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

Professor C. R. Brow, C. Caldwell, S. Casteel**, J. Cook, G. Davis, K. C. Dellsperger, W. Fales*, C. Franklin**, C. Henry, T. Hoffman, G. C. Johnson**, M. Katz, C. Lorson**, D. Lubahn, C. Moore, D. O'Brien, B. Ray**, R. M. Roberts, H. Schatten**, D. Shaw*, G. P. Smith, R. W. Stich**, C. V. Ward, H. Zaghou
Associate Professor Y. Agca**, B. T. Beerntsen**, A. Bermudez**, D. Beversdorf, J. N. Bryan, E. Bryda**, M. Calcutt**, L. Cohn, D. D. Cornelison, J. Dodam, T. Evans**, D. Fox, S. A Grant, G. S. Johnson, M. Lewis, S. Liu, J. Middleton, W. J. Mitchell Jr.*, C. Phillips, C. Reddy, S. G. Sarafianos, C. Wiedmeyer**
Clinical Associate Professor L. Berent*, D. Kim*, T. Reilly**, C. Vogelweid*, M. Whitney*
Associate Research Professor M. Lorson*, A. Ray*
Assistant Professor K. Aldridge, D. Anderson*, U. Atasoy, C. P. Baines, G. Blomquist, M. Daniels, V. Glinskii, Z. Gu, C. Holliday, K. Kuroki**, S. Schommer*, K. Taylor, G. Zhang*
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

Professor J. R. Coates**, L. A. Cohn**, J. L. Cook*, V. K. Ganjam*, C. J. Henry**, P. J. Johnson*, K. Keegan*, T. Mann, R. R. Mohan**, D. O'Brien**, J. Tomlinson*, D. A. Wilson*
Assistant Professor S. M. Axiak*, A. Bukoski*, A. E. DeClue**, M. Heller*, P. Pithua*, F. Wininger*
Associate Professor B. Backus**, J. Bryan**, J. R. Dodam*, D. Fine*, D. B. Fox*, E. Giuliano*, R. Johnson, J. C. Lattimer*, M. R. Lewis**, J. R. Middleton**, C. N. Reinero**
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

Professor F. W. Booth*, D. K. Bowles**, L. L. Clarke**, G. M. Constantinescu*, J. R. Dodam, V. K. Ganjam**, E. M. Hasser*, C. M. Heesch**, S. Hyder**, H. M. Laughlin**, R. L. Terjung**, R. Tsika**
Associate Professor C. S. Reddy**, C. S. Rosenfeld**, L. J. Rubin**, W. V. Welshons*
Assistant Professor C. P. Baines**, K. Cummings**, C. Emter**, 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 I. 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

- Certificate in Biomedical Sciences (https://catalog.missouri.edu/collegeofveterinarymedicine/biomedicalsciences/cert-biomedical-sciences/)

Graduate

- MS in Biomedical Sciences (https://catalog.missouri.edu/collegeofveterinarymedicine/biomedicalsciences/ms-biomedical-sciences/)
  - with emphasis in Biomedical Sciences (https://catalog.missouri.edu/collegeofveterinarymedicine/biomedicalsciences/ms-biomedical-sciences-emphasis-biomedical-sciences/)
  - with emphasis in Comparative Medicine (post DVM) (https://catalog.missouri.edu/collegeofveterinarymedicine/biomedicalsciences/ms-biomedical-sciences-emphasis-comparative-medicine-post-dvm/)
  - with emphasis in Pathobiology (https://catalog.missouri.edu/collegeofveterinarymedicine/biomedicalsciences/ms-biomedical-sciences-emphasis-pathobiology/)
  - with emphasis in Veterinary Medicine and Surgery (https://catalog.missouri.edu/collegeofveterinarymedicine/

biomedicalsciences/ms-biomedical-sciences-emphasis-veterinary-medicine-surgery/)
    - with emphasis in Veterinary Sciences (https://catalog.missouri.edu/collegeofveterinarymedicine/biomedicalsciences/ms-biomedical-sciences-emphasis-veterinary-medicine-sciences/)
- PhD in Biomedical Sciences (https://catalog.missouri.edu/collegeofveterinarymedicine/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.

