STUDENT AND FACULTY HANDBOOK

BIOMEDICAL SCIENCES PROGRAM

THE COLLEGE OF GRADUATE HEALTH SCIENCES

UNIVERSITY OF TENNESSEE HEALTH SCIENCE CENTER

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Introduction

The Ph.D. program in Biomedical Sciences is an integrated, interdisciplinary, research-oriented graduate program that involves faculty from the Departments of Anatomy and Neurobiology; Genetics, Genomics, and Informatics; Microbiology, Immunology, and Biochemistry; Pathology; Pharmacology, Addiction Science, and Toxicology; Physiology; College of Health Professions and their affiliate faculty from St. Jude Children's Research Hospital and the Veterans Affairs Medical Center. Unlike traditional, department-based graduate programs, the Biomedical Sciences program provides the Ph.D. or M.D./Ph.D. degree-seeking student the opportunity for a broad-based, cross-disciplinary training that is essential in today's competitive research environment. The Biomedical Sciences program consists of seven tracks: Cancer and Developmental Biology; Genetics, Genomics, and Informatics; Microbiology, Immunology, and Biochemistry; Molecular and Translational Physiology; Neuroscience; Pharmacology, Addiction Science, and Toxicology; Rehabilitation Sciences.

Faculty

Faculty contributing to the Biomedical Sciences program can be grouped into three categories: (1) regular faculty, (2) affiliate faculty, and (3) outside members from non-participating UTHSC departments or other institutions. Regular faculty members are those with full-time primary appointments in one of the participating departments at UTHSC. Affiliate faculty members are employees of St. Jude Children's Research Hospital or the Veterans Affairs Medical Center who have received a primary academic appointment in one of the participating departments. Faculty mentors, whether regular or affiliated faculty, are expected to cite their UTHSC affiliation on all publications in which Biomedical Sciences program students are co-authors. Outside members who have primary academic appointments from non-participating departments or who are from other institutions may serve on student committees but may not be a research advisor. Outside members are the only faculty not required to retain graduate-faculty status. A complete list of the graduate faculty can be found at:

https://cghs1.uthsc.edu/exist/apps/FacultyCommittees/index.html?tabSelected=institutes

Faculty members select a Biomedical Sciences program appointment in one of the seven tracks and must notify the Biomedical Sciences program director of desired appointments or any changes in appointment status. Faculty members may mentor students in any of the tracks, as the student's track affiliation is determined by the student's research topic and academic plan of study. Consequently, faculty may have students in their laboratories at the same time who are earning degrees in different tracks. Faculty may serve as outside committee members for students pursuing degrees in tracks in which those faculty members do not have a primary appointment. A list of primary faculty appointments in the Biomedical Sciences program tracks can be found on each track's website.

Students

The Biomedical Sciences program enrolls approximately 24 students each year, and each student enters the program under the track that best fits his or her research interests. Three types of Ph.D. degree-seeking students matriculate into the Biomedical Sciences program: (1) "Indirect-entry" students who select a Research Advisor only after completing a series of laboratory rotations, (2) "direct-entry" students who select a Research Advisor at the time of acceptance and directly enter a laboratory, and (3) students seeking a dual M.D./Ph.D. degree. Second- and third-year medical students are eligible to enter the dual-degree program under certain conditions, and they are expected to identify a Research Advisor prior to CGHS matriculation or after completion of a limited number of abbreviated laboratory rotations.

Admission Committees

Each department chair appoints a Track Director or Co-Directors who head the track's admission committee. The committee is responsible for the recruitment and selection of students to be admitted to the track. Recruitment of students who have expressed an interest in more than one track is coordinated with the assistance of the Program Director. Track Directors and Co-Directors serve on the Biomedical Sciences program Admission Committee, which is chaired by the Program Director. Track

admission committees recommend their selections to the Program Director. However, offers of admission may only be made by the Program Director with approval by the Dean of the College of Graduate Health Sciences. Notification to accepted students should only occur after the Dean has approved the request for admission.

Stipends, Insurance, Scholarships, Fellowships, and Training Grants

All students enrolled in the Biomedical Sciences program receive a waiver of tuition for six years of study. The Biomedical Sciences program provides 15 months of stipend and UTHSC student-health insurance support for indirect-entry students who complete laboratory rotations before selecting a Research Advisor. Subsequent stipend and insurance support are provided by the Research Advisors. Should a Research Advisor lose funding, the Biomedical Sciences program may provide bridge funding in which the student stipend and UTHSC student health insurance will be covered by the program for a short period of time. To help avoid the need for bridge funding, Research Advisors must have at least 20 months of future funding available to accept a new student; exceptions may be made by the CGHS Dean at the request of the Track Chair. If a funding lapse occurs, a bridge funding request will be made by the Research Advisor's Chair and negotiated with the college dean of the College of Medicine (COM) research advisor and the Dean of the College of Graduate Health Sciences. Upon receipt of bridge funding, Research Advisors must agree in writing to restart funding for students once any grant containing non-PI salary money is obtained. Should all funding options fail, students will be required to find a new, funded Research Advisor (which can be done through a limited number of lab rotations, such as one six-week lab rotation or two three-week lab rotations). Failure to find a "new" permanent lab will result in termination from the program.

Students who directly enter a laboratory must receive stipend and insurance support from the Research Advisor upon matriculation. M.D./Ph.D. students and students who directly enter a laboratory are not eligible for bridge-funding protection; consent on rare occasions may be obtained from the CGHS Dean. If financial assistance is not approved, such students must identify a new, financially supporting Research Advisor or leave the program.

The CGHS provides up to $3,000 of additional annual funding to select students who qualify for Alumni Endowment Scholarships. These scholarships are intended to enhance the recruitment of outstanding applicants who are nominated at the time of application. Students must remain in good academic standing to continue receiving the scholarship.

Many fellowships are also available to supplement the stipends of Biomedical Sciences program students. A complete list is at www.uthsc.edu/grad/StudentInfo/Funding/index.php?page=Scholarships. For example, the Alma and Hal Reagan Fellowship is awarded through competition to outstanding graduate students conducting cancer research.

Training grants awarded to participating faculty may also be used to provide stipend and insurance support to eligible students. Principal investigators applying for training grants are encouraged to request tuition and fee support for students as well.

Academic Standards

The admission, retention, and graduation standards are the same as those of the CGHS. Students in the Biomedical Sciences program must maintain a minimum cumulative grade-point average of 3.0 as the standard for successful progress. All students are subject to the CGHS Honor Code: www.uthsc.edu/grad/StudentInfo/Judicial/index.php?page=HonorCode.

Core and Elective Curricula

All Biomedical Sciences program students must complete a minimum of 9 credit hours of core courses, as specified by their track requirements. Each track provides a list of required and/or elective curriculum that must be taken to meet the degree requirements for that track. All Biomedical Sciences program students must complete a biostatistics course and the Integrity in the Conduct of Scientific Research course (IP 801), required of all Ph.D. students in the College. M.D./Ph.D. students are also required to take a biostatistics course and the Integrity in the Conduct of Scientific Research course (IP 801). However, we accept their medical-school curriculum in place of the track-specific

coursework, unless the students' dissertation committee requires the student to take one or more of these courses.

Each track provides a list of acceptable elective courses to assist students in their selections. A complete listing of courses can be found in the course catalog at http://www.uthsc.edu/registrar/students.php#catalogs.

Additional Curriculum Requirements

All Biomedical Sciences program students must participate in a journal club or course that follows a journal club format (such as PATH 834 Pathology Seminar or ANAT 821 Neuroscience Seminar) during the second year of study. Certain tracks may require participation for additional years.

Research Colloquia and Laboratory Rotations

Before the start of each fall semester, faculty members are contacted by their Track Director to identify those wishing to accept a student into their laboratories in the upcoming academic year. To be eligible, a faculty member must be a member of the graduate faculty and have financial approval from his/her departmental Chair. **Students should only rotate in labs that are currently able to fund the student for a minimum 20 months.**

During the first weeks of the fall semester, tracks will either hold a Research Colloquium in which eligible faculty members provide a brief (15-minute) overview of their laboratories' research programs or schedule meetings with individual faculty. Interested students may arrange for a meeting with faculty members or a tour of the laboratories. Students will use these interactions as the basis for selecting laboratory rotations. There are six 6-week laboratory rotation periods in the first year. All tracks will adhere to the 6-week schedule. One of the 6 rotations can be skipped only with permission from the Program Director.

