STUDENT AND FACULTY HANDBOOK

INTEGRATED BIOMEDICAL SCIENCES PROGRAM

THE COLLEGE OF GRADUATE HEALTH SCIENCES

UNIVERSITY OF TENNESSEE HEALTH SCIENCE CENTER

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Introduction

The Integrated Biomedical Sciences Program (IBSP), a research-oriented interdisciplinary graduate program, involves faculty from the Departments of Anatomy and Neurobiology; Microbiology, Immunology, and Biochemistry; Pathology; Pharmacology; and Physiology, and their affiliate faculty from St. Jude Children's Research Hospital and the Veterans Affairs Medical Center. Unlike traditional, department-based graduate programs, the IBSP provides the Ph.D. or M.D./Ph.D. degree-seeking student the opportunity for a broad-based, cross-disciplinary training that is all but essential in today's competitive research environment. The IBSP consists of five tracks: Cancer and Developmental Biology; Cell Biology and Physiology; Microbiology, Immunology, and Biochemistry; Molecular and Systems Pharmacology; and Neuroscience.

Faculty

Faculty contributing to the IBSP can be grouped into three categories: (i) regular faculty, (ii) affiliate faculty, and (iii) 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 IBSP students are coauthors. Outside members with 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 www.uthsc.edu/grad/CollegeInfo/index.php?page=Faculty.

Faculty members select an IBSP appointment in one of the five tracks, and must notify the IBSP 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 they do not have a primary appointment. A complete list of primary faculty appointments in IBSP tracks can be found at each track's website.

Students

The IBSP enrolls approximately 20 students each year. Three types of Ph.D. degree-seeking students matriculate into the IBSP: (i) "typical" students who enter with no formal declaration of track affiliation and select a Research Advisor only after completing a series of laboratory rotations, (ii) students who select a Research Advisor at the time of acceptance and directly enter a laboratory, and (iii) students seeking a dual M.D./Ph.D. degree. Second and third year medical students are eligible to enter the dual degree program, and 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 IBSP 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 IBSP receive a waiver of tuition for six years of study. The IBSP provides 15 months of stipend and insurance support for typical students who complete laboratory rotations before selecting a Research Advisor. Subsequent stipend and insurance support is provided by the Research Advisors. Should a Research Advisor lose funding, the IBSP may provide bridge funding in which the student stipend and 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 Dean of the College of Medicine (COM) and Associate Dean of Graduate Studies (COM). 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 or be terminated from the program.

Students who directly enter a laboratory must receive stipend and insurance support from the Research Advisor upon matriculation. Students who directly enter a laboratory and M.D./Ph.D. students are not eligible for bridge funding protection; consent on rare occasions may be obtained from the Associate Dean of Graduate Studies in the COM. 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. Eligible students must have maintained an undergraduate grade point average of at least 3.4 from an accredited US institution and obtained a combined score of 1350 or greater on the verbal and quantitative portions of the Graduate Record Exam. Students must remain in good academic standing to continue receiving the scholarship.

Many fellowships are also available to supplement the stipends of IBSP students. A complete list may be found at www.uthsc.edu/grad/StudentInfo/Funding/index.php?page=Scholarships. The Hal and Alma Reagan Fellowship provides an annual stipend that is $1,000 above the general stipend amount and $1,000 in supplies and travel monies. Reagan Fellowships are 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. All students are subject to the CGHS Honor Code: www.uthsc.edu/grad/StudentInfo/Judicial/index.php?page=HonorCode .

Core and Elective Curricula

All IBSP students must complete a minimum of 9 credit hours of core courses, as specified by their Track requirements. Included in this requirement is a biostatistics course, but the Conduct of Scientific Research course, required of all Ph.D. students in the College, will not be considered as part of the core curriculum.

In consultation with their Research Advisor and Track Director, all students must select a minimum of 6 elective credit hours to supplement the core curriculum. 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 the University's website http://www.uthsc.edu/admiss/catalog2009-10.pdf.

Additional Curriculum Requirements

All IBSP students must participate in a journal club or course that follows a journal club format (such as **PATH 834** Pathology Seminars or **ANAT 821**

Neurosciences 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.

