MS Applied Anatomy

The Applied Anatomy program is designed for students who seek a comprehensive education in the anatomical sciences, particularly those individuals pursuing careers as medical health professionals and teachers who desire an advanced degree to enhance their skills and credentials. The Anatomical Sciences Core Curriculum (ASCC) courses 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. The elective courses allow curriculum flexibility for students to emphasize their diverse individual interests. The Master of Science in Applied Anatomy serves as an excellent preparation for physician assistants, physical therapists, dental technicians, and K-12 life sciences teachers.

Students in this post-baccalaureate program earning the Master of Science in Applied Anatomy use their rigorous training in the anatomical sciences to establish an academic basis for their application to medical schools. Case Western Reserve University medical students earning the joint MD/MS degree program seek advanced training in the anatomical sciences. The joint MD/MS program is undertaken and completed concurrently with the medical curriculum, particularly if the student enters the graduate program during the first year of medical school.

Admission

Acceptance into the Master of Science in Applied Anatomy program requires a baccalaureate degree from an accredited institution and is based on undergraduate and/or graduate GPAs, results of admission examinations (GRE, MCAT, DAT), plus letters of recommendation; an Educational Credential Evaluation and Authentication Report is required for foreign transcripts plus documentation (TOEFL) of English language skills for foreign applicants. Acceptance into the joint MD/MS program requires that the medical student be in good academic standing in the CWRU medical curriculum at the time of matriculation into the program, and a letter of approval from their respective Associate (‘Society’) Dean of Student Affairs. Each student in the Applied Anatomy program has a faculty advisor from the Department of Anatomy Graduate Executive Committee which coordinates the program and reviews the graduate Planned Program of Study for individual students. Contact the Department of Anatomy for additional program and application information.

Degree Requirements

The Master of Science in Applied Anatomy degree requires a minimum of 30 graduate course credits. Required courses include 19 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 of the Surgical Anatomy courses. A research thesis is not required for the non-thesis type B MS Applied Anatomy, although research experience may be obtained as elective coursework ANAT 499: Independent Study with individual faculty members.

Comprehensive written and oral exams 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 program in 2 years. Tuition or stipends will not be provided for the master of science program (no additional tuition is required for enrolled medical students).

These specific sequences of classes, while common, are not exclusive and are meant only to exemplify the typical program of study leading to the Master of Science in Applied Anatomy degree. The required courses (19 credits) comprising the Anatomical Sciences Core Curriculum are specifically delineated, whereas the elective courses (11 credits minimum) are not identified since they vary significantly between individual students. Students become eligible to take the MS Comprehensive Examination upon successful completion of the ASCC courses.

MS & MD/MS Applied Anatomy, Plan of Study (4 semester)

First Year

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<tr>
<th>Fall</th>
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<tbody>
<tr>
<td>ANAT 412</td>
<td>Histology and Ultrastructure (Elective)</td>
<td>4</td>
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<tr>
<td>ANAT 413</td>
<td>General Histology Laboratory ()</td>
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<td>Elective</td>
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<tr>
<th>Spring</th>
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<tr>
<td>ANAT 411</td>
<td>Gross Anatomy</td>
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<td>Elective</td>
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(Medical students apply to MD/MS program)

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<tr>
<th>Summer</th>
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<tr>
<td>Elective</td>
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Second Year

**Fall**
- ANAT 414: Neurological Anatomy 4
- Elective 1-3

**Spring**
- ANAT 491: Embryology 3
- Elective 1-3

Master of Science ASCC Comprehensive Examination (May/June)

(MD/MS Step I Exam)

Summer: MS Graduation (August)

1 Year III & IV MD/MS Only:
- [MD/MS- continue clinical/ research rotations]
- Surgical Anatomy courses [1 required--1 clinical block each]
- Surgical Anatomy I, worth 4 credit hours, to be taken in the fall;
- Surgical Anatomy II, worth 4 credit hours, to be taken in the spring.
  - ANAT 515: ‘Orthopedics’ [Block 4] 4
  - ANAT 516: ‘Head & Neck’ [Block 11] 4
- [Year IV- Spring: MD/MS Graduation]