The rotation process enables students to be exposed to the diversity of research laboratories within the Biomedical Sciences program. Confirmation of a rotation laboratory is through mutual agreement between the student and faculty member. Two restrictions are placed on laboratory rotations: (1) faculty members may accept no more

than two students during a single rotation period, and (2) faculty members may not ask students to spend more than 20 hours per week performing rotation research. The latter limitation is intended to protect the student's time needed to perform well in classes. Students will receive at least one credit hour in IP 900 Doctoral Dissertation and Research for each semester that they participate in laboratory rotations. At the completion of each rotation, the supervising faculty member shall submit to the Program Director and Track Director, a short, written evaluation of the student's performance. Specifically addressed are the student's attendance, enthusiasm, performance, and estimation of the student's potential to become an independent research scientist.

Selection of Research Advisor and Faculty Committee

Each track specifies the minimum number of rotations that must be completed before a student may select a permanent Research Advisor. Factors involved in the final selection of a Research Advisor include (1) mutual acceptance by the student and advisor, (2) certification by the Graduate Studies Council of the faculty member to direct Ph.D. work, (3) the ability of the faculty member to provide financial support for the research project, including the student's stipend after the Biomedical Sciences program fulfills its commitment, and (4) approval by the faculty member's Chair and the Biomedical Sciences program Director. If the mentor is in a different track than the student is, the student may switch to the mentor's track following consultation between the mentor, track, and program director. The track placement is determined at the time the mentor is chosen. Students must choose a mentor by the end of the last rotation. Failure to do so will result in withdrawal from the program.

At the beginning of the second year of study, the student and Research Advisor select a Faculty Committee composed of at least five members of the graduate faculty, including the Research Advisor who serves as Committee Chair. The Faculty Committee Appointment form is available on the CGHS website at https://cghs1.uthsc.edu/exist/apps/FacultyCommittees/index.html. One or more committee members must have a regular full-time appointment with UTHSC and be credentialed in the CGHS. At least four of the committee members must be credentialed in the Biomedical Sciences program by CGHS and may come from the same or different

track than the student. One outside member may be from a non-participating institution. The purpose of the Faculty Committee is to assist the student and ultimately to approve the dissertation. It is recommended that M.D./Ph.D. students form their Faculty Committee by the Spring Semester of their first year.

Students keep the Faculty Committee up to date on the progress of their research through annual committee meetings. The CGHS requires that students have at least one documented committee meeting each year and submit an Annual Student Progress Report form, signed by their committee, to the CGHS administrative office. This form is available at: https://cghs1.uthsc.edu/exist/apps/FacultyCommittees/index.html.

Qualifying Examination for Admission to Candidacy

Students must be formally admitted to Ph.D. candidacy through examination by their Faculty Committee. The timing and format of the admission exam are defined by each track but cannot occur until all required curriculum has been taken. A single pass or fail is determined for the entire exam; a simple majority determines the vote. When the student passes, he/she should have each committee member sign the Application for Admission to Candidacy form, which can be obtained from https://www.uthsc.edu/graduate-health-sciences/students/forms.php. The student will deliver the form, along with a written summation by the exam chair and a copy of the student's unofficial transcript, to the Program Director's office. Assuming the student is in good standing and has met all core and elective requirements, the Program Director will in turn relay the Candidacy form with attachments along to the Dean's office.

If the student marginally passes, he/she may be asked to re-write portions of the proposal if parts are deemed weak, or the student may be told that at the next meeting he/she will be tested on a weak knowledge area. If the student marginally fails, he/she may be required to complete only a portion of the exam rather than completely retake the exam. If the student completely fails and is in good academic standing, then he/she may be allowed to complete a full second exam at a later date. Any student who fails the admission-to-candidacy exam twice may be offered to work toward an M.S. degree or be required to withdraw from the program.

Master's Degree Exit-Option Requirements

While all students accepted into the Biomedical Sciences program are expected to pursue the Ph.D. degree, some will opt for a terminal M.S. degree instead. A student choosing this option will not be eligible to switch to an M.S. until there are at least three (3) terms completed; they must then enroll full-time as an M.S. student in their last term (4th term, or greater), and will receive a tuition waiver and stipend in that last term. The student must notify the Program Director and CGHS office of intent to seek the terminal M.S. option prior to the last term because the transition can only occur at the start of a term (the start of a term is January 1 or July 1). Notification must be in the semester that precedes the semester to which the student's change from Ph.D. to M.S.-seeking status could be applied. There are several key differences between the requirements for the M.S. degree and the Ph.D. degree. For the M.S. degree, students must be enrolled a minimum of four semesters. They will complete the same first-year core curriculum as Ph.D. candidates, including biostatistics, but are required to acquire only three elective credit hours. In the second year, M.S. candidates must participate in a journal club; however, they are not required to complete the IP 801 Integrity in the Conduct of Scientific Research course. Candidates for the M.S. degree will select a Research Advisor at the end of the first year and form a Faculty Committee composed of the advisor, one track-faculty member, and one outside track-faculty member. Soon after the decision to opt for an M.S. degree has been made, the candidate should meet with the committee to outline the research objectives. Admission to candidacy for the master's degree must be granted no later than the end of the second month in the semester in which the thesis is to be submitted. The form to apply for admission to candidacy is available at https://cghs1.uthsc.edu/exist/apps/FacultyCommittees/index.html. The research component of the M.S. degree requires publication-quality data that may not stand alone, but that will contribute significantly to an eventual publication. The work should at least begin to test a hypothesis and serve as the focus of appropriate introduction and general discussion chapters of a thesis. To finish degree requirements, candidates will write a thesis and defend it in the form of an oral presentation before an open audience and the Faculty Committee, followed by a question-and-answer session with the Committee alone. The format and applicable deadlines for the thesis and its defense are those

defined in the CGHS Policies. After the oral defense, the student must submit a Report of Final Examination form to the CGHS administrative office as part of clearance for graduation. This form is available at https://cghs1.uthsc.edu/exist/apps/FacultyCommittees/index.html.

Student Transfer or Termination from a Laboratory

Just as the initial selection of a research advisor and laboratory is predicated on mutual consent, continuance in a laboratory is dependent upon a sustained agreement between the student and the research advisor. While not encouraged, in certain situations a student may leave a laboratory and perform a limited number of abbreviated rotations, such as one six-week rotation or two three-week rotations, to identify a new research advisor. Transfers should be initiated only after extensive discussions among the student, research advisor, track director, and Biomedical Sciences Program Director. A research advisor may also ask a student to leave his/her laboratory even though the student is in good academic standing. However, demonstrated research deficiencies of the student must be recorded through faculty committee meetings before termination may be initiated. Dismissal from one laboratory does not necessarily preclude the student from entering another laboratory to complete his/her degree requirements. Requests for student transfers and dismissals must be in writing and must be approved by the dean.

Please Note: Neither the Biomedical Sciences program nor participating departments will be financially obligated if an M.D./Ph.D. student or a student who directly enters a laboratory opts or is asked to leave a Research Advisor's laboratory. The inability of such a student to find a new, financially supporting research advisor will result in dismissal from the program.

Academic Due Process

If a student is denied continuation in the Biomedical Sciences program, by failing to maintain good academic standing for an extended period of time, by failing admission to candidacy, or through termination from a research laboratory, the student has a right to a hearing. The Biomedical Sciences program adheres to the appeal process of the CGHS,

the specifics of which can be found in The CenterScope: http://catalog.uthsc.edu/index.php?catoid=25

Graduate Research Day

All students are required to participate in Graduate Research Day, unless otherwise excused by the program directors. Third-year students and older must submit an abstract for a poster and/or oral presentation.

Dissertation Defense

Students write their dissertation after completion of experiments and with the approval of the Faculty Committee. The dissertation is submitted to the Faculty Committee prior to an oral, public defense of the student's work, which is followed immediately by a separate oral defense to the Faculty Committee alone. The format and applicable deadlines for the dissertation and its defense are those defined in the CGHS Policies. Information regarding the dissertation process can be found at https://uthsc.edu/graduate-health-sciences/students/thesis-dissertation.php. All committee members should be provided a copy of the final dissertation at least two weeks prior to the scheduled defense date. After the oral defense, the student must submit a Report of Final Examination form to the CGHS administrative office as part of the clearance process for graduation. This form is available at https://cghs1.uthsc.edu/exist/apps/FacultyCommittees/index.html.

College Policies

A complete list of all CGHS policies can be found at: https://www.uthsc.edu/graduate-health-sciences/about/policies.php

Appendix 1: Cancer and Developmental Biology (CDB)

Developmental and cancer biology are two complementary disciplines that can be viewed as the yin and yang of cell survival. Whereas developmental biology is concerned with the acquisition and maintenance of normal cellular function, cancer biology focuses on the disruption and deletion of normal cellular function. Research within the Cancer and Developmental Biology track reflects the complete continuum of cell development, from the regulation of normal cell division to the abnormal development of cancer. The track has a diverse group of research faculty with appointments in 11 different departments both at the University of Tennessee Health Science Center and St. Jude Children's Research Hospital. Interactions and collaborations among the faculty bring together research expertise that focuses on the cell cycle, cell proliferation, cell differentiation, apoptosis, cell migration, angiogenesis, tumorigenesis, metastasis, and stem cell biology. Faculty research interests in this truly interdisciplinary program encompass a wide range of fields, including molecular genetics, cell biology, biochemistry, structural biology, model organism biology, and novel therapeutics.

