

GRADUATE SCHOOL OF BIOMEDICAL SCIENCES



Degree Requirements Academic Year 2018-2019

This document includes all degree requirements for programs in the Graduate School of Biomedical Sciences. A table of contents is included below.

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**Biochemistry and Molecular Biology
CURRICULUM (FLEXIBLE TRACK)**
(30 hours didactic credit required)

REQUIRED COURSES (* = Non-didactic credit courses)

Term 1	Organization of the Cell (2 hrs) Molecular Methods (3 hrs) Genetics A (2 hrs) <i>*Thinking Like a Scientist (1 hr)</i> <i>*Science as a Profession 1 (Ethics for first year students) (0.5 hr)</i> <i>*Seminar in Biochemistry (1 hr)</i> <i>*Research Rotation</i>
Term 2	Cell Division (2 hrs) Thinking Like a Scientist (2 hrs) <i>*Science as a Profession 1 (Ethics for second year students) (0.5 hr)</i> <i>*Seminar in Biochemistry (1 hr)</i> <i>*Research Rotation</i>
Term 3	Macromolecules: Structure and Interactions (3 hrs) Gene Regulation (3 hrs) Thinking Like a Scientist (2 hrs) <i>*Science as a Profession 1 (Ethics for third year students) (0.5 hr)</i> <i>*Seminar in Biochemistry (1 hr)</i> <i>*Research Rotation</i>
Term 4	Biostatistics for Biomedical and Translational Researchers (3 hrs) Thinking Like a Scientist (2 hrs) <i>*Science as a Profession 1 (Ethics for fourth year students) (0.5 hr)</i> <i>*Seminar in Biochemistry (1 hr)</i> <i>*Research Rotation</i>
Term 5	<i>*Research Rotation</i>

FLEXIBLE REQUIRED ELECTIVES (choose at least 7 hrs from at least 3 different areas)

GENETICS

Term 2	Genetics B (2 hrs)
Term 3	Mammalian Genetics (2 hrs)
Term 4	Human Genetics (3 hrs)
Term 4	Genetics of Animal Viruses (3 hrs) <i>odd years only</i>

DEVELOPMENT

Term 1	Classic Developmental Biology (2 hrs)
Term 2	Development (2 hrs)
Term 3	Evolutionary Conservation of Developmental Mechanisms (3 hrs)
Term 4	Neural Development (3 hrs)

IMMUNOLOGY

Term 2	Immunology (3 hrs)
Term 3	Immunology (1 hr)
Term 5	Molecular Immunology (3 hrs)

NEUROSCIENCE

Term 2	Neuroanatomy: Functional Organization of the CNS (2 hrs)
Term 3	Neuroscience (1 hr)
Term 3	Genetics of Neuroscience (2 hrs)
Term 4	Neural Development (3 hrs)
Term 4	Neurobiology of Disease (3 hrs)

DISEASE

Term 1	Cellular & Molecular Basis of Disease (2 hrs)
Term 2	Cancer (1 hr)
Term 4	Pathophysiology & Mechanisms of Human Disease (3 hrs)
Term 4	Introduction to Molecular Carcinogenesis (3 hrs)
Term 4	Gene & Cell Therapy (2 hrs)
Term 4	Biology of Aging & Age-Related Diseases (3hrs)

STRUCTURE & INFORMATICS

Term 2	Bacterial Structure & Function (3 hrs)
Term 2	ABC: Applications to Biology of Computation (2 hrs)
Term 3	Practical Introduction to Programming for Scientists (3 hrs) <i>even years only</i>
Term 4	Computer-Aided Discovery Methods (2 hrs)
Term 4	Electron Cryomicroscopy for Molecules & Cells (3 hrs) <i>odd years only</i>
Term 4	Advanced X-Ray Crystallography (3 hrs) <i>even years only</i>
Term 4	Bioinformatics & Genomic Analysis (3 hrs)

WILD CARDS

Term 2	Method & Logic in Molecular Biology (3 hrs)
Term 4	Regulation of Energy Homeostasis (2 hrs)

OTHER

Term 4	<i>*Introduction to Scientific Writing (1 hr) (Note: ISW is NOT a didactic course; thus, will not count towards your 30 required credit hours)</i>
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BMB CURRICULUM (BIOPHYSICS TRACK)

(30 hours didactic credit required)

REQUIRED COURSES (*Non-didactic credit courses)

- Term 1 Organization of the Cell (2 hrs)
 Molecular Methods (3 hrs)
 Molecular Biophysics I (3 hrs) (Rice U)
 **Thinking Like a Scientist* (1 hr)
 **Science as a Profession (Ethics for first year students)* (0.50 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 2 Molecular Biophysics II (3 hrs) (Rice U)
 Thinking Like a Scientist (2 hrs)
 **Science as a Profession (Ethics for second year students)* (0.50 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 3 Gene Regulation (3 hrs)
 Thinking Like a Scientist (2 hrs)
 **Science as a Profession (Ethics for third year students)* (0.50 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 4 Thinking Like a Scientist (2 hrs)
 **Science as a Profession (Ethics for fourth year students)* (0.50 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 5 *Research Rotation

FLEXIBLE REQUIRED ELECTIVES (choose 10 hours of electives, with at least 6 hours from the Biophysics List, to reach total of 30 didactic hours)

BIOPHYSICS

- Term 2 ABC: Applications to Biology of Computation (2 hrs)
Term 2 Computational Mathematics for Biomedical Students (4 hrs)
Term 3 Computer-Aided Discovery Methods (2 hrs)
Term 3 Macromolecules: Structure and Interactions (3 hrs)
Term 4 Electron Cryomicroscopy for Molecules & Cells (3 hrs) *odd years only*
Term 4 Advanced X-Ray Crystallography (3 hrs) *even years only*

CELL BIOLOGY (This is only a partial list; check with the Program Director for other choices)

- Term 1 Genetics A (2 hrs)
Term 1 Cellular & Molecular Biology of Disease (2 hrs)
Term 2 Method and Logic in Molecular Biology (3 hrs)
Term 2 Cell Division (2 hrs)
Term 2 Cancer (1 hr)

OTHER

- Term 4 *Introduction to Scientific Writing (1 hr) (Note: ISW is NOT a didactic course; thus, will not count towards your 30 required credit hours)

BMB CURRICULUM (MSTP TRACK)
(30 hours didactic credit required)

REQUIRED COURSES (* = Non-didactic credit courses)

- Term 1 Molecular Methods (3 hrs)
 Genetics A (2 hrs)
 **Thinking Like a Scientist* (1 hr)
 **Science as a Profession 1 (Ethics for first year students)* (0.5 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 2 Cell Division (2 hrs)
 Thinking Like a Scientist (2 hrs)
 **Science as a Profession 1 (Ethics for second year students)* (0.5 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 3 Macromolecules: Structure and Interactions (3 hrs)
 Gene Regulation (3 hrs)
 Thinking Like a Scientist (2 hrs)
 **Science as a Profession 1 (Ethics for third year students)* (0.5 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 4 Biostatistics for Translational Researchers (3 hrs)
 Thinking Like a Scientist (2 hrs)
 **Science as a Profession 1 (Ethics for fourth year students)* (0.5 hr)
 *Seminar in Biochemistry (1 hr)
 *Research Rotation
- Term 5 *Research Rotation

ELECTIVES (9 hrs) Medical school coursework will substitute for all elective requirements according to the table below.

Medical School Course	# of lectures	Graduate School Course	# of lectures	GSBS Transfer Credit
Core concepts (Foundations Basic to the Science of Medicine)	20	Organization of the Cell (220-501)	15	2 term hrs
Hematology/Oncology	19	Cancer (220-508)	5	1 term hr
Neuroscience (Nervous System)	51	Neuroscience (220-511)	5	1 term hr
Immunology	40	Immunology (220-512)	5	1 term hr
Immunology	40	Immunology (344-423)	21	3 term hrs
Core Concepts (term 1)	11	Human Physiology I Human Physiology II	48 for both	6 term hrs for both
Core Concepts (term 2)	41			
Foundations Basic to the Science of Medicine: Cardiovascular-Respiratory-Renal System	27			
Core Concepts (term 3)	11			
Foundations Basic to the Science of Medicine: Gastrointestinal System, Metabolism System, Endocrine System and Reproductive System (GIMNER)				
Nervous System (terms 5 & 6)				

Clinical Scientist Training Program

J. Degree Requirements

Requirement	MS Track	PhD Track
Complete 84 term-hours of credit	✓	
Complete 180 term-hours of credit		✓
Write an NIH K-type or other career development award proposal	✓	✓
Pass the Quantifying Progress Review	✓	
Pass the Qualifying Examination		✓
Admission to Candidacy	✓	✓
Serve on an IRB and attend a minimum of 6 meetings	✓	✓
Complete the proposed research	✓	✓
Obtain "permission to write" from the thesis advisory committee	✓	✓
Submit a thesis to Thesis Advisory Committee	✓	✓
Successfully present the completed project to their thesis advisory committee. The program director or co-director will attend.	✓	
Successfully defend the completed thesis in a public defense. The program director or co-director will attend.		✓

K. Certificate of Added Qualification (CAQ) students

CAQ students must pass the CSTP required courses and complete development of a K-type award proposal. In addition, CAQ students are expected to attend the annual retreat.

