary for most students.

Biophysics majors can complete the premedical requirement for a year of college level "biology" laboratory with any two of following (required) courses:

250.315	Biochemistry I
250.316	Biochemistry II
250.345	Cellular & Molecular Physiology
250.372	Biophysical Chemistry

10.2.3 College level "biochemistry" or "biology" lab

Biophysics majors complete the premedical requirement for "biochemistry" or "biology" laboratory with the following (required) courses:

250.253	Protein Engineering & Biochemistry Laboratory
250.383	Molecular Biophysics Laboratory

The following additional lab course can be used as a "List #1" elective and would provide another "biochemistry" or "biology" lab for a medical school application.

250.301	Laboratory in Molecular Evolution

10.2.4 Statistics

Biophysics majors meet the pre-medical requirement for a statistics course through one of the following "List 2" electives:

550.211 Probability and Statistics for the Life Sciences
or
550.311 Probability and Statistics for the Biological Sciences and Engineering

10.2.5 Sociology/Psychology

Biophysics majors meet the pre-medical requirement for a sociology/psychology course through their KSAS H/S distribution choices.

11. Faculty Contact List

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12. Course Listings

This manual serves as a guide for undergraduate planning and is only updated once per year.

The most up-to-date course listings and descriptions can be found in the JHU catalog on line at http://e-catalog.jhu.edu/degree-programs/.

13. Appendix A: Undergraduate Research Guide for Biophysics Majors

Research Requirements

Independent research is a key component (and a formal requirement) of the Hopkins Biophysics Major. It is typically scheduled as a series of formal courses:

250.521/522/597, Research Problems in Biophysics, in the fall/spring/summer terms.

Research during intersession is not accepted to meet the Biophysics major requirements.

The research requirement for the major in Biophysics is six credits. Typically the above courses are taken for three credits per semester, for which a student is expected to work 10-12 or more hours per week in the lab.

Students are only allowed six research credits per year, but can repeat 521/522/597 (for a total of six credits) in subsequent years, if they choose. Over the course of four years, a student could therefore earn a maximum of 24 research credits.

Research Philosophy

Undergraduate biophysics research is pursued in active research laboratories and constitutes an apprenticeship. To initiate this apprenticeship, students must search for and initiate a relationship with a "Research Supervisor" who is willing to work directly with the student.

In the initial phase, which may last for as long as a semester, the student may simply learn techniques, become familiar with the research problem and relevant literature and learn and understand the questions and goals of the overall research project. By the beginning of the second semester, the student is expected to become a semi-independent researcher able to perform experiments and come up with improvements in procedures and experimental design. Repetitive tasks that require little or no initiative or intellectual input from the student, such as plate scoring or bottle washing, do not, by themselves, constitute a suitable research apprenticeship.

By the end of the second semester, most students are able to obtain publishable data. Many students who complete more than two semesters of *Research Problems in Biophysics* become co-authors of abstracts and papers published by their Research Supervisor. Thus, it is strongly encouraged that students participate in research for two or more years. Although effort should be constant, productivity is likely to be low at the start of the apprenticeship, increasing with time. Students and Supervisors both benefit from the significant training, experience, and discoveries that come from years two and beyond. Along these lines, students are *STRONGLY* encouraged *NOT* to switch labs from semester to semester, but rather to pursue one research project during their time at Hopkins.

When to add research to your schedule

It is a good idea to start thinking about undergraduate research as a freshman or sophomore. Many students who enter JHU with AP credits start their research projects early their sophomore year, but starting in your junior year is also fine. Although it is not forbidden, waiting until senior year to start research is strongly discouraged

"Research Supervisor" *versus* "Faculty Sponsor:

The "Research Supervisor" is defined as the head of the laboratory in which you carry out your research.

The "Faculty Sponsor" must be a full-time faculty member in the Jenkins Dept. of Biophysics. This will normally be your Jenkins academic advisor, and this person will assign your research grade in close consultation with the "Research Supervisor". You must always register for the Biophysics research courses using the section of your Faculty Sponsor.

