

# DEPARTMENT OF PHYSIOLOGY AND BIOPHYSICS

Room E-524, School of Medicine  
<http://physiology.case.edu/>  
 Phone: 216.368.2084  
 Walter F. Boron, MD, PhD, Chair  
[walter.boron@case.edu](mailto:walter.boron@case.edu)

Bart Jarmusch ([bj2@case.edu](mailto:bj2@case.edu)), Manager of Graduate Education

The Department of Physiology and Biophysics at Case is a multidisciplinary department that takes great pride in its history of conducting research and training graduate students. The department includes 20 Primary and 33 Secondary faculty members, more than 25 post-doctoral associates, and over 300 full-time PhD, MD/PhD, and Master of Science degree students. The training programs are designed to provide a mentored training environment that maximizes faculty-student interaction.

As outlined below, the department offers PhD, MD/PhD and Master of Science degrees. These programs are tailored to prepare students for successful careers in biomedical, pharmaceutical and industrial research. The department offers multiple graduate-level programs, each of which uses state-of-the-art molecular, cell biology, and biophysical approaches to study physiological questions at a variety of different organizational levels. The goal is to provide an outstanding training opportunity. The major goals of the PhD and Tech Masters programs are to provide students with a broad knowledge base in organ systems and integrated physiology and in-depth expertise and outstanding research potential in the fields of cellular and molecular physiology and molecular and cellular biophysics. These goals are accomplished using a series of foundation and advanced topic courses, skill development courses, laboratory rotations and thesis research. The MS in Medical Physiology program is a post-baccalaureate program designed to help students prepare for admission to medical, dental, pharmacy, or veterinary school or for opportunities to work in the biotechnology industry.

## Masters Degrees

The Master's Program in Medical Physiology is designed for students with at least a bachelor's degree in a chemical, physical, or biological science who are seeking advanced training in the physiological sciences, typically in preparation for admission to a professional medical program (e.g. Medical School, Dental School). The program is flexible in duration. It can take as little as 1 year (2 semesters, 9 months) to complete the required 30 credit hours of course work. However, students who wish to decompress the program can take 14 months or more to complete the requirements. Core courses and flexible electives allow students to focus their work in key areas of medical physiology, including Anatomy, Biochemistry, or Pharmacology. Graduates of the Medical Physiology Master's Program also can pursue careers in basic and clinical research, research administration, teaching or management in academia, the pharmaceutical and biotechnology industries, private research institutions, government science or regulatory agencies, or medicine and health care.

## MS Medical Physiology - Type B Non-Thesis Option

First Year	Units	
	Fall	Spring
Medical Physiology I (PHOL 481)	6	
Translational Physiology I (PHOL 483)	3	
Elective	6	
Physiology and Biophysics Department Seminar for Medical Physiology Students (PHOL 498C)	1	
Medical Physiology II (PHOL 482)		6
Translational Physiology II (PHOL 484)		3
Independent Study (PHOL 451)		1 - 18
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)		1
Elective		3
Physiology MSMP Seminar B (Spring Semester) (PHOL 498D)		1
Year Total:	16	15-32
Total Units in Sequence:		31-48

## MS Physiology - Type A Thesis Option

The Department of Physiology and Biophysics encourages research staff members to expand their critical research knowledge and skills by enrolling in our Master's of Science in Physiology and Biophysics program. This Tech Master's Program, is specifically designed for staff working full time. Each employer has their own policy on allowing staff to take classes and enroll in graduate programs. CWRU's policy is to allow staff, with their supervisor's permission, to take up to 6 credit hours per term, with tuition being covered by CWRU as part of the employee benefit package. Staff are expected to make up the time they spend in class during the day after hours.

First Year	Units	
	Fall	Spring
Conversations on Protein Structure and Function (PHOL 456)	2	
Laboratory Research Rotation (PHOL 505)	1	
Membrane Physiology (PHOL 468)	3	
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1	
Cell Signaling (PHOL 466)		3
Physiology of Organ Systems (PHOL 480)		4
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)		1
Laboratory Research Rotation (PHOL 505)		1
Elective		3
Physiology Seminar B (Spring Semester) (PHOL 498B)		1
Year Total:	7	13
Total Units in Sequence:		20

## MD/MS Biomedical Investigation - Physiology Track

This track offers training in physiology and biomedical laboratory technology, including emphasis on mentored independent research

training which includes both laboratory experience and formal course work in modern laboratory methodology and instrumentation.

**Students in Physiology and Biotechnology track must complete:**

PHOL 498A	Physiology and Biophysics Departmental Seminar	1
PHOL 498B	Physiology Seminar B (Spring Semester)	1
PHOL 601	Research	1 - 18
IBIS 600	Exam in Biomedical Investigation	0

**And 9 credits from the following course list:**

PHOL 456	Conversations on Protein Structure and Function	2
PHOL 466	Cell Signaling	3
PHOL 468	Membrane Physiology	3
PHOL 480	Physiology of Organ Systems	4
PHOL 530	Technology in Physiological Sciences	3

## PhD in Physiology and Biophysics

The Physiology and Biophysics Graduate Program provides comprehensive training leading to the PhD degree and MD/PhD degrees. This program has three tracks of study with emphasis on *Cell and Molecular Physiology*, *Structural Biology and Biophysics*, and *Organ Systems Physiology*. Admissions to the Physiology and Biophysics program may be obtained in the integrated Biomedical Sciences Training Program (<http://casemed.case.edu/bsttp>), by direct admission to the department or via the MSTP (<http://mstp.case.edu/default.asp>) program.