The Cancer and Developmental Biology track is appropriate for students seeking training in cutting-edge research in the following areas:

- Animal models for tumorigenesis and development
- Tumor suppressor and oncogenic signaling pathways
- Cell proliferation and cell death
- Differentiation
- Development
- Pathology
- Normal stem cells/tumor-initiating cells
- Novel therapeutic approaches

Students in the Cancer and Developmental Biology Track must complete the required curriculum described below. In addition, students may take elective courses but are encouraged to complete the electives during the fall semester of the second year.

Students also participate in a seminar course in the fall semester of the first and second years. Students are encouraged to present their research each year at the UTHSC Center for Cancer Research "Research in Progress" meeting or a similar meeting at St Jude Children's Research Hospital.

Required Core and Elective Curriculum Core

- Essentials of Cell Biology (3 credit hours) — IP 841, fall
- Essentials of Molecular Biology (3 credit hours) — IP 805, spring
- Pathology Seminar (1 credit hour) — PATH 834, fall, years 1 and 2
- Biochemistry (3 credit hours) — IP 806, fall
- Ethics (1 credit hour) — IP 801, spring
- Cellular Signaling (3 credit hours) – PATH 861, spring
- Molecular Biology of Cancer (4 credit hours) – IP 940, fall

Electives

- Introduction to Web-Based Bioinformatics and Computational Biology Tools (2 credit hours) —PATH 924, fall

Students may take one additional elective course up to 3 hours at any time in any track before the end of Spring, Year 2. As preparation of the qualifying exam written materials will be time- intensive, it is recommended that any optional elective be completed by Fall of Year 2.

Laboratory Rotations

Students will have the opportunity to complete up to six 6-week laboratory rotations beginning in the fall semester of the first year. The rotation laboratories may be selected at either UTHSC or St. Jude; one UTHSC-based laboratory rotation is required. After two rotations with CDB track faculty members, students may choose a mentor or continue with additional rotations. If a student decides to choose a mentor outside of the CDB-track faculty, at least two rotations with CDB track faculty members must be completed before a mentor can be declared.

Admission-to-Candidacy Exam

By the end of the second year, students must successfully defend their proposed research topic to the Faculty Committee. To do so, the student develops the overall design of the project and several potential specific aims through discussions with the Research Advisor on a topic related to the dissertation research. The deadline for submitting the one-page specific-aims page of the qualifying-exam written proposal to the Faculty Committee and Track Director is **February 1st.** Approval for the one-page aims is obtained in person at the inaugural committee meeting.

The first committee meeting to review the project background, and to approve the general approach to complete the agreed-upon specific aims, should be completed by mid-March. Following initial topic approval with committee input at the inaugural committee meeting, the student will then prepare the full written qualifying exam proposal.

The written proposal of the research plan adheres to the format of an NRSA (F31, predoctoral) proposal of 7 pages: 1 page of specific aims (approved by the committee), plus 6 pages of the proposal that includes significance, innovation, and approach. In addition, the proposal must include a complete list of all literature cited. Students typically require a minimum of 2 weeks of dedicated time to prepare the written proposal, and it is the responsibility of the Research Advisor to provide the student with sufficient time to do so. The written proposal is intended to demonstrate the student's understanding of the research plan and should be written in his/her own words. Preliminary data may be included, but it is not necessary that the student include preliminary data that he/she has generated on the project. Data from prior lab members may be included as long as the data are cited as the work of others. **The written proposal should not be directly edited or written by the Research Advisor** nor by members of the Faculty Committee prior to its distribution. However, this does not preclude the student from consulting with the Research Advisor, Faculty Committee, or any other colleague on specific issues that may arise during the writing of the proposal. Input should be in the form of indications where changes are needed and suggestions for improvements with the student being required to act on those criticisms to finally produce the proposal. Written proposals are due to the Faculty Committee and the Track Director by April 1st of the second year. It is

recommended that students schedule the qualifying exam several months in advance so that all committee members can attend. Admission-to-candidacy exams should be held between April 1st and May 31st of the second year. The deadline for reporting the outcome of all admission-to-candidacy exams is June 1st of the second year.

The admission-to-candidacy exam format is as follows. When the meeting convenes, the student will be asked to leave the room briefly. At that time, the Research Advisor should remind the committee members of the courses that the student has completed so that they have a reference point for testing the student's fund of knowledge. A chair of the meeting will be selected; this cannot be the Research Advisor. The chair will be responsible for running the meeting and for writing up a synopsis of the meeting once it is completed. The student will be asked back into the room and should proceed with about a 30-minute presentation (approximately 20 slides) of his/her proposal. Interruptions should be limited to points of clarification.

After the presentation, the chair will ask a committee member to initiate the questioning. The Q&A session should last no more than two hours. Questions should begin with the proposal but may branch out to test the student's knowledge in pertinent areas. After the Q&A session, the student will be asked to leave the room, and the committee will discuss his/her performance on both the written and oral portions of the exam. A single pass or fail is determined for the entire exam. However, if the student marginally passes, he/she may be asked to re-write portions of the proposal if parts are deemed weak, to be re-tested in the Q&A portion in a shortened, re-examination meeting (to be held within 2-3 weeks of the initial examination), or the student may be told that at the next meeting he/she will be tested on a weak knowledge area. As one example, he/she may not be required to completely re-write the proposal but may be asked to repeat the Q&A session in a shorter duration in the reexamination period. If the student completely fails, then a full second exam will be required to be completed prior to June 30th. A simple majority is needed for a passing vote. After a decision has been reached, the student will rejoin the room, and the chair will summarize the discussion leading up to the decision. Other committee members may give additional advice as they see fit. If the student passes, he/she should have each committee member sign the admission-to-candidacy exam form. The student will email the form, along with the written summation

of the exam by the chair and a copy of the student's unofficial transcript, signed by the track director indicating that the student has completed all required curriculum, to the Program Coordinator. The Program Coordinator will route for the Program directors' and Deans' signatures. The deadline for meeting all the requirements for admission to candidacy will be June 30th of the second year. An extension of this timeline can be requested in writing to the track director, which will be up to their discretion.

Sample Curriculum—Cancer and Developmental Biology Track

YEAR 1

Fall Semester

- Essentials of Cell Biology (3 credit hours) — IP 841
- Biochemistry (3 credit hours) — IP 806
- Pathology Seminar (1 credit hour) — PATH 834
- 2 Laboratory Rotations (1 credit hour) — IP 900

Spring Semester

- Cellular Signaling (3 credit hours) — PATH 861
- Essentials of Molecular Biology (3 credit hours) — IP 805
- Up to 4 Laboratory Rotations (2 credit hours) — IP 900
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801
- June 30th deadline to choose a Research Advisor
- Participation in Cancer Center seminars at the discretion of the current rotation advisor

YEAR 2

Fall Semester

- Molecular Biology of Cancer (4 credit hours) — IP 940
- Pathology Seminar (1 credit hour) — PATH 834
- Dissertation Research (variable credit hours) — IP 900
- Statistics (2 credit hours) — BIOE 845 or other acceptable Biostatistics course
- Elective course at the discretion of the Research Advisor

- September-December: form Faculty Committee and schedule the inaugural committee meeting
- Participation in UTHSC Center for Cancer Research seminars and Research in Progress at the discretion of the Research Advisor.

Spring Semester

- Biostatistics (if not taken in fall semester)
- Dissertation Research (9 credit hours) — IP 900
- February: Specific Aims Exam topic approval
- June 1st: All admission-to-candidacy oral exams must be complete
- June 30th: Deadline for all revisions, any additional requirements, or a retake of the oral defense
- Participation in UTHSC Center for Cancer Research seminars and Research in Progress at the discretion of the Research Advisor.

YEAR 3

Dissertation Research (9 credit hours) — IP 900
Participation in UTHSC Center for Cancer Research seminars and Research in Progress at the discretion of the Research Advisor.

YEAR 4 AND BEYOND

- Dissertation Research (9 credit hours) — IP 900
- Participation in UTHSC Center for Cancer Research seminars and Research in Progress at the discretion of the Research Advisor.
- Students will defend their dissertation with their faculty committee and additional faculty to complete the requirements for the Ph.D. degree.

