Graduate Program in Integrative Biology

Chair: Robert K. Ho
Director of Graduate Studies: Mark Westneat

Professors

- Zeray Alemseged
- Michael I. Coates
- Martin Feder
- Edwin L. Ferguson, Molecular Genetics & Cell Biology
- Melina E. Hale
- Nicholas G. Hatsopoulos
- Robert K. Ho
- David Jablonski, Geophysical Sciences
- Raphael Lee, Surgery
- Zhe-Xi Luo
- Daniel Margoliash
- Nipam Patel, Marine Biological Laboratory
- Victoria E. Prince
- Clifton Ragsdale, Neurobiology
- Callum Ross
- Paul Sereno
- Neil H. Shubin
- Mark Westneat

Associate Professors

- Sliman Bensmaia
- Marcus Kronforst, Ecology & Evolution
- Stephanie Palmer
- Urs Schmidt-Ott

Assistant Professors

- Matthew Kaufman
- Heather Marlow
- Graham Slater, Geosciences

Emeritus Faculty

- James A. Hopson
- Michael LaBarbera
- R. Eric Lombard

The graduate program in integrative biology is housed in the Department of Organismal Biology and Anatomy (OBA), which has a long history of training students in integrative organismal biology. During the 1970s, the focus of the (then) Department of Anatomy shifted from the classic purview of anatomy departments in the middle of the 20th century — histology, neurobiology, and cell biology — to more comparative and functionally oriented topics and an explicit focus on evolutionary biology and functional morphology. The neurobiology section of the department expanded first into explicitly comparative areas and later into neuroethology. Over the next twenty years the department evolved into its present configuration with research and teaching foci which include biomechanics/functionality, organismal neurobiology, developmental biology, and evolutionary biology, all unified by a shared reference point in the biological hierarchy — the organism — an entity we see as the natural reference for all of the biological sciences since it is the natural unit of selection. We see the intellectual areas presently housed in OBA as inextricably and naturally connected. To understand the organismal level in biology requires an understanding of both how organisms have been shaped over evolutionary time scales and how they are generated on developmental time scales, the various interacting tissue and organ systems that generate organismal functions, and the mutual feedback among these functional, evolutionary, and developmental processes. The high degree of connectivity among our core disciplines is exemplified by the integrative nature of student dissertation projects in OBA and by the high level of interaction
and collaboration among our faculty; both faculty and graduate student research in OBA frequently span several of these areas. In recent years there has been a resurgence of interest in and appreciation for organismal-level biology on the national level, putting molecular, genetic, and computational tools and information to use to understand broader systems-level questions. OBA and its integrative biology program has been actively positioning itself as a leader in research and graduate training in this endeavor.

Research and training in the graduate program focus on the integration of four overlapping areas:

1. **Biomechanics**: the application of methods from engineering and physics to understanding the design of organisms.

2. **Developmental Biology**: understanding how information coded into the genome is translated into the patterns seen in organisms. Our developmental biology program has a special emphasis on the interface between evolution and development, an area sometimes called "EvoDevo".

3. **Neurobiology**: understanding how the nervous system regulates and controls the behavior of animals. Our neurobiology program has a special emphasis on the relationship of the nervous system to behavior (or neuroethology) and the application of quantitative methods to understanding neural function (computational neuroscience).

4. **Paleontology**: documenting and understanding evolutionary patterns and processes through analyses of the fossil record.

Training in the department places an emphasis on familiarity with a broad range of ideas and skills in organismal biology. Although students can conduct research in any of the areas represented in the department, they are encouraged to develop research programs that capitalize on the talents of two or more faculty members with different perspectives. The department also encourages students to interact with other units on campus (such as the Department of Ecology and Evolution and the Committees on Development, Regeneration and Stem Cell Biology; Evolutionary Biology; Genetics, Genomics and Systems Biology; and Neurobiology) as well as the Field Museum of Natural History, the Brookfield and Lincoln Park zoos, the Shedd Aquarium, and the Marine Biological Lab at Woods Hole. Students earning doctorates through the department will be qualified, following suitable postdoctoral training, for research and teaching careers in biology departments, anatomy departments and museums.