To earn a PhD in Physiology and Biophysics, a student must complete rotations in at least three laboratories followed by selection of a research advisor, and complete Core and Elective coursework including responsible conduct of research as described in the course of study, below. Students who previously completed relevant coursework, for example with a MS, may petition to complete alternative courses. Each graduate program follows the overall regulations established and described in CWRU Graduate Studies and documented to the Regents of the State of Ohio. Completion of the PhD degree will require 36 hours of coursework (24 hours of which are graded) and 18 hours of PHOL 701 Dissertation Ph.D..

In addition, each student must successfully complete a qualifier examination for advancement to candidacy in the form of a short grant proposal with oral defense. The qualifier is generally completed in the summer after year two. During the dissertation period, students are expected to meet twice a year with the thesis committee, present seminars in the department, and fulfill journal publication requirements. At the completion of the program, successful defense of a doctoral dissertation is required. Throughout the doctoral training, students are expected to be enthusiastic participants in seminars, journal clubs, and research meetings in the lab and program.

### Plan of Study for PhD in Cell and Molecular Physiology \*

§ Please also see Graduate Studies Academic Requirements for Doctoral Degrees (<http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements>)

First Year	Units		
	Fall	Spring	Summer
Cell Biology I (CBIO 453)	3		
Membrane Physiology (PHOL 468)	3		
Laboratory Research Rotation (PHOL 505)	1		
Conversations on Protein Structure and Function (PHOL 456)	2		
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1		
Laboratory Research Rotation (PHOL 505)		1	
Physiology of Organ Systems (PHOL 480)		4	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1	
Laboratory Research Rotation (PHOL 505)		1	
Cell Signaling (PHOL 466)		3	
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)			1
Year Total:	10	10	1

Second Year	Units	
	Fall	Spring
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1	
Research (PHOL 601)	1-9	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1
Research (PHOL 601)		1-9
Year Total:	2-10	2-10

Third Year	Units	
	Fall	Spring
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1	
Dissertation Ph.D. (PHOL 701)	1-9	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1
Dissertation Ph.D. (PHOL 701)		1-9
Year Total:	2-10	2-10

Total Units in Sequence: 29-61

\* After passing qualifying exam - full-time thesis research (701) - 18 total credit hours total

### Plan of Study for PhD in Structural Biology and Biophysics \*

First Year	Units		
	Fall	Spring	Summer
Cell Biology I (CBIO 453)	3		

Physiology and Biophysics Departmental Seminar (PHOL 498A)	1		
Conversations on Protein Structure and Function (PHOL 456)	2		
Membrane Physiology (PHOL 468)	3		
Protein Biophysics (PHOL 475)		3	
(PHOL 476)			
Elective		3	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1	
Laboratory Research Rotation (PHOL 505)		1	
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)			1
Year Total:	9	8	1

Second Year	Units	
	Fall	Spring
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1	
Research (PHOL 601)	1-9	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1
Research (PHOL 601)		1-9
Year Total:	2-10	2-10

Third Year	Units	
	Fall	Spring
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1	
Dissertation Ph.D. (PHOL 701)	1-9	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1
Dissertation Ph.D. (PHOL 701)		1-9
Year Total:	2-10	2-10

Total Units in Sequence: 26-58

\* After passing qualifying exam - full-time thesis research (701) - 18 total credit hours total

## Program of Study for PhD in Organ Systems and Integrated Physiology \*

First Year	Units		
	Fall	Spring	Summer
Cell Biology I (CBIO 453)	3		
Conversations on Protein Structure and Function (PHOL 456)	2		
Membrane Physiology (PHOL 468)	3		
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1		
Laboratory Research Rotation (PHOL 505)	1		

Physiology of Organ Systems (PHOL 480)	4		
Physiology Seminar B (Spring Semester) (PHOL 498B)		1	
Laboratory Research Rotation (PHOL 505)		1	
Cardiovascular Physiology (PHOL 514)		3	
Cardio-Respiratory Physiology (PHOL 519)		3	
On Being a Professional Scientist: The Responsible Conduct of Research (IBMS 500)			1
Year Total:	10	12	1

Second Year	Units	
	Fall	Spring
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1	
Research (PHOL 601)	1-9	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1
Research (PHOL 601)		1-9
Year Total:	2-10	2-10

Third Year	Units	
	Fall	Spring
Physiology and Biophysics Departmental Seminar (PHOL 498A)	1	
Dissertation Ph.D. (PHOL 701)	1-9	
Physiology Seminar B (Spring Semester) (PHOL 498B)		1
Dissertation Ph.D. (PHOL 701)		1-9
Year Total:	2-10	2-10

Total Units in Sequence: 31-63

\* After passing qualifying exam - full-time thesis research (701) - 18 total credit hours total

## Courses

### PHOL 351. Independent Study. 1 - 6 Units.

This course is a guided program of study in physiology textbooks, reviews, and original articles. Guided laboratory projects to reproduce and extend classical physiological experiments are offered to the undergraduate science major. This course is being offered in conjunction with the Graduate level course PHOL 451. Students are required to consult with the faculty member whose work they have interest in and plan their individual experience.