Appendix 2: Genetics, Genomics, and Informatics (GGI)

The field of genetics, genomics, and informatics is growing rapidly. Methods in gene expression, epigenetics, gene mapping, and linking genetics to biochemical processes and pathways, out of reach a mere 20 years ago, are now routinely applied to unlock the secrets of the genome. The GGI Ph.D. track is designed to prepare new scientists broadly so that they may develop their careers in a variety of venues. Faculty research interests in this truly interdisciplinary program encompass a wide range of fields, including molecular genetics, cell biology, biochemistry, structural biology, model organism biology, machine learning, population genetics, and novel therapeutics.

Students in the GGI track must complete their core curriculum described below. A minimum of 52 credits is required, consisting of 24 credits of IP 900, 12 credits of core courses, 6 credit hours (or two courses) of additional elective courses that suit the individual student's needs, and 8 credits of symposia and seminars. Any course required by the other Biomedical Sciences Ph.D. tracks is acceptable as an elective. Other graduate-level courses can be used to satisfy the elective requirement upon approval from the track director(s). Students must register for the GGI Seminar for credit which includes a discussion of a publication by the seminar speaker followed by a meeting with the seminar speaker. All GGI students must take the Informatics Summit in the Spring term of each year if offered. Students may opt not to take this course if they are defending their dissertation that term. Students must maintain at least 9 credit hours but no more than 12 credit hours each term. The following courses comprise the required and elective curriculum for students in the GGI track:

Required Curriculum

- Integrative Genetics (3 credit hours) — GGI 901
- Medical Genetics (3 credit hours) — GGI 903
- Biostatistics for Integrated Biomedical Sciences (2 credit hours) — BIOE 845 or other acceptable Biostatistics course
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801
- Bioinformatics I (2 credit hours) — MSCI 814
- Bioinformatics II (1 credit hour) — MSCI 815

- GGI Seminar (1 credit hour) — GGI 820
- Bioinformatics Summit (1 credit hour) — GGI 905, spring term
- IP 900 (24 credit hours)

Electives

- IP 805 (3 credit hours) Essentials of Molecular Biology OR IP 841 (3 credit hours) Essentials of Cell Biology (one of these must be chosen and constitutes 1 of the 4 elective courses required).
- Genetic Epidemiology (3 credit hours) — BIOE 824
- Pharmacogenomics (2 credit hours) — GGI 902
- Special Topics in Genetics, Genomics, and Informatics (3 credit hours) — GGI 840

Laboratory Rotations

Students are required to do at least three, and up to six, 6-week lab rotations with Biomedical Sciences program faculty. These rotations can occur during any of the six Biomedical Sciences Program prescribed rotational periods during the first year. After three rotations, a student may begin work in his or her chosen mentor's lab or may elect to do more rotations. A mentor's lab must be identified by the end of the first year.

Admission-to-Candidacy Exam

At the end of their second year, students must pass a qualifying exam before admission to Ph.D. candidacy. For the exam, students write a grant application in the form of an NIH F31, National Research Service Award (NRSA) on the topic of their research. As part of the examination, the student must give an oral presentation and defend the application to his or her graduate committee. Students are expected to demonstrate mastery of the required GGI coursework. Passing this exam is required for continuation in the program. If the first submission and defense are found to be unsatisfactory, the student is given one and only one chance for re-examination. Students who do not complete this examination satisfactorily will not be allowed to continue in the program.

Sample Curriculum—GGI Track

YEAR 1

Fall Semester

- Integrative Genetics (3 credit hours) — GGI 901
- GGI Seminar (1 credit hour) — GGI 820
- Essentials of Cell Biology (3 credit hours) — IP 841
- Two 6-week lab rotations (1 credit hour) — IP 900

Spring Semester

- Biostatistics for Integrated Biomedical Sciences (2 credit hours) — BIOE 845 or other acceptable Biostatistics course
- GGI Seminar (1 credit hour) — GGI 820
- Bioinformatics Summit (1 credit hour) — GGI 905
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801
- 6-week lab rotation (1-4 credit hours) — IP 900
- Elective
- Select a mentor and begin research in the mentor's lab

YEAR 2

Fall Semester

- GGI Seminar (1 credit hour) — GGI 820
- Medical Genetics (3 credit hours) — GGI 903
- Special Topics (3 credit hours) — GGI 840
- Dissertation Research (up to 9 credit hours) — IP 900
- Elective
- Assemble faculty committee

Spring Semester

- GGI Seminar (1 credit hour) — GGI 820
- Bioinformatics I (2 credit hours) — MSCI 814
- Genetic Epidemiology (3 credit hours) — BIOE 824
- Dissertation Research (up to 9 credit hours) — IP 900

- Special Topics (3 credit hours) — GGI 840
- Bioinformatics Summit (1 credit hour) — GGI 905
- Elective
- Candidacy exam (research proposal submitted to committee followed by oral defense of proposal)

YEAR 3

- Dissertation Research — IP 900
- GGI Seminar, each semester — GGI 820
- Bioinformatics Summit (1 credit hour)— GGI 905

YEAR 4 AND BEYOND

- Dissertation Research — IP 900
- GGI Seminar, each semester — GGI 820
- Bioinformatics Summit (1 credit hour)— GGI 905
- Students will defend their dissertation in front of GGI faculty with their faculty committee present.

Appendix 3: Microbiology, Immunology, and Biochemistry (MIB)

Students entering the Microbiology, Immunology, and Biochemistry (MIB) Track receive state-of-the-art training designed to prepare them for a research-focused career in academia, industry, or governmental agencies. The goals of the MIB track and its faculty are to ensure that students have the necessary skills to become independent scientists and to successfully compete at the next level of their career development. To achieve these goals, it is essential that students choose a dissertation project that ignites their passion for research. The MIB track is composed of faculty performing cutting-edge research at UTHSC and St. Jude Children's Research Hospital that spans a wide range of research interests, including:

- Molecular and cellular bases for bacterial and viral infectious diseases
- Mechanisms of normal and abnormal immune function
- Chronic inflammatory and immune-mediated diseases in humans
- Animal models of human diseases
- Vaccine design and development
- Cancer gene therapy
- Genomics, transcriptomics, proteomics, and methods to study large biological data sets
- Mechanisms of protein localization and transport
- Cell signaling
- Genetics, biochemistry, and cell biology of transcriptional regulation in prokaryotes and eukaryotes
- Bioinformatics, quantitative trait mapping, and data-mining methodologies

Students in the MIB track are required to complete a minimum of 9 credit hours of a core curriculum consisting of courses that explore emerging concepts in Molecular Biology, Cell Biology, and Biochemistry in addition to the Biostatistics and Ethics courses required by the Biomedical Sciences program. The MIB track offers a diverse range of electives allowing students to tailor the program to meet their specific research interests. Students are required to complete a minimum of 6 credit hours of electives, and these are typically chosen in consultation with the student's faculty mentor.

In addition to the core and elective courses, students in the MIB track also participate in a literature-based journal club (MSCI 811) where second-year students and above present a recent research paper to fellow students and faculty.

The following courses comprise the required and elective curriculum for students in the MIB track:

Required Curriculum

- Essentials of Cell Biology (3 credit hours) — IP 841, fall
- Biochemistry (3 credit hours) — IP 806, fall
- Essentials of Molecular Biology (3 credit hours) — IP 805, spring
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801, spring
- Biostatistics for Biomedical Sciences program (2 credit hours) — BIOE 845 or other acceptable Biostatistics course
- Journal Club (1 credit hour) — MSCI 811 (see course director for options to meet this requirement)
- Student Seminar (1 credit hour) — MSCI 910 (for third-year students and above, may be retaken for credit up to three times)

Electives

- Bioinformatics I (2 credit hours) — MSCI 814, spring
- Bioinformatics II (1 credit hour) — MSCI 815, spring
- Cellular Signaling (3 credit hours) — PATH 861, spring
- Techniques II: Methods for Nucleic Acids (2 credit hours) — MSCI 935, fall
- Immunity and Inflammation (3 credit hours) — MSCI 931, fall
- Molecular and Cellular Basis of Microbial Pathogenesis (3 credit hours) — MSCI 930, spring
- Molecular Biology of Cancer (3 credit hours) — IP 940, fall

Laboratory Rotations

Students in the MIB track will participate in a minimum of 2, or up to a maximum of 6, lab rotations, each lasting 6 weeks. During the rotations, students will work in the laboratories of an individual faculty who has sufficient funds to take a student that

particular year. Students typically choose their faculty mentors in the spring of their first year, upon mutual agreement with the faculty member according to Biomedical Sciences program policies. This allows students to begin developing their dissertation project and working in the lab full-time before the end of their first year.