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

https://biomed.missouri.edu/

BIOMED 1010: Biomedical Career Explorations
(same as VET_TCH 1010). 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 dervation) 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: 3

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.

Credit Hours: 3

BIOMED 2140: Companion Animals
(same as AN_SCI 2140). FCompanion 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
Recommended: sophomore standing

BIOMED 2230: Farm Animal Sanitation and Disease Prevention
(same as VET_TCH 2230). Preventative measures for diseases and parasites of farm animals.

Credit Hours: 3

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: 1-6
Prerequisites: sophomore standing and instructor's consent

BIOMED 3000: Specialty Careers for Veterinary Technicians
(same as VET_TCH 3000). Specialty careers for veterinary technicians are jobs which required knowledge and skills beyond those needed in primary care clinical veterinary practice. This course will explore veterinary technician specialties, the education required, and the advantages of advanced academic training. Course graded on A-F basis only.

Credit Hour: 1
Prerequisites: AAS degree in veterinary technology or instructors consent required

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BIOMED 3001: Topics in Biomedical Sciences
Topics in Biomedical Sciences.

Credit Hour: 1-99

BIOMED 3100: Biomedical Pathophysiology
(same as VET_TCH 3100). Pathophysiology is the study of changes in the body resulting from disease. This course requires knowledge of normal anatomy and physiology. A comparative approach is used involving both domestic animal and human examples. Course graded on A-F basis only.

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 3219: Elements of Comparative Anatomy
(same as VET_TCH 3219). This course is designed to give students an introduction to and appreciation for comparative anatomy of various species encountered in animal science, veterinary technology and veterinary medicine. Detailed and labeled photos of dissected specimens are used to aid instruction. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: five hours of biological science or zoology or equivalent or instructor's consent or an AAS degree in veterinary technology

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BIOMED 3250: Parasitology
(same as VET_TCH 3250). Parasitism is considered as a fundamental type of interspecies interaction. Identifying characteristics, life cycle, and resulting disease caused by the common parasites of domestic animals, common laboratory animals, selected wildlife, and humans are described. Special emphasis is given to parasites that can be transmitted from animals to man. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: 8 hours of biology or instructor's consent

BIOMED 3300: Animal Welfare and Ethics
(same as VET_TCH 3300). An introductory examination of ethical issues related to animal welfare, including animal use for food, research, and companionship, plus contemporary issues affecting companion animals, farm animals, and horses. Topics related to animal pain and legal status will also be discussed. Graded on A-F basis only.

Credit Hours: 3
Recommended: junior standing

BIOMED 3310: Equine Health Topics
An in-depth examination of equine disease and health topics that are pertinent to today's horse owner and veterinarian. The course will integrate horse management practices with disease recognition, control and prevention. Students will learn how to recognize problems and when to call a veterinarian. Emerging disease problems such as West Nile Virus will be examined as well as topics of continuing concern. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: AN_SCI 4977 or equivalent or instructor's consent

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BIOMED 3326: Principles of Veterinary Pharmacology
(same as VET_TCH 3326). Review and clinical application of basic veterinary pharmacology. Topics to be covered include terminology, calculations, physiology, and pharmacokinetics and pharmacodynamics. Both small and large animal organ systems are discussed. Medicolegal aspects of veterinary pharmacology are also reviewed. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: an AAS degree in veterinary technology or AN_SCI 3254 or BIO_SC 3700, or equivalent, or instructor's consent

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BIOMED 3400: Domestic Animal Behavior in Veterinary Practice
(same as VET_TCH 3400). 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

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

Credit Hour: 1-99

BIOMED 4110: Veterinary Cytology
(same as VET_TCH 4110; cross-leveled with V_PBIO 7110). This course of Veterinary Cytology is designed to hone the skills of the practicing veterinary technician, 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. Graded on A-F basis only.