**PHOL 401A. Physiology and Biophysics of Molecules and Cells. 2 Units.**

Physiology and Biophysics of Molecules and Cells is a graduate-level introductory course designed to provide the fundamental principles of modern physiology, protein science and structural biology, and to prepare students for advanced courses in the biomedical sciences. The course is divided into 2 blocks that can be taken independently as PHOL 401A or PHOL 401B (2 credit hrs each) during the Spring semester of each year. The first block will cover the structure and function of proteins and lipids, and the organization of cellular membranes. Topics will include primary, secondary, tertiary and quaternary protein structure and analysis, enzyme kinetics, allostery and cooperativity, lipid membrane organization and domain structure, and protein-protein and protein-lipid interactions. The second block will cover molecular pathways and processes critical for cellular homeostasis, function, and signaling. Topics will include molecular mechanisms of transport across biological membranes and cellular compartments, ionic basis of the resting membrane potential, action potential generation and propagation, osmosis and Gibbs-Donnan equilibria, regulation of voltage-gated channels and electrogenic transporters, cellular pH regulation, and the biophysics of epithelial transport. Format will be a combination of lecture, discussion-based problem sets, journal paper presentations, and computer lab exercises and demonstrations. Grading will be based on performance on two essay-type exams administered in the middle and at the end of each block (80%), and on class participation (20%).

**PHOL 401B. Physiology and Biophysics of Molecules and Cells. 2 Units.**

Physiology and Biophysics of Molecules and Cells is a graduate-level introductory course designed to provide the fundamental principles of modern physiology, protein science and structural biology, and to prepare students for advanced courses in the biomedical sciences. The course is divided into 2 blocks that can be taken independently as PHOL 401A or PHOL 401B (2 credit hrs each) during the Spring semester of each year. The first block will cover the structure and function of proteins and lipids, and the organization of cellular membranes. Topics will include primary, secondary, tertiary and quaternary protein structure and analysis, enzyme kinetics, allostery and cooperativity, lipid membrane organization and domain structure, and protein-protein and protein-lipid interactions. The second block will cover molecular pathways and processes critical for cellular homeostasis, function, and signaling. Topics will include molecular mechanisms of transport across biological membranes and cellular compartments, ionic basis of the resting membrane potential, action potential generation and propagation, osmosis and Gibbs-Donnan equilibria, regulation of voltage-gated channels and electrogenic transporters, cellular pH regulation, and the biophysics of epithelial transport. Format will be a combination of lecture, discussion-based problem sets, journal paper presentations, and computer lab exercises and demonstrations. Grading will be based on performance on two essay-type exams administered in the middle and at the end of each block (80%), and on class participation (20%).

**PHOL 402. Physiological Basis for Disease. 4 Units.**

Physiological Basis for Disease is a graduate-level introductory course designed to provide the fundamental physiology of a select group of organ systems and examples of how the molecular basis of disease affects physiological function of these systems. As such PHOL 402 will prepare students for future study in advanced biomedical sciences courses. Select diseases of the endocrine, central nervous, pulmonary, cardiac and renal systems will be covered. The course is 4 credit hours and will be given in the Fall semester of each year. The format will be a combination of lecture and journal paper presentations and discussion. Grading will be based on five short answer/essay examinations given at the end of each section (50%), class participation (30%) and a final presentation (20%).

**PHOL 410. Basic Oxygen & Physiological Function. 2 Units.**

On-line lecture only course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as NTRN 410 and PHOL 410.

**PHOL 412. Membrane Transport Processes. 3 Units.**

Membranes and membrane transporters are absolutely required for all cells to take up nutrient, maintain membrane potential and efflux toxins. This course will consider the classification and structure of membrane transport proteins and channels, examine the common mechanistic features of all systems and the specific features of different classes of transporter. Understanding the physiological integration of transport processes into cell homeostasis and consideration of transporters and channels as drug targets will be a goal. Course format is minimal lecture, primarily student presentations of primary literature papers. Offered as PHOL 412 and PHRM 412. Prereq: CBIO 453 and CBIO 455.

**PHOL 419. Applied Probability and Stochastic Processes for Biology. 3 Units.**

Applications of probability and stochastic processes to biological systems. Mathematical topics will include: introduction to discrete and continuous probability spaces (including numerical generation of pseudo random samples from specified probability distributions), Markov processes in discrete and continuous time with discrete and continuous sample spaces, point processes including homogeneous and inhomogeneous Poisson processes and Markov chains on graphs, and diffusion processes including Brownian motion and the Ornstein-Uhlenbeck process. Biological topics will be determined by the interests of the students and the instructor. Likely topics include: stochastic ion channels, molecular motors and stochastic ratchets, actin and tubulin polymerization, random walk models for neural spike trains, bacterial chemotaxis, signaling and genetic regulatory networks, and stochastic predator-prey dynamics. The emphasis will be on practical simulation and analysis of stochastic phenomena in biological systems. Numerical methods will be developed using a combination of MATLAB, the R statistical package, MCell, and/or URDME, at the discretion of the instructor. Student projects will comprise a major part of the course. Offered as BIOL 319, EECS 319, MATH 319, SYBB 319, BIOL 419, EBME 419, MATH 419, PHOL 419, and SYBB 419.

**PHOL 430. Advanced Methods in Structural Biology. 1 - 6 Units.**

The course is designed for graduate students who will be focusing on one or more methods of structural biology in their thesis project. This course is divided into 3-6 sections (depending on demand). The topics offered will include X-ray crystallography, nuclear magnetic resonance spectroscopy, optical spectroscopy, mass spectrometry, cryo-electron microscopy, and computational and design methods. Students can select one or more modules. Modules will be scheduled so that students can take all the offered modules in one semester. Each section is given in 5 weeks and is worth 1 credit. Each section covers one area of structural biology at an advanced level such that the student is prepared for graduate level research in that topic. Offered as BIOC 430, CHEM 430, PHOL 430, and PHRM 430.