During the first weeks of the fall semester, each track holds a Research Colloquium in which eligible faculty members provide a brief (15 minute) overview of their laboratories' research programs. Interested students may then arrange for a subsequent meeting with particular faculty members or a tour of the laboratories. Students will use these interactions as the bases for selecting laboratory rotations.

There are six 6-week laboratory rotation periods in the first year. Tracks may specify which periods their students perform rotations, but all tracks will adhere to the 6-week schedule. Prior to and during the rotation process, each student will be assigned a temporary mentor to assist in academic decisions. The temporary mentor will not be selected from the pool of rotation faculty.

The rotation process enables students to be exposed to the diversity of research laboratories within the IBSP. Confirmation of a rotation laboratory is through mutual agreement between the student and faculty member. Two restrictions are placed on laboratory rotations: (i) faculty members may accept no more than two students during a single rotation period, and (ii) 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 one credit hour in **IP 900** Doctoral Dissertation and Research for each semester they participate in laboratory rotations.

Selection of Research Advisor and Faculty Committee

Each track specifies the minimum number of rotations which 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 IBSP fulfills its commitment, and (4) approval by the faculty member's Chair and the IBSP Director.

During the second year of study, the student and Research Advisor select a Faculty Committee composed of five members of the graduate faculty, including the Research Advisor who serves as Chair. The Student Committee Appointment form may be found at www.uthsc.edu/grad/StudentInfo/Forms/index.php?page=FCAF. One or more members must have a regular full-time appointment with UTHSC, at least two members must come from within the track, and at least one member must come from outside of the track. 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.

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. The Annual Student Progress Report form

can be found at the CGHS website www.uthsc.edu/grad/StudentInfo/Forms/index.php?page=Progress.

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 is defined by each track. 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 admission to candidacy exam form (www.uthsc.edu/grad/StudentInfo/Forms/index.php?page=Candidacy). The student will deliver the form to the Program Director's office along with a written summation by the exam chair and a copy of the student's unofficial transcript. Assuming the student is in good standing and has met all core and elective requirements, the Program Director will in turn pass this 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 required to withdraw from the program.

Master's Degree Requirements

While all students accepted into the IBSP program are expected to pursue the Ph.D. degree, some will opt for a terminal M.S. degree instead. It is anticipated that such a decision will not be made until after the completion of the first-year curriculum. 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, but are only required to acquire 3 elective credit hours. In the second year, M.S. candidates must participate in a journal club, however they are not required to complete **IP 801** Integrity in the Conduct of Scientific Research. 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. The candidate should meet with the committee soon after the decision to opt for an M.S. degree has been made to outline the research objectives. The research component of the M.S. degree requires publication quality data that may not stand alone, but which 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 complete the degree, 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 Bylaws. The Report of Final Examination form can be found at www.uthsc.edu/grad/StudentInfo/Forms/index.php?page=FinalExam.

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 sustained agreement between the student and Research Advisor. While not encouraged, in certain situations a student may leave a laboratory and perform a limited number of abbreviated rotations to identify a new Research Advisor. Transfers should be initiated only after extensive discussions between the student, Research Advisor, Track Director, and IBSP 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. Requests for student transfers and dismissals must be in writing and must be approved by the Dean.

Please Note: Neither the IBSP nor participating departments will be financially obligated if a student who directly enters a laboratory or an M.D./Ph.D. student 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 IBSP, 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 IBSP adheres to the appeal process of the CGHS, the specifics of which can be found in *The Centerscope* (www.uthsc.edu/centerscope/).

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 their 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 Bylaws. The Report of Final Examination form can be found at www.uthsc.edu/grad/StudentInfo/Forms/index.php?page=FinalExam.

Appendix 1: Core Course Descriptions

Depending upon the student's research track, the following courses may be used to meet the core curriculum requirements.

ANAT 823 Cellular Neuroscience: Spring semester, odd numbered years (3 credit hours)

Cellular Neuroscience provides the student with an overview of the cellular and molecular processes by which nerve cells communicate. The course covers classical theories and concepts as a basis for appreciation of recent research advances. Lectures by the faculty will provide core material to guide the students in presentation of current research topics. Extensive reading of the literature will supplement those lectures and presentations.