**DEGREES**

**MASTER OF SCIENCE**

Students are not admitted to the program for the sole purpose of obtaining a Master of Science degree, but this degree is awarded to students from other academic units who require a Master of Science degree as one requirement for the doctorate.

**DOCTOR OF PHILOSOPHY**

The requirements for the Doctor of Philosophy are as follows:

- Course requirements are individualized and are defined for students early in their stay in the program, based on the student's background and interests. Students will complete a course distribution requirement by the end of their second year. Students must fulfill the divisional requirement of serving as a teaching assistant in two courses and completing ethics training.

- The preliminary examination, consisting of a written segment which covers a range of topics in organismal biology, as well as both the oral and written presentation of a directed research project or dissertation research proposal.

- The completion of a research project and the presentation of a dissertation satisfactory to the department faculty.

- The passing of a final oral examination.

**ADMISSION**

We strongly advise students considering application to the graduate program to begin preparation of their application early in the autumn quarter, so that all materials will arrive by the December 1 deadline. Foreign applicants whose first language is not English also must submit TOEFL test scores with their application materials. Further information also may be obtained from the department's home page at http://integbio.uchicago.edu (http://pondside.uchicago.edu/).

**COURSES**

Didactic and seminar courses are offered in each of the departmental research foci. The specific courses presented vary from year to year. A list of current courses can be obtained by contacting the graduate program administrator. Students are encouraged to take courses related to their interests in other academic units on campus.
ORGANISMAL BIOLOGY AND ANATOMY COURSES

ORGB 30001. The Human Body. 125 Units.
The Human Body course is the first component of the Scientific Foundations of Medicine curriculum in Year 1. The Human Body course will provide you with a foundation in the structural organization of the body. You will learn gross anatomy of the back, thorax, abdomen, pelvis, head and neck, and upper and lower limbs through large and small group teaching sessions, as well as cadaver dissection. Correlations with Radiology and Surgery are an integral part of the course and provide real world clinical context for the anatomic material.
Instructor(s): C. Ross Terms Offered: Summer
Note(s): For Pritzker students only, unless by instructor consent

ORGB 30002. PE: The Human Body. 300.00 Units.

ORGB 30250. Chordates: Evolution and Comparative Anatomy. 100 Units.
Chordate biology emphasizes the diversity and evolution of modern vertebrate life, drawing on a range of sources (from comparative anatomy and embryology to paleontology, biomechanics, and developmental genetics). Much of the work is lab-based, with ample opportunity to gain firsthand experience of the repeated themes of vertebrate body plans, as well as some of the extraordinary specializations manifest in living forms. The instructors, who are both actively engaged in vertebrate-centered research, take this course beyond the boundaries of standard textbook content.
Instructor(s): M. Coates Terms Offered: Winter.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence, including BIOS 20187 or BIOS 20235
Note(s): Not offered Winter 2019 - Offered Winter 2020 and every other year thereafter.
Equivalent Course(s): EVOL 30200, BIOS 22250

ORGB 30260. Chordate Evolutionary Biology. 100 Units.
Equivalent Course(s): BIOS 20260

ORGB 30415. Evolution Before Darwin. 100 Units.
This course will explore the emergence and development of evolutionary thought prior to Charles Darwin's On the Origin of Species (1859). We will pay particular attention to the way in which transformism was a feature of nineteenth-century thought more generally, connecting natural history to astronomy, theology, and the study of humanity. Natural philosophers and later scientists who wished to make arguments concerning nature's deep past and hidden or obscured processes (such as the long-term transformations of stars, strata, and organic species) faced an essential problem: the power of observation and experiment was limited. Our class will interrogate this problem, and examine the way in which the development of evolutionary thought prior to Darwin was intimately connected to contentious debates regarding speculation and scientific method. We will conclude by contemplating the ways in which the ideas and challenges raised by transformism and evolution influenced the reception of Darwin's work, and the way in which these ideas and challenges remain embedded within seemingly disparate fields of study today.
Instructor(s): J. Daly Terms Offered: Winter
Equivalent Course(s): ECEV 30415, HIPS 21415, HIST 25316, KNOW 21415