Admission-to-Candidacy Exam

During the fall of their second year, students will form their Faculty Committee, and at the end of the spring semester of their second year, students will take the Admission-to-Candidacy exam (Qualifying Exam). This exam, which determines whether a student is sufficiently prepared to pursue a Ph.D. in the Biomedical Sciences program, consists of two parts. First, students will write an NIH F31-style proposal on their dissertation project and submit the proposal to their Faculty Committee. If acceptable, the student then meets with the committee in a closed-door session where the committee members assess the student's competency in fundamental aspects of molecular biology, cell biology, and biochemistry. Once the student has demonstrated proficiency in the core topic areas, the committee will expand the questioning to topics covered in the proposal. The committee then votes either pass or fail; a simple majority determines the vote. If a student does not pass the first time, he or she may have an opportunity to retake the exam before the beginning of the fall semester of his or her third year. Successful completion of the exam results in admission of the student to candidacy to pursue a Ph.D.

Sample Curriculum—Microbiology, Immunology, and Biochemistry Track

YEAR 1

Fall Semester

- Biochemistry (3 credit hours) — IP 806
- Essentials of Cell Biology (3 credit hours) — IP 841
- MIB Journal Club (participation; no credit hours)
- Lab Rotations #1 and #2 (2 credit hours) — IP 900

Spring Semester

- Essentials of Molecular Biology (3 credit hours) — IP 805
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801
- Elective #1

- MIB Journal Club (participation; no credit hours)
- Lab Rotations (variable credit hours) — IP 900
- Select faculty mentor (must select by end of the semester if not before)

YEAR 2

Fall Semester

- Elective #2
- Dissertation research (9 credit hours) — IP 900
- MIB Journal Club (MSCI 811, 1 credit hour; see course director for options to meet this requirement)
- Assemble dissertation committee (Faculty Committee)

Spring Semester

- Elective #3
- Biostatistics for Biomedical Sciences program (2 credit hours) — BIOE 845 or other acceptable Biostatistics course
- Dissertation research (9 credit hours) — IP 900
- Take admission-to-candidacy exam (must complete by end of Spring Semester)
- MIB Journal Club (MSCI 811, 1 credit hour; see course director for options to meet this requirement)

YEAR 3

- Dissertation research (9 credit hours) — IP 900
- MIB Journal Club (MSCI 811, 1 credit hour; see course director for options to meet this requirement)
- MIB Student Seminar (MSCI 910) is required starting 3rd year

YEAR 4 AND BEYOND

- Dissertation research (9 credit hours) — IP 900
- MIB Journal Club (MSCI 811, 1 credit hour; see course director for options to meet this requirement)
- MIB Student Seminar (MSCI 910) is required starting 3rd year

- Students will defend their dissertation in front of their faculty committee.

Appendix 4: Molecular and Translational Physiology (MTP)

Molecular and Translational Physiology explores functional relationships within cells, between cells and their environments to form tissues, between tissues to form organs, communications among organs to form body systems and the mechanisms involved in coordination and regulation of the multiple systems to sustain a viable organism. It is essential to understand the details of these processes at the cellular and molecular levels to seek insight into the dysregulation of this fine-tuned biological system under pathophysiologic conditions and to enable us to develop therapeutics for the treatment of human diseases.

Faculty members under this program are involved in cutting-edge research on diverse topics, including cardiovascular, gastrointestinal, respiratory, neurodegenerative and hematopoietic diseases. Investigations are conducted at the molecular, cellular, and systemic levels on specific topics such as signal transduction, cell adhesion, cell division and death, cell migration and tumor metastasis, cytoskeleton, cerebral circulation, inflammatory responses, gene therapy, ion channels, wound healing, and animal models of diseases.

Students in the Molecular and Translational Physiology Track are required to complete the core course curriculum consisting of Biochemistry (IP 806); Essentials of Cell Biology (IP 841); Physiology and Biophysics (Medical Physiology — PHYS 612), and Essentials of Molecular Biology (IP 805) during the first year. In addition, students are required to take the Advanced Physiology course (PHYS 912) during the second or third year. Students may take optional elective courses, which are generally chosen in consultation with the student's research advisor based on the student's research interest.

Students will also take a seminar course (PHYS 919) by attending the physiology seminar series, participating in lunch discussions with guest speakers and presenting twice in this platform during the course of their dissertation (usually one during the third year and their dissertation defense). Student attendance in seminars and in lunch discussions with external seminar speakers is mandatory. Any student who is absent from two or more seminars, or lunch discussions, must request his/her mentor to submit a written justification for their absence to the department seminar coordinator. Additionally, students are expected to participate in journal clubs and present their research work in

national meetings.

Core Curriculum

- Physiology and Biophysics (Medical Physiology) (5 credit hours) — PHYS 612, spring
- Essentials of Cell Biology (3 credit hours) — IP 841, fall
- Essentials of Molecular Biology (3 credit hours) — IP 805, spring
- Biochemistry (3 credit hours) — IP 806, fall
- Biostatistics (2 credit hours) — BIOE 845, spring, or other acceptable Biostatistics course
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801, spring
- Advanced Physiology (2 credit hours) — PHYS 912, fall
- Physiology Seminar (1 credit hour) — PHYS 919, can be repeated until degree requirements are met

Electives

At least 5 credit hours; choose from the list below or per advice by student's mentor.

- Cellular Signaling (3 credit hours) — PATH 861, spring
- Cell Biology Techniques (2 credit hours) — MSCI 934, spring
- Bioinformatics I (2 credit hours) — MSCI 814, spring
- Bioinformatics II (1 credit hour) — MSCI 815, spring
- Essentials of Animal Experimentation (2 credit hours) — CMED 711, fall
- Physical Biochemistry and Applications in Structural Biology (3 credit hours) — MSCI 812, spring
- Principles of Mass Spectrometry (2 credit hours) — MSCI 928, fall

Laboratory Rotations

Students will participate in a minimum of three 6-week-long laboratory rotations starting in September of the first year. During the rotations, students will work in the labs of individual faculty who will be taking students that particular year and spend a maximum of 20 hours per week. Under the Molecular and Translational Physiology (MTP) track, rotation mentors will be asked to write a brief report, which will be used by the MTP

graduate committee to assess students' enthusiasm and dedication to the graduate program. MTP students will be required to choose their first three rotations in the laboratories of MTP faculty. A maximum of six lab rotations (two during the first semester and four during the second semester) is allowed.

Admission-to-Candidacy Exam

Toward the end of the second year, students will complete admission-to-candidacy, which involves writing a grant proposal in NIH F31 format and successfully defending the proposal to their Faculty Committee. The committee will examine the student's preparedness to pursue a Ph.D. in the Biomedical Sciences program. This will require student knowledge of the chosen research topic as well as in the core curriculum and related topics. The committee then votes pass or fail. This should be completed by May 15 of the second year. If a student is unsuccessful in the first attempt, he/she may retake the exam during the fall of the third year.

Sample Curriculum—Molecular and Translational Physiology Track

YEAR 1

Fall Semester

- Essentials of Cell Biology (3 credit hours) — IP 841
- Biochemistry (3 credit hours) — IP 806
- Physiology Seminar (1 credit hour) — PHYS 919
- Lab Rotations (1 credit hour) — IP 900

Spring Semester

- Physiology and Biophysics (Medical Physiology, 5 credit hours) — PHYS 612
- Cellular Signaling (3 credit hours) — PATH 861 (optional course)
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801
- Physiology Seminar (1 credit hour) — PHYS 919
- Lab Rotations (1 credit hour) — IP 900
- Assemble faculty committee

(Note: Students should not sign up for any course which conflicts in class timings with Medical Physiology PHYS 612. Such courses should be taken the next semester that

they are offered.)