ANAT 841 Behavioral Neuroscience: Fall semester, even numbered years (3)

This is a course designed to introduce graduate students in the Neuroscience Graduate Program to behavioral approaches to the study of neuroscience. This course will combine lectures with review of both classic and current literature in order to develop an extensive appreciation of behavioral techniques used to study neuroscience questions.

ANAT 825 Developmental and Molecular Neurobiology: Spring semester, even numbered years (3)

This one-semester course will serve as an introduction to developmental neurobiology with special emphasis on the molecular analysis of nervous system development. A brief

introduction to molecular analysis will be followed by lectures and student-led discussions of research papers that focus on major epochs/events in the development of the nervous system.

ANAT 827 Functional Neuroanatomy: Fall semester (3)

Functional Neuroanatomy is a lecture and laboratory course dealing with the structure and function of the mammalian central nervous system. The emphasis of the course is on human neuroanatomy but comparisons are made with the rodent brain using the rat as a model system. The first one-third of the course provides a synopsis of core concepts and tools used in contemporary neuroanatomical research. This material focuses on an understanding of the principles underlying neuroanatomical approaches, as well as their advantages and potential pitfalls. The final two-thirds of the course covers the basic organization of the central nervous system including in depth consideration of its major sensory, motor and limbic components. This part of the course includes laboratory study on the gross anatomy of the brain.

IP 805 Essentials of Molecular Biology: Spring semester (3)

This course covers the essentials of prokaryotic and eukaryotic molecular biology. Topics include DNA and RNA structure; DNA replication, repair, and recombination; the mechanism and regulation of transcription; and protein translation. Fundamental concepts are reinforced by the discussion of human genetic diseases. Recommended text: Alberts et al., *Molecular Biology of the Cell*, 5th Ed.

IP 806 Biochemistry: Fall semester (3)

The course presents the fundamental aspects of biochemistry including biochemical and biophysical principles (bonding, properties of water, thermodynamics, ionization and acid-base theory, and enzymology); structure, synthesis, and function of proteins and enzymes; metabolism of sugars, amino acids, nucleotides, nucleosides, vitamins, coenzymes and lipids; energy production and conversion; mitochondria and bioenergetics; photosynthesis; membrane transport proteins; and cytochrome P450. Recommended text: Devlin, *Textbook of Biochemistry with Clinical Correlations,* 6th Ed.

IP 841 Essentials of Cell Biology: Fall semester (3)

This course provides an introduction to the cell and includes topics such as: animal cell structure; membrane compartmentalization; membrane transport; nuclear structure and dynamics; protein transport and modification; receptor signaling; cell motility and migration; cell cycle regulation; extracellular matrix and cell adhesion; general principles of development; and bacterial cell structure. Recommended text: Alberts et al., *Molecular Biology of the Cell,* 5th Ed.

PHARM Receptors, Signaling and Drug Action: semester (4)

This course provides an in-depth look at the major hormone and neurotransmitter receptors, their signaling mechanisms, and their effects on cell function. Lectures will provide an understanding of how drug action at receptors is quantified and will introduce the basic principles of drug absorption, distribution, metabolism and excretion. The pharmacology (therapeutic use, mechanism of action, side effects) of drugs acting on the autonomic nervous system will also be covered.

PHYS Systems Physiology: Spring semester (4)

The properties, composition, and function of living matter and its reactions to internal and external agents are presented. The course is composed of lectures concerning the following organ systems: circulatory, respiratory, renal, digestive, and neuroendocrine. The mechanism of integration of the various physiological systems is stressed. Additionally, the course will require students to write a report and present a research article related to an organ system of interest.

Appendix 2: Cancer and Developmental Biology

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
- Angiogenesis
- 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 each semester beginning with the fall semester of the first year.