The Jenkins Faculty Sponsor must be confident that the Research Supervisor is qualified for and committed to this apprenticeship program. The Research Supervisor must be able and willing to observe and evaluate the performance of the student. Moreover, the research topic should be appropriate to the biophysics major, broadly defined.

If you are conducting research under the supervision of a full-time faculty member in the Jenkins Department of Biophysics, the "Research Supervisor" can also serve as the "Faculty Sponsor".

Biophysics research topics and locations

The Biophysics major allows undergraduate research experiences in a broad range of topics; however clinical research and survey-type investigations are not allowed. With these restrictions in mind, students can initiate an apprenticeship with a "Research Supervisor" in any laboratory in Arts and Sciences, Medicine, Engineering and Public Heath. A vigorous and wide-ranging search for potential Research Supervisors is the best way to ensure a successful apprenticeship.

Four steps to find a research position at JHU

1. Find out what research interests you that is being carried out at JHU.

Follow your natural interests in searching the JHU web pages of science faculty. The web pages for the Jenkins Biophysics Department and the Graduate Program in Biophysics are both good places to start.

As you read faculty research descriptions, you may come across a topic that caught your interest in a previous class or a technique that just sounds cool. Your faculty advisor can help direct you to research labs that match your interests. Do not hesitate to ask them for advice, as your advisor may have insight from previous undergraduate research experiences that you may not be able to identify from published and/or posted material.

Once you have identified two or three labs that interest you, download a paper or two from those labs and familiarize yourself with the scientific questions being addressed as well as the techniques that are employed.

2. Contact faculty members.

As soon as you have identified a research lab that interests you, send an email to the faculty member in charge, inquiring whether he or she has an opening. Since the process of identifying a lab and a research project takes a lot of effort on both sides, it is *strongly advised* that you make faculty contacts the semester *prior* to when you want to start research. It is important in this first contact to introduce yourself to faculty members with a thoughtful paragraph: tell them about yourself (courses you have taken, any previous research experience, your long term goals), and state why you are interested in his or her lab. Be prepared to send a short resume, transcript, or recommendation from an instructor or TA. If the faculty member is interested, make an appointment to discuss potential research projects. Since most faculty have busy schedules, you will have the best luck making an appointment by providing the faculty member with a readable, formatted table letting them know all the times you are available to meet during the week, rather than asking "when can you meet".

3. Register for research.

To register, obtain two forms from the Registrar's office: (1) the usual Add/Drop form; and (2) A "Supplemental Registration Form for Undergraduate Research, Independent Study and Internship", aka, a yellow research form. This form must be signed by the Faculty Sponsor and returned to the Registrar along with the Add/Drop slip.

Students are limited to *six total credits per academic year. This almost always involves two one-semester three-credit courses* (course numbers listed above), taken in the fall, winter, or summer. A maximum of three credits may be taken in any of these three terms. Fewer credits may be taken, although this is not advised, since most research projects require a "critical mass" of effort by the student.

Note that the six-credit limit per year of research is strictly enforced by the registrar's office. The registrar's academic year starts with the summer semester. If you earn 3 research credits in the summer and 3 in the fall, you are not eligible to earn additional research credits in the spring.

4. At the beginning of each semester:

The student and the Research Supervisor must complete **PART 1** of the "**Supervisor's Report for Independent Research in Biophysics**". (attached below) before the end of the second week of the semester (the Add deadline).

5. At the end of each semester:
The student completes one of the course requirements as described below:

5A. If the student is completing their first semester of research (e.g. the student has a total of 3 or less research credits):

- The student is required to write a 2-3 page **Progress Report** and submit this to the Research Supervisor for grading.
- Upon receipt of the Progress Report, the Research Supervisor completes **PART 2 of** "**Supervisor's Report for Independent Research in Biophysics**" (attached below).
- The student delivers the Progress Report and the completed Supervisor's Report to the Faculty Sponsor. The Faculty Sponsor must receive ALL of this material by the end of the final exam period.
- Prior to submitting the grade and credits to the Registrar, the Faculty Sponsor may consult with the Research Supervisor. A general guideline is that 1 credit equals 3-4 hours laboratory work per week during the semester.
- Guidelines for how to write a Progress Report are provided on page 8 of this handout.