APPENDIX A:

Director: Dr. Ashok Balasubramanyam
Co-Directors: Drs. Jesus Vallejo and Fred Pereira

Executive Steering Committee Members:
Drs. Susan Blaney, David Corry, and Hardeep Singh

Academic Administrator: Kelly Levitt

APPENDIX B:

Courses required for all CSTP students:

GS-CT-400, Fundamentals of Clinical Investigation (FCI)

The objective of this course is to train students to interpret the results of other clinical investigators and to use the knowledge for providing state-of-the-art care for their patients. The course includes four modules reflecting specific areas relevant to a clinical researcher. These modules are: principles of clinical research; statistical methods in clinical research; clinical research - related issues.

GS-CT-408, Responsible Conduct of Research for Clinical Investigators (RCRCI)

This course, or equivalent GS course(s) approved by the Senior Associate Dean of the Graduate School, is required.

The RCRCI course is designed for the early career scientist/clinical or translational investigator, and will provide students with a fundamental competency and appreciation for the core topics within the ethical dimensions of biomedical research, as described below. During this eight-hour course, students will receive lectures from faculty with expertise in each of these core topics, to be followed by small group case study discussions illustrating ethics topics from the preceding lecture. This course is designed to meet NIH requirements for training in the responsible conduct of research.

Clinical Investigation for the Career Scientist (CICS)

A year-long series of courses with a strong emphasis on grant writing and preparing an NIH "K" or equivalent career development award proposal.

GS-CT-403, CICS I: Grant Development for Clinical Investigators

This course provides students with the skills to develop an important research question, formulate strong hypotheses and specific aims, and begin to draft the components of a career development grant proposal.

GS-CT-404, CICS II: Clinical Trials for Clinical Investigators

This course provides students with an understanding of the theory and practice of conducting scientifically rigorous clinical trials. Building on the work of the previous CICS I course and from knowledge gained from the Fundamentals in Clinical Investigation course, students will fully develop the hypothesis, specific aims, and experimental design of their projects.

GS-CT-405, CICS III: Translational Research for Clinical Investigators

This course provides students with an understanding of the theory and practice of conducting scientifically rigorous clinical trials. Building on the work of the previous CICS I course and from knowledge gained from the Fundamentals in Clinical Investigation course, students will fully develop the hypothesis, specific aims, and experimental design of their projects.

GS-CT-406, CICS IV: Health Services Research for Clinical Investigators

This course provides students with an understanding of the theory and practice of health services research. Building on the work of the previous term, students will continue the development of a K-type grant proposal.

GS-CT-407, CICS V: Evaluating a Completed Career Development Grant

This course provides students with an appreciation of the NIH study section review process and a completed career development award.

CSTP students enrolled in the M.S. and Ph.D. degree programs must take additional courses, as described below:

Selectives

Graduate students must take at least two of the following four courses that are offered through the Baylor GSBS:

- GS-GS-427, ABC-Applications to Biology of Computation
- GS-TB-403, Biostatistics for Translational Researchers or equivalent
- GS-SB-405, Computer Aided Discovery Methods (“Omics”)
- GS-CT-408, Development and Commercialization of Biomedical Discoveries
- GS-GS-519, Introduction to Scientific Writing
- GS-PG-414, Drug Discovery: From Bench to Bedside

Developmental Biology

2018 Graduate Program Curriculum

Developmental Biology students are required to take all of the required courses with a grade of B or better and an additional 6 hours of elective credits, totaling at least *31 didactic hours*. Additional quantitative electives are highly recommended. (D) – denotes didactic courses

Students are encouraged to continue their education throughout graduate training and may consider auditing courses of interest (without earning credit hours) provided they have agreement from the course director.

	Course #	Course Title	Credits	Course Director
REQUIRED in YEAR 1:				
Term 1				
	GS-DB-402	Classical Developmental Biology	2 (D)	Poche/Lewis
	GS-GS-501	Organization of the Cell	2 (D)	Bissig/Sifers
	GS-GS-502	Molecular Methods	3 (D)	Weigel
	GS-GS-503	Genetics A	2 (D)	Herman/Dierick
	GS-GS-528	Responsible Conduct of Research - Year 1	0.5	Bertuch
Term 2				
	GS-GS-504	Genetics B	2 (D)	Zhou
	GS-GS-505	Cell Division	2 (D)	Ira/Chang
	GS-GS-506	Development	2 (D)	Groves
	GS-GS-508	Cancer	1 (D)	Pangas
	GS-DB-466	Seminar in Developmental Biology	1	Groves
Term 3				
	GS-DB-422	Evolutionary Conservation of Developmental Mechanisms	3 (D)	Groves
		Gene Regulation	3 (D)	Cooper
		Neuroscience	1 (D)	Jankowsky
	GS-DB-466	Seminar in Developmental Biology	1	Groves
Term 4				
	GS-DB-403J	Neural Development	3 (D)	Arenkiel/Sillitoe
	GS-DB-425	Topics in Development	3 (D)	Nakada/Wythe
	GS-GS-521	Introduction to Biostatistics <i>*A different quantitative course may be substituted upon Director's approval.</i>	2 (D)	Minard
	GS-DB-466	Seminar in Developmental Biology	1	Groves
REQUIRED in YEAR 2:				
Term 2				
	GS-DB-400	Preparing for your Developmental Biology Qualifying Exam	1	Samuel/Arenkiel
	GS-GS-529	Responsible Conduct of Research - Year 2	0.5	Bertuch
	GS-DB-466	Seminar in Developmental Biology		Groves
Term 3				
	GS-DB-466	Seminar in Developmental Biology	1	Groves
Term 4				
	GS-DB-466	Seminar in Developmental Biology	1	Groves
REQUIRED in YEARS 3-4:				
Year 3, Term 3: Responsible Conduct of Research, GS-GS-530				
Year 4, Term 3: Responsible Conduct of Research, GS-GS-531				
Years 3-4, Terms 2-4: Seminar in Developmental Biology, GS-DB-466				

7. Required Courses (Ratified by the CPC June 2017)

7.1. Students shall pass the following courses before being Admitted to Candidacy.

7.2. Students shall pass the following courses before being Admitted to Candidacy.

Term	Course Title (credits)
1	<i>Organization of the Cell</i> (2)
	<i>Molecular Methods</i> (3)
	<i>Genetics A</i> (2)
	<i>Logic and Presentation of Problem-Solving Science</i> (1)
	<i>Research Rotation</i> (3)
	<i>Journal Club</i> (1)*
	<i>Seminars in Immunology Research</i> (1)
2	<i>Introduction to Immunology</i> (3)
	<i>Cell Division</i> (2)
	<i>Logic and Rhetoric of Writing Science</i> (1)
	<i>Journal Club</i> (1)
	<i>Research Rotation</i> (3)
	<i>Seminars in Immunology Research</i> (1)
3	<i>Regulation of Immune Response</i> (3)
	<i>Gene Regulation</i> (3)
	<i>Macromolecules: Structure & Function</i> (3)
	<i>Research Rotation</i> (3)
	<i>Journal Club</i> (1)
	<i>Seminars in Immunology Research</i> (1)
4	<i>Molecular Immunology</i> (3)
	<i>Introduction to Biostatistics for Translational Research</i> (3) or <i>Introduction to Biostatistics (GS-GS-521)</i> (2)
	<i>Logic and Rhetoric of Writing Proposals</i> (1)
	<i>Journal Club</i> (1)
	<i>Seminars in Immunology Research</i> (1)
5	<i>Clinical Aspects of Immunology</i> (3)
	<i>Journal Club</i> (1)
	<i>Seminars in Immunology Research</i> (1)

7.2.1. **Exceptions:** Students may request a waiver for courses for which they have had an equivalent. Students may transfer graduate level course credits to fulfill part of the requirement of thirty didactic credits. Waivers and transfers are subject to approval by the Curriculum and Progression Committee, the Program Director, and the Dean of the Graduate School of Biomedical Sciences.

8. Research Rotations

- 8.1. The purpose of the Research Rotations is to allow a student to experience the culture of the prospective laboratory, get to know the prospective Major Advisor, and explore research possibilities in that lab.
- 8.2. According to GSBS rules, students must rotate in three different laboratories but official commitment to any laboratory but are allowed four rotations. Under special circumstances, a fifth rotation is permitted under conditions to be specified by the Program Director
- 8.3. Rotations are subject to approval by Rotation Advisor and the Program Director.
- 8.4. Before the end of the first week of the rotation, students and their Rotation Advisors shall submit a Rotation Plan (see Appendix)
- 8.5. Following each Rotation, students and Rotation Advisors will separately report Rotation Evaluation Reports (see Appendix)

9. Journal Club (Ratified by the CPC June 2017)

- 9.1. Rules for students matriculating in or after 2017. The Program in Immunology requires the students be enrolled in the course for the Program in Immunology Journal Club for four terms each academic year, until they have been granted Permission to Write. (See Course Description in Appendix for details)

- 9.1.1. Briefly, students attend five terms each year and must present once every thirty sessions of the official JC.
- 9.1.2. The location and time of the Journal Club shall be determined by the Program Director in consultation with the Curriculum and Progression Committee and the Course Director.
- 9.1.3. Because of decisions by the Curriculum Committee of the Graduate School of Biomedical Sciences, students operating under the Policy adopted in 2016 must follow the rules of 2017.

