

# Biomedical Sciences

<http://www.med.und.edu/basic-sciences/>

FACULTY: Bradley, Brissette, Brown-Borg, Carr, Carvelli, Chen, Combs (Department Chair), Condry, Dhasarathy, Doze, Dunlevy, Foster, Geiger, Ghribi, Golovko, Grove, Haselton, Henry, Hur, Kotb, Lei, Milavetz, Mishra, Mukundan, Murphy, Nechaev, Nilles, Nookala, Porter, Rosenberger (Program Director), Ruit, Shabb, Sharma, Singh, Sukalski, Tessema, Vaughan, Watt, Wu

JOINT FACULTY: Basson

## Degrees Granted: Master of Science (M.S.), Doctor of Philosophy (Ph.D.), and Combined M.D./Ph.D.

The Department of Biomedical Sciences offers graduate programs leading to the M.S. and Ph.D. degrees, including the combined M.D./Ph.D degree. All programs are research-oriented and students begin research work during their first year. These graduate degree programs prepare scholars for a variety of careers including academic teaching, research, and related careers in various governmental, industrial, and private research laboratories. Research and educational opportunities within the program provide students with focused training in multiple fields including inflammation and infectious disease, neuroscience and neurodegenerative disease, epigenetics, and molecular and cellular biology.

### Master of Science (M.S.)

#### Mission Statement and Program Goals

The mission of the Biomedical Sciences Graduate Program leading to the Master of Science degree is to prepare students for careers in education or technical careers in biomedical sciences.

**Goal 1:** M.S. graduates will possess and be capable of applying knowledge in biomedical sciences related to their field of study.

*Objective 1.1:* Students will demonstrate a breadth of knowledge in the biomedical sciences to support scholarly inquiry and flexibility in their career path.

*Objective 1.2:* Students will demonstrate a depth of knowledge in elected subject areas through scholarly contribution to their field of study.

*Objective 1.3:* Students will demonstrate skills in the use of technology to manage information.

*Objective 1.4:* Students will demonstrate the ability to use primary literature and other resources to support their scholarly efforts.

**Goal 2:** M.S. graduates will demonstrate the ability to understand, develop, and apply multiple approaches to test ideas using the scientific method.

*Objective 2.1:* Students will be able to apply the scientific method to conduct a scholarly investigation.

*Objective 2.2:* Students will demonstrate an ability to formulate questions and generate hypotheses in response to new and unfamiliar problems.

*Objective 2.3:* Students will demonstrate an ability to implement experimental approaches that have been appropriately chosen to test their hypotheses.

*Objective 2.4:* Students will demonstrate the ability to appropriately and accurately collect, record, and analyze research data.

*Objective 2.5:* Students will demonstrate the ability to reach scientifically sound conclusions based on current Knowledge within their field of study.

**Goal 3:** M.S. graduates will master communication skills necessary to convey the results of their scholarly work.

*Objective 3.1:* Students will demonstrate the ability to present their research clearly, concisely, and accurately in both oral and written form to experts in the field and to the general scientific community.

*Objective 3.2:* Students will demonstrate the ability to effectively communicate their scholarly work to a lay audience in a way that illustrates the accomplishments and importance of scientific research.

### Doctor of Philosophy (Ph.D.)

#### Mission Statement and Program Goals

The mission of the Biomedical Sciences Graduate Program leading to the Doctor of Philosophy degree is to prepare students for professional careers in biomedical sciences through personalized and multi-disciplinary graduate education and research experiences.

**Goal 1:** Ph.D. graduates will become professionals who possess a foundational knowledge of the biomedical sciences and are capable of applying that knowledge in scholarly endeavors as self-directed, life-long learners.

*Objective 1.1:* Students will demonstrate breadth of knowledge in the biomedical sciences to form a solid basis for scholarly inquiry and flexibility in their career path.

*Objective 1.2:* Students will demonstrate depth and integration of knowledge in specific subject areas of their choice to support their research and to allow them to make meaningful contributions that advance the discipline.

*Objective 1.3:* Students will demonstrate skills in managing information and searching the biomedical literature and data repositories using appropriate technology.

*Objective 1.4:* Students will remain current in their knowledge of major scientific developments and apply this knowledge to multi-disciplinary problems.

**Goal 2:** Ph.D. graduates will become professionals who demonstrate intellectual curiosity and the ability to conduct meaningful scholarly inquiry.

*Objective 2.1:* Students will demonstrate the ability to develop clearly stated meaningful hypotheses and research questions that lead to scientific investigation in areas relevant to the biomedical sciences.

*Objective 2.2:* Students will demonstrate the ability to select, design, and implement experimental approaches to rigorously test their hypotheses.

*Objective 2.3:* Students will demonstrate the ability to appropriately and accurately record and to analyze data with the degree of rigor expected by the scientific community.

*Objective 2.4:* Students will demonstrate the ability to reach scientifically sound conclusions by integrating their data with existing knowledge and by critical evaluation of their results.

*Objective 2.5:* Students will disseminate their findings through peer-reviewed publications and other means that advance knowledge in their discipline.

