Biomedical Sciences

The study of biomedical sciences includes the major disciplines of:

- anatomy (gross or microscopic)
- physiology/pharmacology (molecular, cellular and integrative)
- biochemistry/molecular biology
- endocrinology
- toxicology

Specific areas of interest are exercise biology including cardiac, vascular and muscle biology; cardiovascular biology including neuroendocrine regulation; membrane transport biology including cystic fibrosis and cardiac disease; and reproductive biology including environmental estrogen toxicities and developmental processes.

All of the biomedical sciences degrees at MU are at the graduate level, and within two very distinct programs. See the Graduate tab for details on these options.

For undergraduate students interested in studying biomedical sciences, there are more than two dozen courses taught at the undergraduate level. See the Courses tab for details on these options.

Faculty

Comparative (Veterinary) Medicine

Professor C. L. Franklin
Associate Professor Y. Agca, E. C. Bryda
Clinical Associate Professor L. W. Dixon
Adjunct Professor C. L. Besch-Williford
Adjunct Clinical Associate Professor R. S. Livingston
Clinical Veterinarian S. W. Korte, E. K. O’Connor

Pathobiology Emphasis

Clinical Associate Professor L. Berent*, D. Kim*, T. Reilly**, C. Vogelweid*, M. Whitney*
Associate Research Professor M. Lorson*, A. Ray*
Professor Emeritus C. A. Carson
R. Phillip and Diane Acuff Endowed Professor D. Pintel
McKee Endowed Professor G. Stewart**

Biomedical Sciences: Veterinary Medicine and Surgery emphasis

Assistant Professor S. M. Afzal*, A. Bukoski*, A. E. DeClue***, M. Heller*, P. Pithua*, F. Winingier*
Clinical Assistant Professor K. R. Branson*
Teaching Professor I. Masseau
Assistant Teaching Professor L. Britt*, C. R Cook*, D. Nagy*, J. Pearce*, S. Reed*
Associate Teaching Professor M. Kerl*, J. Kramer*, L. Schultz*, K. A. Selting*
Assistant Extension Professor S. Poock*

Biomedical Sciences

Associate Professor C. S. Reddy**, C. S. Rosenfeld**, L. J. Rubin**, W. V. Welshons*
Assistant Professor C. P. Baines**, K. Cummings**, C. Emtier**, D. D. Kline**
Adjunct Professor M. B. Brown*, V. H. Huxley, S. S. Segal**
Adjunct Assistant Professor T. Boyd
Adjunct Associate Professor G. S. Johnson*, G. E. Rottinghaus*
Clinical Associate Professor L. A. Constantinescu, B. L. Frappier*
Assistant Teaching Professor D. Cross, M. C. Kuehl-Kovarik**
Research Professor S. Yang**

Graduate Faculty Member - membership is required to teach graduate-level courses, chair master's thesis committees, and serve on doctoral examination and dissertation committees.

** Doctoral Faculty Member - membership is required to chair doctoral examination or dissertation committees. Graduate faculty membership is a prerequisite for Doctoral faculty membership.

Undergraduate

While MU does not offer undergraduate degrees specifically in biomedical sciences, the University does offer baccalaureate opportunities in a number of related areas in the other Schools and Colleges that make up the University. The catalog provides a complete list of these degree options (http://catalog.missouri.edu/degreesanddegreeprograms/).

Graduate

- MS in Biomedical Sciences (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/biomedicalsciences/ms-biomedical-sciences/)
  - with emphasis in Biomedical Sciences (Biomedical Sciences Area program) (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/biomedicalsciences/ms-biomedical-sciences-emphasis-biomedical-sciences/)
  - with emphasis in Comparative Medicine (post DVM degree only) (Veterinary Medicine program) (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/).
biomedicalsciences/ms-biomedical-science-comparative-medicine-post-dvm/)
• with emphasis in Pathobiology (Veterinary Medicine program) (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/biomedicalsciences/ms-biomedical-science-pathobiology/)
• with emphasis in Veterinary Medicine and Surgery (Veterinary Medicine program) (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/biomedicalsciences/ms-biomedical-science-veterinary-medicine-surgery/)
• with emphasis in Veterinary Sciences (Veterinary Medicine program) (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/biomedicalsciences/ms-biomedical-science-veterinary-sciences/)
• PhD in Biomedical Sciences (Biomedical Sciences Area Program) (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/biomedicalsciences/phd-biomedical-sciences/)

An Array of Biomedical Degrees Offered

The University of Missouri offers several degree program options in Biomedical Sciences:

• The Biomedical Sciences Area Program offers a master's program in basic biomedical sciences and a PhD area program. Dual biomedical-DVM degrees are other options. Students in the Biomedical Sciences Area Program do not have to be enrolled in the College of Veterinary Medicine.

• The Graduate School also confers three MS degrees related to veterinary biomedical sciences. Available emphasis areas are (a) comparative veterinary medicine, (b) pathobiology and (c) veterinary medicine and surgery. Generally, applicants to these biomedical degree programs are concurrently enrolled in College of Veterinary Medicine or have previously earned a Doctorate in Veterinary Medicine (DVM).

Additional Program Options

Pathobiology

The Pathobiology Area Program offers a PhD in Pathobiology (http://catalog.missouri.edu/undergraduategraduate/interdisciplinaryacademicprograms/pathobiology/phd-pathobiology/).

DVM/Graduate degree in Biomedical Sciences

The Biomedical Sciences graduate programs enable veterinary medical students to pursue studies in the basic biomedical discipline of their choice for a PhD or MS degree while enrolled in the College of Veterinary Medicine. The program is designed to prepare students for advanced professional careers in universities and colleges, research institutes and industrial research.

With consent of the student’s graduate program committee, courses from the professional curriculum (which includes a major portion of the core curriculum) can be accepted toward the graduate degree.

Master of Science: The MS/DVM program enables veterinary medical students to complete a master’s degree while enrolled in the College of Veterinary Medicine. The program allows qualified students to seek in-depth involvement in the basic biomedical discipline of their choice. Six hours of 9090 Research that result in an original thesis are required. Financial support may be provided to VM2-4 students through teaching assistantships in gross anatomy laboratory (V_BSCI 5500 Veterinary Anatomy with Laboratory).