**PHOL 451. Independent Study. 1 - 18 Units.**

Guided program of study using physiology textbooks, research reviews, and original research articles. An independent laboratory research project may also be included.

**PHOL 456. Conversations on Protein Structure and Function. 2 Units.**

The goal of this course is to supplement the short and basic presentation of Proteins in C3MB by lectures and discussions for students with backgrounds in physical-chemical sciences or students who already have a good basic background in protein science. The course presents an overview of Protein structure/function. Following an introduction to the principles of protein structure, the physical basis of protein folding and stability, and a brief overview of structural and bioinformatics approaches to protein analysis is presented. Typically two lecture/discussion style presentations are followed by a student lead journal club on recent high profile papers. The way the Journal club is done is that one student presents a paper (background and figures in powerpoint slides) while presentation of the main figures is shared between the class. Papers and Figures will be assigned by instructor. Typically two papers will be presented per session. Offered as PHOL 456 and BIOL 457.

**PHOL 466. Cell Signaling. 3 Units.**

This is an advanced lecture/journal/discussion format course that covers cell signaling mechanisms. Included are discussions of neurotransmitter-gated ion channels, growth factor receptor kinases, cytokine receptors, G protein-coupled receptors, steroid receptors, heterotrimeric G proteins, ras family GTPases, second messenger cascades, protein kinase cascades, second messenger regulation of transcription factors, microtubule-based motility, actin/myosin-based motility, signals for regulation of cell cycle, signals for regulation of apoptosis. Offered as CLBY 466, PHOL 466 and PHRM 466.

**PHOL 467. Topics in Evolutionary Biology. 3 Units.**

The focus for this course on a special topic of interest in evolutionary biology will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHIL/PHOL 467/BIOL 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467.

**PHOL 468. Membrane Physiology. 3 Units.**

This student-guided discussion/journal course focuses on biological membranes. Topics discussed include thermodynamics and kinetics of membrane transport, oxidative phosphorylation and bioenergetics, electro-physiology of excitable membranes, and whole and single channel electrophysiology, homeostasis and pH regulation, volume and calcium regulation. Offered as CLBY 468 and PHOL 468.

**PHOL 475. Protein Biophysics. 3 Units.**

This course focuses on in-depth understanding of the molecular biophysics of proteins. Structural, thermodynamic and kinetic aspects of protein function and structure-function relationships will be considered at the advanced conceptual level. The application of these theoretical frameworks will be illustrated with examples from the literature and integration of biophysical knowledge with description at the cellular and systems level. The format consists of lectures, problem sets, and student presentations. A special emphasis will be placed on discussion of original publications. Offered as BIOC 475, CHEM 475, PHOL 475, PHRM 475, and NEUR 475.

**PHOL 477. Human Physiology. 4 Units.**

This lecture/seminar experience is meant to enhance the students fundamental knowledge in human physiology with an emphasis on physiologic concepts in relationship to health, disease and illnesses. The course will provide students with an understanding of the function, regulation and integration of the major organ systems. Offered as PAST 477 and PHOL 477.

**PHOL 478. Lifestyle Medicine. 3 Units.**

While the current acute care model of medicine focuses on disease and treatment of individual organ systems by specialists, 50-60% of the public use complementary and alternative medicine (CAM), which focuses on prevention rather than disease. In CAM, damage caused by Western diets is avoided with low fat, vegetarian, or vegan diets, and with herbs and supplements. Damage mediated by emotional responses to stress is counteracted with relaxation practices such as yoga, meditation or hypnosis. In support of CAM, NIH-funded research performed over the past decade has shown that 70-90% of chronic diseases such as obesity, atherosclerosis, and cancer result from lifestyle. Moreover, mechanisms of lifestyle-induced disease as well as mechanisms by which these can be prevented or reversed by CAM practices have been described. This course examines interrelationships between lifestyle, health and disease and influences of CAM practices in terms of physiological health. Topics include evidence that Western diets, chronic emotional stress resulting from pervasive environmental, societal, workplace, financial, or relationship issues, and changes in circadian rhythms resulting from behaviors such as not getting enough sleep or working night-shifts facilitate disease by inducing cellular events that include epigenetic modification, changes in gene expression, and decreased telomere length. Mechanisms by which CAM practices prevent or reverse these lifestyle-mediated changes are also covered. In addition, the course considers the broader issue of how economic and political pressures are forcing rapid changes in healthcare and the influence that lifestyle-based approaches is likely to have on evolving delivery models, healthcare costs, and public health policies. The course is presented over a period of 8 weeks during the summer session. It is heavily discussion-based delivered in the form of slide presentations, discussions of the literature, video segments, and experiential relaxation instructions. Grading is based on class discussion and a written discussion paper.

**PHOL 479. Clinical Reasoning: Applied Medical Physiology. 3 Units.**

Physicians, detectives, scientists and mechanics all use deductive reasoning with multiple hypotheses to solve problems. The primary objective of this course is to help students apply their knowledge of medical physiology to solving clinical problems. The second objective is to develop an overall view of the clinical reasoning process as a problem-solving method. This will be done primarily through problem-based case studies of patients with cardiovascular, pulmonary and renal disease. Case studies will be supplemented by video presentations of patient history and physical exam, and student-led presentations. Prereq: PHOL 482 and PHOL 484.

