

## **Ph.D. in the Pharmaceutical Sciences Curriculum**

To successfully complete the Ph.D. degree, candidates must complete; year 1 with a minimum grade of B in each graded course (Minimum GPA = 3.0); after the first year, courses must be completed with a cumulative GPA of no less than 3.0; a minimum of 24 graduate level didactic credits and a minimum 56 credits of research courses (PHPS 799V and PHPS 800); a minimum of 96 credit hours overall (Minimum cumulative GPA = 3.0).

### **Ph.D. Year 1 Fall Courses** *Total minimum of 12 credits*

- PHPS 749 Overview of the Pharmaceutical Sciences I (2)
- PHPS 718 Lab Visits and Supervisor Selection (1)
- Area-specific courses (9 credits minimum chosen from among the recommended courses below for a specific area and supplemented with other electives as needed)

#### Cancer Biology Emphasis

- PHPS 751 Biochemistry I - Biomolecules (3)
- PHPS 703 Cancer Biology (2)
- PHPS 710 Laboratory Animal Care, Management and Medicine I (2)
- PHPS 735 Cell Cycle Progression and Apoptosis (2)
- Or other appropriate electives to make up a minimum of 9 credits

#### Medicinal Chemistry Emphasis

- PHPS 713 Organic Medicinal Chemistry I (2)
- PHPS 709 Instrumental Methods and Structural Elucidation of Mainly Natural Products (2)
- PHPS 717 Medicinal Chemistry of CNS Drugs and Development of in vivo CNS Tracers (2)
- PHPS 704 Combinatorial Chemistry and HT Technologies in Drug Discovery (2)
- Or other appropriate electives to make up a minimum of 9 credits

#### Pharmacognosy Emphasis

- PHPS 751 Biochemistry I - Biomolecules (3)
- PHPS 723 Pharmacognosy I (2)
- PHPS 709 Instrumental Methods and Structural Elucidation of Mainly Natural Products (2)
- Or other appropriate electives to make up a minimum of 9 credits

#### Pharmaceutics Emphasis

- PHPS 755 Advanced Pharmaceutics I (3)
- PHPS 733 Advanced Aerosol Physics in Medicine: Inhaled Drug Therapy (1)
- PHPS 709 Instrumental Methods and Structural Elucidation of Mainly Natural Products (2)
- Or other appropriate electives to make up a minimum of 9 credits

#### Pharmacology Emphasis

- PHPS 724 Pharmacology I (3)
- PHPS 703 Cancer Biology (2)
- PHPS 706 Environmental Toxicology (2)
- PHPS 721 Neuropsychopharmacology (2)
- PHPS 735 Cell Cycle Progression and Apoptosis (2)
- Or other appropriate electives to make up a minimum of 9 credits

#### **Ph.D. Year 1 Spring Courses** *Total minimum of 12 credits*

- PHPS 750 Overview of the Pharmaceutical Sciences II (2)
- PHPS 799V Directed Studies (4)
- PHPS 780 Research Seminar (1)
- Area-specific courses (5 credits minimum chosen from the recommended courses listed below for a specific area and supplemented with electives as necessary)

#### Cancer Biology Emphasis

- PHPS 752 Biochemistry II - Metabolism (3)
- PHPS 720 Natural Products and Cancer Chemoprevention (2)

- PHPS 711 Laboratory Animal Care, Management and Medicine II (2)
- PHPS 734 Biotechnology Laboratory (2)
- PHPS 729 Receptor Theory and Signal Transduction (2)
- Or other appropriate electives to make up a minimum of 5 credits

#### Medicinal Chemistry Emphasis

- PHPS 714 Organic Medicinal Chemistry II (2)
- PHPS 720 Natural Products and Cancer Chemoprevention (2)
- Or other appropriate electives to make up a minimum of 5 credits

#### Pharmacognosy Emphasis

- PHPS 752 Biochemistry II - Metabolism (3)
- PHPS 720 Natural Products and Cancer Chemoprevention (2)
- PHPS 702 Bioassay Development: Principles & Practices in Drug Discovery (1)
- PHPS 730 Sample Collection, Documentation and Preservation (1)
- Or other appropriate electives to make up a minimum of 5 credits

#### Pharmaceutics Emphasis

- PHPS 756 Advanced Pharmaceutics II (3)
- Or other appropriate electives to make up a minimum of 5 credits

#### Pharmacology Emphasis

- PHPS 725 Pharmacology II (2)
- PHPS 729 Receptor Theory and Signal Transduction (2)
- Or other appropriate electives to make up a minimum of 5 credits