Doctor of Philosophy: The PhD/DVM program requires a minimum of 30 credit hours of 9090 Research culminating in completion of original research and defense of a written dissertation.

Major biomedical disciplines include anatomy of domestic species (gross or microscopic); physiology/pharmacology (molecular, cellular and integrative); biochemistry/molecular biology; endocrinology; and toxicology. Specific areas of interest are exercise sciences; cardiovascular and neurosciences; muscle biology; membrane transport biology; reproductive biology; and developmental toxicology.

Admission Contact Information
Kevin J. Commings (cummingske@missouri.edu), PhD Associate Professor
E102 Veterinary Medicine Building
(573) 882-0283

http://biomed.missouri.edu/

BIOMED 1010: Biomedical Career Explorations

An introduction to the variety of career possibilities within the growing field of biomedical sciences. Graded on A-F basis only.

Credit Hour: 1

BIOMED 2110: Biomedical Terminology

Life science etymology (Greek for 'true meaning', means the study of word derivation) taught by classroom presentation and discussion. The course organization is based primarily on common themes of Greek and Latin terms along with historical reasons for current usage. The application of these terms is for all biomedical sciences and life sciences. Graded on A-F basis only.

Credit Hours: 3

BIOMED 2111: Veterinary Medical Terminology

Veterinary Medical Terminology is an extension of Biomedical Sciences 2110, Biomedical Terminology. The course organization is lecture, based primarily on domestic species and common themes of Greek and Latin terms. In addition, major veterinary medical eponyms, acronyms, and medical and surgical instruments are included. Graded on A-F basis only.

Credit Hour: 1

Prerequisites: BIOMED 2110 or instructor's consent

BIOMED 2120: Essentials of Animal Handling and Physical Restraint

Fundamentals of handling and physical restraint of domestic large and small animals, laboratory animals, and common non-domestic pets. Graded on A-F basis only.

Credit Hours: 2

BIOMED 2130: Introduction to Veterinary Anatomy and Physiology

This introductory anatomy and physiology course describes the body and its functions from a systemic approach. Suitable for a student with no previous coursework in anatomy and physiology. Graded on A-F only.
## BIOMED 2140: Companion Animals
(same as AN_SCI 2140)
Companion animals form an important part of our society. They serve us, provide companionship and many become members of our families. This class focuses primarily on dogs, cats, and horses. Topics covered include: the pet industry, breeds, wellness, management, care, training, zoonotic diseases, evolution and domestication, toxicology, nutrition, reproduction, genetics, human animal interactions, companion animal enterprise, and biomedical research. Students may enroll in one of two sections: service learning section or traditional course section.

**Credit Hours:** 3

**Prerequisites:**
- AN_SCI 3254 or BIO_SC 3700 or equivalent
- AAS or equivalent degree from AVMA-accredited program or instructor’s consent

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## BIOMED 2230: Animal Sanitation and Disease Prevention
Preventative measures for diseases and parasites of farm animals.

**Credit Hours:** 3

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## BIOMED 2940: Internship in Biomedical Sciences
Supervised work experience to develop technical skills and enhance student knowledge in an area of biomedical science. Not intended for more than 50% independent research. Graded on S/U basis only.

**Credit Hour:** 1

**Recommended:**
- sophomore standing

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## BIOMED 2200: Comparative Hematology
Hematology is the study of blood cells in health and disease. Emphasis in this course is placed on the changes associated with disease. Transfusion medicine and coagulation disorders will also be included. Course graded on A-F basis only.

**Credit Hours:** 2

**Prerequisites:**
- Junior standing

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## BIOMED 3400: Domestic Animal Behavior in Veterinary Practice
Students will be introduced to the key characteristics of behavior among common domestic animals such as dogs, pigs, cats, horses, cattle, sheep and goats. Topics include communication, aggression, biological rhythms, reproductive behavior, learning and development, ingestive behavior and genetics. This course will enable students to gain a thorough understanding of assessing animal behavior, as well as how to utilize the assessment to better the animal’s health. Graded on A-F basis only.

**Credit Hours:** 2

**Prerequisites:**
- Junior standing

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## BIOMED 4001: Topics in Biomedical Sciences
Topics in Biomedical Sciences.

**Credit Hours:** 1

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BIOMED 4100: Veterinary Clinical Chemistry
(cross-leveled with V_PBIO 7100). This course is designed to hone the skills of the practicing veterinary technician, veterinary student, or veterinarian and assumes some basic knowledge of normal serum chemistry and urinalysis results. The review of normal will be minimal and emphasis will be placed on clinical serum chemistry and urinalysis findings associated with diseases. The graduate level course will include discussion of ancillary tests and more extensive case interpretations.

Credit Hours: 3
Prerequisites: An AAS or equivalent degree in veterinary technology from an American Veterinary Medical Association accredited programs; Undergraduate physiology on mammals (AN_SCI 3254, BIO_SC 3700, or equivalent
Recommended: BIOMED 2110 and BIOMED 3200 or instructor's consent

BIOMED 4110: Veterinary Cytology
(cross-leveled with V_PBIO 7110). This course of Veterinary Cytology is designed to hone the skills of the practicing Veterinary Technician, Veterinary Student, or Veterinarian and assumes some basic knowledge of microscope usage and normal hematology. The review of normal cells will be minimal and emphasis will be placed on findings associated with inflammatory and neoplastic diseases. The graduate level course will include discussion of ancillary tests, special stains and treatment alternatives. The focus will be on canine and feline diseases but some common equine and bovine disease. Prerequisites: An AAS or equivalent degree in veterinary technology from an American Veterinary Medical Association-accredited program, or instructor's consent

Credit Hours: 2
Recommended: BIOMED 3200 and BIOMED 2110

BIOMED 4120: Principles of Toxicology
(cross-leveled with V_PBIO 7120). This course will provide an introduction to the general principles of toxicology, including the history and scope of the field; risk assessment and management; mechanisms of toxicology; the disposition of toxicants; non-target organ-directed toxicity; toxic responses of specific target organs; and various toxicological application, such as environmental toxicology.