**PHOL 480. Physiology of Organ Systems. 4 Units.**

Our intent is to expand the course from the current 3 hours per week (1.5 hour on Monday and Wednesday) to 4 hours per week (1.5 hours on Monday and Wednesday plus 1 hour on Friday). Muscle structure and Function, Myasthenia gravis and Sarcopenia; Central Nervous System, (Synaptic Transmission, Sensory System, Autonomic Nervous System, CNS circuits, Motor System, Neurodegenerative Diseases, Paraplegia and Nerve Compression); Cardiovascular Physiology (Regulation of Pressure and flow; Circulation, Cardiac Cycle, Electrophysiology, Cardiac Function, Control of Cardiovascular function, Hypertension); Hemorrhage, Cardiac Hypertrophy and Fibrillation; Respiration Physiology (Gas Transport and Exchange, Control of Breathing, Acid/base regulation, Cor Pulmonaris and Cystic Fibrosis, Sleeping apnea and Emphysema); Renal Physiology (Glomerular Filtration, Tubular Function/transport, Glomerulonephritis, Tubulopathies); Gastro-Intestinal Physiology (Gastric motility, gastric function, pancreas and bile function, digestion and absorption, Liver Physiology; Pancreatitis, Liver Disease and cirrhosis); Endocrine Physiology (Thyroid, Adrenal glands, endocrine pancreas, Parathyroid, calcium sensing receptor, Cushing and diabetes, Reproductive hormones, eclampsia); Integrative Physiology (Response to exercise, fasting and feeding, aging). For all the classes, the students will receive a series of learning objectives by the instructor to help the students address and focus their attention to the key aspects of the organ physiology (and physiopathology). The evaluation of the students will continue to be based upon the students' participation in class (60% of the grade) complemented by a mid-term and a final exam (each one accounting for 20% of the final grade). Offered as BIOL 480 and PHOL 480.

**PHOL 481. Medical Physiology I. 6 Units.**

Physiology is the dynamic study of life. It describes the vital functions of living organisms and their organs, cells, and molecules. For some, physiology is the function of the whole person. For many practicing clinicians, physiology is the function of an individual organ system. For others, physiology may focus on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on how the individual organ systems function, which depends on how the component cells function, which in turn depends on the interactions among subcellular organelles and countless molecules. Thus, it requires an integrated understanding of events at the level of molecules, cells, and organs. Medical Physiology I is a lecture course (3, 2 hr. lectures/week). It is the first of a two-part, comprehensive survey of physiology that is divided into four blocks: Block 1 covers the physiology of cells and molecules, signal transduction, basic electrophysiology, and muscle physiology; Block 2 covers the nervous system; Block 3 covers the cardiovascular system, and; Block 4 covers the respiratory system. Grading in the course will be based on performance on multiple choice/short essay examinations administered at the end of each block with each examination weighted according to the number of lectures contained in that block.

**PHOL 482. Medical Physiology II. 6 Units.**

Physiology is the dynamic study of life. It describes the vital functions of living organisms and their organs, cells, and molecules. For some, physiology is the function of the whole person. For many practicing clinicians, physiology is the function of an individual organ system. For others, physiology may focus on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on how the individual organ systems function, which depends on how the component cells function, which in turn depends on the interactions among subcellular organelles and countless molecules. Thus, it requires an integrated understanding of events at the level of molecules, cells, and organs. Medical Physiology II is a lecture course (3, 2hr. lectures/week). It is the second of a two-part, comprehensive survey of physiology that is divided into five blocks: Block 5 covers the physiology of the urinary system; Block 6 covers the gastrointestinal system; Block 7 covers the endocrine system; Block 8 covers reproduction; and Block 9 covers the physiology of everyday life. Grading in the course will be based on performance on multiple choice/short essay examinations administered at the end of each block with each examination weighted according to the number of lectures contained in that block

**PHOL 483. Translational Physiology I. 3 Units.**

Physiology is the dynamic study of life, describing the vital functions of living organisms and their organs, cells, and molecules. For some clinicians, physiology is the function of an individual organ system. For others, it focuses on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on individual organ systems function, which depends on cellular function, which in turn depends on molecular interactions. Translational Physiology I will explore examples of how the latest basic research in physiology and biophysics is being applied to the treatment of human disease. For example, while the students are studying the basic principles of cardiovascular physiology, they will also be investigating how these principles are being applied to treat/cure human cardiovascular disorders such as congestive heart failure, coronary artery disease, etc. Translational Physiology I is a lecture course (1, 2hr lecture/week, and 1, 1hr lecture/week) taught by clinical and basic science faculty. The 2 hour lecture will be given primarily by clinical faculty and is focused on applying physiological principles to clinical cases of pathophysiology. The 1 hour lecture will be given primarily by basic science faculty and will expose students to the process of translating fundamental basic science research to the clinic, that is bench-to-bedside. It is the first of a two-part course that follows the topics being simultaneously covered in the Medical Physiology I course. It is divided into 4 blocks: Block 1 covers the physiology of cells and molecules, signal transduction, basic electrophysiology, and muscle physiology; Block 2 covers the nervous system; Block 3 covers the cardiovascular system, and; Block 4 covers the respiratory system. Grading in the course will be based on performance on multiple choice examinations administered at the end of each block with each examination weighted according to the number of lectures contained in the block.