#### **Ph.D. Year 2 Fall Courses** *Total minimum of 12 credits*

- PHPS 799V Directed Studies (Minimum 7)
- Electives as needed

#### **Ph.D. Year 2 Spring Courses** *Total minimum of 12 credits*

- PHPS 799V Directed Studies (Minimum 7)
- PHPS 780 Research Seminar (1)
- Electives as needed

**Ph.D. Year 3 Fall Courses** *Total minimum of 12 credits*

- PHPS 799V Directed Studies (Minimum 7)
- PHPS 780 Research Seminar (1)
- Electives as needed

**Ph.D. Year 3 Spring Courses** Total minimum of 12 credits

- PHPS 799V Directed Studies (Minimum 7)
- Electives as needed

**Ph.D. Year 4 Fall Courses** *Total minimum of 12 credits*

- PHPS 799V Directed Studies (Minimum 7)
- Electives as needed

**Ph.D. Year 4 Spring Courses** *Total minimum of 12 credits*

- PHPS 799V Directed Studies (Minimum 6)
- For final semester in program: PHPS 800 Dissertation Research and Graduate Seminar (1)
- Electives as needed, electives plus PHPS 799V and PHPS 800 should total a minimum of 12 credits

**Ph.D. Year 5 and beyond are taken on an as required basis.** *Total minimum of 12 credits*

- PHPS 799V Directed Studies (Minimum 6)
- For final semester in program: PHPS 800 Dissertation Research and Graduate Seminar (Minimum 1)
- Electives as needed, electives plus PHPS 799V and PHPS 800 should total a minimum of 12 credits unless invoking the final semester rule

## **Ph.D. Course Listings**

### **Ph.D. First Year, Fall (12 credit hours)**

#### **PHPS-749\* Overview of the Pharmaceutical Sciences I (2 Core credit hours)**

This 2 credit, 30 lecture, course will draw on the basic principles drug design, development and drug action (medicinal chemistry and pharmacology) to provide an introduction to the basics of the Pharmaceutical Sciences. Some of, but not all, the areas covered include: Introduction to medicinal chemistry and pharmacology, physicochemical properties of compounds including basic organic functional group chemistry, drug targets, drug target interactions, and the architecture of drugs. Pre: Enrollment in the College of Pharmacy PhD program.

#### **PHPS-718 Lab Visits & Supervisor Selection (1 Core credit hour)**

This one credit course is designed to enable all Ph.D. candidates time to become familiar with the research being undertaken by possible dissertation supervisors. Each candidate will visit with and interview at least six possible dissertation supervisors and discuss with them dissertation research projects they will be offering. As required, individual candidates may want to spend a longer period in the laboratory of potential dissertation supervisors to actual gain some hands on experience as to what is going on in given laboratory to assist them in making their decision about whose group they would like to join. At the end of the interview process each candidate will submit a three page paper detailing the overall process they went through to eventually select a dissertation supervisor and dissertation topic. Pre: admission into the Ph.D. program in Pharmaceutical Science.

### **Ph.D. First Year, Spring (12 credit hours)**

#### **PHPS-750\* Overview of the Pharmaceutical Sciences II (2 Core credit hours)**

This 2 credit, 30 lecture, course will draw on the basic principles of drug design, development and drug action (medicinal chemistry and pharmacology) to provide an introduction to the basics of the Pharmaceutical Sciences. Some of, but not all, the areas covered include: ADME, structural changes during metabolism (chemistry), chemical mutagenesis, carcinogenesis, and teratogenesis, drug-drug interactions, drug allergy, drug resistance, tolerance and dependence, pharmacogenomics, and drug discovery. Pre: Enrollment in the College of

Pharmacy PhD program.

### **PHPS-799V Directed Studies**

The majority of Ph.D. research may be performed under this directed research course. Unlike PHPS 800, PHPS 799V will be graded and credited as work is completed. Students, together with their advisors, must fill out the Directed Studies Form describing the proposed research.

### **PHPS-780 Research Seminar**

The transfer of information in the pharmaceutical sciences is often achieved through the presentation of seminars. Students will prepare and present the annual research seminar required for partial fulfillment of the PhD degree. Pre: Enrollment in the College of Pharmacy PhD program. Course may be repeated for credit.

### **Ph.D. Second Year Fall to end of Program**

A minimum of 12 credit hours have to be taken each semester. Six credit hours of didactic courses need to be taken after the first year in order to satisfy the requirement for 24 credits of didactic courses.