Credit Hours: 3
Prerequisites: one year of college chemistry and biology, each or instructor's consent

BIOMED 4210: Animal Issues in Disasters
(cross-leveled with V_PBIO 7210). This course describes the various aspects of responding to disasters that involve animals. Government involvement, legal requirements, effects on the human-animal bond, preparation for disasters of different kinds, and impacts on animal-related businesses will be discussed.

Credit Hour: 1
Prerequisites: an AAS in veterinary technology from an American Veterinary Medical Association accredited program, or equivalent training, or instructor's consent

BIOMED 4300: Clinical Veterinary Neurology
Clinical veterinary neurology will review the neurologic examination, common neurologic diseases and techniques to properly care for the neurologic patient. The course organization is based primarily on neuroanatomic localization of disease. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: AAS in Veterinary Technology or BIOMED 3219 and 3100 or instructor's consent; junior or senior standing

BIOMED 4320: Fundamentals of Small Animal Emergency and Critical Care
(cross-leveled with V_BSCI 7320). This course will provide students with the knowledge and skills to assist in small animal medical emergency and critical care facilities.

Credit Hours: 3
Prerequisites: An AAS in veterinary technology from an American Veterinary Medical Association accredited program, or equivalent training, or instructor's consent

BIOMED 4333: Veterinary Cell Biology
(same as V_BSCI 5506). Course material stresses cell biology as related to animal health and medical issues. A comprehensive course overviewing molecular and biochemical issues of cell function especially as related to medicine and the underlying molecular causes of disease.

Credit Hours: 4
Prerequisites: B_C 1500, or equivalent, 1 course in biochemistry or 4 credit hours in chemistry; or instructor's consent

BIOMED 4400: Veterinary Surgical Nursing
Veterinary Surgical Nursing will enable the student to properly identify, care for, and maintain surgical equipment. The course will also prepare the student to learn surgical anatomy as will as the potential complications of common clinical setting surgeries. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: BIOMED 2111, BIOMED 3219, and BIOMED 3100, or instructor's consent

BIOMED 4410: Small Animal Physical Rehabilitation
This course will review the science of veterinary rehabilitation, assessment of rehabilitation patients, and the techniques used to treat these patients. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: AAS degree in veterinary technology or BIOMED 2110 or HTHL_PR 2190 or equivalent, plus BIOMED 3219 or PTH_AS 2201 or equivalent, or instructor's permission

BIOMED 4500: Equine Critical Care and Nursing
This course provides advanced information for veterinary technicians, veterinary assistants, and pre-veterinary students wishing to enhance and focus their understanding of equine critical care and nursing concepts. Course graded on A-F basis only.

Credit Hours: 3
Prerequisites: AN_SCI 2095 and AN_SCI 3254 or BIO_SC 3700 or equivalents, AAS or equivalent degree from AVMA-accredited program or instructor's consent
BIOMED 4510: Equine Clinical Anatomy: Forelimbs
(cross-leveled with V_BSCI 7510). Basic foundation in selected aspects of equine clinical anatomy from veterinary technicians, pre-veterinary students, and other students wishing to enhance their understanding of anatomical structures of the horse's forelimbs.

Credit Hour: 1
Prerequisites: five hours of biologic science or zoology, or equivalent, or instructor's consent, or an AAS or equivalent degree in veterinary technology from an American Veterinary Medical Association accredited program

BIOMED 4520: Equine Clinical Practice
This course is an introduction to a common medical conditions of the horse. Emphasis will be placed on the presenting complaint and the veterinarians approach to diagnosis, treatment, and prognosis.

Credit Hour: 1
Prerequisites: BIOMED 2110, BIOMED 2111 and AN_SCI 4977 or their equivalents, or an associate's degree in veterinary technology, or instructor's consent

BIOMED 8100: Veterinary Online Course Development and Teaching
Best practices of online teaching in veterinary medicine are taught. Emphasis is placed on proper course objectives, productive instructor and student interactions, appropriate student assessments, and essentials of course alignment. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: ED_LPA 9456
Prerequisites: ED_LPA 9448

BIOMED 8310: Advanced Topics in Stress Physiology
An in-depth study of the causes and physiological responses to internal and external stress conditions that affect animals throughout life. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Admission to the MS in Biomedical Sciences program

BIOMED 8311: Clinical Veterinary Physiology Review Series A: Cells, Circulation, Musculoskeletal, Renal, Immune
This course will provide graduate level instruction to review cellular, circulation, musculoskeletal, renal, and immune physiology, and apply concepts to the veterinary patient. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Acceptance into program

BIOMED 8312: Clinical Veterinary Physiology Review Series B: Respiration, Neurological, Gastrointestinal, Metabol
This course will provide graduate level instruction to review respiratory, neurological, gastrointestinal, metabolic, and endocrine physiology, and apply concepts to the veterinary patient. Graded on A-F only.

Credit Hours: 3
Prerequisites: admission into program

BIOMED 8700: Principles of Veterinary Pain Management
Pain pathophysiology, assessment, and management in veterinary patients. Graded on A-F basis only.

Credit Hours: 2
Prerequisites: Admission to the MS in Biomedical Sciences program

BIOMED 8710: Essentials of Radiation Biology
Essentials of Radiation Biology begins with an overview of pertinent medical physics and cell biology, then continues with the biologic, cellular and systemic responses to ionizing radiation. This course also includes a presentation of the early and late somatic and genetic effects of ionizing radiation. Required radiation protection guidelines and regulations will be taught as well as methods and techniques to reduce whole body and organ occupational radiation exposure. Graded on A-F basis only.

Credit Hours: 2
Prerequisites: Successful completion of undergraduate Biology; admission into the program

BIOMED 8900: Small Animal Wound Management and Reconstructive Surgery
This course addresses wound physiology, management and reconstructive surgery in small animal patients. Graded on A-F basis only.

Credit Hours: 2
Prerequisites: Admission to program

V_BSCI 5011: Veterinary Anatomy
In-depth study of the structure of the horse, ox, sheep, goat, pig and avian species. (Instructional periods 3 and 4).

Credit Hours: 3

V_BSCI 5012: Veterinary Anatomy with Laboratory
Continuation of V_BSCI 5011. In-depth study of the structure of the horse, ox, sheep, goat, pig and avian species. (Instructional periods 3 and 4).