Pre-Approved Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Units</th>
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<tbody>
<tr>
<td>ANAT 445</td>
<td>Mammal Diversity and Evolution</td>
<td>4</td>
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<tr>
<td>ANAT 475</td>
<td>Human Evolution: The Fossil Evidence</td>
<td>3</td>
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<tr>
<td>ANAT 477</td>
<td>Human Osteology</td>
<td>4</td>
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<tr>
<td>ANAT 520</td>
<td>Imaging Anatomy</td>
<td>3</td>
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<td>ANAT 560</td>
<td>Applied Neuroanatomy</td>
<td>3</td>
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<tr>
<td>BIOC 407</td>
<td>Introduction to Biochemistry: From Molecules To Medical Science</td>
<td>4</td>
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<tr>
<td>BIOC 408</td>
<td>Molecular Biology</td>
<td>4</td>
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<tr>
<td>PATH 416</td>
<td>Fundamental Immunology</td>
<td>4</td>
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<tr>
<td>ANAT 462</td>
<td>Principles of Developmental Biology</td>
<td>3</td>
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<tr>
<td>PAST 510</td>
<td>Clinical Residency, Elective</td>
<td>3</td>
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<tr>
<td>ANAT 523</td>
<td>Histopathology of Organ Systems</td>
<td>3</td>
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<tr>
<td>PHRM 409</td>
<td>Principles of Pharmacology</td>
<td>3</td>
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<tr>
<td>PHOL 480</td>
<td>Physiology of Organ Systems</td>
<td>4</td>
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<tr>
<td>ANAT 499</td>
<td>Independent Study</td>
<td>1-4</td>
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<tr>
<td>ANAT 503</td>
<td>Readings and Discussions</td>
<td>1-3</td>
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<tr>
<td>ANAT 611</td>
<td>Practicum in Human Gross Anatomy</td>
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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 hominin 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 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, cadaver dissection-based, course covers all aspects of human gross anatomy. The course is modeled after a traditional medical school gross anatomy curriculum and taught by the CWRU School of Medicine, Department of Anatomy faculty. It is divided into three sections: thorax and abdomen; pelvis/perineum and limbs/back; and head and neck. One hour of lecture will precede 3 hours of dissection laboratory Monday, Wednesday, and Friday. Lectures and dissection labs will cover all human anatomy, and students should be prepared to devote more time that the scheduled hours of 1:00 to 5:00pm. Dissection labs are open 24 hours 7 days a week. Recommended preparation: B.A./B.S., or fourth year undergraduate science major.

**ANAT 412. Histology and Ultrastructure. 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 413. General Histology Laboratory. 2 Units.
Microscopic structure of tissues and organs. Laboratory course associated with ANAT 412 (see ANAT 412 description). Recommended preparation: ANAT 312 or ANAT 412 or concurrent enrollment.

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 415. Functional Neuroanatomy. 4 Units.
This course focuses on concepts underlying the structure and function of important sensory and motor systems in both the central and peripheral nervous systems. Emphasis is placed on learning how different patterns of neuronal connectivity give rise to certain perceptions and motor behaviors. Additionally, the composition and distribution of peripheral nerves—spinal, cranial, and autonomic—is studied. Particular attention is paid to the anatomy and function of those structures innervated by the cranial nerves. A variety of teaching-learning activities is employed—among them, lectures, small-group discussions, student presentations, and examination of preserved brains and brain sections.

ANAT 424. Neural Integrative and Regulatory Mechanisms. 3 Units.
This course is designed as a sequence to ANAT 414, Neurological Anatomy, or any other "introductory" course in neuroanatomy. Topics to be addressed include central regulation of pain, the regulation of somatic and visceral motor activity, neurotransmitter substances, the basal forebrain, the blood-brain barrier, levels of consciousness, sleep-wake mechanisms, cognitive behaviors and memory. Appreciation of the three-dimensional anatomy and vasculature of the spinal cord and brain will be gained through brain dissection and study of stained and unstained sections. Recommended preparation: ANAT 414 or permission.

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. 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 hominin 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.

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ANAT 497. Scientific Presentations. 1 Unit.
These courses provide a foundation and experience for making scientific presentations. Scheduled simultaneously with ANAT 498 and students from both courses are present, but the requirements for passing differ. Students in ANAT 497 prepare PowerPoint and poster presentations. Oral presentations by students taking ANAT 498 will occur during the class periods for the remainder of the semester. Students taking 497 and 498 must participate in these discussions. Students must take ANAT 497: Scientific Presentations before ANAT 498: Applied Anatomy Seminar.

ANAT 498. Applied Anatomy Seminar. 1 Unit.
These courses provide a foundation and experience for making scientific presentations. Scheduled simultaneously with ANAT 497 and students from both courses are present, but the requirements for passing differ. Students in ANAT 497 prepare PowerPoint and poster presentations. Oral presentations by students taking ANAT 498 will occur during the class periods for the remainder of the semester. Students taking 497 and 498 must participate in these discussions. Students must take ANAT 497: Scientific Presentations before ANAT 498: Applied Anatomy Seminar.

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 513. Surgical Anatomy of the Thorax and Abdomen. 4 Units.
This course is intended for graduate and fourth-year medical students interested in surgery and surgical subspecialties. This integrated course will review basic gross anatomy, provide advanced training in gross and surgical anatomy, introduce common clinical problems and their anatomical consequences, and basic surgical approaches. Recommended preparation: ANAT 411 and permission of instructor.

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, pathologic, 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.
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 by oral or written account, for example course, area of supply, relations, morphology, etc. Recommended Preparation: Comprehensive knowledge of human anatomy, such as ANAT 411.

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 neurosurgical 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 510. 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 614. Practicum in Neurological Anatomy. 1 Unit.
A course of study designed especially for the preparation of teachers that involves the supervised practical application of previously studied theory. The graduate student will administer all laboratory sessions, assisting students with identification of structures and with understanding the functional aspects of neuroanatomical pathways. The graduate student will meet with the course director once per week to discuss the student’s performance and progress and to plan for upcoming class sessions. The course director will assist the student in developing the organizational skills necessary to be a course director as the student learns to anticipate questions, define problematic areas, and recognize varying learning styles. The graduate student will be evaluated by the course director with reference to the graduate student’s overall progress and performance as a teacher. Recommended preparation: ANAT 414.

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