The Department of Anatomy provides cutting-edge instruction in human anatomy to medical students, graduate students, and undergraduate students and is home to international research programs in paleontology and paleobiology. Our program leading to the Master of Science degree in Applied Anatomy provides rigorous training for students who aspire to careers requiring a solid foundation in human anatomy. This curriculum is ideal for students with a range of career goals, including those who will be future teachers of anatomy or who will pursue careers in medicine or other health professions or scientific fields that involve anatomy. The MS in Applied Anatomy can be combined with the MD curriculum in a four-year joint MD-MS curriculum. This provides an enhanced background for medical students who plan to enter a surgical specialty, radiology, or another field that relies on detailed understanding of human anatomy.

**MS in Applied Anatomy (Plan A and Plan B)**

The Applied Anatomy program is designed for students who seek a comprehensive education in the anatomical sciences, particularly those pursuing careers as medical health professionals or as teachers who desire an advanced degree to enhance their skills and credentials.

The four courses of the Anatomical Sciences Core Curriculum (ASCC) emphasize the traditional aspects of anatomical structure, function, and nomenclature with critical aspects of cell and developmental biology, biochemistry, and physiology of cells, tissues, and organs integrated into their content. Elective courses allow curriculum flexibility for students to emphasize their diverse individual interests. The Master of Science (MS) in Applied Anatomy serves as excellent preparation for subsequent studies in schools of medicine, dentistry, and nursing.

The knowledge of the human body and its physiological processes gained through this program also forms a solid foundation for physician assistants, physical therapists, dental technicians, and university and K-12 life sciences teachers. Case Western Reserve University medical students earning the joint MD/MS degree program benefit from advanced training in the anatomical sciences. The joint MD/MS program is undertaken and completed concurrently with the medical curriculum.

Each student in the Applied Anatomy program has a faculty advisor from the Department of Anatomy Graduate Executive Committee who coordinates the program and works with the student to develop their Program of Study. Contact the Department of Anatomy for additional program and application information.

**Admission**

Acceptance into the Master of Science in Applied Anatomy program (Plan A or B) requires a baccalaureate degree from an accredited institution and is based on undergraduate and/or graduate GPAs, results of admission examinations (GRE, MCAT, DAT), letters of recommendation, and a personal statement. An Educational Credential Evaluation and Authentication Report is required for foreign transcripts, and foreign applicants must provide documentation of English language skills (TOEFL).

Acceptance into the joint MD/MS program requires: (1) that the medical student be in good academic standing in the CWRU medical curriculum at the time of matriculation into the program; and (2) approval from their respective Associate (‘Society’) Dean of Student Affairs.

No direct tuition or stipend support is currently provided with acceptance into the MS in Applied Anatomy program (Plan A or B). No additional tuition is required for enrolled medical students who pursue the joint MD/MS degree.

**Degree Requirements**

The MS in Applied Anatomy degree requires a minimum of 30 graduate course credits. Required courses generally include 17 credits of the Anatomical Sciences Core Curriculum; the remaining credits are elective courses selected to fulfill individual student interests and goals. Medical students are required to take at least one surgical anatomy course (ANAT 515 - Orthopedics or ANAT 516 - Head & Neck), typically during their final year. A research thesis is required only for students pursuing the Plan A MS in Applied Anatomy degree; students pursuing the Plan B MS in Applied Anatomy degree can gain research experience by enrolling in ANAT 499: Independent Study with individual faculty members.

A comprehensive written (Plan B) or oral (Plan A) exam covering the basic scientific principles presented in the core curriculum must be passed after successful completion of the formal coursework comprising the Anatomical Sciences Core Curriculum. All degree requirements must be completed within five years. Most students complete the degree requirements in two years; they can be completed in one year, but this is not generally recommended.

**MS in Applied Anatomy (Plan A and B) & MD/MS in Applied Anatomy, Plan of Study (4 semesters)**

The sequence of classes below shows the order in which the courses are typically taken to complete the Master of Science in Applied Anatomy degree. The four required courses comprising the Anatomical Sciences Core Curriculum (17 credits) are listed individually; elective courses (13 credits minimum) are not specified since they vary significantly among students. Students become eligible to take the MS Comprehensive Examination upon successful completion of the ASCC courses.