Credit Hours: 3

V_BSCI 5020: Developmental Anatomy
Provides a comprehensive and rational interpretation of the intricate mechanisms of normal development to better understanding the complex anatomy of the adult. A substantial portion will be dedicated to commonly encountered congenital abnormalities for each major organ system.

Credit Hours: 0.5
Prerequisites: 1st year Veterinary students

V_BSCI 5021: Developmental Anatomy
Provides a comprehensive and rational interpretation of the intricate mechanisms of normal development to better understanding the complex anatomy of the adult. A substantial portion will be dedicated to commonly encountered congenital abnormalities for each major organ system.

Credit Hours: 0.5
Prerequisites: 1st year Veterinary students
V_BSCI 5051: Veterinary Gastrointestinal
Continuation of V_BSCI 5504. Physiology of the gastrointestinal tract, exocrine pancreas and liver. Lecture and lab designed to emphasize principles important to the practice of veterinary medicine.
Credit Hours: 2

V_BSCI 5052: Veterinary Endocrinology and Reproductive Physiology
Continuation of Veterinary Biomedical Science 5051. Comparative endocrinology and reproductive biology.
Credit Hours: 2

V_BSCI 5100: Veterinary Neuroscience
A laboratory and lecture-based course emphasizing the applied anatomy and physiology of the nervous system of domestic animals.
Credit Hours: 2
Prerequisites: first year Veterinary students

V_BSCI 5500: Veterinary Anatomy with Laboratory
Correlative study of the anatomy of domestic and laboratory animals in which the developmental and gross anatomy are integrated. A segment is devoted to neuroanatomy. Dissection includes the dog, cat and common laboratory animals. (Instructional periods 1 and 2).
Credit Hours: 4

V_BSCI 5502: Veterinary Microscopic Anatomy with Laboratory
A study of microscopic anatomy including cytology, histology of basic tissues and microscopic anatomy of cardiovascular, urinary, respiratory systems and the special senses and integument. (Instructional periods 1 and 2).
Credit Hours: 3

V_BSCI 5503: Veterinary Microscopic Anatomy
Particular attention to digestive systems, endocrine organs and reproductive systems. (Instructional period 3).
Credit Hours: 2

V_BSCI 5504: Veterinary Physiology
This course is designed to provide an opportunity and motivation for the student to acquire an understanding of the physiological principles on which rational therapy in medical practice is based. Topics include: Cellular Neurophysiology, Muscle, Cardiovascular, Renal and Respiratory Physiology. The course also encourages the student to apply these principles in solving problems so that it becomes habitual for him or her to think in terms of 'mechanisms of action' as he or she approaches a problem in disturbed physiology.
Credit Hours: 5

V_BSCI 5506: Veterinary Molecular and Cellular Biology
(same as V_BSCI 7333) A comprehensive course overviewing molecular and biochemical issues of cell function especially as related to medicine and the underlying molecular causes of disease.
Credit Hours: 4

V_BSCI 5507: Veterinary Pharmacology with Laboratory
General principles of pharmacy, pharmacokinetics, and pharmacodynamics, with emphasis on drugs affecting the central and autonomic nervous system, cardiovascular and hematologic systems.
Credit Hours: 3

V_BSCI 5508: Veterinary Pharmacology
Continuation of V_BSCI 5507. Antiseptics, autocoids, hemostatics and anticoagulants, fluid and electrolytes, reproductive, endocrine, and gastrointestinal drugs.
Credit Hours: 2

V_BSCI 5509: Veterinary Toxicology
(Same as V_BSCI 8509) Local and various systemic clinical responses of domestic animals to foreign chemicals including metals, pesticides, water-and food-borne agents, biotoxins, industrial and plant toxins. The principles, mechanism(s) of action, diagnosis, prevention and treatment of chemical intoxications are also presented.
Credit Hours: 3

V_BSCI 7333: Veterinary Cell Biology
(same as V_BSCI 5506). Course material stresses cell biology as related to animal health and medical issues. A comprehensive course overviewing molecular and biochemical issues of cell function especially as related to medicine and the underlying molecular causes of disease.
Credit Hours: 4
Prerequisites: instructor's consent

V_BSCI 8085: Problems in Veterinary Biomedical Science
Selected problems and/or topics for advanced study in special areas to meet needs of individual students.
Credit Hour: 1-99

V_BSCI 8090: Research in Veterinary Biomedical Science
Open to graduate students with requisite preparation. Research expected to be presented as a thesis. Graded on a S/U basis only.
Credit Hour: 1-99

V_BSCI 8100: Veterinary Neuroscience
A laboratory and lecture based course emphasizing the applied anatomy and physiology of the nervous system of domestic animals.
Credit Hours: 2
Prerequisites: Restricted to first year veterinary students or graduate students

V_BSCI 8200: Multidisciplinary Approaches to Biomedical Sciences
The goal of this course is to aid the student in developing a multidisciplinary philosophy to problem solving in biomedical research. Methods used in molecular, biochemical, cellular, tissue, organ, and whole animal studies will be emphasized.
Credit Hours: 2
Prerequisites: instructor's consent
V_BSCI 8410: Seminar in Veterinary Biomedical Science
Presentation and discussion of investigations and topics in veterinary anatomy-physiology or related fields, by qualified students, instructors, and guests.

Credit Hour: 1
Prerequisites: departmental consent

V_BSCI 8420: Veterinary Physiology
This course is designed to provide an opportunity and motivation for the student to acquire an understanding of the physiological principles on which rational therapy in medical practice is based. Topics include: Cellular Neurophysiology, Muscle, Cardiovascular, Renal and Respiratory Physiology. The course also encourages the student to apply these principles in solving problems so that it becomes habitual for him or her to think in terms of ‘mechanisms of action’ as he or she approaches a problem in disturbed physiology.

Credit Hours: 5
Prerequisites: BIOCHM 4270 and BIOCHM 4272

V_BSCI 8421: Veterinary Physiology
Continuation of V_BSCI 8420. Physiology of the gastrointestinal tract, exocrine pancreas, liver, endocrine system and reproduction.