**PHOL 484. Translational Physiology II. 3 Units.**

Physiology is the dynamic study of life, describing the vital functions of living organisms and their organs, cells, and molecules. For some clinicians, physiology is the function of an individual organ system. For others, it focuses on the cellular principles that are common to the function of all organs and tissues. Medical physiology deals with how the human body functions, which depends on how the individual organ systems function, which depends on how the component cells function, which in turn depends on the interactions among subcellular organelles and countless molecules. Translational Physiology II will explore examples of how the latest basic research in physiology and biophysics is being applied to the treatment of human disease. For example, while the students are studying the basic physiology of the urinary system, they will also be investigating how these principles are being applied to treat/cure human kidney disorders such as renal failure, high blood pressure, glomerular disease, etc.. Translational Physiology II is a lecture course (1, 2hr lecture/week, and 1, 1hr lecture/week) taught by clinical and basic science faculty. The 2 hour lecture will be given primarily by clinical faculty and is focused on applying physiological principles to clinical cases of pathophysiology. The 1 hour lecture will be given primarily by basic science faculty and will expose students to the process of translating fundamental basic science research to the clinic, that is bench-to-bedside. It is the second of a two-part course that follows topics being simultaneously covered in the Medical Physiology II course. It is divided into 4 blocks: Block 5 covers the physiology of the urinary system; Block 6 covers the gastrointestinal system and metabolism; Block 7 covers the endocrine system and reproduction, and, Block 8 covers the physiology of everyday life. Grading in the course will be based on performance on multiple choice examinations administered at the end of each block with each examination weighted according to the number of lectures contained in the block. Coreq: PHOL 482.

**PHOL 485. Comparative & Evolutionary Physiology. 4 Units.**

This course presents physiological concepts from the comparative and evolutionary perspective. Aspects of vertebrate and mammalian evolution will be considered with respect to the generation of adaptive advantages for organisms to changing environmental challenges since the Cambrian. Comparative physiological concepts include scaling, variations in nutrition, energy metabolism and work efficiency. The important influences of time, temperature, water and energy on mammalian biology will be presented. The course is a lecture based course that can be taken in person or on-line. Evaluations will be by regular quizzes, a mid-term and a final exam, all MCQ. Offered as PHOL 485 and ORIG 485.

**PHOL 492. Clinical Reasoning II. 3 Units.**

The objective of this course is to help students use principles of medical physiology to solve clinical problems. The second objective is to develop an overall view of clinical reasoning and improve critical thinking skills. The topics in Clinical Reasoning II are neurology, gastroenterology and endocrine/metabolic diseases. PHOL 479 Clinical Reasoning I, which covers cardiovascular, pulmonary and renal diseases, is not required. I anticipate that you will learn to: - Recognize physiologic mechanisms underlying abnormal physical findings, laboratory tests and imaging. - Use signs, symptoms, physical findings, laboratory tests and imaging to generate patient problem lists. - Develop and refine diagnostic hypotheses, i.e., differential diagnosis. - Understand the physiological basis of appropriate treatment plans. Prereq: PHOL 481.

**PHOL 497. Journal Club in Structural Biology and Biophysics. 1 Unit.**

Biweekly Journal club to engage faculty and students in discussion of recent high profile papers in structural biology and protein biophysics. Registered students have to present one entire seminar on an assigned paper and attend all seminars, as well as participate in discussion. Recommended Preparation: undergraduate biochemistry or equivalent.

**PHOL 497A. Neurology Grand Rounds. 1 Unit.**

This course is a weekly seminar series offered summer, fall, and spring semesters by the Department of Neurology at University Hospitals Case Medical Center. To earn a Passing grade in this course, students must attend at least 75% of the grand rounds offered by the Department of Neurology during the semester (signing in at the session) and submit to the course director within the week following the Grand Rounds, a one page report containing: 1) the name of the presenter and their professional affiliation; 2) the title of the presentation; 3) time and place of the Grand Rounds; 4) a one paragraph synopsis of the content of the presentation. Recommended Preparation: Pass the NBME Subject Exam in Physiology and Neurophysiology. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

**PHOL 497B. Neurology Grand Rounds. 1 Unit.**

This course is a weekly seminar series offered summer, fall, and spring semesters by the Department of Neurology at University Hospitals Case Medical Center. To earn a Passing grade in this course, students must attend at least 75% of the grand rounds offered by the Department of Neurology during the semester (signing in at the session) and submit to the course director within the week following the Grand Rounds, a one page report containing: 1) the name of the presenter and their professional affiliation; 2) the title of the presentation; 3) time and place of the Grand Rounds; 4) a one paragraph synopsis of the content of the presentation. Recommended Preparation: Pass the NBME Subject Exam in Physiology and Neurophysiology. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 497A, PHOL 498A and PHOL 498B.

**PHOL 497C. Clinical Nephrology Conference. 1 Unit.**

Clinical Nephrology Conference (CNC) at MetroHealth Medical Center, Dept. Medicine, Division of Nephrology. This course must be taken at least once and can be taken up to 2 times for a total of 2 credit hours. For the 15-week semester, students are responsible for attending and reporting on 12 of the scheduled CNC. For each CNC, the student must submit to the course director (Dr. Liedtke) within the week following the CNC, a one page report stating: a. The name of the presenter and their professional affiliation b. The title of the presentation c. Time and place of the CNC d. A one paragraph synopsis of the presentation The course director is responsible for assigning the grades for this course. Prior or concurrent CITI training must be completed. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

**PHOL 497D. Clinical Nephrology Conference. 1 Unit.**

Clinical Nephrology Conference (CNC) at MetroHealth Medical Center, Dept. Medicine, Division of Nephrology. This course must be taken at least once and can be taken up to 2 times for a total of 2 credit hours. For the 15-week semester, students are responsible for attending and reporting on 12 of the scheduled CNC. For each CNC, the student must submit to the course director (Dr. Liedtke) within the week following the CNC, a one page report stating: a. The name of the presenter and their professional affiliation b. The title of the presentation c. Time and place of the CNC d. A one paragraph synopsis of the presentation The course director is responsible for assigning the grades for this course. Prior or concurrent CITI training must be completed. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