### **PHPS-800 Research Dissertation Research and Graduate Seminar**

This course outlines the conduct of the dissertation project and preparation of the actual dissertation document for the Doctoral level student. The dissertation is a major undertaking that is a demonstration of mastery of a field of research in the Pharmaceutical Sciences and should represent an original and significant contribution to the field. The project may take a variety of forms, for example, be quantitative, qualitative, or theoretical, the main criteria being that at the completion of the research the candidate can demonstrate mastery of, and excellence in, their chosen area of research. Prerequisites, students must have been advanced to Candidacy by completing the Comprehensive Examination and the Proposal Defense Examination. Students may take PHPS 800 once they have been advanced to Candidacy or just in their final semester.

## **Electives**

### **PHPS-701 Apoptosis and Angiogenesis in Disease Processes and Drug Development (1 credit hour)**

The course will cover mechanisms of apoptosis, or programmed cell death, and angiogenesis, or new vessel growth, and mechanisms of their regulation in different cell types. Students will learn how unbalanced angiogenic and apoptotic responses contribute to a wide variety of disease conditions, including cancer, neurodegenerative, cardiac, inflammatory and autoimmune diseases. The course will discuss experimental techniques that are used in the studies of these processes. Part of the course is devoted to approaches to development of drugs that will modulate apoptotic and angiogenic processes, and discussions of critical signaling molecules in these pathways as potential targets for drug development efforts. Pre: Approval of Major Professor.

### **PHPS-702 Bioassay Development: Principles & Practices in Drug Discovery (1 credit hour)**

This course will explore the biological activities of secondary metabolites that are central to the process of drug discovery and development from nature. This course will emphasize the chemically-driven approach that seeks biological activities for purified compounds. Pre: Approval of Major Professor.

### **PHPS-703 Cancer Biology (2 credit hours)**

An introduction to cancer biology covering the processes involved in tumorigenesis (oncogenes, mutagenesis, proliferation, apoptosis, angiogenesis, invasion and metastasis). There will be discussion of active areas of interest such as cancer stem cells and the role of inflammation in cancer. Lectures will include descriptions of current therapeutics, describe efforts to design new drugs and recent clinical trials. Pre: Approval of Major Professor.

### **PHPS-704 Combinatorial Chemistry and High Throughput Technologies in Drug Discovery (2 credit hours)**

This course is designed to teach students the essential elements of combinatorial chemistry and evolving high throughput technologies in drug discovery. Combinatorial chemistry and high throughput chemistries are dynamic, rapidly

evolving fields that have an important role in drug discovery. Most pharmaceutical companies have now incorporated combinatorial and high throughput platforms into their drug discovery research program. Combinatorial chemistry is a relatively new approach to the synthesis of compound libraries in a highly efficient and automated fashion. The topics of this course will include, but not limited to, combinatorial chemistry and parallel synthesis; solid-phase organic synthesis; solution-phase synthesis with solid supported reagents and scavenger resin technology; diversity-oriented synthesis; dynamic combinatorial chemistry; high throughput screening of combinatorial libraries; microwave-assisted organic synthesis; fluorous technology, fragment-based drug discovery; and automation and instrumentation. Pre: Approval of Major Professor.

### **PHPS-705 Designing Clinical Research (3 credit hours)**

The course introduces the science and methodological principles of undertaking clinical research. Emphasis is placed upon clinical trials of complementary and alternative medicine therapies. Topics include research question/problem/objective, research hypothesis, research processes, types of clinical research design, strengths and weaknesses of each design, measurements, concepts of reliability and validity, sampling designs, recruitment, sample size determinations, chance and bias, threats to the internal and external validity, monitoring safety and efficacy data, statistical tests and data management, ethical and regulatory considerations, translational research and funding agency. Students will be given the opportunity to identify a researchable idea/ question and design his/her own clinical or translational research project by preparing a written mini-proposal and then its presentation. Pre: Approval of Major Professor.

### **PHPS-706 Environmental Toxicology (2 credit hours)**

This course is designed to introduce students to the field of environmental toxicology. The emphasis will focus more on ecotoxicology, rather than classical toxicology. Topics that will be covered include toxic and radioactive metal, toxicity of solvents and pesticides, halogenated aromatic compounds, environmental endocrine disruptors, and pharmaceuticals and personal care products in the environment. The environmental impact of global warming will also be addressed. Course format will include student lead discussions and presentations, lectures, and general discussion. Pre: Approval of Major Professor.