Credit Hours: 4

V_BSCI 8509: Veterinary Toxicology
(Same as V_BSCI 5509) Local and various systemic clinical responses of domestic animals to foreign chemicals including metals, pesticides, water-and food-borne agents, biotoxins, industrial and plant toxins. The principles, mechanism(s) of action, diagnosis, prevention and treatment of chemical intoxications are also presented. Graded A-F only.

Credit Hours: 3

V_BSCI 9090: Research in Veterinary Biomedical Sciences
Research in Veterinary Biomedical Sciences. Graded on S/U basis only.

Credit Hour: 1-99

V_BSCI 9425: Microvascular Circulatory Function
(same as MPP 9434). An in-depth study of microcirculatory structure and function in various tissues with emphasis on recent developments in the understanding of the mechanisms involved in nutrient supply, edema formation, lymphatic function and fluid balance.

Credit Hours: 3
Prerequisites: V_BSCI 8420 and V_BSCI 8422 or Mammalian Physiology or equivalent

V_BSCI 9435: Molecular Exercise Biology
(same as MPP 9435). Integrated adaptations of adipose tissue, blood vessels, bone, brain, heart, immune, liver, microbiome, and skeletal muscle to physical training during life. Lifecourse emphasis will be placed upon the role of physical activity during growth and aging in increasing and decreasing, respectively, cardiovascular fitness and strength fitness. The roles of the level of cardiovascular and strength fitness in slowing the onset of chronic diseases and death will be one outcome of the curriculum. Graded on A-F basis only.

Credit Hours: 3

V_BSCI 9462: Hormone Action
(same as BIOCHM 9462). A lecture course with weekly assigned readings. Topics will include: a description of selected polypeptide, steroid and other hormones and their biological effects; receptors; second messengers; protein phosphorylation in hormone mediation; growth factors; cellular oncogenes.

Credit Hours: 2
Prerequisites: BIOCHM 7272

V_BSCI 9467: Neural Cardiorespiratory Control
(same as MPP 9437). Course objectives include developing a general understanding of CNS mechanisms in the regulation of the cardiovascular and respiratory system, including autonomic, neurohumoral and body fluid homeostatic mechanisms, gaining knowledge of the major advances and topics in the field and becoming familiar with some of the methods used to study CNS cardiorespiratory regulation. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: instructor's consent

V_PBIO 2001: Fundamentals of Microbiology
This course, which is designed for microbiology or life sciences majors, provides an overview of the classification, structure, metabolism, genetics, and isolation and identification of the principal groups of bacteria. Additional topics to be covered include an introduction to viruses, protozoa, and fungi, the nature of infectious diseases, and the immune response. The course includes both lecture and laboratory. The laboratory component of the course is intended to provide students with a broad background in microbiology laboratory practice and theory. Students will learn fundamentals of light microscopy, bacterial culture techniques, and methods to isolate and identify microorganisms. Other laboratory testing platforms, such as PCR and ELISA, will be covered. The laboratory will meet for two hours, twice a week. Graded on A-F basis only.

Credit Hours: 5
Recommended: Introductory physiology and molecular biology

V_PBIO 2950: Undergraduate Research in Microbiology
Research for students in which independent research is less than 50% of total. Graded on S/U basis only.

Credit Hour: 1-3
Prerequisites: Departmental consent

V_PBIO 3345: Fundamentals of Parasitology
This course will provide a basic understanding of protozoan and metazoan parasites as well as the vectors that transmit these parasites. Special emphasis will be placed on those parasites and vectors of major medical/veterinary consequence throughout the world. Because parasites cause significant morbidity and mortality throughout the world, the main focus of lectures will be on the biology and epidemiology of parasitic diseases and on the parasite-host association. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: BIO_SC 1030 or BIO_SC 1500 or consent of instructor
V_PBIO 3551: Introduction to Immunology I
Comprehensive introduction to the basic principles of immunology. The course is designed for undergraduates majoring in biology, biochemistry or health professions. Introduction to cells and organs of the immune system, innate and adaptive immunity, development, activation and effector functions of lymphocytes, hypersensitivity, host response to infection and vaccination, autoimmunity and tumor immunology. Introduction to Immunology 1. Graded on A-F basis only.
Credit Hours: 3
Recommended: BIO_SC 2200 and BIO_SC 2300

V_PBIO 3554: Introduction to Virology
Comprehensive introduction to the basic principles of virology. The course is designed for undergraduates majoring in biology, biochemistry, or health professions. The course covers general virology including the molecular structure of viruses, the multiplication strategies of the major virus families, and viral latency, persistence, and oncology. The major families of the bacterial, plant, and animal viruses are discussed. Human viruses and infectious diseases are emphasized. Viral immunology, viral defenses, viral vaccines and antiviral compounds will also be addressed. Graded on A-F basis only.
Credit Hours: 3
Recommended: BIO_SC 3750, BIO_SC 2300

V_PBIO 3557: Microbial Pathogenesis I
This course is the first of two courses that examine the relationships between microbes and their hosts that lead to human disease. Emphasis is placed on bacterial and fungal infection, and the basic mechanisms of pathogenesis that lead to disease. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: BIO_SC 2200, BIO_SC 3750, or consent of instructor

V_PBIO 3558: Microbial Pathogenesis II
This course is the second of two courses that examine the relationships between pathogens and their hosts that lead to human disease. Emphasis is placed on viral and parasite infection and the basic properties of pathogenesis. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: BIO_SC 3750, V_PBIO 3554, or consent of instructor

V_PBIO 3560: Microbial Physiology
The course will focus on introducing the basic principles of the functions and activities of microorganisms and we will discuss on the normal cellular mechanisms associated with growth, metabolism, reproduction and survival. The course will cover our understanding and knowledge about the way in which a living microorganism functions including all physical and chemical processes. We will also focus on anatomy i.e., physical characteristics, growth and living, metabolism, chemical processes and control functions and functional entities. Graded on A-F basis only.
Credit Hours: 3
Recommended: A course in microbiology or biochemistry or permission of the instructor