YEAR 2

Fall Semester

- Advanced Physiology (2 credit hours) — PHYS 912, offered once in two years. Therefore, this course is available during Fall Semester of 2nd or 3rd year. Students can elect to take one of the 7 units to fulfill the 2 credit hours. The 7 units are: (1) Gastro-intestinal Epithelium, (2) Respiratory Physiology, (3) Vascular Biology, (4) Heart, (5) Ion Channels and Electrophysiology, (6) Developmental Biology—Animal Models, and (7) Lipids in Cell Signaling.
- Doctoral Dissertation and Research (9 credit hours) — IP 900
- Physiology Seminar (1 credit hour) — PHYS 919
- Lab Rotations (if needed)

Spring Semester

- Doctoral Dissertation and Research (6 credit hours) — IP 900
- Essentials of Molecular Biology (3 credit hours) — IP 805
- Physiology Seminar (1 credit hour) — PHYS 919
- Biostatistics (2 credit hours) — BIOE 845 or other acceptable Biostatistics course
- Take admission-to-candidacy exam

YEAR 3

Fall Semester

- Advanced Physiology (2 credit hours) — PHYS 912, as described above (if not taken during the second year)
- Doctoral Dissertation and Research (9 credit hours) — IP 900
- Physiology Seminar (1 credit hour) — PHYS 919

Spring Semester

- Doctoral Dissertation and Research (9 credit hours) — IP 900
- Physiology Seminar (1 credit hour) — PHYS 919

YEAR 4 AND BEYOND

- Doctoral Dissertation and Research (9 credit hours) — IP 900
- Physiology Seminar (1 credit hour) — PHYS 919
- Students will defend their dissertation in front of their faculty committee

Appendix 5: Neuroscience

The Neuroscience Track provides broad research training in neurophysiology, neuroanatomy, neuropharmacology, molecular and cellular neuroscience, developmental neurobiology, and behavioral neuroscience. The Neuroscience Track is composed of faculty from multiple departments at UTHSC and St. Jude Children's Research Hospital who are actively involved in neuroscience research, graduate student courses, seminars, guidance committees, and other functions necessary for the continued development of a graduate program. Members of the Neuroscience Track Committee will be appointed by the chairman of the Anatomy and Neurobiology Department and will include the Neuroscience Track directors.

Basic and clinical Neuroscience research at UTHSC and St. Jude Children's Research Hospital focuses on intracellular signaling pathways, neuronal excitability, synaptic transmission, sensory processing, retinal biology, neurological and neurodegenerative disorders, brain tumors, neurogenetics and neural development, and mental and addictive disorders. Techniques in use include genetics and molecular biology, bioinformatics, optical imaging and neurophysiology, functional MRI, neuro-pharmacology and neurochemistry, neuroanatomy, and behavior.

Students in the Neuroscience Track complete their core curriculum by taking all four Neuroscience courses listed below, and a statistics course. Students will choose at least 3 credit hours of additional elective courses that suit the individual student’s needs. Any course required by other Biomedical Sciences tracks is acceptable as an elective.

Seminar — Students must take at least 4 semesters of Neuroscience Seminar (ANAT 821) with Special Topics (ANAT 840). Special Topics course includes a discussion of a publication by the seminar speaker followed by a meeting with the seminar speaker. After this, students must either take Neuroscience Seminar without Special Topics or attend at least one seminar course or journal club suited to their research topic.

Symposium — All neuroscience students must take Neuroscience Symposium (ANAT 826) in the Spring term of each year. Students may opt not to take this course if they are defending their dissertation that semester.

Teaching — Students are expected to assist with teaching in Neuroanatomy lab at least one term. The total time commitment in lab is 15 hours for one term. Students may opt for additional teaching experience by volunteering for more than one term. Students should take Functional Neuroanatomy before completing this requirement.

Core Curriculum

- Functional Neuroanatomy (3 credit hours) — ANAT 827, fall
- Cellular Neuroscience (3 credit hours) — ANAT 823, spring, odd-# years
- Behavioral Neuroscience (3 credit hours) — ANAT 841, fall, even-# years
- Developmental and Molecular Neurobiology (3 hours) — ANAT 825, spring, even-# years

Additional Requirements

- Statistics (2 credit hours) — BIOE 845 or other acceptable Biostatistics course, spring or fall in year 1 or year 2.
- Neuroscience Seminar (1 credit hour), first 4 semesters, recommended every semester — ANAT 821

Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801, spring

- Special Topics (1 credit hour), first four semesters — ANAT 840
- Neuroscience Symposium (1 credit hour), every spring semester — ANAT 826
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801, spring
- Any additional 3 credit hours (not including seminar/symposium-type classes)

Laboratory Rotations

Students are required to do two lab rotations with Biomedical Sciences program faculty. These rotations can occur during any of the six prescribed rotational periods during the first year. After two rotations, a student may begin work in his or her chosen mentor's lab or may elect to do more rotations. A mentor's lab must be identified by the end of the first year.

Faculty Committee

The Faculty Committee must meet the requirements in the Graduate College Policies and the Biomedical Sciences program. The committee should be formed as soon as possible after a mentor is chosen and before the end of the second year. In addition, the outside committee member should not be a member of the UTHSC Anatomy and Neurobiology Department including adjunct and affiliate members. At least two committee members must be full-time UTHSC faculty. The student will meet with his or her committee twice per year and submit a summary of that meeting to the track directors and program director.

Admission-to-Candidacy Exam

At the end of the second year, students must pass a qualifying exam. The examination will consist of a written portion research proposal in the form of an NIH F31 pre-doctoral fellowship, National Research Service Award (NRSA), followed by an oral examination. The topic or choices of topics for the application will be provided by or approved by the Student's Faculty Committee and may be related to a student's expected thesis research. The written portion will include 1 page of specific aims, 6 pages of the proposal, and additionally, a complete list of all literature cited. The proposal should be generated independently and should not reflect input from the Mentor, other faculty, or students. Applications must be completed and submitted to the committee within 6 weeks of topic approval.

Once the proposal has been received, the track committee will schedule the oral portion of the examinations. At the meeting, not to exceed 2 hours, the student will answer questions about his or her proposal as well as questions related to his or her first two years of course work. Following the meeting, committee members will assign a passing or failing grade. To pass, the student must not receive a failing grade from more than one committee member. If the student partially fails, being weak in an identified area, he or she may only require re-writing specific parts of the proposal or re-examination of a certain subject. In this case, details and deadlines will be specified by the Neuroscience Track Graduate Committee. If a student fails completely, a second full exam will be required, and any written materials must be provided to the committee at least two weeks prior to the exam. As indicated in the College Policies, the result of the second exam is final.

Neuroscience students will be admitted to candidacy after passing the qualifying exam and completing required program courses.

Dissertation Proposal

By the end of their third year, students should write a second NIH F31 grant application based on their ongoing and proposed Ph.D. research or revise the grant application used for the qualifying examination if appropriate. This proposal is discussed with a student's Faculty Committee before approval to continue research.

Sample Curriculum—Neuroscience Track

YEAR 1

Fall Semester

- Functional Neuroanatomy (3 credit hours) — ANAT 827
- Essentials of Cell Biology (3 credit hours) — IP 841
- Neuroscience Seminar (1 credit hour) — ANAT 821
- Special Topics (variable credit hours) — ANAT 840
- Two 6-week lab rotations (1 credit hour) — IP 900

Spring Semester

- Cellular Neuroscience (3 credit hours) — ANAT 823 (3 credit hours), odd-# years
- Statistics (2 credit hours) — BIOE 845 or other acceptable Biostatistics course (spring 2019 or fall 2019 depending on course availability)
- Neuroscience Seminar (1 credit hour) — ANAT 821
- Special Topics (variable credit hours) — ANAT 840
- Neuroscience Symposium (1 credit hour) — ANAT 826
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801
- One 6-week lab rotation (1 credit hour) — IP 900
- End of spring semester/summer: choose Mentor and begin research

Please note: Students with an emphasis in neurocancer will take Essentials of Molecular Biology [IP 805, spring] and Pathobiology of Cancer [IP 940, fall] instead of Essentials of Cell Biology [IP 841, fall].

Please note: Students with an emphasis in neuropharmacology will take Biochemistry [IP 806, fall] and Cellular Signaling [PATH 861, spring] instead of Essentials of Cell Biology [IP 841, fall].

YEAR 2

Fall Semester

- Behavioral Neuroscience (3 credit hours) — ANAT 841, fall, even-# years
- Neuroscience Seminar (1 credit hour) — ANAT 821
- Special Topics (variable credit hours) — ANAT 840
- Dissertation Research (variable credit hours) — IP 900
- Elective

Spring Semester

- Developmental and Molecular Neurobiology (3 credit hours) — ANAT 825, spring, even-# years
- Neuroscience Seminar (1 credit hour) — ANAT 821
- Special Topics (variable credit hours) — ANAT 840
- Neuroscience Symposium (1 credit hour) — ANAT 826
- Dissertation Research (variable credit hours) — IP 900
- Elective
- End of spring semester/summer: take admission-to-candidacy exam.

Please note: Students with an emphasis in neurocancer will take Biochemistry [IP 806, fall] instead of Behavioral Neuroscience [ANAT 841, fall].

YEAR 3

- Dissertation Research (9 credit hours) — IP 900
- Neuroscience Seminar, each semester (1 credit hour) — ANAT 821
- Neuroscience Symposium, spring semester (1 credit hour) — ANAT 826
- 15 total hours of teaching assistance in Neuroanatomy Lab
- Complete and defend dissertation proposal.

Please note: Students with an emphasis in neurocancer or neuropharmacology will additionally participate in cancer or pharmacology seminar, respectively.