### **PHPS-707 Genetics in Medicine (2 credit hours)**



This course will provide an exposition of the fundamental principles of human and medical genetics with emphasis on the genes and molecular mechanisms operating in human diseases. The contributions made by genetic variation to disease susceptibility and treatment outcomes will be discussed. Clinical cases will be used to demonstrate and reinforce the general principles of disease inheritance, pathogenesis, diagnosis, management, and genetic counseling. Students will learn how understanding genetics can lead to new strategies in drug development and treatment. A seminar experience will keep students abreast of recent developments in the field by presenting current literature. Pre: Approval of Major Professor.

### **PHPS-708 Isolation Methods for Natural Product Discovery (2 credit hours)**

This course will examine the theory and practice of the various types of chromatographic and non-chromatographic methods that are commonly used for the isolation of biologically active natural products from plants, microorganisms and marine organisms on scales ranging from microgram to kilograms of pure compound. Starting with simple extraction methods, the course will progress through liquid-liquid interactions to liquid-solid interactions and then to gas-solid interactions. Completion of this course will provide the student an understanding of the application of each of the techniques discussed, as well as their relative advantages and disadvantages. Pre: Approval of Major Professor.

### **PHPS-709 Instrumental Methods and Structure Elucidation of Mainly Natural Products (2 credit hours)**

This course will introduce many of the pieces of spectroscopic equipment relevant to solving the three dimensional structure of organic molecules. Hands on use of the equipment to obtain spectroscopic data will be an emphasis of this course. The other emphasis of this course will be how to interpret the recorded information to enable a viable chemical structure to be proposed. During each session it is anticipated that prepared examples and examples arising from current research will be used to enhance participants' knowledge. Pre: Approval of Major Professor.

### **PHPS-710 Laboratory Animal Care, Management and Medicine I (2 credit hours)**

This course is part one of a two part lecture series and is designed to introduce students to the care and use of laboratory animals in accordance with the National Research Council and the Institutional Animal Care and Use Committee (IACUC). Included in this course are alternatives to traditional use of live animal species and

the laws, regulations and guidelines important to laboratory animal research. Emphasis will be placed on the use of rats and mice, rodent anesthesia and analgesia and rodent surgery. Pre: Approval of Major Professor.

### **PHPS-711 Laboratory Animal Care, Management and Medicine II (2 credit hours)**

This course is part two of a two part lecture series and is designed to introduce students to the care and use of laboratory animals in accordance with the National Research Council and the Institutional Animal Care and Use Committee (IACUC). Included in this course is a review of Laboratory Animal Care, Management and Medicine I. Emphasis will be placed on rabbits, Mongolian gerbils, guinea pigs, Syrian hamsters, dogs and cats, and primates. Pre: Approval of Major Professor.

### **PHPS-712 Medical Cell Biology (2 credit hours)**

This course focuses on the scientific aspects of cell biology important to graduate students with primary focus on eukaryotic cell biology. The course will provide a basis to general cell biology principles in the context of organ systems and human and animal disease. Clinical cases will be used to build a framework for the basic concepts of medical cell biology and help reinforce conceptual understanding. Pre: Approval of Major Professor.

### **PHPS-713 Organic Medicinal Chemistry I (2 credit hours)**

Organic Medicinal Chemistry I provides the chemical and structural basis for the interdisciplinary field of therapeutics related to diuretics, autonomic nervous system and cardiovascular systems. The topics will include the drug discovery and development process of these important medicines, the chemical and structural basis for the pharmacological and therapeutic action drugs, structural classifications, molecular mechanism of actions, structure activity relationship and how the physicochemical properties of drug molecules affect their route of administration stability, and absorption, distribution, metabolism and excretion. Synthesis of important molecules from each drug class will also be presented. Pre: Approval of Major Professor.

### **PHPS-714 Organic Medicinal Chemistry II (2 credit hours)**

Organic Medicinal Chemistry II provides the chemical and structural basis for the interdisciplinary field of therapeutics related to diabetes, thyroid/pituitary disorders,

hormones/osteoporosis/adrenal, asthma/COPD, and infectious diseases. The topics will include the drug discovery and development process of these important medicines, the chemical and structural basis for the pharmacological and therapeutic action of drugs, structural classifications, molecular mechanism of actions, structure activity relationship, and how the physicochemical properties of drug molecules affect their route of administration, stability, and absorption, distribution, metabolism and excretion. Synthesis of important drug molecules from each drug class will also be presented. Pre: PHPS 713 and Approval of Major Professor