9.2. Rules for students matriculating before 2016.

- 9.2.1. Rules for JC are in JC policy adopted in 2008. (See Appendix @), unless students opted into a newer policy.
- 9.2.2. Briefly, students register for JC every term until Admitted to candidacy. They must present a minimum of six (6) time and record 212 attendances.

10. The Methodological Annex (TMA) (Ratified by the CPC June 2017)

- 10.1. **Summary** TMA is provided to first and second year immunology graduate students who have yet to pass their qualifying exam. The course is an adjunct to the weekly immunology journal club and reviews the scientific and logical methods and procedures used in the literature. Students are assigned a specific question stemming from the current journal club paper and present their answer in a 15 minute chalk talk to the class.
- 10.2. **Specific needs addressed by TMA:** This course serves as skills preparation for the qualifying exam. It does this by reviewing the mechanisms and logic of scientific methods, techniques, models, reagents and procedures used in the literature that are often overlooked in the reading of published papers. Further, the course prepares student by

**INTEGRATIVE MOLECULAR AND BIOMEDICAL SCIENCES GRADUATE PROGRAM
FIRST YEAR CURRICULUM**

(30 hours didactic credit required/courses in *italics* are not didactic/minimum three rotations required)

TERM 1	REQUIRED COURSES	FLEXIBLE REQUIRED COURSES	ELECTIVES
	GS-GS-501 Organization of the Cell (2 hrs) GS-GS-502 Molecular Methods (3 hrs) GS-GS-503 Genetics A (2 hrs) <i>GS-GS-528 Resp Conduct Res (Ethics) Yr 1 (1 hr)</i> <i>GS-MB-466 IMBS Seminar (1 hr)</i> <i>GS-MB-401 IMBS Director's Course (1hr)</i> <i>GS-MB-549 Research Rotation (3 hrs) OR</i> <i>GS-MB-548 Reading (0-1 hr)</i>		See GSBS Schedule of Classes for electives
TERM 2	REQUIRED COURSES	FLEXIBLE REQUIRED COURSES	ELECTIVES
	GS-GS-505 Cell Division (2 hrs) GS-GS-523 Method & Logic in Mol Biol (3hrs)** <i>GS-MB-466 IMBS Seminar (1 hr)</i> <i>GS-MB-401 IMBS Director's Course (1hr)</i> <i>GS-MB-549 Research Rotation (1-4 hrs) OR</i> <i>GS-MB-548 Reading (0-1 hr)</i>	GS-GS-504 Genetics B (2 hrs) GS-GS-506 Development (2 hrs) GS-GS-508 Cancer (1 hr) GS-MB-431 Translational Cancer Biology (2 hrs)*** GS-IM-423 Immunology (3 hrs) GS-MV-417 Bacterial Structure and Function (3 hrs)	GS-TB-405 Translational Breast Cancer Res (2 hrs) GS-GS-427 ABC-Applications to Biol of Comp (2 hrs) See GSBS Schedule of Classes for more electives
TERM 3	REQUIRED COURSES	FLEXIBLE REQUIRED COURSES	ELECTIVES
	GS-GS-518 Macrom: Structure & Interactions (3 hrs) GS-GS-509 Gene Regulation (3 hrs) GS-TB-409 Method & Logic in Transl Bio (2 hrs)** <i>GS-MB-466 IMBS Seminar (1 hr)</i> <i>GS-MB-401 IMBS Director's Course (1hr)</i> <i>GS-MB-549 Research Rotation (1-4 hrs) OR</i> <i>GS-MB-548 Reading (0-1 hr)</i>	GS-GS-511 Neuroscience (1 hr) GS-GS-512 Immunology (1 hr) GS-GE-421 Mammalian Genetics (2 hrs) GS-DB-422 Evolutionary Conservation of Developing Mechanisms (2 hrs) GS-IM-425 Regulation of Immune Responses (3 hrs)	GS-CB-400 Explorative Data Analysis (2 hrs) GS-CB-426 Integrated Microscopy (2 hrs) See GSBS Schedule of Classes for more electives
TERM 4	REQUIRED COURSES	FLEXIBLE REQUIRED COURSES	ELECTIVES
	GS-GS-532 Biostats Biomed & Transl Res (3 hrs) <i>GS-MB-466 IMBS Seminar (1 hr)</i> <i>GS-MB-401 IMBS Director's Course (1hr)</i> <i>GS-MB-549 Research Rotation (3-8 hrs)OR</i> <i>GS-MB-548 Reading (0-1 hr)</i>	GS-CB-457 Intro to Molecular Carcinogen (3 hrs)*** GS-MB-430 Biol of Aging & Age Related Dis (3 hrs)* GS-NE-462 Concepts of Learning & Memory (3 hrs) GS-DB-403 Neural Development (3 hrs) GS-NE-422 Neurobiology of Disease (2 hrs) GS-MV-411 Gen of Animal Viruses (3hrs) odd yrs only GS-GE-403 Gene and Cell Therapy (2hrs) GS-IM-428 Molecular Immunology (3 hrs)	GS-GS-522 Research Design (3 hrs) GS-TB-402 Pathophys & Mech of Human Dis (2 hrs) See GSBS Schedule of Classes for more electives
TERM 5	REQUIRED COURSES	FLEXIBLE REQUIRED COURSES	ELECTIVES
	<i>GS-MB-549 Research Rotation (6-12 hrs) OR</i> <i>GS-MB-548 Reading (0-1 hr)</i>		GS-TB-401 Animal Models of Human Disease (2 hrs) See GSBS Schedule of Classes for more electives

One course is required from each of the colors in the Flexible Required Courses column (Category 1-Cancer/Aging, Category 2-Genetics, Category 3-Development/Neuroscience, Category 4-Immunology/Microbiology/Virology * Biology of Aging course required for all Biology of Aging Track students ** Either course will fulfill requirement. ***Required for all Cancer Track students.

The Department of Molecular & Cellular Biology
Requirement Checklist For Students Matriculating in 2018

Students must satisfactorily complete the Service Curriculum before taking the Qualifying Examination in the Department of Molecular and Cellular Biology.

Service Courses [16 didactic credits]	Term Taken
GS-GS-501 Organization of the Cell [2]	
GS-GS-502 Molecular Methods [3]	
GS-GS-503 Genetics A [2]	
GS-GS-504 Genetics B *[2]	
GS-GS-505 Cell Division [2]	
GS-GS-506 Development * [2]	
GS-GS-518 Macromolecules: Structure and Interactions [3]	
GS-GS-509 Gene Regulation [3]	
GS-GS-518 Science as a Profession – Term 1 year 1 = ethics	
GS-GS-515 Science as a Profession - Term 2 year 2 = ethics	
GS-GS-516 Science as a Profession - Term 3 year 3 = ethics	

GS-GS-504 Genetics B or GS-GS-506 Development may be taken.

Department Requirements [5 didactic credits]	Term Taken
GS-CB-425 Cellular Signaling [3]	
GS-CB-461 Cells, Tissues & Organs [2]	
GS-CB-465 Introduction to Research and Research Proposals	
GS-CB -466 Seminar 1 (required)	
GS-CB -466 Seminar 2 (required)	
GS-CB -466 Seminar 3 (required)	
GS-CB -466 Seminar 4 (required)	
GS-CB -548 Reading 1 (required)	
GS-CB -548 Reading 2 (required)	
GS-CB -548 Reading 3 (recommended)	
GS-CB -548 Reading 4 (recommended)	
GS-CB -549 Rotation 1 (required)	
GS-CB -549 Rotation 2 (required)	
GS-CB -549 Rotation 3 (required)	
GS-CB -549 Rotation 4 (recommended)	

Elective Courses (at least 3 courses) [8+ didactic credits]	Term Taken
GS-CB-426 Integrated Microscopy [2]	
GS-CB-470J Neuroanatomy [2]	
GS-CB-406 Reproductive Biology [3]	
GS-CB-457J Introduction to Molecular Carcinogenesis [3]	
GS-CB-459J Bioinformatics and Genomic Analysis [3]	
GS-CB-462J Concepts of Learning & Memory [3]	
GS-GS-508 Cancer* [1]	
GS-GS-511 Neuroscience* [1]	
GS-GS-512 Immunology* [1]	
GS-GS-521 Introduction to Biostatistics [2]	
GS-MB-430 Biology of Aging & Age Related Disease [3]	
GS-IM-423 Immunology [3]	
GS-GE-421 Mammalian Genetics [2]	
GS-GE-403 Gene and Cell Therapy [2]	
GS-GE-407 Basic Biostatistics [retired 2012]	
GS-PY-430 Human Physiology I [3]	
GS-PY-431 Human Physiology II [3]	
GS-TB-405 Translational Breast Cancer Research [2]	
GS-TB-403 Biostatistics for Translational Researchers [3]	
GS-MB-431 Translational Cancer Biology [2]	

Revised 04/15/2020

GS-CB-468 Regulation of Energy Homeostasis [2]	
GS-GS-427 ABC: Applications to Biology of Computation [2]	
GS-GS-400 Explorative Data Analysis [2]	
GS-SB-406 Practical Intro to Programming for Scientists [3]	
GS-GS-532 Biostatistics for Biomedical Translational Researches [3]	
GS-NE6201 Analyses of Neuronal Function A Fall 2019	

Molecular and Human Genetics

Changes in the Major Thesis Advisor and/or the Thesis Research Advisory Committee membership must be approved by the Dean. Appointments are made upon written request. The Graduate School form, Request for Appointment of Student's Advisory Committee, must be re-filed in the Graduate School Office.