YEAR 4 AND BEYOND

- Dissertation Research (9 credit hours) — IP 900
- Neuroscience Seminar, each semester (1 credit hour) — ANAT 821
- Neuroscience Symposium, spring semester (1 credit hour) — ANAT 826
- Students defend their dissertation before their Faculty Committee to complete the requirements for the Ph.D. degree.

Please note: Students with an emphasis in neurocancer or neuropharmacology will additionally participate in cancer or pharmacology seminar, respectively.

Appendix 6: Pharmacology, Addiction Science, and Toxicology (PhAST)

The Pharmacology, Addiction Science, and Toxicology Track provides a broad training in pharmacology, addictive substances, molecular biology, and cell signaling. The research interests of the faculty in the PAST track include neuropharmacology, behavioral neuroscience, drug development, cardio- and cerebrovascular pharmacology, and cell signaling. The Pharmacology, Addiction Science, and Toxicology Track is uniquely positioned to integrate pharmacologic and molecular approaches to problems in addiction, recreational drug misuse, neurological diseases, cardio- and cerebrovascular disease, cell signaling, and regulation of channels. The general areas covered in this track are:

- Drug Targets and Disease
- Pharmacology and Drug Design
- Receptor Kinetics and Structure
- Signal Transduction

Students in the Pharmacology, Addiction Science, and Toxicology Track are required to take the core courses listed below. Students choose at least 6 credit hours of additional elective courses that suit the individual student's needs. Any course required by other Biomedical Sciences program tracks is acceptable as an elective. Relevant pharmacology-related courses offered in the CGHS/Pharmaceutical Sciences program may be acceptable for elective credit, upon approval of the track and program director. Students are also required to participate in a journal club beginning in their second year through the completion of the program.

Core Requirements

- Biochemistry (3 credit hours) — IP 806, fall
- Essentials of Cell Biology (3 credit hours) — IP 841, fall
- Principles of Pharmacology (4 credit hours) — PHAR 830, spring

or other acceptable general principles of pharmacology course (min. 3 credit hours)

- Essentials of Molecular Biology (3 credit hours) — IP 805, spring

Additional Requirements

- Biostatistics (2 credit hours) — BIOE 720 or other acceptable Biostatistics course
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801, spring
- PhAST Journal Club (1 credit hour) — PHAR 824 or another acceptable course

Electives

Common electives for PhAST students include (but are not limited to):

- Functional Neuroanatomy (3 credit hours) — ANAT 827, fall
- Behavioral Neuroscience (3 credit hours) — ANAT 841, fall, even-# years
- Cellular Neuroscience (3 credit hours) — ANAT 823, spring, odd-# years
- Developmental and Molecular Neurobiology (3 credit hours) — ANAT 825, spring, even-# years
- Special Topics in Pharmacology (variable) — PHAR 840
- Modern Pharmacology Research Techniques (variable) — PHAR 803
- Current Topics in Clinical Pharmacology (variable) — PHAR 802
- Bioinformatics (3 credit hours) — MSCI 814 and MSCI 815 together, spring
- Cellular Signaling (3 credit hours) — PATH 861, spring
- Molecular biology of Cancer (3 credit hours) — IP 940, fall
- Physiology and Biophysics (Medical Physiology) (5 credit hours) – PHYS 612
- Molecular and Cellular Basis of Pathogenesis (3 credit hours) MSCI 930, spring

Laboratory Rotations

Students are required to do three lab rotations with Biomedical Sciences program faculty. These rotations can occur during any of the six prescribed rotational periods during the first year. After three rotations, a student may begin work in his or her chosen mentor's lab or may elect to do more rotations. A mentor's lab must be identified by the end of the first year.

Admission-to-Candidacy Exam

Admission to candidacy occurs in two steps. A written dissertation proposal, in the form of a fellowship application based on their research project, must be submitted to the Faculty Committee. This proposal must then be successfully orally defended in front of the Faculty Committee by the end of the third year. The committee will evaluate the student's command of knowledge gained from the first two years of coursework in addition to the contents of the proposal. This exam is administered on a pass/fail basis. One re-take opportunity will be offered to those students who do not pass the initial examination. Because of the necessity to successfully pass this exam by the end of the third year, students are encouraged to prepare their proposal and complete their initial oral examination by the end of the Fall term of their third year.

Sample Curriculum—Pharmacology, Addiction Science, and Toxicology Track

YEAR 1

Fall Semester

- Biochemistry (3 credit hours) — IP 806
- Essentials of Cell Biology (3 credit hours) — IP 841
- Lab Rotations (variable credit hours) — IP 900

Spring Semester

- Biostatistics (2 credit hours) — BIOE 845
- Principles of Pharmacology (4 credits) – PHAR 830
- Essentials of Molecular Biology (3 credit hours) — IP 805
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801
- Lab Rotations (variable credit hours) — IP 900

YEAR 2

Fall Semester

- Medical Pharmacology I (4 credit hours) — PHAR 611
- Dissertation Research (variable credit hours) — IP 900
- Elective
- Journal Club
- Assemble faculty committee

Spring Semester

- Dissertation Research (variable credit hours) — IP 900
- Elective
- Journal Club
- Take admission-to-candidacy exam

YEAR 3

- Dissertation Research (9 credit hours) — IP 900
- Journal Club

YEAR 4 AND BEYOND

- Dissertation Research (9 credit hours) — IP 900
- Journal Club
- Students will defend their dissertation in front of their faculty committee in order to complete the requirements for the Ph.D. degree

Appendix 7: Regenerative and Rehabilitation Sciences (RRS)

Regenerative and Rehabilitation sciences encompass highly interdisciplinary fields of study. These fields incorporate knowledge from physiology, regenerative and preventative medicine, orthopedics, genomics, neuroscience, kinesiology, engineering, and public health. Regeneration focuses on tissue repair or replacement due to injury, disease, or age loss. This goal is achieved primarily by enhancing endogenous stem cell function or transplanting exogenous stem cells. Rehabilitation focuses on using exercise, manual, mechanical, and other stimuli to promote functional recovery. This natural interaction has led to the recent expansive growth of the Regenerative - Rehabilitation discipline, which integrates regenerative technologies with clinical rehabilitation practice. The knowledge from these disciplines is aimed at enhancing injury prevention, increasing activity, and improving tissue regeneration/repair and function. RRS spans the entire life course, from infancy to geriatric populations, and addresses various acute and chronic physical conditions that may negatively impact the ability of people to perform daily activities and fully participate in their lives.

The overall goal of RRS is to generate knowledge that promotes health and wellness among persons with or at risk of developing disabilities or persons with acquired pathophysiology. This type of research training is necessary to provide needed university academicians that can advance the fields of rehabilitation and repair/regeneration of tissue after acute or chronic injuries. Patient health is central to all rehabilitation, and underlying conditions such as cancer, diabetes, obesity, cardiovascular disease, and aging can negatively impact the ability to recover from either injury or disability. The study of regenerative and rehabilitation sciences represents a significant expansion of the student's research training that extends beyond a professional degree (e.g., DPT, OTD, MOT). Thus, the RRS track offers an innovative opportunity for student training in research who can pursue clinical and academic research careers in the biomedical sciences. Our RRS track prepares graduates with the skills needed to become successful educators, researchers, and innovators. RRS graduates will develop strong research, student mentorship, and leadership skills, essential for a successful academic career involving a high commitment to research. Through didactic training and mentored

research activities, the RS student will develop the skills needed to become an independent scientist.

The Ph.D. program in Biomedical Sciences with a research track in Regenerative and Rehabilitation Sciences allows for an integrated, interdisciplinary, research-oriented graduate program in which students train in faculty laboratories focusing on current approaches to tissue regeneration and rehabilitation. As in all tracks within Biomedical Sciences, all students complete a core curriculum of nine credit hours. All students are required to take Biostatistics and ethics courses. The remaining courses include six elective credits and a research dissertation. Students will take didactic coursework in the first year and begin working with a Ph.D. advisor. During the second year, students select their dissertation committee of five faculty members who can best guide them through their graduate research. Also, before the third year, students will complete an admission-to-candidacy exam. Each student will complete the goals of an approved research proposal and provide a written document and an oral defense of the student's dissertation following the research phase of his/her training.

The Ph.D. track in RRS is designed to prepare individuals for careers in research. The program uses a mentorship model. Participating in ongoing research with guidance from the conducting faculty member will prepare the student for independent research and scholarship. The student initially assists the faculty mentor with a specific inquiry. During the first two years in the program, the student will identify a related line of investigation with the faculty mentor, which can be pursued for the dissertation under the mentor’s guidance. The doctoral student’s experience will be enriched by the faculty mentor’s more extensive research program. Students must commit to consistent involvement in their mentor’s research program full-time. Student research activities may vary because individual faculty members’ research programs can differ in focus and methodology. The faculty mentor will serve as a professional role model during the student’s time in the program and provide the student guidance in developing and achieving their professional and academic goals.