5B. If the student is completing their second (and all subsequent) semesters of research (for a total of six or more research credits):

- The student should prepare a poster and submit this to both the Research Supervisor and Faculty Sponsor for grading, as described above.
- Upon receipt of the Poster, the Research Supervisor completes **PART 2 of** "**Supervisor's Report for Independent Research in Biophysics**" (attached below)
- The student delivers the Poster and the completed Supervisor's Report to the Faculty Sponsor before the end of the final exam period. Graduating seniors in their terminal semester should note that they risk losing their "graduating" status for that

commencement period if they miss this deadline. This is a hard deadline established by the Registrar.

- Prior to submitting the grade and credits to the Registrar, the Faculty Sponsor may consult with the Research Supervisor. A general guideline is that 1 credit equals 3-4 hours laboratory work per week during the semester.
- Guidelines describing how to prepare a poster are provided on page 8 of this handout.

6. Grading:

Research using numbered Biophysics courses (see above) is graded. The Faculty Sponsor will submit the research grade online upon receipt of the following:

The Progress Report or Poster; and
The "Supervisor's Report for Independent Research in Biophysics" Part 2

SUPERVISOR'S REPORT FOR INDEPENDENT RESEARCH IN BIOPHYSICS

PART 1. To be completed by the RESEARCH SUPERVISOR and STUDENT at the START of the semester.

Independent research is a key component of the Biophysics Major. Student research involves significant independent effort in the laboratory. Students must work ten hours per week in the lab (at a minimum) to receive three credits during a full (fall or spring) semester. As the summer period is shorter, summer research is expected to involve a proportionately greater effort per week, so that the total effort matches that for the fall / spring semester. By signing below, we (Student and Supervisor) agree to this effort level in the coming semester:

Student signature_____ Date:_____

Supervisor signature _____ Date: _____

Student: return a COPY of PART 2 this form (next page) to your Jenkins Faculty Sponsor in biophysics prior to the drop/add deadline of the current semester. Part 2, on the next page, must be filled out by your Supervisor and returned to your biophysics sponsor *before the end of finals, along with your written Progress Report or Poster (see above for details on the Progress Report or Poster)*.

SUPERVISOR'S REPORT FOR INDEPENDENT RESEARCH IN BIOPHYSICS

PART 2. To be completed by the RESEARCH SUPERVISOR at the END of the SEMESTER.

Student/HopkinsID_____/_____Term _____

Biophysics Faculty Sponsor _____

Research Supervisor _____

Course number (circle one):
250.531 (1st Sem) / 250.521 (fall) / 250.522 (spring) / 250.597 (summer)

Supervisor: In the space below and on the back, describe in a few paragraphs the research accomplishments made by the student in the last semester and its significance. Also, comment on level of effort made by the student, their proficiency level, and any areas where the student can make improvements. Then fill out the check boxes at the bottom

	Needs work	Average	Good	Excellent
Understanding of the problem				
Effort				
Skill at the bench				
Interpretation of results				
Lab notebook				

SUGGESTED GRADE_____ CREDITS_____

SUPERVISOR'S SIGNATURE_____
Student: return a COPY of PART 2 of this form to your research sponsor in biophysics prior to the end of finals week, along with the written component (i.e., your Research Report or Poster; see above).

Progress Report Guidelines

The Progress Report should include:

- The Student's name, the Research Supervisor's name, his/her title and affiliation, student's name, when accomplished e.g., Fall 2012, Spring 2013, Summer 2013.

- **Introduction**: Background rationale with reference/s; how the work fits into the overall objectives of the research program.