VI. PROGRAM DESCRIPTION

A. Required Courses

The program provides didactic training in a variety of areas of Genetics.

Required courses for all students include the following:

Genetics A (2 hrs)
Responsible Conduct of Research- Year 1 (1 hr)
Method and Logic in Molecular Biology (3 hrs)
Genetics B (2 hrs)
Gene Regulation (3 hrs)
Human Genetics (3 hrs)
Introduction to Biostatistics for Translational Researchers (3 hrs)
Seminars in Molecular & Human Genetics (3 terms)
Student Research Seminars (4 terms)
A minimum of three Laboratory Rotations (Research Rotations)

Required courses **for students in the regular track** include the following (in addition to the courses listed above):

Molecular Methods (3 hrs)
Organization of the Cell (2 hrs)
Mammalian Molecular Genetics (2 hrs)

Required courses **for students in the BiGSB track** include the following (in addition to the courses listed above):

Introduction to Data Mining (2 hrs)

Typically, students would complete the required courses, and a minimum of 3 laboratory rotations (8 weeks each) by the end of the fifth term.

Requirements may be waived by the Graduate Education Committee based on the student's background in various subject areas. Students may petition the GEC for such waivers. Seminars in Molecular & Human Genetics is a required course for all first and second-year students.

B. Elective Courses

Students are required to complete a minimum of 60 term hours of course work, of which 30 term hours must be in courses that either have a letter grade assignment or are specifically designated by the Graduate School as "approved pass/fail" graded courses (e.g. Method and Logic in Molecular Biology and Research Design). Please note that completion of the required courses above will satisfy 23 of the 30 hours; therefore, a minimum of 7 course hour of electives will be required for students entering in 2017. Selection of elective courses will be made in consultation with the thesis advisor or the Director of the Graduate program.

Highly recommended electives include:

Introduction to Data Mining (required for BiGSB track students)
Cell Division
Development
Cancer
Neuroscience
Immunology
Computer-Aided Discovery Methods
Practical Introduction to Programming for Scientists
Macromolecules: Structure and Function
Gene and Cell Therapy
Concepts of Learning & Memory
Biology of Aging & Age Related Diseases
Research Design
Computer-Aided Discovery Methods
Introduction to Medical Genetics

Transfer of credit for work completed at another university or in another advanced program may be requested. No more than 60 term hours (30 semester) may be submitted for transfer.

Transfer credit can only be granted for courses receiving a grade based on performance on an examination. No research or seminar credit will be transferred. Requests for transfer must be approved by the Director of Graduate Studies and the GEC for first year students, or the Major Advisor and the student's thesis committee for more senior students. Subsequently, the request is sent to the Promotions Committee of the Graduate School for final decision on acceptance.

C. Laboratory Rotations

Laboratory rotations (Research Rotations) are to be conducted in a minimum of three different laboratories. Students who wish to petition for a reduction in the number of required rotations may submit a written request for review by the GEC. Incoming students who work full-time for a minimum of four weeks in the lab of a faculty member participating in the MHG Graduate Program may count that work as a research rotation. To request approval for summer work to count as a rotation, the student should submit a written request to the GEC.

Laboratory rotation (Research Rotation) credit hours are considered course hours by the Graduate School and contribute to the total of 60 credit hours that are required for graduation. Students should expect to spend approximately 3 hours per week per credit hour in the laboratory during a rotation. The rotation period ends when classes end at the beginning of the study period before exams. Students and faculty should discuss the work schedule of the student, the class time and course load. The specific issue of time off for studying for mid-term and final examinations should be addressed at the time the student is considering doing a rotation in the lab. Major departmental events such as the annual retreat are very important for the students and rotation demands should not compromise their ability to attend these activities.

The grade of Pass/Marginal Pass/Fail is given for a rotation. The students should discuss with the faculty how they will be evaluated and should meet to evaluate the student's progress during the rotation period at various points (for example 2 to 3 weeks after the rotation starts, after mid-term and at the end). One of the major purposes of the rotation is to permit students to explore various experimental systems and laboratory settings in order to better select a thesis advisor. If a faculty member is unable to take a student for the coming year for thesis research, the student should be advised of this situation.

Because the terms are only 8-10 weeks in length, the academic demands are high, and many of the students are inexperienced in laboratory work, much of the "education" of the rotation is likely to be introducing students to the overall goals of the laboratory's research and instruction in basic laboratory skills.

It is expected that the faculty will make no commitments or request a commitment from a student prior to the completion of three rotation periods. The students need the opportunity to explore various labs without the pressure of "losing out" for a position in a particular lab that has more than one student interested.

D. Seminars and Retreats

1. Faculty Research Presentations: In the first term, faculty will meet with students to briefly describe their research interests. This activity is not a course and no credit is received; nevertheless it is an integral part of the training program. It is a particularly valuable way for students to learn about research activities of the department and to select future rotation sponsors and potential thesis sponsors.

2. Departmental Seminars: Participation and attendance at the departmental seminars and retreats are an important part of graduate training. Student attendance is expected throughout this term as a graduate student and should be strongly encouraged by the faculty preceptor.

VII. TYPICAL PROGRAM IN MOLECULAR AND HUMAN GENETICS

First Term	Credit Hours
Organization of the Cell (required for regular track)	(2)
Molecular Methods (required for regular track)	(3)
Genetics A	(2)
Responsible Conduct of Research	(1)
Student Research Seminar	(1)
Introduction to Data Mining (required for BiGSB elective for regular track)	(2)
Research Rotation	(4)
 Second Term	
Genetics B	(2)
Method and Logic in Molecular Biology	(3)
Student Research Seminar	(1)
Cancer (elective)	(1)
Cell Division (elective)	(2)
Development (elective)	(2)
Research Rotation	(1-6)
 Third Term	
Gene Regulation	(3)
Mammalian Molecular Genetics (elective for BiGSB track)	(2)
Seminars in Molecular & Human Genetics	(1)
Student Research Seminar	(1)
Macromolecules Structure and Function (elective)	(3)
Neuroscience (elective)	(1)
Immunology (elective)	(1)
Practical Introduction to Programming for Scientists (elective)	(3)
Explorative Data Analysis	(2)
Research Rotation	(2-5)
 Fourth Term	
Human Genetics	(3)
Introduction to Biostatistics for Translational Researchers	(3)
Seminars in Molecular & Human Genetics	(1)

Student Research Seminar	(1)
Gene and Cell Therapy (elective)	(2)
Computer-Aided Discovery Methods (elective)	(3)
Concepts of Learning & Memory (elective)	(3)
Biology of Aging & Age Related Diseases (elective)	(3)
Research Design (elective)	(3)
Introduction to Medical Genetics	(3)
Research Rotation	(1-4)

Fifth Term

Seminars in Molecular & Human Genetics	(1)
Research Rotation	(11)

VIII. QUALIFYING EXAMINATION

Upon completion of the first year of study students will be evaluated on the basis of their academic performance and by completion of the Qualifying Examination. The format of this examination is the definition of a novel research problem and the development of a proposal to address the stated question and hypothesis. The significance, feasibility, and the relationship of the proposal to the literature will be important criteria for evaluation. The Qualifying Examination determines, in part, the student's eligibility for admission to candidacy for the Ph.D. degree. The examination is designed to test the student's basic knowledge of molecular biology and genetics, as well as assess creativity and rationality of research design.

The Qualifying Examination will be held near the end of Term 1 of the second year, unless the student petitions the GEC for a delay due, for example, to the need to make up courses that were not passed in year 1 or other extenuating circumstances. Students must take the qualifying examination by the end of their 2nd year of enrollment. Any exception must be approved by the Director of Graduate Studies and the Dean.

The Qualifying Examination Committee will consist of five (5) members; four are faculty (primary or secondary appointees) in the Department of Molecular and Human Genetics and one member is from outside the Department. The composition of the Qualifying Examination Committee will be formulated by the Director of the Qualifying Examination Committee in consultation with the Director of Graduate Studies. The student's advisor may not serve on the student's Qualifying Examination Committee, but is encouraged to attend the examination as an observer only.