**Goal 3:** Ph.D. graduates will master communication skills necessary to convey the results of their scholarly work.

*Objective 3.1:* Students will demonstrate the ability to present their research clearly, concisely, and accurately in both oral and written form to experts in the field and to the general scientific community.

*Objective 3.2:* Students will demonstrate the ability to effectively communicate their scholarly work to a lay audience in a way that illustrates the accomplishments and importance of scientific research.

**Goal 4:** Ph.D. graduates will gain experience in education and mentorship.

*Objective 4.1:* Students will demonstrate the ability to teach biomedical science to a precollege, undergraduate, graduate, or health professional audience.

**Objective 4.2:** Students will demonstrate the ability to provide formative and summative feedback that encourages, assesses, and improves learning.

**Objective 4.3:** Students will demonstrate the principles of effective mentorship.

**Goal 5:** Ph.D. graduates will recognize and abide by professional and ethical standards and participate in service to their institution, the scientific community, and society in general.

**Objective 5.1:** Students will demonstrate the ability to establish rapport with colleagues and peers that encourages a team-based mindset toward the accomplishment of departmental and institutional goals.

**Objective 5.2:** Students will demonstrate the ability to articulate and abide by the standards of ethical behavior and responsible conduct in research.

**Objective 5.3:** Students will demonstrate the ability to articulate and abide by the acceptable standards of conduct in the teacher-learner relationship.

**Objective 5.4:** Students will engage in on-going service to the department, the school, the university, the profession, and the community.

## Master of Science (M.S.)

### Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog.

- Completion of a four-year Bachelor's degree or equivalent from a recognized college or university as described in the UND Undergraduate and Graduate Academic Catalog. Exceptions must be approved by the Dean of the School of Graduate Studies.
- Coursework: Admission into the Biomedical Sciences Graduate Program is dependent upon the applicant's demonstration of effective academic skills and appropriate undergraduate training. Ideally, the applicant will have completed the following coursework:
  - General Biology with laboratory
  - General Chemistry with laboratory
  - Organic Chemistry with laboratory
  - Physics with laboratory
  - Biochemistry or equivalent
  - Calculus
  - Advanced undergraduate coursework in at least one of the following areas: molecular biology, cell/developmental biology, genetics, neuroscience, biochemistry, microbiology, immunology, anatomy, or physiology.
- Applicants must have a cumulative undergraduate GPA of at least 3.0/4.0. Applicants with previous graduate education should have a cumulative GPA of 3.5/4.0 in their graduate level course work. Graduate Record Examination scores: Applicants must submit Graduate Record Examination scores. The General test is required; the Subject test is strongly recommended. The Biochemistry, Cell and Molecular Biology, Biology, or Chemistry subject tests are acceptable. Preference for admission will be given to applicants whose averaged test scores are at or above the 50<sup>th</sup> percentile.
- International applicants must satisfy the School of Graduate Studies English Language Proficiency Requirements.
- A Statement of Goals must be included with the application materials. This statement will describe the student's academic achievements, research experience and accomplishments, career goals, and objectives for applying to the Biomedical Sciences Graduate Program.
- Three letters of recommendation addressing the student's academic performance and research or professional experience are required to complete the application. At least two letters must be from faculty having direct knowledge of the student's academic capabilities.

7. Preference will be given to students who can demonstrate undergraduate research and/or a record of scholarly publication or other relevant experience.

### Degree Requirements

Students seeking the Master of Science degree in the Biomedical Sciences Graduate Program must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Biomedical Sciences Graduate Program. In addition to course work, the M.S. degree requires completion of an acceptable thesis in a program of study designed by the student with Faculty Advisory Committee approval.

1. A minimum of 30 credit hours of graduate level courses including research and thesis.

2. Completion of the following core graduate courses:

BIMD 501	Scientific Discovery I	6
BIMD 510	Basic Biomedical Statistics (fulfills the scholarly tool requirement)	2
BIMD 516	Responsible Conduct of Research	2
BIMD 590	Research	at least 8
BIMD 998	Thesis	4

3. Completion of a minimum of 4 credit hours of graduate level elective courses selected from the following:

ANAT 513	Gross Anatomy	6
ANAT 517		3
ANAT 521	Principles of Developmental Biology	3
ANAT 522	Neuroscience	6
ANAT 591	Special Topics in Anatomy and Cell Biology	1-3
BMB 533	Advanced Topics	1
MBIO 501	Molecular Virology	2
MBIO 504	Microbial Physiology	2
MBIO 508	Microbial Pathogenesis	2
MBIO 509	Immunology	3
MBIO 512	Microbial Genetics	2
MBIO 515	Advanced Topics	2
MBIO 519	Advanced Immunology	2
PPT 500	Principles of Physiology and Pharmacology	6
PPT 503	Advanced Pharmacology or Physiology	3
PPT 505	Research Techniques	1-3
PPT 511	Biochemical and Molecular Mechanisms of Pharmacology	3
PPT 512	Special Topics in Pharmacology, Physiology and Therapeutics	2
PPT 525	Advanced Renal Physiology	3
PPT 526	Advanced Respiratory Physiology	3
PPT 527	Advanced Neurophysiology	3
PPT 528	Advanced Endocrinology	3
PPT 529	Adv Cardiovascular Physiology	3
PPT 530	Advanced Neurochemistry	3
PPT 535	Mechanisms of Neurodegenerative Disorders	3
PPT 540	Molecular Neuropharmacology	3
BIMD 520	Principles of Neuroanatomy	2
BIMD 521	Neurophysiology	2
BIMD 522	Principles of Neuropharmacology	2
BIMD 523	Neurochemical Basis of the Nervous System	2
BIMD 524	Neurodegenerative Diseases and Pathophysiology	2
BIMD 530	Components of the Immune System	2
BIMD 531	Components of Microbial Pathogenesis	2
BIMD 532	Microbial Gene Regulation	1
BIMD 533	Microbial Membranes and Transport	1