### **PHPS-715 Organic Medicinal Chemistry III (2 credit hours)**

Organic Medicinal Chemistry III provides the chemical and structural basis for the interdisciplinary field of therapeutics related to antiviral agents, OA/RA/Gout, migraine, CNS agents including Parkinson/Alzheimer/Seizure. The topics will include the drug discovery and development process of these important medicines, the chemical and structural basis for the pharmacological and therapeutic action of drugs, structural classifications, molecular mechanism of actions, structure activity relationship, and how the physicochemical properties of drug molecules affect their route of administration, stability, and absorption, distribution, metabolism and excretion. Synthesis of important drug molecules from each drug class will also be presented. Pre: PHPS 714 and Approval of Major Professor

### **PHPS-716 Organic Medicinal Chemistry IV (2 credit hours)**

Organic Medicinal Chemistry IV provides the chemical and structural basis for the interdisciplinary field of therapeutics related to gastro-intestinal/genito-urinary, chemotherapy, pain management, radiopharmaceuticals. The topics will include the drug discovery and development process of these important medicines, the chemical and structural basis for the pharmacological and therapeutic action of drugs, structural classifications, molecular mechanism of actions, structure activity relationship, and how the physicochemical properties of drug molecules affect their route of administration, stability, and absorption, distribution, metabolism and excretion. Synthesis of important drug molecules from each drug class will also be presented. Pre: PHPS 715 and Approval of Major Professor

### **PHPS-717 Medicinal Chemistry of CNS Drugs and Development of *in vivo* CNS Tracers (2 credit hours)**

The course will focus on modern aspects of the design and development of compounds for the treatment of central nervous system disorders, and in addition on

the development of PET (positron emission tomography) and SPECT (single photon emission computed tomography) tracers to monitor functional processes in vivo in the human body. Important properties and steps for profiling a drug to enhance the access to the brain will be discussed. The course will start with an overview about CNS targets and pharmacophore models for diverse compound families and will provide synthetic aspects of important drug templates. The production of relevant radio-nuclides, precursor and radiochemical synthesis, quality control and radio-pharmacological aspects (in vitro, ex vivo, in vivo experiments) will be discussed. Pre: Approval of Major Professor.

### **PHPS-719 Molecular Biology Techniques and Applications for Healthcare Professionals (2 credit hours)**

This course will provide students with basic and advanced information regarding DNA, RNA, and proteins, and describe current available techniques used in detecting genetic variation. Potential applications of these techniques to disease screening, drug resistance, and drug discovery and development will be reviewed. Isolation and purification of DNA samples from different cell types and tissues, DNA concentration techniques, restriction digestion and analysis, ligation of DNA to create recombinant molecules and designer genes will be discussed. Students will be provided with access to reference texts and selected online peer-reviewed articles in .pdf format by the Instructor. The Instructor will conduct lectures for sessions 1 and 15 and provide background material. Each student will select a topic from the remaining sessions (2-14) and will lead the discussion for that selected topic on the assigned day. Students may work in pairs (or more if necessary), depending on student enrollment. Students will learn to retrieve information from a variety of sources, comprehend and critically evaluate it, and subsequently lead a discussion on the selected topic. There will be no laboratory component. Pre: Approval of Major Professor.

### **PHPS-720 Natural Products and Cancer Chemoprevention (2 credit hours)**

The course will concentrate on the molecular aspects of chemoprevention as a viable strategy in the fight against cancer. The treatment of many diseases is dependent on natural products. Over half of the currently approved anti-cancer and anti-infective drugs are of natural origin. Active leads from different structural classes such as alkaloids, flavonoids, coumarins, and phenazines will be described. Since carcinogenesis is a multistage process, different approaches to monitor inhibition of cancer initiation, promotion and progression will be characterized. The course will provide the student with an understanding of detailed aspects of research processes

leading to the discovery of promising natural as well as synthetic and semi-synthetic chemopreventive compounds. Special attention will be given to ensure students are aware that the science of chemoprevention research is well established and offers great research opportunities. Pre: Approval of Major Professor.

### **PHPS-721 Neuropsychopharmacology (2 credit hours)**

This course is designed as an intense, doctoral level class that amalgamates the disciplines of neuroscience, animal behavior, neurochemistry, and pharmacology. The course will cover the major topics of neuropharmacology such as cellular and molecular foundations of neuropsychopharmacology, behavioral pharmacology, receptor biology, major neurotransmitter systems and antidepressants, anxiolytics, antipsychotics, drugs of abuse, and cognitive and movement disorders. Further, this course will integrate some of the principle topics in behavioral neuroscience, including aggression, fear, stress, memory, internal state, and evolution of sex and mating systems, communication, feeding behavior, anti-predator behavior, and the evolution of behavior. Course format will consist of lectures and exams, student presentations, and require a capstone research review paper. Pre: Approval of Major Professor.