The Qualifying Examination is comprised of four parts: 1) Preparation of one written abstract; 2) Preparation of a written proposal based on the abstract; 3) Oral presentation of the proposal; and 4) Oral defense of the proposal. Sample abstracts and proposals are available to students on the MHG web page. Note that effective 2013 the Qualifying Examination was changed from an "off-topic" format to an "in the field" format as described below. Consequently, the examples from prior to 2013 do not provide ideal guidance for the current format.

INSTRUCTIONS FOR THE STUDENT

"In-the-Field" format and PI involvement: Students will choose a Qualifying Exam topic that is in the field of their thesis research. The Specific Aims cannot be ones proposed previously or under consideration currently by their PI or members of their lab. The aims **can but do not necessarily** need to be aims the student will pursue for their thesis research, but must be relevant to the field. The proposal must be strongly rooted in genetics, include a hypothesis and be hypothesis driven. We encourage you to solicit the advice of your advisor and any other members of the scientific community. Nevertheless, it

MOLECULAR PHYSIOLOGY & BIOPHYSICS CURRICULUM

(30 hours didactic credit required)

REQUIRED COURSES (* = Didactic credit courses)

Term 1	Organization of the Cell * Responsible Conduct of Research/Ethics Seminar in MPB Research Rotation Cell Physiology *
Term 2	Human Physiology I * Grant Writing Year 2 Ethics Year 2 Seminar in MPB Research Rotation
Term 3	Human Physiology II * Ethics Year 3 Seminar in MPB Research Rotation
Term 4	Introduction to Biostatistics)* Transmembrane Signaling)* Seminar in MPB Research Rotation
Term 5	Research Rotation

Electives (choose at least 17 hours, to reach total of 30 **didactic** hours)

BIOPHYSICS and BIOENGINEERING

- Term 1 Molecular Methods
- Term 1 Fundamentals of Human Neuroimaging
- Term 1 Electrical Signaling in the Brain
- Term 1&2 Fundamentals of Human Neuroimaging
- Term 2&3 Functional Magnetic Resonance Imaging Lab
- Term 3 Macromolecules: Structure and Interactions
- Term 4 Structural Basis of Human Disease
- Term 4 Cellular Neurophysiology

(Rice courses 3 semester hours ~ 6 BCM credits each)

- BIOE 505 Optical Imaging
- BIOE 507 Systems Biology of Blood Vessels
- BIOE 512 Biophotonics Instrumentation
- BIOE 516 Mechanics, Transport, and Cellular Signaling
- BIOE 517 Instrumentation and Molecular Analysis
- BIOE 519 Biomaterials Synthesis
- BIOE 540 Introduction to Synthesis

METABOLISM

- Term 1 Molecular Methods
- Term 2 Cell Signaling
- Term 3 Gene Regulation
- Term 3 Macromolecules: Structure and Interactions
- Term 4 Structural Basis of Human Disease
- Term 4 Bioinformatics and Genomic Analysis
- Term 4 Regulation of Energy Homeostasis

- BIOE 540 Introduction to Systems Biology and Systems Biotechnology

CARDIOVASCULAR SCIENCES

- All terms: Seminar in Cardiovascular Sciences
- Term 1 Genetics A
- Term 2 Genetics B
- Term 3 Cell Division
- Term 3 Development
- Term 3 Gene Regulation
- Term 3 Neuroscience
- Term 4 Cardiovascular Physiology
- Term 5 Cardiovascular Disease and Pathology

NEURAL AND MUSCLE PHYSIOLOGY

- Term 1 Brain Cell Biology
- Term 1 Electrical Signaling in the Brain
- Term 1&2 Fundamentals of Human Neuroimaging
- Term 1&2 Theoretical Neuroscience: Cells, Circuits and Systems
- Term 2 Anatomy & Development of the Nervous System
- Term 2 Analyses of Neuronal Function
- Term 2 Introduction to MatLab for Neuroscience
- Term 3 Advanced Topics in Muscle Physiology
- Term 3 Advanced MatLab for Neuroscience
- Term 3&4 Functional Magnetic Resonance Imaging Lab
- Term 4 Cellular Neurophysiology
- Term 4 Neurobiology of Disease

PHYSIOLOGY OF CANCER

- Term 2 Cancer
- Term 2 Translational Cancer Biology
- Term 2 Cell Signaling
- Term 2 Cell Division
- Term 3 Immunology
- Term 3 Gene Regulation
- Term 4 Regulation of Energy Homeostasis

Physiology Recommended Course of Study

* Didactic Credits

Total Term Credits = 12

Biophysics and Bioengineering 1st Year

Term 1 Aug. – Oct.	Course #		Course Title	Instructor's Name
Required				
	GS-GS-501	*	Organization of the Cell	Pedersen/Sifers
	GS-GS-528		Responsible Conduct of Research/Ethics	Bertuch
	GS-PY-415	*	Cell Physiology	Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	Rice BIOE 516	* +	Mechanics, Transport, and Cellular Signaling	Raphael
		*	Electrical Signaling in the Brain	
	GS-GS-502	*	Molecular Methods	Weigel
Term 2 Oct. – Dec.	Course #		Course Title	Instructor's Name
Required				
	GS-PY-430	*	Human Physiology I	Horrigan/ Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	Rice BIOE 516	* (cont'd)	Mechanics, Transport, Cellular Signaling	Raphael
		*	Functional MRI Lab	
Term 3 Jan. – Mar.	Course #		Course Title	Instructor's Name
Required				
	GS-PY-431	*	Human Physiology II	Horrigan/ Poche`
	GS-GS-518	*	Macromolecules: Structure and Interaction	Prasad/Pedersen
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	GS-GS-509	*	Functional MRI Lab	
	Rice BIOE512	*	BioPhotonics Instrumentation	Tkaczyk

Physiology Recommended Course of Study

*** Didactic Credits**

Total Term Credits = 12

Term 4 Mar. - May	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-465		Transmembrane Signaling	Beeton
	GS-GE-407	*	Basic Biostatistics	Paylor
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
	Recommended			
			Structural Basis of Human Disease	
	GS-NE-464	*	Cellular Neurophysiology	Wu
	Rice BIOE512	*	BioPhotonics Instrumentation	Tkaczyk
Term 5 May - Jul.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-549		Laboratory Rotation	

Physiology Recommended Course of Study

* Didactic Credits

Total Term Credits = 12

Metabolism 1st Year

Term 1 Aug. – Oct.	Course #		Course Title	Instructor's Name
Required				
	GS-GS-501	*	Organization of the Cell	Pedersen/Sifers
	GS-GS-528		Responsible Conduct of Research/Ethics	Bertuch
	GS-PY-415	*	Cell Physiology	Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	BIOE 540	*	Introduction to Systems Biology and Systems Biotechnology	Bio. Dept. Faculty
	GS-GS-502	*	Molecular Methods	Gilbert/Highlander
Term 2 Oct. – Dec.	Course #		Course Title	Instructor's Name
Required				
	GS-PY-430	*	Human Physiology I	Horrigan/ Poche`
	GS-PY-415	*	Cell Physiology	Bayle
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	GS-CB-425	*	Cell Signaling	Weigel
	BIOE 540	*	Introduction to Systems Biology and Systems Biotechnology	Bio. Dept. Faculty
Term 3 Jan. – Mar.	Course #		Course Title	Instructor's Name
Required				
	GS-PY-431	*	Human Physiology II	Horrigan/ Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	GS-GS-509	*	Gene Regulation	Rosen
	GS-GS-518	*	Macromolecules: Structure & Interactions	Prasad/Pedersen
Term 4 Mar. - May	Course #		Course Title	Instructor's Name
Required				

Physiology Recommended Course of Study

*** Didactic Credits**

Total Term Credits = 12

	GS-PY-465		Transmembrane Signaling	Beeton
	GS-GE-407	*	Basic Biostatistics	Paylor
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
	Recommended			
		*	Regulation of Energy Homeostasis	Moses
		*	Adv. Top. Muscle Physiology	Rodney
			Structural Basis of Human Disease	Prasad
Term 5 May – Jul.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	

Physiology Recommended Course of Study

* Didactic Credits

Total Term Credits = 12

Physiology of Cancer 1st Year

Term 1 Aug. – Oct.	Course #		Course Title	Instructor's Name
	Required			
	GS-GS-501	*	Organization of the Cell	Pedersen/Sifers
	GS-GS-528		Responsible Conduct of Research/Ethics	Bertuch
	GS-PY-415	*	Cell Physiology	Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
	Recommended			
	GS-GS-503	*	Genetics A	Rosenberg/Kelley
	GS-GS-502	*	Molecular Methods	Gilbert/Highlander
Term 2 Oct. – Dec.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-430	*	Human Physiology I	Horrigan/ Poche`
	GS-PY-415	*	Cell Physiology	
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
	Recommended			
			Cell Division	
			Cancer	
	GS-MB-431	*	Translational Cancer Biology	Yustein/Marriot
	GS-GS-512	*	Immunology	Levitt
Term 3 Jan. – Mar.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-431	*	Human Physiology II	Horrigan/ Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
	Recommended			
	GS-GS-509	*	Gene Regulation	Rosen