BIMD 534	Microbial Cell Structure and Function	1
BIMD 535	Bacterial Host: Pathogen Interactions	1
BIMD 536	Molecular Biology and Pathogenesis of Viruses	1
BIMD 537	Host-Pathogen Interactions involving Eukaryotic Microbes (Parasites/Fungi)	1
BIMD 538	Immunological Disorders	1

4. A student must obtain at least a "B" in all required courses in order to remain in good standing in the graduate program. If less than a "B" is received, the student will be given the opportunity to remediate in a manner determined by the course director. If remediation is unsuccessful, the student may petition the Graduate Faculty to take the course a second time. In the event that the student is unable to raise the grade to at least a "B", the student must petition the Graduate Faculty to be allowed to remain in the program.

5. Students must maintain a minimum 3.0 GPA in accordance with School of Graduate Studies guidelines (UND Graduate and Undergraduate Academic Catalog).

6. In addition to course work, the Master of Science degree requires completion of a thesis-based scholarly project completed by the graduate student under the guidance of a faculty advisor. It is expected that the results of the scholarly work will be publishable in a peer-reviewed journal.

## Doctor of Philosophy (Ph.D.)

### Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog.

- Completion of a four-year Bachelor's degree or equivalent from a recognized college or university as described in the UND Undergraduate and Graduate Academic Catalog. Exceptions must be approved by the Dean of the School of Graduate Studies.
- Coursework: Admission into the Biomedical Sciences Graduate Program is dependent upon the applicant's demonstration of effective academic skills and appropriate undergraduate training. Ideally, the applicant will have completed the following coursework:
  - General Biology with laboratory
  - General Chemistry with laboratory
  - Organic Chemistry with laboratory
  - Physics with laboratory
  - Biochemistry or equivalent
  - Calculus
  - Advanced undergraduate coursework in at least one of the following areas: molecular biology, cell/developmental biology, genetics, neuroscience, biochemistry, microbiology, immunology, anatomy, or physiology.
- Applicants must have a cumulative undergraduate GPA of at least 3.0/4.0. Applicants with previous graduate education should have a cumulative GPA of 3.5/4.0 in their graduate level course work.
- Graduate Record Examination scores: Applicants must submit Graduate Record Examination scores. The General test is required; the Subject test is strongly recommended. The Biochemistry, Cell and Molecular Biology, Biology, or Chemistry subject tests are acceptable. Preference for admission will be given to applicants whose averaged test scores are at or above the 50<sup>th</sup> percentile.
- International applicants must satisfy the School of Graduate Studies English Language Proficiency Requirements.
- A Statement of Goals must be included with the application materials. This statement will describe the student's academic achievements, research experience and accomplishments, career goals, and objectives for applying to the Biomedical Sciences Graduate Program.
- Three letters of recommendation addressing the student's academic performance and research or professional experience are required to complete

the application. At least two letters must be from faculty having direct knowledge of the student's academic capabilities.

8. Preference will be given to students who can demonstrate undergraduate research and/or a record of scholarly publication or other relevant experience.

## Degree Requirements

Students seeking the Ph.D. degree in the Biomedical Sciences Graduate Program must satisfy all general requirements set forth by the School of Graduate Studies as well as particular requirements set forth by the Biomedical Sciences Graduate Program. In addition to course work, the Ph.D. degree requires completion of an acceptable dissertation in a program of study designed by the student with Faculty Advisory Committee approval.

1. A minimum of 90 credit hours of graduate level courses including research and dissertation.

2. Completion of the following graduate level courses:

BIMD 501	Scientific Discovery I	6
BIMD 502	Scientific Discovery II	6
BIMD 510	Basic Biomedical Statistics (fulfills the scholarly tool requirement)	2
BIMD 516	Responsible Conduct of Research	2
BIMD 518	Grant Writing	2
BIMD 590	Research	at least 50
BIMD 999	Dissertation	6

3. The optional transcriptable subplan (Specialization) in Neuroscience requires completion of the following 5 courses (10 credits):

BIMD 520	Principles of Neuroanatomy	2
BIMD 521	Neurophysiology	2
BIMD 522	Principles of Neuropharmacology	2
BIMD 523	Neurochemical Basis of the Nervous System	2
BIMD 524	Neurodegenerative Diseases and Pathophysiology	2

4. The optional transcriptable subplan (Specialization) in Microbiology and Immunology requires completion of the following 2 courses (4 credits):