### **PHPS-722 Pharmaceutical Marketing (2 credit hours)**

This course has two major areas of emphasis in pharmaceutical marketing. The first part of the course will introduce the basic theory of pharmaceutical marketing and creative thinking behind product development. Students will learn the basic principles of consumer behavior and evaluation, environmental framework, social, and various other marketing theories to provide an understanding of how these concepts can influence product development in laboratories or drug industries. This section will also integrate these principles and concepts to understand issues related to the distribution and design of an innovative drug product development. The second part of the course is intended to use the principles and concepts learned in the first part to effectively develop a market plan for an innovative product. Pre: Approval of Major Professor.

### **PHPS-723 Pharmacognosy (2 credit hours)**

Pharmacognosy is a highly interdisciplinary field which is one of five major areas of pharmaceutical education. Its scope includes the study of the physical, chemical, biochemical and biological properties of drugs, drug substances, or potential drugs or drug substances of natural origin as well as the search for new drugs from natural

sources. This course will focus on chemical aspects of Pharmacognosy. Natural products are normally classified according to their biosynthetic origins and chemical properties. Thus, the objective of the course is to familiarize students with an introduction to and classification of natural products (terpenoids, alkaloids, phenylpropanoids and allied phenolic compounds). The basic metabolic pathways and the origin of secondary metabolites such as the shikimic acid pathways, the acetate-malonate pathway, the mevalonate pathways will be discussed. It is a core course of Pharmacognosy and enable students to use this knowledge in the future to explore Advanced Pharmacognosy. A special emphasis will be placed on how chemical structure affects physiological function of various natural products. Pre: Approval of Major Professor.

### **PHPS-724 Pharmacology I (3 credit hours)**

In this 3 credit, 45 hour lecture, course students will learn pharmacology of specific drug groups. The course uses organ system approach. This course will begin with a discussion of diuretics followed by autonomic nervous system pharmacology and conclude with a discussion of drug groups used for the treatment of cardiovascular disorders. In the autonomic pharmacology unit, students will learn about adrenergic and cholinergic drugs that possess agonist and /or antagonist activities at different types and subtypes of receptors that are present in autonomic nervous system and other tissues in the body. Cardiovascular pharmacology will include drug groups that are used in the management of hypertension, hyperlipidemia, heart failure, disorders of coagulation, cardiac arrhythmias, and ischemic heart disease. Pre: Approval of Major Professor.

### **PHPS-725 Pharmacology II (3 credit hours)**

In this 3 credit, 45 hour lecture, course students will learn pharmacology of specific drug groups. The course uses organ system approach. This course will begin with a discussion of endocrine disorders pharmacology followed by pharmacology of asthma and chronic obstructive pulmonary disease (COPD), and conclude with a discussion of drug groups used for the treatment of infectious diseases. In the endocrine pharmacology unit, students will learn about drug groups that are used in the treatment of diabetes, thyroid and pituitary disorders, osteoporosis, as well as corticosteroid drugs. Respiratory pharmacology unit will include pathophysiology and pharmacology of drug groups that are used in the treatment of asthma and COPD. Infectious disease pharmacology unit will include discussions of antibacterial, antifungal, antiviral, antiprotozoal and antihelminthic drugs. Pre: Approval of Major Professor.

### **PHPS-726 Pharmacology III (3 credit hours)**

This graduate-level course introduces the student to the basis of disease and pharmacology of drugs used to treat viral infections, osteoarthritis, rheumatoid arthritis, gout, and CNS disorders. Course material covers principles of drug action including drug-receptor interactions and mechanism of action, adverse effects, absorption, distribution, metabolism, elimination and pharmacogenomics. The focus of CNS lectures include therapeutics used to treat migraine, schizophrenia, depression, bipolar disorder, attention deficit hyperactivity disorder, sleep disorders, anesthesia, and neurodegenerative diseases. Students will be assigned a scientific article to read in advance of “Special Topics” lectures. For five of these assignments, the student will also be required to write a one-page summary of the article and its main findings. Pre: PHPS 725.

### **PHPS-727 Pharmacology IV (3 credit hours)**

This graduate-level course introduces the student to the basis of disease and pharmacology of drugs used to treat gastrointestinal and genitourinary disorders, fertility and contraception, as well as cancer and pain management. Course material covers principles of drug action including drug-receptor interactions and mechanism of action, adverse effects, absorption, distribution, metabolism, elimination and pharmacogenomics. Students will be assigned a scientific article to read in advance of “Special Topics” lectures. For five of these assignments, the student will also be required to write a one-page summary of the article and its main findings. Pre: PHPS 726.