V_PBIO 3600: Bacterial Genetics and Genomics
This course will provide undergraduate students with an understanding of bacterial genes, genomes and genetic systems that will serve as both a ‘stand-alone’ course as well as one that synergizes with courses taken by students pursuing degrees in Microbiology, Biochemistry, Biological Sciences, Food Science, Animal Sciences, Health Professions or students interested in the ’One Health’ paradigm. The course covers diverse aspects of bacterial genetics and genomics, beginning with asking ‘what is a gene?’ through understanding how this genetic information is stored and processed into biological function in a highly regulated manner. The course will also familiarize students with the discoveries that have powered the field of molecular biology (e.g. cloning, DNA sequencing and CRISPR-mediated gene editing) to current cutting-edge research that is driving advances at the interface of microbial science and engineering, as well as microbiomes. Knowledge gained by completion of this course will be of value to those interested in basic microbiology, bacterial pathogenesis, environmental and food microbiology. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: V_PBIO 2001 or BIO_SC 3750 or equivalent

V_PBIO 3650: Applied Microbiology and Biotechnology
Introduction to the basic principles of molecular microbiology in relation to the industrial applicability. The course will focus on microorganisms commonly used in industrial microbiology and biotechnology with an emphasis on the biological and molecular basis of productivity. We will also focus on nutrition of industrial organisms and metabolic pathways for the biosynthesis of industrial microbiology products such as engineered or designer proteins, antibiotics and products of medical importance. Manipulation of the genome of industrial organisms will be discussed in the context of making beneficial products. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: BIO_SC 3750 or V_PBIO 2001 or a course in microbiology

V_PBIO 3658: Public Health Microbiology
Epidemiology of transmissible diseases including pathogenic characteristics of the infectious organism, modes of transmission, mechanism of infection, diagnostic aids, effective treatments, immunizing procedures, and methods of preventing infection. Subjects covered will include emerging infectious diseases, vector borne diseases, control of infectious human disease, water and food borne disease, zoonotic diseases, sexually transmitted diseases and antibiotic resistance. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: BIO_SC 1500 or equivalent

V_PBIO 3700: Medical and Veterinary Entomology
Ecology and systematics of arthropods that affect the health of animals and people, including insect and tick vectors of pathogens causing tropical and temperate diseases such as African sleeping sickness, anaplasmosis, babesiosis, bartonellosis, Chagas' disease, chikungunya, dengue, ehrlichiosis, filariasis and heartworm disease, leishmaniasis, Lyme disease, malaria, mosquito-borne encephalitis, plague, rickettsiosis, theileriosis, tick-borne encephalitis and yellow fever. Emphasis will be placed on arthropod identification and effects of arthropods and arthropod-borne pathogens on vertebrate hosts. Graded on A-F basis
only. Prerequisites: Completion of 60 credit hours and one of the following: BIO_SC 1500 or equivalent, or consent of instructor.

**Credit Hours:** 4  
**Recommended:** V_PBIO 3345 or PLNT_S 3710

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**V_PBIO 4787: Historical, Societal and Ethical Topics in Medicine and Biomedical Research**  
(cross-leveled with V_PBIO 7787). Advances in medicine, genetics, reproduction and technologies underpinning biomedical research can have profound implications not only scientifically but in terms of societal and ethical impact. Using several historical events such as the establishment of the first immortal cell line, the Tuskegee syphilis study, the eugenics movement in the United States and the cloning of Dolly the sheep as starting points, we will explore the historical, societal and ethical context and issues surrounding these events and relate them to current ethical and moral questions that have been generated by recent scientific and medical progress. Graded on A-F basis only.

**Credit Hours:** 2  
**Prerequisites:** B or better in BIO_SC 2300 and BIO_SC 2200

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**V_PBIO 4950: Advanced Undergraduate Research in Microbiology**  
Research credit for students doing an independent microbiology research project under the guidance of a faculty member. Project must be arranged by student and faculty member prior to registration. May be repeated to a maximum of 6 hours. Student may choose the S/U grading option only if not using course to fulfill microbiology degree capstone and/or honors program requirements.

**Credit Hour:** 1-3  
**Prerequisites:** Departmental consent  
**Recommended:** Overall GPA of at least 2.75; 20 hours of Microbiology/Biological Sciences and/or Chemistry

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**V_PBIO 4970: Capstone Undergraduate Research in Microbiology**  
Capstone research course for students doing an independent microbiology research project under the guidance of a faculty member. Project must be arranged by student and faculty member prior to registration. Includes presentation of the research as an oral presentation or poster at a scientific meeting OR writing up the research project in a scientific journal article format. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** 3 credit hours of V_PBIO 4950

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**V_PBIO 4980: Capstone Senior Seminar**  
Readings and critical evaluation of selected problems and theories in microbiology. Integrates perspectives, methods, and topics from undergraduate courses. Requires written and oral presentations. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** Microbiology major, senior standing, or instructor’s consent

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**V_PBIO 5511: Veterinary Immunology**  
(same as V_PBIO 8451). Basic immunology techniques. Topics include innate and adaptive immunity, development of the immune system, induction and expression of the immune response, structure and function of antibodies, antigen-antibody reactions, the major histocompatibility complex, aspects of immunology in disease.

**Credit Hour:** 1.5

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**V_PBIO 5512: Veterinary Immunology**  
(Continuation of V_PBIO 5511)

**Credit Hour:** 1.5

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**V_PBIO 5552: Veterinary Bacteriology with Laboratory**  
Classification and properties of pathogenic bacteria and fungi of animals; relationship to public health; considers pathogenesis, immunology of infection. Instructional period 5.

**Credit Hours:** 3  
**Prerequisites:** enrollment in the College of Veterinary Medicine

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**V_PBIO 5553: Veterinary Bacteriology II**  
(Continuation of V_PBIO 5552). Instructional period 6.

**Credit Hours:** 2.5

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**V_PBIO 5554: Veterinary Virology**  
(same as V_PBIO 8454). Classification and properties of viruses. Considers the etiologic, pathologic and immunologic aspects of viral diseases of animals. Instructional periods 6 and 7.