Required Curriculum

- Essentials of Cell Biology (3)
- Essentials of Molecular Biology (3)
- Pathology Seminar (1)
- Biochemistry (3)
- Cellular Signaling (3)
- Special Topics, related to Career Development (1)
- Molecular Biology of Cancer (3)
- Special Topics, Pathobiology of Cancer (1)
- Ethics (1)
- Statistics (1-3, to be determined)

Electives

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. After two rotations, students may choose a mentor or continue with additional rotations.

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 student then schedules a committee meeting, no later than early in the spring semester of the second academic year, and proposes the specific aims and presents supporting preliminary data to the Faculty Committee. The deadline for submitting the one page specific aims page of the background and aims is due by February 1st and the committee meeting to approve these aims must be completed by mid-March. Following committee input and initial topic approval, the student then prepares a written proposal.

The written proposal of the research plan adheres to the format of a 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 2-4 weeks 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. The written proposal should not be directly edited by the Research Advisor nor 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.

The written proposal is provided to the Faculty Committee at least two weeks prior to a meeting held to discuss the proposal. Written proposals are due by April 1st of the second year. 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 (~20 slide) presentation 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 re-examination meeting (to be held prior to June 1st), or the student may be told that at the next meeting he/she will be tested on a weak knowledge area. For 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 re-examination 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 deliver the form to the Program Director's office along with the written summation of the exam by the chair and a copy of the student's unofficial transcript. The Program Director will in turn pass this along to the Dean's office.

The deadline for meeting the requirements for admission to candidacy will be June 30th of the second year.

Sample Curriculum

Year 1

Fall Semester

- Essentials of Cell Biology
- Biochemistry
- IBS Seminars
- Pathology Seminar
- 2 Laboratory Rotations

Spring Semester

- Cell Signaling
- Essentials of Molecular Biology
- Science as a Profession
- Cancer Track Seminar
- Up to 4 Laboratory Rotations
- July: Choose a Mentor

Year 2

Fall Semester

- Ethics

- Molecular Biology of Cancer
- Pathobiology of Cancer
- Cancer Seminar
- Dissertation Research
- September: Form Faculty Committee

Spring Semester

- Statistics
- Dissertation Research
- Department Seminar Attendance
- February: Exam topic approval
- June 1st: All admission to candidacy exams must be complete
- June 30th: Deadline for revisions, additional requirements or second chance defense

Year 3

Fall Semester

- Dissertation Research
- Department Seminar Attendance

Year 4 and Beyond

- Dissertation Research
- Cancer Seminar
- Students will defend their dissertation before their faculty committee in order to complete the requirements for the Ph.D. degree

Appendix 3: Cell Biology and Physiology

Cell Biology and 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 cellular and molecular levels on specific topics such as signal transduction, cell adhesion, cell division and death, cell migration and tumor metastasis, animal models of diseases including genetically engineered mice, cytoskeleton, cerebral circulation, inflammatory responses, gene therapy, ion channels and wound healing.

Students in the Cell Biology and Physiology Track are required to complete the core course curriculum consisting of Biochemistry, Essentials of Cell Biology, Systems Physiology and Essentials of Molecular Biology during the first year. In addition, students are required to take elective courses equivalent to a minimum of 3 credit hours, by selecting two units (2 credit hours) from the Advanced Physiology course during the second year and the Scientific Presentation course during their 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 by attending the physiology seminar series, participating in lunch discussion with guest speakers and presenting two seminars in this platform during the course of their dissertation (usually one during third year and one on the day of their thesis defense). Additionally, students are expected to participate in journal clubs and present their research work in national meetings.

Core Curriculum

- Systems Physiology (4)
- Essentials of Cell Biology (3)
- Essentials of Molecular Biology (3)
- Biochemistry (3)

Electives

- Advanced Physiology (2)
- Biostatistics (?)
- Ethics

Optional

- Cellular signaling (3)
- Cell Biology Techniques (2)
- Bioinformatics I (2)
- Bioinformatics II (1)

- Essentials of Animal Experimentation (2)
- Physical Biochemistry and Application in Structural Biology
- Principles of Mass Spectrometry

Laboratory Rotations

Students will participate in a minimum of two 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. Students may choose a mentor after their second rotation and begin their dissertation research. Students must choose their mentor by June of the first academic year. This allows students to begin their dissertation research work and spend full time in their mentor's laboratory. A maximum of six lab rotations (2 during first semester and 4 during the second semester) are allowed.