Students will use rotations to identify faculty members in research areas of interest within RRS. Students will perform rotations within the RRS track or other tracks within the Biomedical Sciences program. Students who choose a permanent mentor outside the

RRS track may switch tracks after consultation with respective track and program directors. After the student has chosen his/her mentor, a mentorship plan will be developed that specifies learning goals, performance expectations, and required tasks. For example, the mentorship relationship will likely involve the student working on the mentor's research project; the mentorship plan would indicate the work schedule, responsibilities, and supervision format.

The Regenerative and Rehabilitation Sciences track in Biomedical Sciences focuses on neurobiology and pathophysiology of tissue regeneration and rehabilitation. Neurobiology-related areas of RRS involve neurophysiology, neuroanatomy, behavioral neuroscience, and biomechanics that can impact movement and mobility. RRS also explores how pathophysiological conditions (aging, cancer, metabolic diseases, cardiovascular diseases, etc.) alter physical function, movement, and mobility by disrupting muscle, bone, cardiac, and vascular tissues. Studying these processes at the cellular and molecular levels is critical to understanding the mechanisms driving pathological changes to tissue and organ function. Furthermore, this knowledge is required to develop and refine therapeutics and interventions to reduce dysfunction, improve mobility, and increase tissue regeneration after either injury or periods of disuse.

The Regenerative and Rehabilitation Sciences track is composed of Biomedical Sciences Program faculty are involved in researching the neurobiology or pathophysiology of regeneration and rehabilitation in humans and preclinical animal models. Cancer cachexia, sarcopenia, stroke, heart failure, diabetes, and metabolic diseases cause reduced function and mobility. Investigations are conducted at the systemic, organ, tissue, cellular, and molecular levels. Research areas include understanding disrupted metabolism, muscle atrophy signaling, organ and tissue crosstalk regulating muscle atrophy, cellular mitochondrial dysfunction, and cell death with chronic disease, cancer, and aging. The neurobiology of rehabilitation concentration is involved in innovative research on diverse topics, including sensory processing required for movement, prosthetics in movement, and movement disorders associated with disruptions of neural input such as stroke and Parkinson's disease. Techniques include biomechanical assessment of function, gait patterns, fatigue, EMG, optical

imaging and neurophysiology, neuroanatomy, and behavior. Research is conducted in humans and preclinical animal models of diseases.

Required Curriculum

The required coursework for the Ph.D. program includes credits in core, cognate, elective courses. Research milestones include the successful completion of the Candidacy Exam, Dissertation Proposal and a Dissertation Defense. All Biomedical Sciences program students must complete 9 credit hours of core courses, as specified below. A biostatistics course is also required. The Integrity in the Conduct of Scientific Research course (IP 801), required of all Ph.D. students, will not be considered as part of the core curriculum. All Biomedical Sciences program students will take Essentials of Cell Biology (IP 841). In consultation with their Faculty Mentor and RRS Ph.D. Track Director, students interested in neurobiology aspects of RRS will be able to take either Biochemistry (IP 806) or Functional Neuroanatomy (ANAT 827), and either Essentials of Molecular Biology (IP 805) or Behavioral Neuroscience (ANAT 841). In consultation with their Faculty Mentor and RRS Track Director, a minimum of 6 elective credit hours to supplement the core curriculum will be taken. Students in the RRS track must take at least 4 semesters of Regenerative and Rehabilitation Sciences Seminar (1 credit hour, RSHP 919) and complete 24 credit hours of Doctoral Dissertation and Research (IP 900). At the beginning of the first semester in the program, the student will develop a plan of study with the RRS Track Director, which will be submitted to the Graduate School.

Core Curriculum

Overall Biomedical Sciences Program and RRS Track Requirements

- Biostatistics (2 credit hours) — BIOE 811 or another approved statistics course
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801, spring
- Regenerative and Rehabilitation Sciences Seminar (1 credit hour), repeated 4 semesters — RSHP 919 fall/spring

Core Required Courses in the RRS track (9 credit hours)

- Essentials of Cell Biology (3 credit hours) — IP 841, fall
- Biochemistry (3 credit hours) — IP 806, fall

or Functional Neuroanatomy (3 credit hours) — ANAT 827, fall

- Essentials of Molecular Biology (3 credit hours) — IP 805, spring

or Behavioral Neuroscience (3 credit hours) — ANAT 841, fall, even-numbered years

Electives (6 credit hours)

- Special Topics in Regenerative and Rehabilitation Sciences (1-5 credit hours) — RSHP 840, fall/spring
- Bioinformatics I (2 credit hours) — MSCI 814, spring
- Bioinformatics II (1 credit hour) — MSCI 815, spring
- Cellular Neuroscience (3 credit hours) — ANAT 823, spring, odd-numbered years
- Cellular Signaling (3 credit hours) — PATH 861, spring
- Developmental & Molecular Neurobiology (3 credit hours) — ANAT 825, spring, even-# years
- Epidemiology of Childhood Diseases (2 credit hours) – BIOE 834, spring
- Fundamentals of Epidemiology (3 credit hours)- BIOE 812, fall
- Immunity and Inflammation (3 credit hours)- MSCI931, fall
- Molecular Biology of Cancer (3 credit hours) — IP 940, fall
- Techniques I: Biochemical and Cellular Methods (2 credit hours) — MSCI 934, spring
- Techniques II: Methods for Nucleic Acids Fall (2 credit hours) — MSCI 935, fall
- Physiology and Biophysics (Medical Physiology) (5 credit hours) — PHYS 612, spring

Laboratory Rotations

Students will participate in a minimum of two and a maximum of six, 6-week-long laboratory rotations starting in September of the first year. During the rotations, students will work in the labs of individual Biomedical Sciences program faculty who are interested in taking a student that particular year. RS students may choose a mentor after their second rotation and begin their dissertation research.

Admission-to-Candidacy Exam

Toward the end of the second year, students will complete the admission-to-candidacy exam, which involves writing a grant proposal in NIH F31 format and successfully defending the proposal to their Faculty Committee. The student will assemble their admission-to-candidacy exam committee following the Biomedical Sciences program rules on faculty committee membership. Committee formation is the initial step in starting the admission-to-candidacy exam process and should be initiated early in the spring semester of year 2. The student's committee will examine the student's preparedness to pursue a Ph.D. in the Biomedical Sciences program. The exam encompasses student knowledge of the chosen research topic and the ability to design research to address important questions in the field. The committee can also assess knowledge related to the core curriculum and related topics. The committee can vote pass or fail. The process should be completed before the beginning of the 3rd year in the program. If a student is unsuccessful in the first attempt, he/she may retake the exam.

Sample Curriculum— Regenerative and Rehabilitation Sciences Track

YEAR 1

Fall Semester

- Essentials of Cell Biology (3 credit hours) — IP 841, fall
- Biochemistry (3 credit hours) — IP 806, fall

or Functional Neuroanatomy (3 credit hours) — ANAT 827, fall

- Lab Rotation (1–4 credit hours) — IP 900

Spring Semester

- Essentials of Molecular Biology (3 credit hours) — IP 805, spring
- or Elective Course (3 credit hours)
- Elective Course (3 credit hours)
- Integrity in the Conduct of Scientific Research (1 credit hour) — IP 801, spring
- Rehabilitation Sciences Seminar (1 credit hour) — RSHP 919
- Lab Rotations (1-4 credit hours) — IP 900
- Assemble faculty committee

YEAR 2

Fall Semester

- Biostatistics - BIOE 811, or another approved statistics course
- Behavioral Neuroscience (3 credit hours) — ANAT 841, odd-numbered years
- Elective Course (3 credit hours)
- Doctoral Dissertation and Research (6 credit hours) — IP 900
- Rehabilitation Sciences Seminar (1 credit hour) — RSHP 919
- Take admission-to-candidacy exam (place where appropriate)

YEAR 3

Fall Semester

- Doctoral Dissertation and Research (9 credit hours) — IP 900
- Rehabilitation Sciences Seminar (1 credit hour) — RSHP 919

Spring Semester

- Doctoral Dissertation and Research (9 credit hours) — IP 900
- Rehabilitation Sciences Seminar (1 credit hour) — RSHP 919

YEAR 4 AND BEYOND

- Doctoral Dissertation and Research (9 credit hours) — IP 900
- Rehabilitation Sciences Seminar (1 credit hour) — RSHP 919
- Students will defend their dissertation.