BIMD 530	Components of the Immune System	2
BIMD 531	Components of Microbial Pathogenesis	2

and also requires completion of 5 credits chosen from the following courses:

BIMD 532	Microbial Gene Regulation	1
BIMD 533	Microbial Membranes and Transport	1
BIMD 534	Microbial Cell Structure and Function	1
BIMD 535	Bacterial Host: Pathogen Interactions	1
BIMD 536	Molecular Biology and Pathogenesis of Viruses	1
BIMD 537	Host-Pathogen Interactions involving Eukaryotic Microbes (Parasites/Fungi)	1
BIMD 538	Immunological Disorders	1

5. Students who choose not to complete a subplan must complete a minimum of 6 credit hours of graduate level elective courses selected from the following:

ANAT 513	Gross Anatomy	6
ANAT 517		3
ANAT 521	Principles of Developmental Biology	3
ANAT 522	Neuroscience	6
ANAT 591	Special Topics in Anatomy and Cell Biology	1-3
BMB 533	Advanced Topics	1-9
MBIO 501	Molecular Virology	2
MBIO 504	Microbial Physiology	2
MBIO 508	Microbial Pathogenesis	2
MBIO 509	Immunology	3

MBIO 512	Microbial Genetics	2
MBIO 515	Advanced Topics	2
MBIO 519	Advanced Immunology	2
PPT 500	Principles of Physiology and Pharmacology	6
PPT 503	Advanced Pharmacology or Physiology	3
PPT 505	Research Techniques	1
PPT 511	Biochemical and Molecular Mechanisms of Pharmacology	3
PPT 512	Special Topics in Pharmacology, Physiology and Therapeutics	1
PPT 525	Advanced Renal Physiology	3
PPT 526	Advanced Respiratory Physiology	3
PPT 527	Advanced Neurophysiology	3
PPT 528	Advanced Endocrinology	3
PPT 529	Adv Cardiovascular Physiology	3
PPT 530	Advanced Neurochemistry	3
PPT 535	Mechanisms of Neurodegenerative Disorders	3
PPT 540	Molecular Neuropharmacology	3
BIMD 520	Principles of Neuroanatomy	2
BIMD 521	Neurophysiology	2
BIMD 522	Principles of Neuropharmacology	2
BIMD 523	Neurochemical Basis of the Nervous System	2
BIMD 524	Neurodegenerative Diseases and Pathophysiology	2
BIMD 530	Components of the Immune System	2
BIMD 531	Components of Microbial Pathogenesis	2
BIMD 532	Microbial Gene Regulation	1
BIMD 533	Microbial Membranes and Transport	1
BIMD 534	Microbial Cell Structure and Function	1
BIMD 535	Bacterial Host: Pathogen Interactions	1
BIMD 536	Molecular Biology and Pathogenesis of Viruses	1
BIMD 537	Host-Pathogen Interactions involving Eukaryotic Microbes (Parasites/Fungi)	1
BIMD 538	Immunological Disorders	1

6. A student must obtain at least a "B" in all required courses in order to remain in good standing in the graduate program. If less than a "B" is received, the student will be given the opportunity to remediate in a manner determined by the course director. If remediation is unsuccessful, the student may petition the Graduate Faculty to take the course a second time. In the event that the student is unable to raise the grade to at least a "B", the student must petition the Graduate Faculty to be allowed to remain in the program.

7. Students must maintain a minimum 3.0 GPA in accordance with School of Graduate Studies guidelines (UND Graduate and Undergraduate Academic Catalog).

8. Students must successfully complete the comprehensive examination.

9. Students must fulfill the teaching requirement as defined by the student's Faculty Advisory Committee in consultation with the Department Chair and the Director of Graduate Studies in Biomedical Sciences.

10. Research and Dissertation: The Ph.D. degree requires completion of a dissertation based on the results of a project completed by the graduate student under the guidance of a faculty advisor. The project must represent an original and independent investigation by the student. It is expected that the student will publish at least one first author peer-reviewed manuscript in a scientific or academic journal prior to the defense of their dissertation. The dissertation prepared by the candidate must be presented orally in a public forum and defended before the Faculty Advisory Committee and the Departmental Graduate Faculty and will be open to all members of the academic community.

## Combined M.D./Ph.D.

Through the cooperation of the School of Graduate Studies and the School of Medicine, students may concurrently pursue the Doctor of Philosophy degree in a medical science field (Anatomy and Cell Biology, Biochemistry and Molecular Biology, Microbiology and Immunology, Pharmacology, Physiology

and Therapeutics) and the Doctor of Medicine degree. The minimum time required to complete the joint program is six years of full-time academic study.

Students interested in the joint M.D./Ph.D. program should first obtain admission to the School of Medicine and Health Sciences to the M.D. degree program, following the normal application process and meeting the selection criteria. A student admitted to the M.D. program may apply to School of Graduate Studies as soon as he/she has selected a graduate program, which may occur before matriculation in Medical School but not later than the end of the first year of Medical School.