Admission-to-Candidacy Exam

Toward the end of 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 advisory committee. The committee will examine the student's preparedness to pursue a Ph.D. in IBS program. This will require student knowledge in 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

Year 1

Fall Semester

- Essentials of Cell Biology
- Biochemistry
- Physiology Seminars
- Lab Rotations

Spring Semester

- Systems Physiology
- Essentials of Molecular Biology
- Cellular Signaling
- Integrity in the Conduct of Scientific Research
- Physiology Seminars
- Lab rotations
- Assemble faculty committee

Year 2

Fall Semester

- Advanced Physiology (2)– Offered once in two years. Therefore, this course is available during Fall Semester of 2nd or 3rd year. Although this is a part of the elective requirement, this course is a requirement for CBP track students. However, students can elect to take one of the 7 units to fulfill 2-credit hour course. The 7 units are: 1) Gastrointestinal 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
- Physiology seminars
- Lab rotations (if needed)

Spring Semester

- Doctoral Dissertation and Research
- Take admission-to-candidacy exam (place where appropriate)
- Physiology Seminars

Year 3

Fall Semester

- Advanced Physiology (2)– as described above (if not taken during second year)
- Doctoral Dissertation and Research
- Physiology Seminars

Spring Semester

- Scientific writing
- Doctoral Dissertation and Research
- Physiology Seminars

Year 4 and Beyond

- Students will defend their dissertation before their faculty committee
- Physiology Seminars

Appendix 4: Microbiology, Immunology, and Biochemistry

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 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. Students interested in host-pathogen interactions, mechanisms governing innate and acquired immune responses, vaccine and therapeutic vector development, utilization of genomics/bioinformatics to study human disease, and research into the genetics, biochemical and/or cell biological mechanisms of eukaryotic or prokaryotic organisms, the MIB track has 35 faculty with active research programs spanning 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

Qualified minority students have an opportunity to participate in a one-of-a-kind T32 training grant to study bacterial pathogenesis. This grant provides a much needed way to help produce a larger professional talent pool of underrepresented minorities in academia and industry upon completion of their graduate training.

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, students are required to complete a minimum of 6 credit hours of electives. Selection of electives will depend on the research interests of the students, and typically are chosen in consultation with the student's faculty mentor.

In addition to the core and elective courses, 1st year students will participate in a weekly seminar course (IP 810) where they learn how to read, discuss and present a recent scientific journal article. Students in the MIB track also participate in a literature-based journal club where 2nd year students and above present a recent research paper to fellow students and faculty. Second year students also have an opportunity to obtain teaching experience as a Teaching Assistants in two different laboratory sessions for the second-year medical students taking the Medical Microbiology course.

The following courses comprise the core curriculum for students in the MIB track. Also listed are two additional required courses and the electives that are taught by the MIB faculty.

Required Courses

- Essentials of Cell Biology – (3 hrs)
- Biochemistry – (3 hrs)
- Essentials of Molecular Biology – (3 hrs)
- Integrity in the Conduct of Scientific Research – (1 hr)
- Biostatistics – (1 hr)

Electives

- Physical Biochemistry and Applications in Structural Biology – (3)
- Bioinformatics-I – (2)
- Bioinformatics-II – (1)
- Cellular Signaling – (3)
- Principles of Mass Spectrometry – (3)
- Techniques in Molecular Biology – (4)*
- Immunity and Inflammation – (2)
- Viral Pathogenesis – (2)
- Molecular Basis of Bacterial Pathogenesis – (2)

* This course will be divided into two x 2 credit courses starting in 2013.

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 individual faculty who have 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 IBSP 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 dissertation committee and at the end of the spring semester of their second year students will take the Admission to Candidacy exam (or Qualifying Exam). This exam, which determines whether a student is sufficiently prepared to pursue a Ph.D. in the IBS program, consists of two parts. First, students will write an NIH F31-style proposal on their dissertation project and submit the proposal to their dissertation committee. If acceptable, the student then meets with the committee in a closed-door session where the committee members assess the student's competency on 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. If a student does not pass the first time, they may have an opportunity to retake the exam before the beginning of the fall semester of

their third year. Successful completion of the exam results in admission of the student to candidacy to pursue a Ph.D.