- **Methods**: Briefly give techniques used.

- **Results**: Give results obtained. If too early in the project for results, more on methodology might be appropriate.

- **Discussion**: Significance of results and their relation to future plans.

Poster Preparation Guidelines

Supervisors may have specific instructions or styles for laboratory posters, but a general guide for approaching this task is to prepare 9 OR 12 letter-sized (8.5 x 11 in) power point slides as following:

- **Title**: (1 slide) This slide contains the title of your study along with your name and the name of your Research Supervisor and when the work was accomplished, e.g. Fall 2012, Spring 2013, etc..
- **Abstract**: (1 Slide) This is essentially one paragraph that outlines the question that was addressed, summarizes the main results and states the conclusions. Do not use a font size smaller than 18.
- **Introduction**: (1 Slide) *This slide is optional*. You may choose to include it if you feel that your Abstract does not adequately describe the background for your project. Do not use a font size smaller than 18.
- **Results**: (5 or 8 Slides) Provide figures or graphs of data. Each result should have a scientific title that summarizes the main finding as well as a figure legend that briefly describes the methods. Do not use a font size smaller than 18.
- **Conclusions**: (1 Slide) A bullet point list of the main conclusions of the work. This section also contains a reference to the funding source for the work. A brief description of future experiments may also be appropriate in the Conclusions section. Do not use a font size smaller than 18.
- You must submit both paper and electronic copies of your poster to your Jenkins Faculty Advisor.

Frequently Asked Questions about Graded Research in Biophysics & the Biophysics Poster Session:

What time commitment is expected for research?

A general guideline is that 1 credit equals 3-4 hours laboratory work per week during the semester. An absolute minimum effort of 10 hours per week is expected for 3 credits of research. As the research progresses, students often find that they want to work more hours in the laboratory so that they can get more done. We encourage this, but cannot award more than three credits per semester, and six credits per academic year. Note that the level of effort should be evenly maintained throughout the semester.

Is research a guaranteed grade of "A"?

No. Research is a graded class, and "grades" necessarily have more than one value. Thus, you should take it seriously, like all your other classes. At a minimum, you should be committing 10-12 hours per week for 3 credits of research. However, simply showing up for this many hours will not guarantee a grade of "A". You want to show interest and initiative with your project; you want to ask lots of questions, and make progress in gaining technical skills, optimizing methods, acquiring knowledge, and making discoveries.

My Progress Report is longer than 3 pages. Is this a problem?

A Progress Report longer than 3 pages is generally not a problem. If you have questions about what to include, you should seek the advice of your Faculty Sponsor.

What is the Biophysics Poster Session?

Biophysics has an Undergraduate Poster Session that takes place at the end of the spring semester. This Poster Session is part of our spring party to welcome new majors and to celebrate our graduating seniors. All biophysics majors are invited to present their research in our annual Poster Session.

The 2016 Biophysics Poster Session is scheduled for Wednesday April 27 sometime in the afternoon. More details will be forthcoming as the date approaches.

I have only completed 3 credits of research, but it went really well, and I was able to collect a lot of cool data. I want to make a poster and participate in the Biophysics Poster Session. Am I allowed?

Congratulations on your early success in the lab! During your first semester of research, you will still need to write your paper for your grade, but of course you are welcome to

additionally prepare a poster and participate in the Biophysics Poster Session. You should have both your Research Supervisor and your Faculty Sponsor approve your poster.

I did research in the fall (or previous summer) but not in the spring. Can I still participate in the poster session?

Yes, even if you conducted your research in the fall (or previous summer) but did not continue through the spring, you are still invited to present your poster in the Biophysics Poster Session. In fact, we encourage you to participate. Keep in mind that you should have submitted both paper and electronic copies of your poster to your Jenkins Faculty Sponsor during the semester you conducted research for a grade. Thus, printing your submitted poster for the spring BPS should only require some file formatting.

Am I required to participate in the Biophysics Poster Session?