Credit Hours: 2
Prerequisites: An AAS or equivalent degree in veterinary technology from an American Veterinary Medical Association-accredited program, or instructor's consent
Recommended: BIOMED 3200 and BIOMED 2110

BIOMED 4120: Principles of Toxicology
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 toxicity; the disposition of toxicants, non-target organ-directed toxicity; toxic responses of specific target organs/systems; an overview of a number of specific classes of toxic agents, including pesticides and metals; and various toxicological applications, such as environmental, forensic, and occupational toxicology. Graded on A-F basis only.

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

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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

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BIOMED 4250: Human-Animal Bond in Veterinary Practice
(same as VET_TCH 4250; cross-leveled with BIOMED 7250). Exploration of historical & theoretical bases of human-companion animal interaction (HAI), the nature, issues, & clinical applications of HAI in a veterinary practice. Graded on A-F basis only.

Credit Hours: 3

BIOMED 4300: Clinical Veterinary Neurology
(same as VET_TCH 4300). 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

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BIOMED 4320: Fundamentals of Small Animal Emergency and Critical Care
(same as VET_TCH 4320; cross-leveled with V_M_S 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

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BIOMED 4333: Veterinary Cell Biology
(same as VET_TCH 4333; cross-leveled with V_BSCI 7333). 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. Graded on A-F basis only.

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

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BIOMED 4335: Comparative Physiology of Health and Disease
This course is intended to provide students with an overview of physiology of health and disease in mammals. The areas of cell and muscle physiology, neurophysiology, cardiovascular, renal, respiratory gastrointestinal and endocrine physiology will be presented and explained. Emphasis will be placed on core concepts that are central to understanding the function of the body, relationship to disease pathogenesis, maintenance of homeostasis and normal function, and comparisons among species. The successful student will master these concepts as a basis for explaining physiological principles in general, for solving problems and for lifelong learning. Graded on A-F only.

Credit Hours: 3
Prerequisites: Instructor's consent required

BIOMED 4400: Veterinary Surgical Nursing
(same as VET_TCH 4400). 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

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BIOMED 4410: Small Animal Physical Rehabilitation
(same as VET_TCH 4410). 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 equivalent, plus BIOMED 3219 or PTH_AS 2201 or equivalent, or instructor's permission

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BIOMED 4420: Canine and Feline Nutrition
(same as VET_TCH 4420). This course begins with a brief review of nutrition basics. The following units include the nutrient requirements for dogs and cats; history, regulation and evaluation of pet foods; feeding management throughout the life cycle, and treatment of nutritionally responsive disorders. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Instructor's permission; College level undergraduate courses in biology & chemistry - minimum 3 credit hours each

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BIOMED 4500: Equine Critical Care and Nursing
(same as VET_TCH 4500). 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

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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

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BIOMED 4520: Introduction to Equine Clinical Practice
This course is an introduction to common medical conditions of the horse. Emphasis will be placed on the presenting complaint, identification of symptoms requiring assistance from a veterinary professional, and the approach to diagnosis, treatment, and prognosis.

Credit Hours: 2
Recommended: BIOMED 2110, BIOMED 2111 and AN_SCI 4977 or their equivalents, an associate's degree in veterinary technology, or instructor's consent

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BIOMED 7250: Human-Animal Bond in Veterinary Practice
(cross-leveled with BIOMED 4250, VET_TCH 4250). Exploration of historical and theoretical bases of human-companion animal interaction (HAI), the nature, issues, and clinical applications of HAI in a veterinary practice. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Admission to program

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

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

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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 8330: Animal Welfare and Ethics
The question of how we treat animals is one that all societies have addressed throughout history and it is an issue that remains even more pertinent today. Ultimately, the welfare of animals under our supervision is dependent on the knowledge, behaviors and attitudes of humans. Ethical norms indicate that anyone interacting with animals must consider what should, rather than what is or could be done regarding animals. This question will be explored and evaluated via online discussion and critical evaluation of literature. Course information will be applied to personal interactions with animals. Students will be required to synthesize, evaluate, and clearly write their responses to course information. Graded on A-F basis only.

Credit Hours: 3

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

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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

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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