Final admission requirements for the M.D./Ph.D. program include:

1. Satisfactory performance in the first two years of the medical education curriculum with passing scores on all required assessment tools.
2. Successful completion of the USMLE Step 1 examination.
3. Satisfactory scores achieved on General and Subject GRE examination or MCAT scores.
4. All other UND School of Graduate Studies admission requirements listed in the UND Academic Catalog.

If admission to a Ph.D. program is granted, the student should apply to the School of Medicine and Health Sciences Student Performance and Recognition Committee for a "modification of original program," which will allow the student to pursue the M.D. degree and Ph.D. degree concurrently. The student also must request the Office of Student Affairs to certify to the School of Graduate Studies his/her satisfactory completion of the first two years of the M.D. program.

Students are expected to complete the following general requirements for the Ph.D. degree in a medical science field:

1. Performance of original research of a quality suitable for publication in refereed, professional journals.
2. Pass final examination which includes preparation and oral defense of a satisfactory dissertation.
3. Completion of .
4. A minimum of 90 credit hours, including research and dissertation.
5. Successful completion of a scholarly tool (Note: May be specified by a department.)
6. Completion of the first two years of the medical education curriculum, transferred as 44 credits toward the Ph.D.

## ANAT Courses

### ANAT 501. Biomedical Information Retrieval. 1 Credit.

This course integrates electron information retrieval techniques with biomedical research education to develop the student's ability to augment traditional learning and research. Electronic techniques covered include data base searching and internet resources. S/U grading. F,S,SS.

### ANAT 505. Seminar in Anatomy and Cell Biology. 1 Credit.

This course provides students an opportunity to organize and orally present scientific information to an audience in a forum conducive to the development of their skills in effective communication. Seminars delivered by students, UND faculty, and other invited speakers present current advancements in biomedical research that promote student learning of principles of biomedical sciences. Repeatable to 5 credits.

### ANAT 513. Gross Anatomy. 6 Credits.

Gross Anatomy will be an intensive one semester course that will use a regional approach to enhance the understanding of the structural and functional relationships as well as organization of the adult human body. Lectures will be reinforced with complete cadaver dissection and multiple clinical imaging modalities to strengthen problem solving and critical thinking skills. Prerequisites: ANAT 204L and permission of the instructor. S.

### ANAT 521. Principles of Developmental Biology. 3 Credits.

This is a student driven course designed to provide the student with a firm understanding of the concepts in developmental biology. Students will be using a wide range of materials from textbooks to the internet to gain a graduate level understanding including how to apply this knowledge to research applications. Student presentations will address advanced principles of developmental mechanisms and underlying human embryology. S.



**ANAT 590. Readings in Anatomy and Cell Biology. 1-3 Credits.**

Students may elect to do a readings.

**ANAT 591. Special Topics in Anatomy and Cell Biology. 1-3 Credits.**

A series of lectures, discussions and/or laboratory experiences developed around a specific topic in the anatomical or cell biological sciences.

Prerequisite: Permission of instructor. Repeatable to 3 credits.

**ANAT 593. Research in Anatomy and Cell Biology. 1-15 Credits.**

Research is offered in the specialty fields of the faculty of the department, and involves a variety of problems and research tools in morphology and cell biology. Repeatable.

**ANAT 996. Continuing Enrollment. 1-12 Credits.**

Repeatable. S/U grading.

**ANAT 997. Independent Study. 2 Credits.****ANAT 998. Thesis. 1-9 Credits.**

Repeatable to 9 credits.

**ANAT 999. Dissertation. 1-15 Credits.**

Repeatable to 15 credits.

**BIMD Courses****BIMD 501. Scientific Discovery I. 6 Credits.**

A problem based course in which students will address a set of biomedical research scenarios that have been designed so that students will acquire skills in critical thinking, finding, interpreting, and analyzing scientific literature, developing hypothesis-driven questions, proposing and designing experiments, and communicating scientific outcomes orally and in written format. F.

**BIMD 502. Scientific Discovery II. 6 Credits.**

A problem based course in which students will address a set of biomedical research scenarios that have been designed so that students will advance their skills in critical thinking, finding, interpreting, and analyzing scientific literature, developing hypothesis-driven questions, proposing and designing experiments, and communicating scientific outcomes orally and in written format. This course is a continuation and advancement of BIMD 501. Prerequisite: BIMD 501. S.

**BIMD 510. Basic Biomedical Statistics. 2 Credits.**

A series of lectures, demonstrations and exercises to provide students with the basic rationales for the use of statistics in the assessment of biomedical data and a selected set of the most common and useful statistical tests.

Prerequisite: BIMD 500 or permission of course director. S.

**BIMD 513. Seminars in Biomedical Science. 1 Credit.**

A series of presentations on original research conducted by UND faculty members as well as extramural leaders in academic and industrial research in the biomedical sciences. Students will participate through assigned reading and writing exercises related to the presentations.