No, since our poster session will be annually, it is not a course requirement per se. Therefore, you are not required to participate, and your participation will not be graded. However, it is highly recommended that you participate in the BPS for as many years as you can. A poster session is a valuable opportunity for you to present your work to the faculty and to your peers. It will allow faculty to get to know you better, see what kind of researcher you have become, and in general, write stronger letters of recommendation on your behalf.

I will be seeking Honors in Biophysics. Does the poster take the place of the Honors Paper?

No, the requirements for Honors in Biophysics have not changed. These requirements can be found here:

http://biophysics.jhu.edu/undergraduate_awards_and_honors.html

In the future, participation in the Biophysics Poster Session will be a requirement (in addition to the Honors Paper) for majors seeking to earn Honors in Biophysics.

14. Appendix B: Departmental Honors in Biophysics

14.1 Eligibility

Students who have met the requirements for the Biophysics major and who satisfy the following requirements are eligible for departmental honors at graduation:

• Overall GPA 3.5 or better

• "Honors Paper" in Biophysics approved in writing by the student's *Research Supervisor* and *Faculty Sponsor* and conforming to the attached guidelines.

To evaluate if you are eligible:

- Determine your overall GPA and complete the Honors Clearance Form (available on the Academic Advising website). You do not need to complete the GPA Worksheet.

- Consult with your research advisor about writing a paper describing your research project.

14.2 Honors Paper

The honors paper must describe independent research carried out by student as part of biophysics research requirement (250.521/522/597). Library research is not acceptable for this purpose. The length should be ~20 pages double-spaced, plus figures and literature citations. The format should follow the layout of a research paper; a guide for each section is given below.

14.2.1 Honors Paper Layout

Abstract (250 words, no longer)

A typical abstract typically contains one sentence describing the problem, one sentence describing its significance, one sentence describing the approach, and two-three sentences stating the results and conclusions.

Introduction (~4-6 pages)

Provide background information necessary to understand the study undertaken. Be sure to state why the problem you addressed is important as well as how your research relates to previous work. Assume that your reader is another undergraduate biophysics major with some scientific training but who does not work in the same lab. Your goal is to provide

sufficient information for such a reader to understand and appreciate your project, but nothing extraneous.

Materials and Methods (~2-3 pages)

Describe your experimental protocols, and state where you obtained reagents. There should be enough detail to allow an independent researcher to reproduce your experiments. Since the methods section describes the experiments you have already done, it should be written in the past tense.

Results (~4-10 pages)

Provide a narrative that describes the outcome of the experiments performed. Figures documenting the results should be accompanied by legends that enable the reader to understand what is in the figure. It is preferable if the figures are imbedded in the text, but they can also be placed together at the end of the paper. The space taken by figures is not counted in the page limitation of the paper. The results section should be written in the past tense.

Discussion (~4 pages)

Discuss what was learned, the reliability of the results, any limitations to the interpretation, significance of your conclusions, future directions.

Literature references

These must follow the format of a standard journal in the field, such as *Biophysical Journal*, *Protein Science*, *Nature Structural Biology*, *Nucleic Acids Research*, etc. Take care to include references to the primary literature, not just review articles or textbooks. Your paper should represent a scholarly effort. In general, any time you report a specific scientific finding or restate a specific idea or thesis, the author of the experiments or the idea should be cited. The citation of a timely review article can support general statements that refer to a collection of phenomena. Your research advisor can direct you to the best literature sources in the area of your research project. The citations should be placed in a list at the end of the paper (endnotes rather than footnotes). Citations can either be numbered in order of appeared in the main text, or marked by Author, year in the main text and listed alphabetically in the reference section.