Sample Curriculum

Year 1

Fall Semester

- Biochemistry
- Essentials of Cell Biology
- MIB Journal Club
- Lab rotations #1 & 2

Spring Semester

- Essentials of Molecular Biology
- Integrity in the Conduct of Scientific Research
- Elective #1
- IBS Student Seminar
- MIB Journal Club
- Lab rotations
- Select faculty mentor (must select by end of semester if not before)

Year 2

Fall Semester

- Elective #2
- Dissertation research
- MIB Journal Club
- Assemble dissertation committee

Spring Semester

- Elective #3 (if needed)
- Dissertation research
- Take admission-to-candidacy exam (must complete by end of Spring Semester)
- MIB Journal Club

Year 3

- Dissertation research
- MIB Journal Club

Year 4 and Beyond

- Students will defend their dissertation before their faculty committee

Appendix 5: Molecular and Systems Pharmacology

The Molecular and Systems Pharmacology Track provides a broad training in pharmacology, molecular biology, and cell signaling. The research interests of the faculty in the molecular therapeutic track include neuropharmacology, behavioral neuroscience, cancer pharmacology and drug development, cardiovascular pharmacology, and cell signaling and the regulation of gene expression. The Molecular and Systems Pharmacology Track is uniquely positioned to integrate pharmacologic and molecular approaches to problems in addiction, cancer therapeutics, cardiovascular disease, cell signaling, and regulation of channels. The general areas covered in our track are:

- Drug Targets and Disease
- Pharmacology
- Receptor Kinetics and Structure
- Signal Transduction
- Transcriptional Regulation

Students in the Molecular and Systems Pharmacology Track are required to take the core courses listed below totaling 9 credit hours. Students choose at least 6 credit hours of additional elective courses that suit the individual student's needs. Any course required by other IBS tracks is acceptable as an elective. Other graduate level courses can be used to satisfy the elective requirement upon approval from the track director.

Students are also required to participate in a journal club beginning in their second year through completion of the program.

Required Curriculum

- Receptors, Signaling and Drug Action (4 credit hours)
- Biochemistry (3)
- Biostatistics (2)

Electives

- Essentials of Cell Biology (3)
- Essentials of Molecular Biology (3)
- Cellular Neuroscience (3)
- Functional Neuroanatomy (3)
- Behavioral Neuroscience (3)
- Developmental and Molecular Neurobiology (3)
- Foundations of Pharmacology (V)
- Special Topics in Pharmacology (V)
- Modern Pharmacology Research Techniques (V)
- Current Topics in Clinical Pharmacology (V)
- Bioinformatics (3)
- Cellular Signaling (3)
- The Tools of Molecular Biomedical Research (3)
- Pathobiology of Cancer (3)

- Systems Physiology (3)

Laboratory Rotations

Students are required to do three lab rotations with IBS 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 their 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 qualifying exam is administered at the end of the second year that covers the core curriculum. A written thesis proposal then must be orally defended in front of the thesis committee by the end of the third year.

Sample Curriculum

Year 1

Fall Semester

- Receptors, Signaling and Drug Action
- Biochemistry

Spring Semester

- Biostatistics
- Cellular Neuroscience

Year 2

Fall Semester

- Foundations of Pharmacology
- Special Topics in Pharmacology

Spring Semester

- Modern Pharmacology Research Techniques
- Integrity in the Conduct of Scientific Research
- Journal club
- Take admission-to-candidacy exam
- Assemble faculty committee

Year 3

- Dissertation Research
- Journal club

Year 4 and Beyond

- Dissertation Research
- Journal club
- Students will defend their dissertation before their faculty committee in order to complete the requirements for the Ph.D. degree

Appendix 6: Neuroscience

The Neuroscience Track provides broad research training in neurophysiology, neuropharmacology, neuroanatomy, molecular and cellular neuroscience, developmental neurobiology, and behavioral neuroscience. The Neuroscience Track is composed of 43 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.