**First Year**

**Fall**  
ANAT 412 Histology and Ultrastructure (Elective)  
ANAT 491 Embryology

**Spring**  
ANAT 411 Gross Anatomy

(Medical students apply to MD/MS program)

**Summer**  
Elective(s)
Second Year

Fall
ANAT 414 Neurological Anatomy 4
Elective 1-3

Spring
Elective 1-3

Master of Science ASCC Comprehensive Examination

Courses
ANAT 312. Basic Histology. 3 Units.
Fundamental histology course covering microscopic structure, nomenclature, and function of normal cells, tissues, and organs (human emphasis) to provide a sound foundation for bioengineering, pre-medical and pre-dental students.

ANAT 375. Human Evolution: The Fossil Evidence. 3 Units.
This course will survey the biological and behavioral changes that occurred in the hominid lineage during the past five million years. In addition to a thorough review of the fossil evidence for human evolution, students will develop the theoretical framework in evolutionary biology. Recommended preparation: ANTH 377, BIOL 225. Offered as ANAT 375, ANTH 375, ANAT 475 and ANTH 475. Prereq: ANTH 103.

ANAT 377. Human Osteology. 4 Units.
This course for upper division undergraduates and graduate students will review the following topics: human skeletal development and identification; and forensic identification (skeletal aging, sex identification and population affiliation). Offered as ANAT 377, ANTH 377, ANAT 477 and ANTH 477.

ANAT 391. Embryology. 3 Units.
A detailed description of development will be presented, focusing mainly on the developing human. Discussions and presentations will also include several developing systems that have served as useful models in experimental embryology for deciphering mechanisms responsible for producing adult metazoan organisms. Offered as ANAT 391 and ANAT 491.

ANAT 399. Independent Study. 1 - 4 Units.
Laboratory research project. Student must obtain approval of a supervising Anatomy department professor before registration and list the professor's name on the schedule card.

ANAT 401. Virtual Anatomy of Human Body. 2 Units.
This course introduces students to the gross anatomical structure of the human body using innovative Microsoft HoloLens and other virtual technologies. It differs from most traditional anatomy courses not only in its use of three-dimensional imaging technology but also in its systemic rather than regional approach; the structure of the human body is learned by studying organ systems (e.g., the nervous system, the musculoskeletal system) rather than focusing on one region at a time (e.g., the thorax or the lower limb). This approach gives students the 'big picture' of how the human body is organized, thereby providing a solid foundation for other courses that deal with the anatomy of the human body in greater detail.

ANAT 410. Cadaver dissection-based human anatomy with histology and physiologic correlations. 6 Units.
This course will provide students with a sound understanding of the normal human body as a foundation for subsequent pursuing biomedical careers. A combination of daily lectures and laboratories integrates cadaver dissection-based gross anatomy with the associated histology, embryology, neuroanatomy and basic physiology. This course is well-suited to all biomedical careers, including pre-clinical and biomedical undergraduates, post-baccalaureate, pre-clinical master of science graduate programs, plus medical and dental students seeking additional training in the anatomical sciences. It will meet any of the anatomy-oriented prerequisites being implemented for medical and dental school applications, including those preferring or requiring a cadaver-based experience. The assessments will include a combination of written and cadaver-based practical questions. Offered as ANAT 410 and PAST 410.

ANAT 411. Gross Anatomy. 6 Units.
This in-depth, regionally-oriented, cadaver dissection-based course covers all aspects of human gross anatomy. It is team-taught by Department of Anatomy faculty and is divided into six sections: thorax, abdomen, pelvis and perineum, upper limb and back, lower limb, and head and neck. Registration for both the lecture and lab components is required. Students should be prepared to devote additional time outside of class in order to master the material. The dissection lab is open 24 hours, 7 days a week to students registered for the course. Recommended preparation: introductory coursework in human anatomy or B.A./B.S. in Biology or related field.

ANAT 412. Histology and Ultracepture. 4 Units.
Comprehensive functional histology course integrating microscopic identification ('structure plus nomenclature') of normal cells, tissues, and organs with aspects of their cell biology, biochemistry, and physiology ('function'). Topical coverage includes complete (‘head-to-toe’) tissue and organ survey with human emphasis.

ANAT 414. Neurological Anatomy. 4 Units.
This course employs a variety of teaching-learning methods—among them lectures, small-group discussions, hands-on “construction” of pathways, and brain dissection. Regional morphology will be studied via examination of the preserved brain and of sections through the CNS; functional systems will be “followed” through the spinal cord, brain stem and/or forebrain.