**PHOL 497E. Pulmonary Grand Rounds. 1 Unit.**

Students are responsible for attending 10 of 15 sessions for that semester. Pulmonary Science Grand Rounds (adult pulmonology) and Pediatric Basic Science Seminar Series are convened Friday mornings at UH Case Medical Center at 8:00 am and 9:00 am, respectively. For each session attended, the student must submit to the course director (Dr. Liedtke) within the week following the session, a one page report stating: a. name of the presenter and their professional affiliation, b. title of the presentation, c. time and place of the session, and d. one paragraph synopsis of the presentation. The course director is responsible for assigning the grades for this course. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL 498B.

**PHOL 497F. Pulmonary Grand Rounds. 1 Unit.**

This course must be taken once and can be taken up to 2 times for a total of 2 credit hours. Students are responsible for attending 10 of 15 sessions for that semester. Pulmonary Science Grand Rounds (adult pulmonology) and Pediatric Basic Science Seminar Series are convened Friday mornings at UH Case Medical Center at 8:00 am and 9:00 am, respectively. For each session attended, the student must submit to the course director (Dr. Liedtke) within the week following the session, a one page report stating: a. name of the presenter and their professional affiliation, b. title of the presentation, c. time and place of the session, and d. one paragraph synopsis of the presentation. The course director is responsible for assigning the grades for this course. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL 498B.

**PHOL 498A. Physiology and Biophysics Departmental Seminar. 1 Unit.**

Weekly one-hour reviews by invited speakers of their research. Students present literature reviews or summaries of their research.

**PHOL 498B. Physiology Seminar B (Spring Semester). 1 Unit.**

Weekly one-hour reviews by invited speakers of their research. Offered spring semester.

**PHOL 498C. Physiology and Biophysics Department Seminar for Medical Physiology Students. 1 Unit.**

Weekly one-hour research reviews offered by various speakers, upon invitation. Students will present literature reviews or summaries of their own research throughout the course. Grades will be determined by quizzes based on the research presented.

**PHOL 498D. Physiology MSMP Seminar B (Spring Semester). 1 Unit.**

Weekly one-hour research reviews offered by various speakers, upon invitation. Students will present literature reviews or summaries of their own research throughout the course. Grades will be determined by quizzes based on the research presented. Offered spring semester.

**PHOL 505. Laboratory Research Rotation. 1 Unit.**

Six week experience in a selected faculty research laboratory designed to introduce the student to all aspects of modern laboratory research including the design, execution and analysis of original experimental work. Recommended preparation: Consent of instructor and scheduled laboratory.

**PHOL 513. Structural Journal Club. 1 Unit.**

Current topics of interest in structural biology, and protein biophysics. Offered as PHOL 513 and PHRM 513.

**PHOL 514. Cardiovascular Physiology. 3 Units.**

The goal of this course is to provide the student with a solid foundation in cardiovascular physiology and pathophysiology. The course will begin by providing a solid foundation in the structure, phenotype and function of cardiac and vascular muscle. In addition, electrophysiology and metabolism will be addressed. Both basic physiology and more advanced topics, such as pathophysiology, will be covered using a journal club format. (Twice weekly; 1.5hrs/class.) Student participation is required.

**PHOL 519. Cardio-Respiratory Physiology. 3 Units.**

This course is designed to integrate systemic, cellular and molecular aspects of cardio-respiratory systems in physiological and pathophysiological states. The course requires prior knowledge of basic physiology of the cardiovascular systems. Extensive student participation is required. Instructors provide a brief overview of the topic followed by presentation and critical appraisal of recent scientific literature by students.

**PHOL 528. Contemporary Approaches to Drug Discovery. 3 Units.**

This course is designed to teach the students how lead compounds are discovered, optimized, and processed through clinical trials for FDA approval. Topics will include: medicinal chemistry, parallel synthesis, drug delivery and devices, drug administration and pharmacokinetics, and clinical trials. A special emphasis will be placed on describing how structural biology is used for in silico screening and lead optimization. This component will include hands-on experience in using sophisticated drug discovery software to conduct in silico screening and the development of drug libraries. Each student will conduct a course project involving in silico screening and lead optimization against known drug targets, followed by the drafting of an inventory disclosure. Another important aspect of this course will be inclusion of guest lectures by industrial leaders who describe examples of success stories of drug development. Offered as BIOC 528, PHOL 528, PHRM 528, and SYBB 528.

**PHOL 530. Technology in Physiological Sciences. 3 Units.**

This lecture/discussion/journal course focuses on techniques in the physiological sciences. Topics include spectroscopy, microscopy, and electrophysiology. The theory and practice are covered with an emphasis on examples taken from the scientific literature.

**PHOL 537. Microscopy-Principles and Applications. 3 Units.**

This course provides an introduction to various types of light microscopy, digital and video imaging techniques, and their applications to biological and biomedical sciences via lectures and hands-on experience. Topics covered include geometrical and physical optics; brightfield, darkfield, phase contrast, DIC, fluorescence and confocal microscopes; and digital image processing. Offered as GENE 537, MBIO 537, and PHOL 537.

**PHOL 601. Research. 1 - 18 Units.**

Cellular physiology laboratory research activities that are based on faculty and student interests.