ORGB 31201. Mammalian Evolutionary Biology. 100 Units.
This course examines mammalian evolution—the rise of living mammals from ancient fossil ancestors stretching back over 300 million years. Lectures focus on the evolutionary diversification of mammals, including anatomical structure, evolutionary adaptations, life history, and developmental patterns. Labs involve detailed comparative study of mammalian skeletons, dissection of muscular and other systems, trips to the Field Museum to study fossil collections, and studies of human anatomy at the Pritzker School of Medicine. Students will learn mammalian evolution, functional morphology, and development, and will gain hands-on experience in dissection. Taught by instructors who are active in scientific research on mammalian evolution, the course is aimed to convey new insights and the latest progress in mammalian paleontology, functional morphology, and evolution. Prerequisite(s): Second-year standing and completion of a Biological Sciences Fundamentals sequence; or GEOS 13100-13200 or GEOS 22300, or consent of instructors.
Instructor(s): Z. Luo, K. Angielczyk Terms Offered: Autumn.
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence including BIOS 20187 or BIOS 20235; or GEOS 13100-13200 or GEOS 22300, or consent of instructors.
Equivalent Course(s): EVOL 31201, BIOS 23262

ORGB 31300. Key Issues in Early Vertebrate Evolution. 100 Units.
Equivalent Course(s): EVOL 30300

ORGB 32233. Comparative Vertebrate Anatomy. 100 Units.
This course covers the structure and function of major anatomical systems of vertebrates. Lectures focus on vertebrate diversity, biomechanics, and behavior (from swimming and feeding to running, flying, seeing, and hearing). Labs involve detailed dissection of animals (muscles, organs, brains) and a focus on skull bones in a broad comparative context from fishes to frogs, turtles, alligators, mammals, birds, and humans. Field trip to Field Museum and visit to medical school lab for human dissection required.
Instructor(s): M. Westneat. L. Terms Offered: Winter
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence.
This course will explore form and function in a diversity of organisms, using the principles of physics and evolutionary theory to understand why living things are shaped as they are and behave in such a diversity of ways. Biomechanics is at the interface of biology, physics, art, and engineering. We will study the impact of size on biological systems, address the implications of solid and fluid mechanics for organismal design, learn fundamental principles of animal locomotion, and survey biomechanical approaches. Understanding the mechanics of biological organisms can help us gain insight into their behavior, ecology and evolution.

Instructor(s): U. Schmidt-Ott
Terms Offered: Autumn

Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence. Physics useful.

Note(s): This course will include a lab and will alternate years with BIOS 22233.
Equivalent Course(s): EVOL 32245, BIOS 22245
networks and algorithms for studying neural encoding in individual neurons and decoding in populations of neurons) are discussed. Weekly lab sections allow students to program cognitive neuroscientific experiments and simulations.

Instructor(s): N. Hatsopoulos Terms Offered: Winter
Prerequisite(s): For Neuroscience Majors: NSCI 20110, NSCI 20130, BIOS 26210, and knowledge using Matlab, or consent of instructor.
Equivalent Course(s): PSYC 34410, CPNS 33200, NSCI 23600, BIOS 24232

ORGB 36400. Molecular Phylogenetics. 100 Units.
While evolution by natural selection is an elegantly simple phenomenon, modern research in evolutionary biology contains a variety of controversial, and sometimes confusing, topics. In this course, we will explore, as a group, a select list of controversial or confusing topics in evolutionary biology through a mix of student-led presentations and discussion of the primary literature. Each student will also write a review paper about his or her selected topic.

Instructor(s): J. Thornton, A. Drummond Terms Offered: Spring, offered in alternate (even) years
Note(s): not offered in 2018-19
Equivalent Course(s): ECEV 36400, HGEN 36400

ORGB 40000. Intro to Integrative Organismal Biology. 100 Units.
A graduate seminar to introduce students to research of faculty in the Department of Organismal Biology and Anatomy. Prerequisite(s): Required for first and second year graduate students in Integrative Biology.

Instructor(s): M. Westneat Terms Offered: Autumn
Prerequisite(s): Required for first and second year graduate students in Integrative Biology.