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, neuropharmacology and neurochemistry, neuroanatomy, and behavior.

Students in the Neuroscience Track complete their core curriculum by taking Functional Neuroanatomy, any 2 of the 3 Neuroscience courses listed below, and a statistics course. Students will choose at least 6 credit hours of additional elective courses that suit the individual student’s needs. Any course required by other IBS tracks is acceptable as an elective. Other graduate level courses can be used to satisfy the elective requirement upon approval from the track director.

Seminar - Students must take at least 4 semesters of Neuroscience Seminar with Special Topics. Special Topics 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 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)
- *Any 2 of the 3 courses below (6):*
  - Cellular Neuroscience (3)
  - Behavioral Neuroscience (3)
  - Developmental and Molecular Neurobiology (3)

Additional Requirements

- Statistics (2)

- Neuroscience Seminar (1) - every semester
- Special Topics (1) - first four semesters
- Neuroscience Symposium (1) - every Spring semester

Electives

- any additional 6 credit hours (not including seminar/symposium type classes)

Laboratory Rotations

Students are required to do three lab rotations with IBS 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 their 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, between May and August, students must pass a qualifying exam before admission to Ph.D. candidacy. Scheduling will depend on the availability of the student's graduate committee.

The qualifying exam will consist of a grant application in the form of an NIH F31 pre-doctoral fellowship, National Research Service Award (NRSA). All aspects of the grant application must be completed as if it were to be submitted to NIH though budget pages may be excluded. The mentor will complete the relevant evaluation in the F31 application.

The topic of the research proposal will be determined by the student's thesis committee or the Neuroscience Track committee. Students may be given a number of

topics to choose from and may suggest topics to the committees, but the topic may not be directly related to their mentor's laboratory research or their anticipated thesis research.

The grant application must be submitted to the thesis committee at least two weeks prior to a scheduled committee meeting. A committee member other than the student's mentor will be assigned to chair and lead the meeting. At the meeting the student will present and defend their application to the committee. During this meeting students are also expected to be able to answer questions related to their first two years of course work as well as the application itself. Following the meeting committee members, excluding the mentor, will assign a passing or failing grade. In order to pass the student must not receive a failing grade from more than one committee member.

Failing students may be allowed a second examination with the approval of the Program Chair and thesis committee after a period not exceeding 6 months. As indicated in the College Bylaws 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.

Thesis Proposal

By the end of their third year students write a second NIH F31 grant application based on their ongoing and proposed Ph.D. research. This proposal is discussed with a student's graduate committee before approval to continue research.

Sample Curriculum

Year 1

Fall Semester

- Functional Neuroanatomy
- Essentials of Cell Biology
- Neuroscience Seminar
- Special Topics
- Two 6 week lab rotations

Spring Semester

- Cellular Neuroscience
- Statistics
- Neuroscience Seminar
- Special Topics
- Neuroscience Symposium
- Integrity in the Conduct of Scientific Research
- One 6 week lab rotation

End of Spring Semester/Summer

- Choose Mentor and begin research

Please note: Students with an emphasis in neurocancer will take Essentials of Molecular Biology and Pathobiology of Cancer instead of Essentials of Cell Biology

Please note: Students with an emphasis in neuropharmacology will take Biochemistry and Receptor Signaling and Drug Action instead of Essentials of Cell Biology

Year 2

Fall Semester

- Behavioral Neuroscience
- Neuroscience Seminar
- Special Topics
- Independent Research

Spring Semester

- Developmental and Molecular Neurobiology
- Neuroscience Seminar
- Special Topics
- Neuroscience Symposium

End of Spring Semester/Summer

- Take admission to candidacy exam

Please note: Students with an emphasis in neurocancer will take Biochemistry instead of Behavioral Neuroscience

Year 3

- Dissertation Research
- Neuroscience Seminar - each term
- Neuroscience Symposium - Spring term
- 15 total hours of teaching assistance in Neuroanatomy Lab
- Complete and defend thesis 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
- Neuroscience Seminar - each term
- Neuroscience Symposium - Spring term
- 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