**Credit Hours:** 2.5  
**Prerequisites:** enrollment in the College of Veterinary Medicine

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**V_PBIO 5555: Epidemiology and Biostatistics with Laboratory**  
(same as V_PBIO 8455). This course introduces students to methods of determining the influence of disease on populations and how this information is applied to individual animals. Biostatistics and evidence based medicine are also discussed in this course. The knowledge gained in this course is applied to reading professional literature during the course. Instructional period 4.

**Credit Hours:** 2

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**V_PBIO 5557: Veterinary Parasitology with Laboratory**  
(same as V_PBIO 8457). Parasites and parasitic diseases of ruminants, horses, swine, dogs, cats, poultry and other animals. Includes classification, morphology, and bionomics of protozoa, helminths, and arthropods. Instructional period 6.

**Credit Hours:** 3

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**V_PBIO 5558: Veterinary Public Health**  
(same as V_PBIO 8458). In this course students are introduced to the wide range of veterinary involvement in maintaining and assuring human health, nationally and globally. Topics discussed include: agencies such as USDA, FDA, CDC, food safety and meat inspection, veterinary responsibility in identifying diseases, legal issues of drug use, and zoonotic diseases. Instructional period 7.

**Credit Hours:** 2

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**V_PBIO 5575: Veterinary Pathology with Laboratory**  
General Pathology. Tissue reactions to various disease agents in domestic animals. Instructional period 5.
Credit Hours: 3

V_PBIO 5576: Veterinary Systemic and Special Pathology with Laboratories
Special and systemic pathology. Tissue reactions to disease in special systems in domestic animals. Instructional period 6.

Credit Hours: 3

V_PBIO 5577: Veterinary Systemic and Special Pathology II with Laboratories
Follows the general pathology and continues the systemic pathology taught in V_PBIO 5576. The course, consisting of daily lectures and weekly laboratories, covers disease, mainly in domestic animals, of the following systems or organs: cardiovascular, respiratory, lymphoid, cutaneous, mammary, ophthalmic, and etc. Instructional period 7.

Credit Hours: 3

V_PBIO 5578: Veterinary Clinical Pathology with Laboratory
Physiologic basis, interpretation and clinical application of laboratory assays in hematology, chemistry, cytology, and urinalysis, utilization of laboratory methods to define pathological states and to diagnose disorders of domestic animals. Instructional period 8.

Credit Hours: 3

V_PBIO 5579: Veterinary Genomics
Study of genomes, an organism's entire set of the genetic information. Used for detection of pathogen genomes, and markers for mutation causing inherited disease. Instructional period 5.

Credit Hour: 1

V_PBIO 5601: Animals in Emergencies & Basic Emergency Response Training for Vet Students
This course will enable veterinary and graduate students to understand their role in society during disasters and credential as responders. Graded on A-F basis only.

Credit Hour: 1

V_PBIO 5991: Introduction to Avian Medicine
Introduction to Avian Medicine

Credit Hour: 1

V_PBIO 5995: Foundations in Veterinary Research and Discovery
This course will introduce veterinary students to concepts of research including hypothesis development, experimental design, data interpretation, grantsmanship, responsible conduct of research, biomedical research careers and presentation and publication methods.

Credit Hours: 2

V_PBIO 6010: Laboratory Animal Medicine
Principles of Veterinary Medicine applied to laboratory animals as pets and in research. Husbandry, handling and clinical techniques, diseases, and use as disease models are discussed. Instructional period 8.

Credit Hour: 1.5

V_PBIO 6647: Diagnostic Pathology and Special Species Medicine
Application of laboratory techniques used to diagnose disease by macroscopic, microscopic, biochemical, microbiologic, and toxicologic findings. Case method of teaching. Domestic avian species and laboratory animals included. Six times yearly.

Credit Hours: 8

V_PBIO 6676: Laboratory Animal Medicine and Management Elective
Elective offered 3rd- and 4th-year students, subject to approval of course coordinator and supervising faculty. Concentrated study/experience in laboratory animal disease(s)/colony management. Available to veterinarians as a continuing education program.

Credit Hour: 2-6

V_PBIO 6679: Diagnostic Pathology and Special Species Medicine
Third- and fourth-year students. Elective. Approval of coordinator and supervisory staff. Continuation of V_PBIO 6647 with more depth. Available to D.V.M.'s as part of continuing education program.

Credit Hour: 2-6

V_PBIO 6684: Research Techniques in Veterinary Pathobiology
Research Techniques in Veterinary Pathobiology

Credit Hour: 1-6

V_PBIO 7110: Veterinary Cytology
(cross-leveled with BIOMED 4110). This course of Veterinary Cytology is designed to hone the skills of the practicing Veterinary Technician, Veterinary Student, or Veterinarian and assumes some basic knowledge of microscope usage and normal hematology. The review of normal cells will be minimal and emphasis will be placed on findings associated with inflammatory and neoplastic diseases. The graduate level course will include discussion of ancillary tests, special stains and treatment alternatives. The focus will be on canine and feline diseases but some common equine and bovine disease.

Credit Hours: 2

V_PBIO 7120: Principles of Toxicology
(cross-leveled with BIOMED 4120). This course will provide an introduction to the general principles of toxicology, including the history
and scope of the field; risk assessment and management; mechanisms of toxicology; the disposition of toxicants; non-target organ-directed toxicity; toxic responses of specific target organs; and various toxicological application, such as environmental toxicology.

**Credit Hours:** 3  
**Prerequisites:** BS in Biology, Biochemistry, or equivalent, or permission of instructor

**V_PBIO 7210: Animal Issues in Disasters**  
(cross-leveled BIOMED 4210). Animal Issues in Disasters describes the various aspects of responding to disasters that involve animals. Government involvement, legal requirements, effects on the human-animal bond, preparation for disasters of different kinds, and impacts on animal-related businesses will be discussed.

**Credit Hour:** 1  
**Prerequisites:** a bachelor's degree in a biological science or veterinary technology, or DVM degree, or instructor's consent

**V_PBIO 7787: Historical, Societal and Ethical Topics in Medicine and Biomedical Research**  
(cross-leveled with V_PBIO 4787). Advances in medicine, genetics, reproduction and technologies underpinning biomedical research can have profound implications not only scientifically but in terms of societal and ethical impact. Using several historical events such as the establishment of the first immortal cell line, the Tuskegee syphilis study, the eugenics movement in the United States and the cloning of Dolly the sheep as starting points, we will explore the historical, societal and ethical context and issues surrounding these events and relate them to current ethical and moral questions that have been generated by recent scientific and medical progress. Graded on A-F basis only.