**BIMD 514. Foundations of Bioinformatics. 3 Credits.**

In this course, students will learn fundamental concepts and methods in bioinformatics, a field at the intersection of biology and computing. The course surveys a wide range of topics including bioinformatics web resources, computational sequence analysis, sequence homology searching and motif finding, transcriptome analysis, and network/pathway analysis. Students will also have opportunities to learn about available bioinformatics web-resources (e.g. UCSC Genome Browser, STRING/BioGRID interaction databases, and etc), next-generation sequencing analysis (focusing on RNA-Seq data) as well as relevant data-analysis tools (R and BioConductor, Ingenuity Pathway Analysis, DAVID, etc). The course will also familiarize students with the Linux environment and computational tools needed to manipulate and analyze large biological sequencing data sets. Students will need a familiarity with basic biomedical concepts and basic knowledge of computer usage. No programming skills are required. Students should bring their own wifi-enabled laptop to lectures to fully benefit from the hands-on components of each lecture. Prerequisite: Open to graduate and senior undergraduate students with permission of the instructor. F.

**BIMD 516. Responsible Conduct of Research. 2 Credits.**

A series of lectures and discussion sessions covering topics related to responsible conduct in research. Students will examine a variety of issues including introduction to ethical decision making, the experience of conflict, laboratory practices, data management, reporting of research, conflict of interest, and compliance. Examples and case studies will be drawn primarily from the biomedical sciences. F.

**BIMD 517. Principles of Histology. 3 Credits.**

Principles of Histology is a laboratory and discussion based course that builds on prior experience in cell biology and involves a strong self-study component through the use of virtual slides as well as lecture and laboratory orientation videos. By the end of the course the student will have demonstrated a significant knowledge base of tissue microanatomy sufficient for understanding and applying the principles to a wide range of research projects. The student will also have gained sufficient knowledge of histology to be capable of teaching this material to medical, professional, graduate, and undergraduate students. Prerequisite: PATH 500 or permission of instructor. S.

**BIMD 518. Grant Writing. 2 Credits.**

This is an advanced graduate grant writing and oral presentation course. The objectives of this course are to challenge students: (1) to critically evaluate their own research in an effort to clearly define the significance and innovation of their project, (2) to begin to develop novel ideas based on their research efforts that have the potential to significantly impact their field of study, and (3) to prepare students to present these ideas orally and in writing in a manner that is both logical and convincing. Prerequisites: BIMD 501 and BIMD 502, or consent of instructor. F.

**BIMD 520. Principles of Neuroanatomy. 2 Credits.**

In this course students will learn the fundamental principles of neuroscience, particularly gross and cellular anatomy, development and systems physiology of the nervous system. Behavioral, cognitive and clinical manifestations of abnormal neural functions will also be addressed. Prerequisite: BIMD 502 or permission of instructor. F.

**BIMD 521. Neurophysiology. 2 Credits.**

This course is designed to introduce students to the electrical properties of neuronal membranes. The course is organized to first provide a brief review of the basic properties of semi-permeable membranes. The electrical and biochemistry principles that apply to neuronal membranes are discussed. Prerequisite: BIMD 502 or consent of instructor. F.

**BIMD 522. Principles of Neuropharmacology. 2 Credits.**

This course is designed to introduce students to the latest developments in molecular neuropharmacology. The course directive is to provide an up-to-date foundation for clinical neuroscience by emphasizing a comprehensive molecular and cellular approach to the effects of drugs on the nervous system. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 523. Neurochemical Basis of the Nervous System. 2 Credits.**

This course is designed to introduce students to fundamental concepts of brain metabolism and neurochemical signaling. It emphasizes recent advances in understanding brain biochemical processes and molecular mechanisms occurring in health and disease. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 524. Neurodegenerative Diseases and Pathophysiology. 2 Credits.**

This course exposes students to diverse neurodegenerative diseases and nervous system pathophysiology. The emphasis is on mechanistic understanding of the most recent advances in the field. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 525. Readings in Neuroscience. 1-4 Credits.**

A supervised readings course on topics of mutual interest to the student and a faculty member. Prerequisite: BIMD 502 or consent of instructor. Repeatable to 4 credits. On demand.

**BIMD 526. Medical Experiences for Graduate Students. 1 Credit.**

The goal of this course is to introduce the graduate student to a "disease-specific" clinical experience so that the student can acquire a better understanding of the importance of translational medicine, develop a firm appreciation of a patient's and a physician's understanding of disease and its treatment, and to introduce the student to the overall culture of clinical research. Prerequisites: Successful completion of comprehensive exam and permission of academic advisor and Instructor of Record; student should initiate discussion with the Instructor of Record at least one month prior to the start of enrollment. S/U grading. On demand.

**BIMD 530. Components of the Immune System. 2 Credits.**

Have you ever wondered why you don't get sick every time you breathe air which can carry as many as 2000 different kinds of microbes on any given day? Or what keeps your defense system from attacking your own cells but can get rid of most invaders without you even noticing? This is the amazing task of your fascinating immune system! This course will provide an overview of cellular and molecular components of mammalian immune system and their function. The students will learn how these components are derived and how they interact and communicate with each other to coordinate a response to pathological insults in order to protect the human body. Prerequisite: BIMD 502 or consent of instructor. F.

**BIMD 531. Components of Microbial Pathogenesis. 2 Credits.**

The objective of the course is to provide students with a background in the mechanisms of microbial pathogenesis. Students will learn basic principles of host-parasite interactions. Paradigms of host-parasite interactions will be illustrated by studying, at the molecular and cellular levels, specific infectious diseases and the agents that cause them. Prerequisite: BIMD 502 or consent of instructor. F.