14.2.2 Honors Paper Due Date

For a May commencement, the honors distinction is due to the Registrar's Office in early April. To meet that deadline, the following is a suggested timeline for completing the paper requirements:

- Turn your completed honors paper into your *Research Supervisor* for comments and/or approval no later than March 1. **Give your *Research Supervisor* at least one week to read the paper and provide feedback to you.**

- Once your *Research Supervisor* has approved your honors paper, give a copy to your *Faculty Sponsor* for comments and/or approval. Your faculty sponsor should receive the paper no later than March 20. (Sometimes the Research Supervisor and the Faculty Sponsor are the same person.) **Give your *Faculty Sponsor* at least one week to read the paper and provide feedback.**

- Ask both your *Research Supervisor* and your *Faculty Sponsor* to send a note to the Biophysics DUS in writing indicating their approval of the paper. It is fine to have them send a simple email sent directly to the DUS stating, "I approve the honors paper written by xx student entitled "Your fabulous title."".

- Complete the Honors Clearance Form (available on the Academic Advising website). You do not need to complete the GPA Worksheet.

- Bring the Honors Clearance Form and a copy of your Honors paper to the Biophysics DUS. They will sign the Honors Clearance form and keep the paper.

- Bring the signed Honors Clearance Form over to Academic Advising before the deadline.

For Honors Designations in the May graduation program, all six of these steps must be completed no later than April 1.

This means that the latest time to set up an appointment with your *Research Supervisor* to discuss the honors paper should be early February.

15. Appendix C: History of Jenkins Biophysics

The Biophysics Department was established with funds from Mrs. May McShane Jenkins and named in honor of her late husband Thomas Courtenay Jenkins (1866-1938), a Baltimore financier and art collector. Mrs. Jenkins was always interested in physiotherapy. Her eagerness (as her will stated) to encourage exploration of "water, heat, and light in the treatment of disease" led Mrs. Jenkins to make donations in 1947 and 1955 for the study of biophysics at Johns Hopkins. Upon her death in 1957 the University received the bulk of her estate to endow the Thomas C. Jenkins Department of Biophysics. A final distribution took place in 2000.

In 1949, the first course in biophysics was offered at Johns Hopkins. The following year Jenkins Hall was dedicated as the center of biophysical research at the Homewood campus. In 1953, the first Chairman of Biophysics Dr. F. Keffer Hartline (1967 Nobel Prize winner in Physiology or Medicine) left the University and was replaced the following year by Dr. Francis "Spike" Carlson, who was part of the faculty group to start biophysics here. He served until 1971. Under his leadership in 1956 "fundamental studies" in biophysics was formally established as the separate Thomas C. Jenkins Department of Biophysics in the Faculty of Philosophy (the predecessor of the School of Arts and Sciences). Medicine and health studies in biophysics were placed under the Schools of Medicine and Public Health, respectively. Jenkins Hall was expanded to its current size three years later. Dr. Carlson was succeeded as Chairman by Dr. Warner Love (1971-74); Dr. Michael Beer (1974-80); Dr. Warner Love again (1980-83), Dr. Shin Lin (1983-96), Dr. Eaton E. Lattman (1996-2004) and Dr. George Rose (2004-2007). The current Chair is Prof. Bertrand Garcia-Moreno E. (2008-Pres.).

In accepting Mrs. Jenkins' 1957 bequest, Dr. Milton S. Eisenhower, then President of Johns Hopkins explained the significance of biophysics:

> *The interrelation of biology and physics is an important field of study. There are few investigators with the thorough training of both biology and physics, who can do advanced work in the combined biophysics field. Johns Hopkins is performing a unique service in producing investigators who are capable of advancing biology in terms of physics and mathematics.*

In that spirit, this Department always seeks to be a center of "fundamental" biophysical studies. Faculty members from other disciplines who are oriented towards biophysics receive joint appointments. We are very much involved in the Program in Molecular and Computational Biophysics (PMCB) and the Institute for Multiscale Modeling of Biological Interactions (IMMBI). In the mid 1980s, Jenkins Hall was completely renovated, allowing us to easily take advantage of the burgeoning use of computers and other new technologies. This permitted the installation of a University-run computer lab. The building has been upgraded several times, most recently in 2014. An x-ray crystallography lab was added in 2000.

End of Advising Manual