Physiology Recommended Course of Study

*** Didactic Credits**

Total Term Credits = 12

Term 4 Mar. - May	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-465		Transmembrane Signaling	Beeton
	GS-GE-407	*	Basic Biostatistics	Paylor
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
	Recommended			
	GS-MV-457J	*	Introduction to Molecular Carcinogenesis	Li
	GS-CB-468	*	Regulation of Energy Homeostasis	Moses
Term 5 May – Jul.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-549		Laboratory Rotation	
	Recommended			
	GS-PG-413		Drug Discovery: From Bench to Bedside	

Physiology Recommended Course of Study

* Didactic Credits

Total Term Credits = 12

Neural and Muscle Physiology 1st Year

Term 1 Aug. – Oct.	Course #		Course Title	Instructor's Name
Required				
	GS-GS-501	*	Organization of the Cell	Pedersen/Sifers
	GS-GS-528		Responsible Conduct of Research/Ethic	Bertuch
	GS-PY-415	*	Cell Physiology	Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	GS-NE-400	*	Fundamentals of Human NeuroImaging	Ress
Term 2 Oct. – Dec.	Course #		Course Title	Instructor's Name
Required				
	GS-PY-430	*	Human Physiology I	Horrigan/ Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
		*	Immunology	
	GS-NE-400	*	Fundamentals of Human NeuroImaging	Ress
	GS-NE-430	*	Anatomy and Development of the Nervous system	Rasband
Term 3 Jan. – Mar.	Course #		Course Title	Instructor's Name
Required				
	GS-PY-431	*	Human Physiology II	Horrigan/ Poche`
	GS-PY-466	1	Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
Recommended				
	GS-PY-415	*	Advanced Topics in Muscle Physiology	Rodney
	GS-GS-511	*	Neuroscience	Jankowski
	GS-GS-512	*	Immunology	Levitt
	GS-NE441	*	Genetics for Neuroscience	Deneen
Term 4 Mar. - May	Course #		Course Title	Instructor's Name

Physiology Recommended Course of Study

*** Didactic Credits**

Total Term Credits = 12

	Required			
	GS-PY-465		Transmembrane Signaling	Beeton
	GS-GE-407	*	Basic Biostatistics	Paylor
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-549		Laboratory Rotation	
	Recommended			
	GS-CS-411	*	Cardiovascular Physiology	Wehrens / Li
GS-NE-462J	*	Concepts of Learning and Memory	Costa-Mattioli/Ji	
Term 5 May – Jul.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-549		Laboratory Rotation	
	GS-CS-412	*	Cardiovascular Disease and Pathology	Martin/Wang

Physiology Recommended Course of Study

* Didactic Credits

Total Term Credits = 12

Cardiovascular Sciences

1st Year

Term 1 Aug. – Oct.	Course #		Course Title	Instructor's Name
	Required			
	GS-GS-501	*	Organization of the Cell	Pedersen/Sifers
	GS-GS-528		Responsible Conduct of Research/Ethics	Bertuch
	GS-PY-415	*	Cell Physiology	Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-CS-549		Laboratory Rotation	
	Recommended			
	GS-GS-503	*	Genetics A	Rosenberg/Kelley
Term 2 Oct. – Dec.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-430	*	Human Physiology I	Horrigan/ Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-CS-549		Laboratory Rotation	
	Recommended			
	GS-GS-504	*	Genetics B	Zhou
	GS-GS-505	*	Cell Division	Sazer
	GS-GS-506	*	Development	S. Lee
Term 3 Jan. – Mar.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-431	*	Human Physiology II	Horrigan/ Poche`
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-CS-549		Laboratory Rotation	
	Recommended			
	GS-GS-518	*	Macromolecules: Structure and Function	Prasad/Pedersen
	GS-GS-509	*	Gene Regulation	Rosen
	GS-GS-511	*	Neuroscience	Jankowski
Term 4 Mar. - May	Course #		Course Title	Instructor's Name
	Required			
	GS-CS-411	*	Cardiovascular Physiology	Wehrens/Li

Physiology Recommended Course of Study

*** Didactic Credits**

Total Term Credits = 12

	GS-GE-407	*	Basic Biostatistics	Paylor
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-CS-549		Laboratory Rotation	
	GS-PY-465		Transmembrane Signaling	Beeton
	Recommended			
Term 5 May – Jul.	Course #		Course Title	Instructor's Name
	Required			
	GS-CS-412	*	Cardiovascular Disease and Pathology	Martin/Wang
	GS-CS-549		Laboratory Rotation	

Recommended Course of Study
2nd Year All Areas of Emphasis

Term 1 Aug. – Oct.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS-PY-435		Special Projects	
Term 2 Oct. – Dec.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-413		Grand Writing Skills	Lagor/Larina
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS- PY -435		Special Projects	
Term 3 Jan. – Mar.	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS- PY -435		Special Projects	
Term 4 Mar. - May	Course #		Course Title	Instructor's Name
	Required			
	GS-PY-466		Seminar in Molecular Physiology	Larina
	GS- PY -435		Special Projects	
Term 5 May – Jul.	Course #		Course Title	Instructor's Name
	Required			
	GS- PY-435		Special Projects	

APPENDIX A

Areas of Competence Department of Molecular Virology and Microbiology

AREA OF COMPETENCE	REQUIRED COURSE TO FULFILL COMPETENCE	ELECTIVE COURSES THAT CAN SATISFY COMPETENCE*
Fundamental Microbiology	GS-MV-401 General Virology GS-MV-417 Bacterial Structure and Function	
Basic Immunology	GS-IM-423 Immunology I	
Biochemistry	GS-GS-518 Macromolecules: Structure and Interactions	
Molecular Biology	GS-GS-501 Organization of the Cell GS-GS-502 Molecular Methods GS-GS-502 Genetics A GS-GS-509 Gene Regulation	GS-GS-505 Cell Division GS-GS-523 Method & Logic in Molecular Biology
<u>Advanced Virology</u>		
Tumor Virology		GS-CB-457 Intro to Molecular Carcinogenesis
Viral Replication & Gene Expression		Cross-Registration
Viral Genetics		GS-MV-411 Genetics of Animal Viruses
Viral Pathogenesis		Cross-Registration
Viral Epidemiology		Cross-Registration
Viral Methods/Techniques		GS-GS-521 Biostatistics GS-GS-522 Research Design
<u>Advanced Microbiology</u>		
Microbial Replication & Gene Expression	GS-GS-417 Bacterial Structure and Function	
Microbial Genetics		Cross-Registration
Microbial Pathogenesis		GS-MV-413 Concepts of Microbial Pathogenesis
Microbial Epidemiology		Cross-Registration
Microbial Methods/Techniques		GS-GS-521 Biostatistics GS-GS-422 Research Design

* Other electives can provide content for areas of competence. Those electives shown are those most frequently taken by MVM students.

APPENDIX B

Standard Graduate Curriculum Department of Molecular Virology and Microbiology

NUMBER	COURSE	REQUIRED OR ELECTIVE	YEAR OFFERED	CREDITS
TERM 1 (AUGUST – OCTOBER)				
GS-GS-501	Organization of the Cell	Required	Every	2
GS-GS-502	Molecular Methods	Required	Every	3
GS-GS-503	Genetics A	Required	Every	2
GS-GS-528	Ethics – Year 1	Required	Every	1
GS-MV-549	Research Rotation	Required	Every	Variable
GS-MV-410	Literature Reports	Required	Every	1
TERM 2 (OCTOBER – DECEMBER)				
GS-MV-401	General Virology	Required	Every	4
GS-MV-417	Bacterial Structure and Function	Required	Every	3
GS-IM-423	Immunology I	Required	Every	3
GS-GS-515	Ethics – Year 2	Required	Every	0.5
GS-MV-549	Research Rotation	Required	Every	Variable
GS-MV-410	Literature Reports	Required	Every	1
GS-MV-466	Seminar	Required	Every	1
GS-GS-505	Cell Division	Elective	Every	2
TERM 3 (JANUARY – MARCH)				
GS-GS-518	Macromolecules: Structure & Interactions	Required	Every	3
GS-GS-509	Gene Regulation	Required	Every	3
GS-GS-516	Ethics – Year 3	Required	Every	0.5
GS-GS-517	Ethics – Year 4	Required	Every	0.5
GS-MV-549	Research Rotation	Required	Every	Variable
GS-MV-410	Literature Reports	Required	Every	1
GS-MV-466	Seminar	Required	Every	1
TERM 4 (MARCH – MAY)				
GS-MV-549	Research Rotation	Required	Every	Variable
GS-MV-410	Literature Reports	Required	Every	1
GS-MV-466	Seminar	Required	Every	1
GS-MV-411	Genetics of Animal Viruses	Elective	Odd	3
GS-CB-457	Introduction to Molecular Carcinogenesis	Elective	Every	3
GS-MV-413	Concepts in Microbial Pathogenesis	Elective	Even	4
TERM 5 (MAY – JULY)				
GS-MV-549	Research Rotation	Elective	Every	Variable
GS-GS-521	Introduction to Biostatistics	Elective	Every	2

In general all of the required courses are taken during the first year of residence. Electives that do not fit in year one are generally completed in the second year.