**BIMD 532. Microbial Gene Regulation. 1 Credit.**

This course will provide an understanding of genetic regulation in bacteria. Classic pathways will be examined as paradigms of regulatory circuits. These examples will be expanded to learn how bacteria exploit host cells as well as the use of bacterial regulatory circuits in modern molecular biology. S.

**BIMD 533. Microbial Membranes and Transport. 1 Credit.**

This course will explore bacterial membranes with particular emphasis on generation of energy and transport of molecules across the membranes. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 534. Microbial Cell Structure and Function. 1 Credit.**

Microbial cells have unique structures that relate their functions. Students completing this course will have an understanding of how prokaryotic and eukaryotic organisms differ and how different structures can be used to obtain similar functions. They will understand how microbial structures influence interactions between microbes and between microbes and eukaryotic organisms. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 535. Bacterial Host: Pathogen Interactions. 1 Credit.**

The objective of the course is to provide students with a background in the fundamental aspects that occur at the bacterial: host interface. Students will learn the interplay between bacterial virulence factors, strategies used to evade host defenses, and host responses to infection. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 536. Molecular Biology and Pathogenesis of Viruses. 1 Credit.**

This course will cover the structure, replication, and pathogenesis of human RNA and DNA viruses, the host immune response to viral infection and the strategies employed by viruses to escape immune detection and elimination. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 537. Host-Pathogen Interactions Involving Eukaryotic Microbes (Parasites/Fungi). 1 Credit.**

Eukaryotic microbe infections have a devastating impact on global health and economic development as they infect over one third of the world's population and cause acute and chronic pathologies. Furthermore, macroscopic parasites (helminths/ worms) are master regulators of host inflammatory response and hence reduce the immune response to coinfections and negatively affect the success of vaccination programs against many other pathogens. In contrast, it has been proposed that the rise in autoimmune diseases in the developed world could be a direct result of the successful complete elimination of parasitic helminths in these communities. Thus, the purpose of this course is to provide a basic knowledge of the clinically important eukaryotic microbe pathogens and the immune response associated with their infections. A series of lectures will cover course components; a) basic introduction to protozoa, helminth, and fungi, and b) basic knowledge of the immune response and its involvement in parasitic/ fungal infections. An effort has been made to increase clinical relevance and problem-solving skills through a team-learning exercise involving quiz and paper presentations. S.

**BIMD 538. Immunological Disorders. 1 Credit.**

This course will include discussion of cellular and molecular immunopathologies leading to autoimmune diseases, and primary and secondary immunodeficiencies; and the role of the immune system in tumorigenesis and transplantation, as well as various methods of modification of the immune response. Prerequisite: BIMD 502 or consent of instructor. S.

**BIMD 539. Readings in Microbiology and Immunology. 1-4 Credits.**

A supervised readings course on topics of mutual interest to the student and a faculty member. Prerequisite: BIMD 502 or consent of instructor. Repeatable to 4 credits. On demand.

**BIMD 590. Research. 1-12 Credits.**

The course allows research in pertinent problems in various aspects of biomedical sciences. Repeatable. F,S,SS.

**BIMD 591. Advanced Topics in Biomedical Sciences. 1-3 Credits.**

A series of lectures, discussions and/or laboratory experiences developed around a specific topic in the biomedical sciences. Repeatable as topics vary. Prerequisite: BIMD 502 or consent of instructor. Repeatable to 6 credits. On demand.

**BIMD 998. Thesis. 1-6 Credits.**

Completion of thesis required for M.S. Repeatable to 6 credits. F,S,SS.

**BIMD 999. Dissertation. 1-12 Credits.**

Completion of dissertation required for Ph.D. Repeatable to 12 credits. F,S,SS.

## BMB Courses

**BMB 514. Current Literature. 1 Credit.**

Students of the department rotate in leading informal reviews, analyses, and the discussions of research papers selected from current journals in the areas of biochemistry and molecular biology. Prerequisite: BIMD 500 or consent of instructor. S/U grading.

**BMB 521. Seminar. 1 Credit.**

Students present topics in biochemistry and molecular biology based on reviews of the current literature. Each presentation is followed by a discussion of the topic by the faculty and students of the department. Prerequisite: BIMD 500 or consent of instructor. S/U grading.

**BMB 533. Advanced Topics. 1 Credit.**

The purpose of this course is to provide an in-depth exploration of selected areas of protein structure and function, metabolism, regulation of cell functions, proteomics, recombinant DNA technology, eukaryotic nucleic acid metabolism, and gene expression with the intent of complementing and extending the knowledge base gained in BIMD 500. Extensive independent learning is expected. Prerequisites: BIMD 500; alternatively, BMB 301 or equivalent and permission of instructor. Repeatable to 9 credits.

**BMB 540. Special Topics. 1-3 Credits.**

Discussion of a topic in biochemistry and/or molecular biology of current interest to faculty and students. Prerequisites: BIMD 500 or consent of instructor. Repeatable to 3 credits.