**Credit Hours:** 2  
**Prerequisites:** Consent of Instructor

**V_PBIO 8090: Thesis Research in Veterinary Pathobiology**  
Open to graduate students with requisite preparation. Research on specific animal diseases, prevention and treatment. Graded on a S/U basis only.

**Credit Hour:** 1-99

**V_PBIO 8410: Seminar in Veterinary Pathobiology**  
Discussion of current research methods in veterinary pathobiology.

**Credit Hour:** 1

**V_PBIO 8431: Research Methods and Data Analysis**  
Specific assignments on diagnostic methods including surgical pathology, necropsies, toxicology.

**Credit Hour:** 2-4  
**Prerequisites:** departmental consent

**V_PBIO 8432: Advanced Histopathology**  
Advanced microscopic study of pathological tissues.

**Credit Hours:** 5  
**Prerequisites:** departmental consent

**V_PBIO 8434: Advanced Clinical Pathology**  
Lecture/tutorial teaching; pathogenesis of clinical laboratory abnormalities in the common domesticated species. Emphasis is placed on mechanisms of disease and pathophysiology of the changes seen in each organ system.

**Credit Hours:** 3  
**Prerequisites:** departmental consent

**V_PBIO 8435: Advanced Microscopy in Veterinary Clinical Pathology**  
Recognition and pathogenesis of abnormalities found via microscopic analysis of blood smears or cytology.

**Credit Hour:** 1  
**Prerequisites:** V_PBIO 5578 and departmental consent; DVM or current enrollment in veterinary curriculum

**V_PBIO 8436: Pathogenic Mechanisms in Veterinary Pathobiology**  
This course will include disease mechanisms, described at the cellular and molecular level, which result in tissue morphologic (gross and microscopic) and clinical abnormalities. Examples of discussion topics include soluble mediators of inflammatory processes, host-agent interactions, and host defense mechanisms.

**Credit Hours:** 3  
**Prerequisites:** instructor's consent

**V_PBIO 8445: Vectors and Vector-borne Diseases**  
This course will focus on arthropod vectors (insects and ticks) and the medically important pathogens / diseases that they transmit, including arboviruses, bacteria, protozoa and nematodes. An emphasis will be on the interactions between the vectors and disease-causing pathogens. Topics include: introductions to systematics, anatomy, physiology, life cycles, and ecology of vectors and classification and biology of the pathogens responsible for such diseases as dengue, yellow fever, malaria, leishmaniasis, lymphatic filariasis, etc. The focus will be not only on specific pathogen-vector interactions but also on big picture topics / discussions of vector competence, insecticide resistance, vector control (including genetically modified insects) and other current issues in vector biology research. Students will learn how these important vector-
borne diseases are transmitted, how they are spread and introduced into new regions, and what control strategies exist or are currently under development. Students will realize what impact vector-borne diseases have on global human and animal health as well as develop and hone critical thinking skills.

Credit Hours: 3  
Prerequisites: Graduate standing in the Life Sciences

V_PBIO 8448: Molecular Methods in Nucleic Acids  
The course will focus on the most recent developments in technology related to eukaryotic and prokaryotic molecular biology and as analysis a manipulation of nucleic acids and their application to define structure, function and biosynthesis of macromolecules.

Credit Hours: 3  
Prerequisites: instructor's consent

V_PBIO 8450: Non-Thesis Research in Veterinary Pathobiology  
Research not expected to terminate in dissertation.

Credit Hour: 1-99

V_PBIO 8451: Introduction to Immunology  
(same as V_PBIO 5511 and V_PBIO 5512). Fundamentals of immunology as applied to domestic animals.

Credit Hours: 3

V_PBIO 8452: Cell and Molecular Electron Microscopy  
Lecture class that describes the use of electron microscopy (transmission and scanning) in biomedical research. Students receive hands-on experience by completing a laboratory project.

Credit Hours: 4

V_PBIO 8454: Domestic Animal Virology  

Credit Hours: 2.5

V_PBIO 8455: Epidemiology and Biostatistics  
Graduate level introduction to veterinary epidemiology and bio-statistics.

Credit Hour: 2-3

V_PBIO 8457: Animal Parasitology  
(same as V_PBIO 5557).

Credit Hour: 3-5

V_PBIO 8458: Veterinary Public Health  
(same as V_PBIO 5558).

Credit Hours: 2

V_PBIO 8552: Veterinary Pathogenic Bacteriology and Mycology I  
This course deals with the bacterial pathogens of animals emphasizing the pathogenesis and pathology of the diseases, diagnostic problems, appropriate treatments and prevention measures. Course graded A-F only.

Credit Hours: 3  
Prerequisites: instructor's consent

V_PBIO 8553: Veterinary Pathogenic Bacteriology and Mycology II  
This course deals with the bacterial pathogens of animals emphasizing the pathogenesis and pathology of the diseases, diagnostic procedures, appropriate treatments and prevention measures. Graded on A-F basis only.

Credit Hours: 2.5  
Prerequisites: V_PBIO 5552 or V_PBIO 8552 and instructor's consent

V_PBIO 8601: Animals in Emergencies & Basic Emergency Response Training for Vet Students  
This course will enable veterinary and graduate students to understand their role in society during disasters and credential as responders. Graded on A-F basis only.

Credit Hour: 1  
Prerequisites: Students must be enrolled in the College of Veterinary Medicine and pursuing a DVM degree or be a student pursuing an MPH degree. Instructor consent required for non-veterinary graduate students seeking MPH degrees

V_PBIO 8641: Introduction to Research Ethics  
This course provides students with a brief overview of many of the ethical issues that confront today's scientist. It is important that scientist think about and develop their abilities to make well-reasoned responses to ethical problems.

Credit Hour: 1

V_PBIO 9090: Area Veterinary Pathobiology Dissertation Research  
Dissertation Research for PhD students. May be repeated for credit. Graded on S/U basis only.

Credit Hour: 1-99  
Prerequisites: departmental consent