### **PHPS-728 Phytochemistry of Terrestrial Plants (2 credit hours)**

This course will survey the chemical structures, spectroscopic properties, biosynthesis/biogenesis and biological activities of a wide range of major and minor chemical classes occurring in terrestrial plants. These compound classes will include alkaloids, terpenoids, steroids, coumarins, Flavonoids, tannins and other polyphenols, pyrones, quinones, phenylpropanoids, lignans, depsides, depsidones, fats, waxes and lipids among others. Completion of this course will provide the student with a basic familiarity with the kinds of chemical structures found in plants enabling her/him to embark on a career in phytochemical research. Pre: Approval of Major Professor.

### **PHPS-729 Receptor Theory and Signal Transduction (2 credit hours)**

This course is designed to provide the student with knowledge of the historical and practical aspects of receptor theory as it applies to drug action, and to introduce how drug actions are mediated through signal transduction cascades, based on specific examples. Lecture topics include: models for receptor-drug interactions; methods for receptor identification; structure-function analysis of GTP-binding proteins and ligand-operated ion channels; receptor tyrosine kinases; nuclear receptors; and receptor-induced signal transduction cascades. Laboratory component of the course is designed to complement lecture topics. Pre: Approval of Major Professor.

### **PHPS-730 Sample collection, documentation and preservation (1 credit hour)**

Participants in this course will learn strategies for sample collection from both the terrestrial and marine environments and for both macro- and micro-organisms. The course will cover permit application, sample collection, and the various ways in which different sample types are preserved for long term storage and how taxonomic voucher specimens are prepared. Pre: Approval of Major Professor.

### **PHPS-731 Toxicants and Toxicity (3 credit hours)**

This course will provide a general foundation in the understanding of basic toxicological principles. The mechanisms of toxicity and contemporary treatment plans for the most common chemical, environmental and pharmaceutical agents will be presented. Additionally, this course will provide an in-depth review of the neuropharmacology of substances of abuse including stimulants, depressants, hallucinogens and anabolic steroids. Other types of addiction will be discussed. Special emphasis will be given to basic pharmacokinetic and pharmacodynamic mechanisms as they relate to the effects of the individual substances of abuse. Current theories of addiction and tolerance development will be discussed. Pre: Approval of Major Professor.

### **PHPS-732 Toxic plant natural products and their therapeutic potential (2 credit hours)**

This course will draw on the basic principles of organic chemistry and biology to provide an understanding of the biosynthesis of toxic natural products in plants, their bioassay-directed fractionation and isolation, structural identification, and mode of action in mammalian systems. Toxins discussed will be those responsible for hepatotoxicity, teratogenicity, cardiotoxicity, lysosomal storage diseases, and



reproductive defects. Students will integrate these principles to understand the importance of dose in discriminating between toxicity and therapeutic action, as well as the role of natural products as lead compounds in drug development. The major classes of toxic compounds occurring in plants will be discussed, with particular reference to those occurring in Hawaii. Discussions of proper experimental design, plant sampling and identification, and structural classification will carry over into the laboratory portion of the class. Students will become familiar with procedures for plant collection, extraction and isolation of pure compounds, and structural identification. Pre: Approval of Major Professor.

### **PHPS-733 Aerosol Physics in Medicine: Inhaled Drug Therapy (1 credit hour)**

The course is structured in two equal halves. Part 1 focuses on fundamentals concerned with aerosol behavior and assessment of orally and nasally inhaled products (OINDP). Part 2 applies the knowledge gained in the first part to develop an understanding of the current regulatory science and newer methods of assessment to provide more meaningful data to prescribing clinicians and the patients themselves. Pre: First year standing (Ph.D.) in UHH DKICP or B.S or equivalent.

### **PHPS-734 Biotechnology Laboratory (2 credit hours)**

Biotechnology continues to play a greater and greater role in pharmacy. Health conditions can be treated with DNA vaccines, RNAi, monoclonal antibodies, recombinant proteins including peptide hormones, etc. This course will provide hands-on experience with biotechnology techniques. Techniques will be covered from DNA manipulations to expression of recombinant proteins. Students will become familiar with the propagation and purification of bacteria, miniprep isolation of DNA, restriction enzyme digestion of DNA, agarose gel electrophoretic separation of DNA fragments, isolation and cloning of DNA fragments, DNA amplification by polymerase chain reaction (PCR), and detection of DNA sequences by Southern blot hybridization. Proteins will be expressed from inducible promoters and purified by elution of His-Tag proteins from nickel-chelating columns. Proteins will be separated by SDS-polyacrylamide gel electrophoresis (SDS-PAGE) and characterized by antibody techniques employing ELISA, Western blotting, and immunofluorescence microscopy. The utility of GFP-labeled proteins in drug discovery will be demonstrated by screening for compounds that result in nuclear localization of a GFP-tagged FOXO transcription factor in the nematode, *C. elegans*. Pre: Approval of Major Professor.