ANAT 431. Statistical Methods I. 3 Units.
Application of statistical techniques with particular emphasis on problems in the biomedical sciences. Basic probability theory, random variables, and distribution functions. Point and interval estimation, regression, and correlation. Problems whose solution involves using packaged statistical programs. First part of year-long sequence. Offered as ANAT 431, BIOL 431, CRSP 431, PQHS 431 and MPHP 431.
ANAT 445. Mammal Diversity and Evolution. 4 Units.
This course focuses on the anatomical and taxonomic diversity of mammals in an evolutionary context. The emphasis is on living (extant) mammals, but extinct mammals are also discussed. By the end of the course, students will be able to: (1) describe the key anatomical and physiological features of mammals; (2) name all orders and most families of living mammals; (3) identify a mammal skull to order and family; (4) understand how to create and interpret a phylogenetic tree; (5) appreciate major historical patterns in mammal diversity and biogeography as revealed by the fossil record; (6) read and critique a scientific article dealing with mammal evolution. One weekend field trip to Cleveland Metroparks Zoo; additional individual and group visits to the Cleveland Museum of Natural History. This course satisfies a laboratory requirement for the biology major. Recommended preparation: BIOL 223 Vertebrate Biology, BIOL 225 Evolution, or BIOL 346 Human Anatomy. Offered as ANAT 445 and BIOL 345. Prereq: BIOL 214.

ANAT 462. Principles of Developmental Biology. 3 Units.
The descriptive and experimental aspects of animal development. Gametogenesis, fertilization, cleavage, morphogenesis, induction, differentiation, organogenesis, growth, and regeneration. Students taking the graduate-level course will prepare an NIH-format research proposal as the required term paper. Offered as BIOL 362, BIOL 462 and ANAT 462.

ANAT 467. Topics in Evolutionary Biology. 3 Units.
The focus for this course on a special topic of interest in evolutionary biology will vary from one offering to the next. Examples of possible topics include theories of speciation, the evolution of language, the evolution of sex, evolution and biodiversity, molecular evolution. ANAT/ANTH/EEPS/PHIL/PHOL 467/BIOL 468 will require a longer, more sophisticated term paper, and additional class presentation. Offered as ANTH 367, BIOL 368, EEPS 367, PHIL 367, ANAT 467, ANTH 467, BIOL 468, EEPS 467, PHIL 467 and PHOL 467.

ANAT 475. Human Evolution: The Fossil Evidence. 3 Units.
This course will survey the biological and behavioral changes that occurred in the hominid lineage during the past five million years. In addition to a thorough review of the fossil evidence for human evolution, students will develop the theoretical framework in evolutionary biology. Recommended preparation: ANTH 377, BIOL 225. Offered as ANAT 375, ANTH 375, ANAT 475 and ANTH 475. Prereq: ANTH 103.

ANAT 477. Human Osteology. 4 Units.
This course for upper division undergraduates and graduate students will review the following topics: human skeletal development and identification; and forensic identification (skeletal aging, sex identification and population affiliation). Offered as ANAT 377, ANTH 377, ANAT 477 and ANTH 477.

ANAT 491. Embryology. 3 Units.
A detailed description of development will be presented, focusing mainly on the developing human. Discussions and presentations will also include several developing systems that have served as useful models in experimental embryology for deciphering mechanisms responsible for producing adult metazoan organisms. Offered as ANAT 391 and ANAT 491.

ANAT 499. Independent Study. 1 - 4 Units.
Laboratory research project. Student must obtain approval of a supervising Anatomy department professor before registration and list the professor's name on the schedule card.

ANAT 503. Readings and Discussions. 1 - 3 Units.
In-depth consideration of special selected topics through critical evaluation of the literature. Student must obtain approval of supervising Anatomy department professor before registration.

ANAT 515. Surgical Anatomy: Orthopaedic Musculoskeletal. 4 Units.
This orthopaedic musculoskeletal anatomy course is offered to M.S. in Applied Anatomy students and fourth year medical students. The course will familiarize participants with surgical approaches used to treat musculoskeletal disease. Students will learn to correlate normal and abnormal anatomical findings with radiographical studies. Recommended preparation: ANAT 411.