Neuroscience

2018 Graduate Program Curriculum

	Course #	Course Title	Credits	Course Director
REQUIRED in YEAR 1:				
Term 1				
	GS-NE-448	Electrical Signaling in the Brain	3 (D)	Paul Pfaffinger
	GS-NE-449	Neuroscience Lab I	1	Paul Pfaffinger
	GS-NE-459	Brain Cell Biology & Development	3 (D)	Matt Rasband
	GS-GS-528	Responsible Conduct of Research - Year 1	1	Alison Bertuch
Term 2				
	GS-NE-431	Analyses of Neuronal Functions (Synaptic Transmission and Plasticity)	2 (D)	Mingshan Xue
	GS-NE-471	Anatomy of the Nervous System	2 (D)	David Shine
	GS-NE-450	Neuroscience Lab II	1	Russell Ray
	GS-NE-474	Neuroscience Seminar Journal Club	1	Javier Medina / Jeannie Chin-Medina
Term 3				
	GS-NE-455	Neural Systems I (Neuroscience of Perception)	3 (D)	Jeff Yau
	GS-NE-441	Genetics for Neuroscience	2 (D)	Ron Parchem
	GS-NE-474	Neuroscience Seminar Journal Club	1	Javier Medina / Jeannie Chin-Medina
Term 4				
	GS-NE-456	Neural Systems II (Cognition and Action)	3 (D)	Roy Sillitoe
	GS-NE-475	Core Concepts in Computational Neuroscience <i>*A different computational course may be substituted upon Director's approval.</i>	1 (D)	Ankit Patel
	GS-NE-422	Neurobiology of Disease	2 (D)	Jeff Noebels
	GS-NE-474	Neuroscience Seminar Journal Club	1	Javier Medina / Jeannie Chin-Medina
REQUIRED in YEAR 2:				
Term 2				
	GS-NE-447	Preparing for your Neuroscience Qualifying Exam	2	Joanna Jankowsky / Kim Tolias
	GS-GS-529	Responsible Conduct of Research - Year 2	0.5	Alison Bertuch
	GS-NE-474	Neuroscience Seminar Journal Club	1	Javier Medina / Jeannie Chin-Medina
Term 3				
	GS-NE-474	Neuroscience Seminar Journal Club	1	Javier Medina / Jeannie Chin-Medina
Term 4				
	GS-GS-532	Biostatistics for Biomedical and Translational Researchers <i>*A different quantitative course may be substituted upon Director's approval.</i>	3 (D)	Susan Hilsenbeck / Charles Minard
	GS-NE-474	Neuroscience Seminar Journal Club	1	Javier Medina / Jeannie Chin-Medina

REQUIRED in YEARS 3-4:

Year 3, Term 3: Responsible Conduct of Research, GS-GS-530

Year 4, Term 4: Responsible Conduct of Research, GS-GS-531

ELECTIVES offered by the GSBS core service and by other BCM departments:

Students must complete 30 hours of didactic course work to be eligible for admission to candidacy. All GSBS core courses and most courses offered through another BCM department are open to Neuroscience students, provided they meet all stated pre-requisites.

ELECTIVES offered at Rice:

BCM GSBS students can cross-register for Rice courses provided four conditions are met:

1. The student has checked with the course director to ensure that the class will be offered that year. More courses are listed than are offered each year.
2. The thesis advisor must agree that the class is appropriate for the student's Ph.D. studies.
3. The Rice listing for the course must indicate that it has a graduate level designation (level 500 or above).
4. The course director must agree to accept the student into the class (provided there is space and our student meets the class requirements)

In order to enroll for the Rice class, BCM students must fill out an inter-institutional course registration form available on the Graduate School website under "Forms." After completing the Rice course with a grade of B or above, BCM students can then petition the GSBS promotions committee to obtain transfer credit towards their BCM degree.

MD/PhD students in the Neuroscience Program may transfer credit hours from Medical School to fulfill the following Neuroscience requirements:

- Neurobiology of Disease (If this course was taken as an elective in Medical School) 2(D)
- Anatomy of the Nervous System 2(D)
- Electives

Program Director: Matt Rasband, rasband@bcm.edu

Associate Director: Joanna Jankowsky, jankowsk@bcm.edu

Pharmacology

Curriculum

Required Courses – Students should complete the required courses and a minimum of 4 lab rotations by the end of the fifth term of the first year.

FIRST TERM

MOLECULAR METHODS (3 HRS)
ORGANIZATION OF THE CELL (2 HRS)
RESPONSIBLE CONDUCT OF RESEARCH (1 HR)
ROTATION (VARIABLE HRS)

SECOND TERM

CANCER (1 HR)
IMMUNOLOGY (3 HR)
ROTATION (VARIABLE HRS)

THIRD TERM

GENE REGULATION (3 HRS)
MACROMOLECULES: STRUCTURE AND INTERACTIONS (3 HRS)
ROTATION (VARIABLE HRS)

FOURTH TERM

GENERAL PHARMACOLOGY (4 HRS)
RESEARCH DESIGN (3 HRS)
ROTATION (VARIABLE HRS)

FIFTH TERM

DRUG DISCOVERY (2 HRS)
CHEMICAL BIOLOGY (2 HRS)
ROTATION (VARIABLE HRS)

Elective Courses - Students are required to complete a minimum of 60 term hours of course work, of which 30 term hours must be in courses that either have a letter grade assignment or are specifically designated by the Graduate School as “approved pass/fail” graded courses (e.g. Method and Logic in Molecular Biology and Research Design). Selection of elective courses will be made in consultation with the Pharmacology Graduate Program Committee.

The following courses are approved by the Pharmacology Graduate Program Committee as electives:

FIRST TERM

CELLULAR AND MOLECULAR BIOLOGY OF DISEASE (2 HRS)
COMPUTATIONAL MOLECULAR BIOPHYSICS & STRUCTURAL BIOLOGY (6 HRS)
METHOD & LOGIC IN MOLECULAR BIOLOGY (3 HRS)
GENETICS A (2 HRS)

SECOND TERM

CELL DIVISION (2 HRS)
GENETICS B (2 HRS)

THIRD TERM

COMPUTER-AIDED DISCOVERY METHODS (2 HRS)

FOURTH TERM

BIOINFORMATICS & GENOMIC ANALYSIS (3 HRS)

BIostatISTICS FOR TRANSLATIONAL RESEARCHERS (3 HRS)

CELLULAR SIGNALING (3 HRS)

INTRODUCTION TO MOLECULAR CARCINOGENESIS (3 HRS)

INTRODUCTION TO STATISTICAL COMPUTING & MODELING (3 HRS)

PRACTICAL INTRODUCTION TO PROGRAMMING FOR SCIENTISTS (3 HRS)

FIFTH TERM

PROTEOMICS & FUNCTIONAL GENOMICS (3 HRS)

Faculty Research Presentations – Each faculty member is given the opportunity to make a short presentation to the first year students describing their overall research program. These are informal talks and should last only around 20 minutes. Two faculty members will present twice a week for during the First Term. Attendance is mandatory for first year students.

Research Rotations - The primary goals for the research rotations are twofold: First, rotations allow new students to become familiar with research conducted in the laboratories of Pharmacology faculty members. Second, rotations allow students to familiarize themselves with laboratory procedures, approaches and a variety of research projects.

The student will select their Major Thesis Advisor primarily based on these rotations. All students are required by the department to complete four rotations in the first four terms. Students will select laboratories of professors with primary or secondary appointment in the Department of Pharmacology for rotation. At the fifth term, students will either choose their lab of study for their thesis work or participate in one more rotation.

Research Rotation credit hours are considered course hours (370-549) by the GSBS and contribute to the total of 60 credit hours that are required for graduation. For every credit hour of laboratory rotation for which a student is enrolled, they are expected to work a minimum of 3 hours per week in the laboratory. Some rotations may require more effort for limited periods of time (evenings or weekends). However, students are NOT expected to be full-time laboratory personnel.

In order to make the best of the research rotation for both the student and the faculty, they should meet before the rotation begins. If the faculty member will not be the direct supervisor for experimentation, the laboratory supervisor must be present at this meeting and understand the guidelines and requirements for the student's lab rotation. Both the faculty member and student should discuss and sign the Goals for Research Rotation Form and submit it to the PGP Director. The form will go into the student's program file. The form is due by the end of the first week of rotation.

The rotation period ends when classes end at the beginning of the study period preceding exams. At that time, the student and the faculty member should meet again. In consultation

with the faculty member, the student is to write a one-page description of the rotation. This will be attached to the Evaluation of Research Rotation Form (from PGP) which is filled out by the faculty member and discussed with the student. Both the faculty mentor and student sign the form indicating that they have discussed it. The form should be submitted to the department by the end of the corresponding term's exam week. The grade of Pass/Fail is given for a rotation by the faculty mentor.