**BMB 590. Research. 1-12 Credits.**

The assignments deal with pertinent research problems in various aspects of biochemistry and molecular biology. Repeatable.

**BMB 594. Special Problems in Biochemistry and Molecular Biology. 1-6 Credits.**

The student in consultation with a faculty member of the department undertakes a laboratory research project. Prerequisite: Consent of instructor.

**BMB 595. Readings in Biochemistry and Molecular Biology. 1-3 Credits.**

Selected readings and library research in an area of mutual interest to the student and a faculty member of the department. Conferences and/or written reports are required. Prerequisites: BIMD 500 or consent of instructor.

**BMB 996. Continuing Enrollment. 1-12 Credits.**

Repeatable. S/U grading.

**BMB 998. Thesis. 1-9 Credits.**

Repeatable to 9 credits.

**BMB 999. Dissertation. 1-15 Credits.**

Repeatable to 15 credits.

## MBIO Courses

**MBIO 507. Seminar in Microbiology. 1 Credit.**

S/U grading. F.

**MBIO 511. Microbiology and Immunology Literature. 1 Credit.**

A series of reports of current scientific literature in Microbiology and Immunology. S/U grading. S.

**MBIO 513. Research Tools. 2 Credits.**

Orientation to research and laboratory safety. The theory and application of modern laboratory techniques include tissue culture, cell fractionation, enzyme assay, immunization procedures, bacterial growth curves, photomicrography, strain construction, genetic engineering, gel electrophoresis, enzyme immunoassay, and western blot techniques are presented. S/U grading. F.

**MBIO 515. Advanced Topics. 2 Credits.**

A series of topics in microbiology and immunology presented on an episodic basis. The topics may vary, but are expected to include: (A) Immunology, (B) Infectious Diseases, and (C) Molecular Biology. Prerequisite: Previous basic course in the area to be covered.

**MBIO 590. Research in Microbiology. 2-6 Credits.**

Advanced problems in microbiology and related fields. Hours arranged. Repeatable.

**MBIO 591. Special Problems in Microbiology. 1-6 Credits.**

Short-term research projects.

**MBIO 996. Continuing Enrollment. 1-12 Credits.**

Repeatable. S/U grading.

**MBIO 997. Independent Study. 2 Credits.****MBIO 998. Thesis. 1-8 Credits.**

Repeatable to 8 credits.

**MBIO 999. Dissertation. 1-15 Credits.**

Repeatable to 15 credits.

## PPT Courses

**PPT 500. Principles of Physiology and Pharmacology. 6 Credits.**

Graduate level survey course covering basic principles of human physiology and pharmacology. Material covered will include the physiology (how the body works) and the pharmacology (how drugs affect physiological functions) of the major organ systems. Covered also will be basic pharmacological principles including pharmacodynamics, pharmacokinetics and therapeutics. Teaching modalities used are designed to actively engage students in critical thinking and knowledge application. Prerequisite: BIMD 500 or consent of instructor.

**PPT 503. Advanced Pharmacology or Physiology. 3 Credits.**

Prerequisite: PPT 500 or consent of instructor.

**PPT 505. Research Techniques. 1-3 Credits.**

Prerequisite: Consent of instructor.

**PPT 511. Biochemical and Molecular Mechanisms of Pharmacology. 3 Credits.**

Fundamental concepts of pharmacology with emphasis on biochemical and molecular mechanisms. Prerequisites: BIMD 500 and PPT 500, or consent of instructor.

**PPT 512. Special Topics in Pharmacology, Physiology and Therapeutics. 2 Credits.**

An in-depth coverage of a particular topic chosen by the instructor.

Prerequisite: Consent of instructor.

**PPT 521. Seminar in Pharmacology, Physiology and Therapeutics. 1 Credit.**

S/U grading.

**PPT 525. Advanced Renal Physiology. 3 Credits.**

Prerequisite: PPT 500 or consent of instructor.

**PPT 526. Advanced Respiratory Physiology. 3 Credits.**

Prerequisite: PPT 500 or consent of instructor.

**PPT 528. Advanced Endocrinology. 3 Credits.**

Prerequisite: PPT 500 or consent of instructor.

**PPT 529. Adv Cardiovascular Physiology. 3 Credits.**

Prerequisite: PPT 500 or consent of instructor.

**PPT 530. Advanced Neurochemistry. 3 Credits.**

This course is designed to introduce graduate students to the discipline of neurochemistry. This course builds on concepts introduced in PPT 500, with an emphasis on brain biochemical processes occurring in health and disease. Prerequisite: PPT 500 or consent of instructor.

**PPT 590. Readings in PPT. 1-4 Credits.**

Prerequisite: Consent of instructor. Repeatable to 8 credits.

**PPT 591. Research in PPT. 1-15 Credits.**

Repeatable.

**PPT 996. Continuing Enrollment. 1-12 Credits.**

Prerequisite: Consent of instructor. Repeatable. S/U grading.

**PPT 998. Thesis. 1-9 Credits.**

Prerequisite: Consent of instructor. Repeatable to 9 credits.

**PPT 999. Dissertation. 1-12 Credits.**

Prerequisite: Consent of instructor. Repeatable.