ANAT 516. Surgical Anatomy: Head and Neck. 4 Units.
This cadaver-based advanced anatomy course is offered to M.S. in Applied Anatomy students and fourth year medical students. Students will build on their understanding of basic gross, histological, pathological, and embryonic anatomy of the head and neck. The course will familiarize participants with surgical approaches used to treat pathological conditions of the head and neck including cranial cavity, cranial base, orbit, maxillofacial, oral, otic, pharyngeal, and airway. Students are required to attend and participate in lectures, surgical labs, and discussions in order to successfully complete the course. Instructor consent is required. Recommended preparation: ANAT 411.

ANAT 520. Imaging Anatomy. 3 Units.
This course is constructed to reinforce normal anatomy by imaging modalities of plain film, CT, and MRI images. Imaging anatomy will reinforce the student’s knowledge of anatomy and introduce the field of radiology. Students would be motivated to broaden their understanding of anatomy by being exposed to the application of that knowledge. The curriculum would introduce radiologic concepts, while stressing the normal anatomy of organ systems by imaging modalities. Anatomical structures will be recognized by projectional and cross-sectional modalities. The student will be expected to demonstrate the anatomical characteristics of that structure, for example course, area of supply, relations, morphology, etc. Primarily for medical and graduate students who have a comprehensive knowledge of human anatomy. We would encourage having taken ANAT 411, Gross Anatomy or Structure.

ANAT 523. Histopathology of Organ Systems. 3 Units.
Comprehensive course covering the underlying basic mechanisms of injury and cell death, inflammation, immunity, infection, and neoplasia followed by pathology of specific organ systems. Material will include histological ('structure') and physiological ('function') aspects related to pathology (human emphasis). Recommended preparation: ANAT 412 or permission of instructor. Offered as ANAT 523 and PATH 523.

ANAT 560. Applied Neuroanatomy. 3 Units.
This course is constructed to reinforce the student’s understanding of neuroanatomy. Through problem-based learning the student will set their own learning objectives based on a neurological case. Presentations will use imaging, anatomic diagrams, and cadaveric dissection to demonstrate applications. Learning in this clinical context will increase motivation and understanding of this important subject. Primarily for medical students and graduate students, enrollment is by permission of instructor and completing ANAT 414, Neurological Anatomy. Prereq: ANAT 414.

ANAT 610. Oxygen and Physiological Function. 1 Unit.
Lecture/discussion course which explores the significance and consequences of oxygen and oxygen metabolism in living organisms. Topics to be covered include oxygen transport by blood tissues, oxygen toxicity, and mitochondrial metabolism. Emphasis will be placed on mammalian physiology with special reference to brain oxidative metabolism and blood flow as well as whole body energy expenditure and oxidative stress related to disease. The course will cover additional spans of physiology, nutrition and anatomy. Offered as ANAT 610, NTRN 610, and PHOL 610.
ANAT 611. Practicum in Human Gross Anatomy. 3 Units.
A course of study designed especially for the preparation of teachers that involves the supervised practical application of previously studied theory. The teaching experience obtained will be obtained in ANAT 411 - Human Gross Anatomy. Teaching will be guided, supervised, and evaluated by the appropriate faculty from the department of anatomy. The three sections of ANAT 611 and the subjects covered are: Trunk Gross Anatomy (6 weeks), Musculoskeletal Gross Anatomy (3 weeks), Head & Neck Gross Anatomy (4 weeks). Required preparation: ANAT 411 and permission of instructor.

ANAT 612. Practicum in Histology and Ultrastructure. 2 Units.
A course of study designed especially for the preparation of teachers that involves the supervised practical application of previously studied theory. The prerequisite knowledge required for ANAT 612 must have been obtained previously in ANAT 412: Histology and Ultrastructure and the associated laboratory ANAT 413: Histology Laboratory. Required participation in ANAT 612 is defined as: 1. Meet weekly with course instructor to (pre)review course material; 2. Attend all ANAT 412 lectures; 3. Participate/assist in all ANAT 413 laboratory sessions. Teaching will be guided, supervised, and evaluated by the course instructor with reference to the graduate student’s overall progress and performance as a teacher. Required prerequisites: ‘A’ grades on ANAT 412 and ANAT 413; permission of instructor required.

ANAT 651. Thesis M.S.. 1 - 9 Units.
Master's Thesis Plan A.