**PHOL 610. Oxygen and Physiological Function. 3 Units.**

Lecture/discussion course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include oxygen transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as ANAT 610, NTRN 610, and PHOL 610.

**PHOL 614. Sleep Physiology - Neurobiology of Sleep/Wake. 3 Units.**

Participants in this course will gain an understanding of the neural mechanisms contributing to the states of sleep and wakefulness. Contemporary theories regarding why humans need to sleep will be reviewed. We will also review how perturbations within specific neurotransmitter systems become manifest as sleep related disorders and the pharmacological interventions used to normalize activity within those neural pathways. Prereq: PHOL 481 and PHOL 482 or requisites not met permission.

**PHOL 620A. Clinical Observer: Neurology Service. 2 Units.**

This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care; he/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

**PHOL 620B. Clinical Observer: Stroke Service. 2 Units.**

This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care; he/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

**PHOL 620C. Clinical Observer: Epilepsy Service. 2 Units.**

This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care - he/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A and PHOL 498B.

**PHOL 620D. Clinical Observer: Neurology (Neuromuscular). 2 Units.**

This course is a 2 week intensive experience offered summer, fall, and spring semesters on a schedule set by the Department of Neurology at University Hospitals Case Medical Center. Students are expected to be present and observe at all of the times set forth by the house staff and attending, generally a 40 hour week minimum. The Objective of the course is to provide the students with the experience of observing patient care provided by 3rd year medical students on a clinical rotation under direct supervision by house staff and attending on an active acute Neurology Service. The PGY-2 Neurology Resident and PGY-3 Chief Resident will always be available for immediate supervision. Students round as Clinical Observers with the CWRU medical students according to their daily schedule. They will learn the basics of neurological history-taking, neurological examination, neurodiagnostic studies, and neurological therapeutics. Didactic sessions covering a wide range of neurologic and neurosurgical topics are covered by faculty members from both departments. The lectures cover the gamut of neurological and neurosurgical disease processes and treatments. Neurosurgery lectures include such topics as cerebrovascular disease, brain tumors, hydrocephalus, spinal disorders, and head trauma as well as doctor-patient communication. Unlike the medical students on the rotation, a Clinical Observer will only observe procedures and will not actively take part in any health care. He/she will act strictly as an observer, but will act as a physiological consultant to the team responsible for providing basic science input to the clinical cases. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL 498B. Coreq: PHOL 620A, PHOL 620B, or PHOL 620C.

**PHOL 621. Clinical Nephrology Observer. 4 Units.**

This course is a total of 4 week intensive experience offered on the School of Medicine elective schedule. Students will round with fellow and Medicine residents rotating during the elective on a daily basis starting with morning work rounds. Attending rounds generally begin in the afternoon. The student is restricted to a total of 15 hrs/ week on clinical rounds. The student is expected to read appropriate or assigned text, journal and internet resources for necessary background reading; the time spent on these resources do not count toward the 15 hrs/week for rounds. The fellow or attending physician on the service will recommend to the course director (Dr. Liedtke) whether the student earned a Pass or Fail in the course based upon attendance, professional demeanor, active participation, and knowledge of the area. The course director is responsible for assigning the grades for this course. CITI training must be completed prior to enrollment. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, PHOL 498B.

**PHOL 622. Pediatric Pulmonology Observation. 2 Units.**

Pediatric Pulmonology Observation (must be approved). 2 credit hours. Location: University Hospital, Rainbow Babies & Children Hospital. This course is an intensive experience with 2 weeks offered on the elective schedule detailed in Appendix A and 1 week with attending physician reading PFTs. For 2 weeks, students will round with attending staff and medical students according to their daily schedule at Rainbow Babies & Children Hospital, Pulmonary Division, starting with morning work rounds. Attending rounds generally begin in the afternoon. The student will not have direct patient contact. The student is expected to read appropriate or assigned text, journal and internet resources for necessary background reading. Students will journal their daily experience. Students will write a paper relating basic physiology to a case identified during rounds; the Director (Dr. Liedtke) will grade the paper. The attending physician on the service will recommend to the course director (Dr. Liedtke) based upon attendance, professional demeanor, active participation, and knowledge of the area. The course director is responsible for assigning the grades for this course. Dr. Ross Meyers will serve as the student's mentor and assign students to services. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL498B.

**PHOL 623. Adult Pulmonology Observation. 2 Units.**

Adult Pulmonology AOC (must be approved). 2 credit hours. Location: University Hospital and VA Hospital. This course is an intensive experience with 2 weeks offered on the elective schedule detailed in Appendix A and 1 week with attending physician reading PFTs to evaluate 25 adult PFT, 6 exercise tests, and 6 methacholine challenges. For 2 weeks, students will round with attending staff and medical students according to their daily schedule at University Hospital starting with morning work rounds. Attending rounds generally begin in the afternoon. The student will not have direct patient contact. The student is expected to read appropriate or assigned text, journal and internet resources for necessary background reading. Students will journal their daily experience. Students will write a paper relating basic physiology to a case identified during rounds; the Director (Dr. Liedtke) will grade the paper. The attending physician on the service will recommend to the course director (Dr. Liedtke) based upon attendance, professional demeanor, active participation, and knowledge of the area. The course director is responsible for assigning the grades for this course. Dr. (TBN) will serve as the student's mentor and assign students to services. Prereq: PHOL 481, PHOL 482, PHOL 483, PHOL 484, PHOL 498A, and PHOL 498B.

**PHOL 651. Thesis M.S.. 1 - 18 Units.**

**PHOL 701. Dissertation Ph.D.. 1 - 9 Units.**

Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.