Research Hours - All students must register for some form of research throughout their graduate career. First year students who are rotating through labs should register for Research Rotation (370-549). Students who have joined a laboratory, but have not yet been admitted to candidacy should register for Special Projects (370-435). Students who have been admitted to candidacy should register for Dissertation Research (370-550). The total number of hours of research and course credits each term should be at least 12. If the student is not taking courses during a term, they will register for 12 research hours.

Journal Club – Students will participate in a monthly journal club, led by faculty members. They will be notified of the dates and time by the Graduate Program office.

Student Presentation – All students who have passed their Qualifying Exams are required to make a formal presentation each academic year. These should be oral talks, not posters. Proof should be given to the Pharmacology Program Office. If the student is nearing the end of the academic year without having presented a talk, then they will be scheduled to do a departmental talk before the end of the year.

Departmental Retreat – The Department of Pharmacology participates in an annual retreat with the Department of Biochemistry and Molecular Biology. The research efforts of the faculty, post-doctoral researchers and graduate students are discussed at the retreat. Students are expected to participate in the departmental retreat. First year graduate student participation will be funded by the department.

Qualifying Examination

The purpose of the qualifying examination is to assess the student's eligibility for admission to candidacy for the Ph.D. degree. Eligibility is determined by examination of the student's capacity for originality and scientific approach to research as well as his/her knowledge of the core curriculum of Pharmacology. All students must complete the Qualifying Examination processes by the end of their second year of enrollment.

Abstracts – Each student is expected to submit one abstract to the Qualifying Examination Committee by August 1 of their second year. The abstract should cover a topic that the student is considering for development into a dissertation project. Students should submit an electronic document containing the following to the Program office:

1. Background and Significance – Introduce the proposed research problem and highlight the gap in the field that the research proposal would fill. ~ 1 page
2. Hypothesis to be Tested – Clearly define the specific hypothesis that the proposal will address. ~ 1 paragraph
3. Specific Aims – List the specific question that the proposal will address and basic statement of the experimental procedures you plan to utilize to pursue answer to the hypothesis. ~ 3 to 5 Specific Aims

Quantitative and Computational Biology 2018-19

Curriculum is designed to meet the specific needs of students with B.S. degrees in biology, math, physics, chemistry, computer science, or engineering. The overall philosophy of the course requirements is to prepare the students in both the specialized areas of research and cell and molecular biology. All classes must be completed with a grade of B or better.

Note: Courses at Baylor College of Medicine (BCM) are scheduled in eight-week terms. Courses at the University of Houston (UH), Rice University (Rice), and The University of Texas – Houston Health Science Center (UTHSC) are based on 16-week semesters.

- Advanced Topics in SCB (GS-SB-430) Terms 1, 2, 4 - Cr: 1 each term: Fridays, Noon-1pm
- Method and Logic (GS-GS-523) Term 2 – Cr: 3: Tuesdays/Thursdays, 10:00-Noon
- Molecular Biophysics: Methods and Principles (GS-SB-408) Fall Semester at Rice – Cr: 3 each Terms 1 & 2
- Current Topics in Computational Biomedicine (GS-SB-407) Terms 1-4- Cr: 1 ea semester: Wednesdays, 12-1pm
- Computational Mathematics for Quantitative Biomedicine (GS-SB-401) Term 1-2- Cr: 8: Tuesdays/Thursdays, Noon-2pm
- Responsible Conduct of Research – Year 1 (GS-GS-528), Term 1 - Cr: 1: See GSBS website for schedule
- Structural Basis of Human Diseases (GS-SB-423J) Term 4 - Cr: 1: Thursdays, Noon-1pm
- Research Design (GS-GS-522), Term 4 – Cr: 3: Tuesdays, 1:15-4pm
- A computational course at Rice or UH (upon Director's approval) – 1 semester
- Electives:
 - Any course in the Graduate School Service Curriculum
 - Electron Cryomicroscopy for Molecules and Cells (GS-SB-410), Term 4 – Cr: 3 (taught odd years only): Thursdays, 9-10:30am
 - Advanced X-ray Crystallography (GS-SB-403), Term 4 - Cr: 3 (taught even years only): Mondays/Wednesdays, 2-4pm
 - Practical Introduction to Programming (GS-SB-406), Term 3 – Cr: 3: Mondays/Wednesdays, 10:30-Noon
 - Computer-Aided Discovery Methods (GS-SB-405), Term 3– Cr: 2: Wednesdays/Fridays, 10:00-Noon
 - Courses offered at Rice, UH, or UTH as approved by the Directors (must be 500 level or above)

The following is an example of coursework for a first-year student:

TERM 1 Advanced Topics in SCB (GS-SB-430)
Responsible Conduct of Research – Year 1 (GS-GS-528)
Molecular Biophysics: Methods & Principles (GS-SB-408)
Current Topics in Computational Biomedicine (GS-SB-407)
Research Rotation (GS-SB-549)
Computational Mathematics for Quantitative Biomedicine (GS-SB-401)
1 or 2 Electives

TERM 2 Advanced Topics in SCB (GS-SB-430)
Computational Mathematics for Quantitative Biomedicine (GS-SB-401)
Method and Logic (GS-GS-523)
Molecular Biophysics: Methods & Principles (GS-SB-408)
Current Topics in Computational Biomedicine (GS-SB-407)
Research Rotation (GS-SB-549)
1 or 2 Electives

TERM 3 Current Topics in Computational Biomedicine (GS-SB-407)
Research Rotation (GS-SB-549)
1 or 2 Electives

TERM 4 Advanced Topics in SCB (GS-SB-430)
Research Design (GS-GS-522)
Structural Basis of Human Diseases (GS-SB-423J)
Current Topics in Computational Biomedicine (GS-SB-407)
Research Rotation (GS-SB-549)
Elective

TERM 5 Research Rotation (GS-SB-549)
Elective

Translational Biology and Molecular Medicine

TBMM Standard Graduate Curriculum – Year 1

The academic calendar for the Program in Translational Biology and Molecular Medicine is divided into five terms of nine weeks each. In the first year, each term is followed by a one-week break. Course work is required in the following subjects:

- Molecular Methods
- Genetics A and B
- Human Physiology I & II
- Immunology
- Gene Regulation
- Organization of the Cell
- Method & Logic of Translational Biology
- Pathophysiology & Mechanisms of Human Disease
- Animal Models of Human Disease
- Introductory Biostatistics for Translational Research
- Cells Tissues & Organs
- Ethics, Conduct & Practical Aspects of Clinical Research

First year students also participate in laboratory rotations and the Bench-to-Bedside journal club. In general, all required courses are taken in the first year of residence.

TBMM Graduate Curriculum - Year 2 and above

In the 2nd year of the TBMM program, students begin their **Thesis Research Projects**, engage in **Leadership training** and work on their **Clinical Projects**. **Clinical projects** continue in year 3, for a total of ten terms. The goal of the Clinical Projects, which are focused on the area of each student's thesis project, is to provide students with direct observation of clinical medicine in practice in an in-patient or out-patient setting, and with practical knowledge regarding the methodologies by which patient encounters are systematically transformed into useful research data. Typically the mentor for this rotation is the student's clinical co-mentor. Clinical projects include: exposure to clinical medicine, attendance at clinical meetings such as diagnostic consensus conferences or clinical research meetings and exposure to at least one clinical research project. To begin clinical projects, all students are required to complete a yearly background check administered through BCM. This allows the program to establish medical malpractice insurance to our students to protect them if legal concerns arise while participating in clinical projects.

In general, all the required courses are taken in the first year of residence. Electives that do not fit in year one are generally completed in the second year.

In addition, TBMM students are required to complete BCM-required human research subjects (CITI) training and animal training

Human

“Biomedical Research – Basic/Refresher, Basic Course”

- a. Complete The Integrity Assurance Statement before beginning the course
- b. Belmont Report and CITI Course Introduction
- c. History and Ethical Principles
- d. Basic Institutional Review Board (IRB) Regulations and Review Process
- e. Informed Consent
- f. Social and Behavioral Research for Biomedical Researchers
- g. Records-Based Research
- h. Genetic Research in Human Populations
- i. Research With Protected Populations - Vulnerable Subjects: An Overview
- j. FDA-Regulated Research
- k. Conflicts of Interest in Research Involving Human Subjects
- l. The IRB Member Module - "What Every New IRB Member Needs to Know"
- m. Baylor College of Medicine

Animal

- “CCM Mandates and Guidelines”
 - a. Guide to the Care and Use of Laboratory Animals
 - b. Public Health Service policy on humane care and use of laboratory animals
- “BCM USDA Covered Species: Mandates and Guidelines”
 - a. Animal Welfare Act regulations
 - b. Public Health Service policy on humane care and use of laboratory animals
 - c. Pain recognition and alleviation in laboratory animals