### **PHPS-735 Cell Cycle Progression and Apoptosis, Methodological Approaches (2 credit hours)**

Apoptosis (programmed cell death) and proliferation are intimately coupled. Tissue homeostasis is dependent on the balance between cell proliferation and cell death. Some cell cycle regulators can influence both proliferation and apoptosis. An imbalance can result in diseases linked with unwanted apoptosis or unwanted cell growth. The fact that a number of similar morphological features exist between mitosis and apoptosis demonstrates a direct link between the cell cycle and apoptosis. These include substrate detachment, cell rounding and shrinkage, and chromatin condensation. The course will provide lectures and hands on experience with modern methodological approaches for studying apoptosis and the cell cycle. Since molecular techniques that are included are all have direct relevance to cell culture, the course is targeted to students with little or no previous experience in mammalian tissue culture. Lectures will cover the current understanding of cell cycle regulators in apoptosis. The knowledge of the links between the cell cycle and apoptosis should be of help in understanding pathological conditions, in addition to identifying new therapeutic strategies.

### **PHPS-751 Biochemistry I - Biomolecules (3 credit hours)**

This course is designed to provide a basic foundation for the understanding of medicinal biochemistry, pharmacology, and the structure and function of various biomolecules. Topics will include physical and chemical properties of amino acids, structural and physical properties of proteins, nucleic acids (DNA and RNA), lipids, and their relationship to their biological function, fundamentals of signal transduction, DNA replication, mutation, and repair, nucleotide biosynthesis, protein synthesis, and transcription. These principles will provide the basic concepts for understanding the biochemical basis for disease states and drug action. Pre: Enrollment in the College of Pharmacy Pharmaceutical Sciences PhD program.

### **PHPS-752 Biochemistry II– Metabolism (3 credit hours)**

Biochemistry II - Metabolism will delve into metabolism and the interrelationships/integration of metabolic processes. The biochemistry of metabolism focuses on glycolysis, the tricarboxylic acid cycle, gluconeogenesis, and the synthesis and breakdown of biomolecules (carbohydrates, lipids, and amino acids). Metabolic control and regulation of pathways will be emphasized. This includes a discussion of mechanisms and control of signal transduction

pathways, and recurring motifs in metabolism. Clinical correlates and metabolic diseases will be examined, with a substantial emphasis on metabolic syndrome. A sampling of biochemical techniques will also be described. Pre: Enrollment in the College of Pharmacy Pharmaceutical Sciences Ph.D. Program

**PHPS-755 Advanced Pharmaceutics I, including Dosage Form Design and Processing (3 credit hours)**

This course will draw on the basic principles of chemistry, biology and physics to provide an understanding of how drug physico-chemical properties at the molecular and macroscopic assembly level are manifest in dosage form properties and performance. Students will integrate these principles to understand issues in the rational selection of dosage forms and drug delivery systems as well as their role in drug product development. Discussions of Good Manufacturing Practices and Good Compounding Practices will carry over into the lab portion of the class. Students will become comfortable with equipment; procedures and records used in the compounding of various dosage forms, and will practice clinical dispensing skills vital to shaping a truly professional pharmacist. Pre: Approval of Major Professor.

**PHPS-756 Advanced Pharmaceutics II, including Dosage Form Design and Processing (3 credit hours)**

This course will draw on the basic principles and developmental aspects of drug formulation to deliver the active pharmaceutical ingredient through biological membranes to exert the therapeutic effect at site of action. Understanding of physicochemical properties of active pharmaceutical ingredient and additives or excipients, pharmacological properties and processability of drug delivery systems can be utilized for optimal performance of the drug delivery systems. Understanding of active pharmaceutical ingredient and additive or excipients physico-chemical properties at the molecular and macroscopic assembly level are manifest in dosage form properties and performance. Students will integrate these principles to understand issues in the rational choice of dosage forms and drug delivery systems as well as their role in drug product development. Discussions of Good Manufacturing Practices and Good Compounding Practices will carry over into the lab portion of the class. Students will become familiar with procedures and records used in the compounding of various dosage forms, and will practice clinical dispensing skills vital to shaping a truly professional pharmacy professional scientist. Pre: Enrollment in the College of Pharmacy Pharmaceutical Sciences Ph.D. program.