ORGB 40001. Topics: Integrative Organismal Biology. 100 Units.
Prerequisite(s): Required for first and second year graduate students in Integrative Biology.

ORGB 40100. Anatomical Research. 100 Units.
Course description unavailable.
Terms Offered: Autumn
Note(s): Only open to first year graduate students in the Darwinian Sciences Cluster

ORGB 40101. Grants, Publications, and Professional Issues. 100 Units.
Covers professional topics in evolutionary biology, primarily strategies in grant writing and review. Each student will work towards the submission of an application of their choice. The course meets weekly and involves extensive writing and discussion.

Instructor(s): J. Bergelson, R. Ho, M. Coates Terms Offered: Autumn
Note(s): Open to first and second year graduate students in the Darwinian Sciences Cluster
Equivalent Course(s): ECEV 40100, EVOL 40100

ORGB 40200. Advanced Topics in Ethics for the Darwinian Sciences. 100 Units.
This course covers advanced topics in ethics relevant to senior Ph.D. students in the Darwinian Sciences. CEB students are required to successfully complete this course before being awarded the Ph.D

Instructor(s): M. Coates, P. Herendeen Terms Offered: Winter
Prerequisite(s): Open to Ph.D. students in the Darwinian Sciences
Equivalent Course(s): EVOL 40200, ECEV 40200

ORGB 42600. Theoretical Neuroscience: Statistics and Information Theory. 100 Units.
This course begins with an introduction to inference and statistical methods in data analysis. We then cover the two main sections of the course: I) Encoding and II) Decoding in single neurons and neural populations. The encoding section will cover receptive field analysis (STA, STC and non-linear methods such as maximally informative dimensions) and will explore linear-nonlinear-Poisson models of neural encoding as well as generalized linear models alongside newer population coding models. The decoding section will cover basic methods for inferring stimuli or behaviors from spike train data, including both linear and correlational approaches to population decoding. The course will use examples from real data (where appropriate) in the problem sets which students will solve using MATLAB.

Prerequisite(s): Prior exposure to basic calculus and probability theory, CPNS 35500 or instructor consent.
Equivalent Course(s): CPNS 35600, STAT 42600

ORGB 49401. Approaches to Teaching in The Darwinian Sciences. 100 Units.
This course will introduce different teaching philosophies and methods that address how to be an effective teacher in the Darwinian Sciences. Specifically, the course will address what skills and knowledge undergraduates need to acquire and which assignments best teach these skills. Students will prepare course syllabi, discuss different approaches to teaching, and draft a philosophy of teaching statement. The overall goal for the course is that the students think critically about the art of teaching and formulate their own thoughts on the matter to better prepare them for their own careers in teaching.

Equivalent Course(s): ECEV 49401, EVOL 49401
ORGB 49500. Lab Teaching/Teaching: Organismal Biology/Anatomy. 100 Units.
For graduate students to build their teaching skills by assisting with the instruction of a course in a core area of Integrative Biology. Students should register for the section under the faculty member who is their teaching mentor for the quarter.

ORGB 49700. Rdgs: Organismal Biology/Anatomy. 300.00 Units.

ORGB 49800. Rsch: ORGB-Off Campus. 300.00 Units.
For graduate students conducting dissertation research at an off-campus lab or field location. Students should register for the section under their adviser only when using pro forma status for the quarter.

ORGB 49900. Rsch: ORGB-On Campus. 300.00 Units.
For graduate students conducting dissertation research wholly or partly on campus for the quarter. Students should register for the section under their adviser and time spent should directly advance their dissertation in Integrative Biology.

ORGB 57500. Cell Growth, Injury, Repair and Death. 100 Units.
This course reviews the various modes of cell injury that can occur, the basic molecular healing responses, and pathways of metabolic survival or death. This course may be of interest to those interested in wound healing, biological stress responses, molecular chaperones, radiobiology, biomechanics, biomedical engineering, as well as trauma and critical care medicine.
Instructor(s): R. Lee Terms Offered: Autumn
Equivalent Course(s): MPMM 57500, MOLM 57500

ORGB 70000. Advanced Study: Organismal Biology & Anatomy. 300.00 Units.
Advanced Study: Organismal Biology & Anatomy