

Evolutionary Developmental Biology
-The deep origins of the vertebrate body plan-

Course Syllabus (Spring 2021)

Course number: 01:447:470

Class location: Online

Class meeting times: Tuesdays and Fridays, 12PM-1:20PM,

Canvas site: <https://rutgers.instructure.com/courses/105886>

Instructor: Tetsuya Nakamura, Ph.D.

Office: LSB224, Department of Genetics, Rutgers, The State University of New Jersey
145 Bevier Rd. Piscataway (Busch Campus)

Phone: 848-445-7191

Email: nakamura@dls.rutgers.edu (*email is the preferred method of contact*)

Office Hours: Thursday 9:30-12:00, **Arranging time before meeting is necessary.** Please send an email to me if you have any questions and want to discuss

Course Description: Evolutionary origins of the vertebrate body plan are major problems in biology. While paleontology and comparative anatomy have revealed the evolutionary trajectories of organs, recent genetics, genomics and developmental biology have been becoming the powerful approaches to answer classical problems. The goal of this course is providing knowledge of comparative anatomy, developmental mechanisms of organs, and methodologies to integrate genetics, genomics and developmental biology to answer evolutionary questions. The recent contribution of state-of-the-art genomics into evolutionary developmental biology will be particularly highlighted during the course. The training to discover and answer scientific problems in animal diversity will be performed online.

Course Goals: Students are expected to:

- Understand the concept of comparative anatomy and evolutionary history of vertebrate body.
- Understand the evolutionary mechanisms of vertebrate body in the light of genetics and genomics.
- Study state-of-the-art genomics to answer evolutionary questions.
- Learn how to integrate genomics, genetics, and developmental biology to reveal evolutionary mechanisms.
- Learn how to discover scientific problems from vertebrate morphology on sites.
- Learn how to approach scientific problems and how to discuss scientific ideas.

Departmental Learning Goal:

- Study basic concepts and terminology of comparative anatomy, developmental biology, and evolutionary genomics.
- Learn how to integrate genomics, genetics, and developmental biology to understand vertebrate evolution.
- Discuss methods to approach evolutionary problems based on published scientific papers.

Textbook

Vertebrates: Comparative Anatomy, Function, Evolution 6th Edition by Kenneth Kardong.
ISBN-13: 978-0073524238

Recommendation (but not a requirement. Copy will be provided via Sakai for Pre-reading)
Developmental Biology 11th Edition by Scott F. Gilbert and Michael J. F. Barresi
ISBN-13: 978-0878939787

Other scientific articles that explain evolutionary genomics will be provided via Sakai.

Academic integrity policy

In accordance with Departmental and University Policies, violations of academic integrity will be reported to the dean. Violations include: cheating, fabrication, plagiarism, and facilitating violations of academic integrity. The use of another person's words, ideas, or results without giving that person appropriate credit or copying another student's work or answers on a quiz or examination are strictly prohibited. More information about violations of academic integrity is available on the following website:

<http://academicintegrity.rutgers.edu/academic-integrity-policy/>. You are supposed to read all information and agree Departmental and University Policies.

Class Attendance (IMPORTANT-READ CAREFULLY)

Students are expected to attend and be punctual for all classes. **Attendance will be taken at the beginning of class.** Students will lose points for habitual lateness. If you expect to miss a class, you **MUST** use the University absence reporting website <https://sims.rutgers.edu/ssra/> to indicate the date and reason for your absence. If a student misses more than two classes prior to the withdrawal deadline, they will be asked to withdraw. **If students have difficulties to attend classes, please contact an instructor before the course starts.**

Performance Expectations and Evaluation Methods

Grades will be based on attendance to lectures, performance of exams and quizzes, and presentations after a field trip. Percent contribution towards the final course grade will be as follows:

- 20% for pre-class reading – quizzes
- 20% Attendance
- 15% for a presentation of approaches to evodevo questions
- 15% for exam I
- 15% for exam II
- 15% for final exam

Grades will be calculated based on overall course performance. The following grading scale will be used:

- 90% A
- 85% B+
- 75% B
- 70% C+
- 60% C

I reserve the right to modify the grading scale downward (e.g., making the lowest A an 88%), but I will not adjust the grading scale upward. Grades below "C" will be determined based on the final score distribution at the end of the course.

Important: points will be taken off for not following instructions or not meeting deadlines!

Rules of conduct

Cell phone use is not allowed in class. If a student is found to use a cell phone in class, she/he will lose a point of attendance in that lecture. Laptop computers are necessary to attend classes, but not for surfing the internet or playing games. Such behavior is distracting to other students in the class. If a student is found to have violated this policy, that student will lose a point of attendance. Recording of lectures or classmate presentations by students is not permitted.

What is the class like?

This is a course to help students understand how we approach evolutionary problems by integrating comparative anatomy, genetics, genomics, and developmental biology. To follow the course, pre-reading the provided materials or text books are necessary. The course will proceed with a significant amount of small group discussion, presenting own ideas, and discussion with the instructor. **Presenting your idea and discussing scientific problems in a class are significantly encouraged.** The course is roughly divided into three components and a group presentation:

-Comparative Anatomy

The Instructor will explain the basic anatomy of the vertebrate body and the ways to compare morphologies among different species. Pre-reading of text books is necessary, and the knowledge will be tested by a mini quiz at the beginning of lectures. You do not need to remember all of the anatomical vocabulary.

-Development

The molecular mechanisms of vertebrate development and current problems will be explained by an instructor. Pre-reading of text books is necessary, and the knowledge will be tested by mini quiz at the beginning of lectures. Basically, lectures will proceed with active group discussions and Q&A style with an instructor.

-Genomics and genetics

An Instructor will provide recent articles that deploy state-of-the-art genomics techniques to answer evolutionary questions before lectures. Pre-reading of these papers is necessary. An Instructor will do a mini quiz at the beginning of lectures. The lectures of genomics and genetics would be more practical than that of anatomy and development. Through discussion in lectures, students will learn how to combine anatomy, genomics, genetics, and developmental biology to answer evolutionary questions.

YOU CAN CHECK YOUR TEXTBOOKS/NOTES DURING MINI-QUIZ IF NECESSARY. However, if you do not pre-read textbooks, you do not have enough time to answer all of the mini-quiz. Some group activity will be followed by discussion with an instructor.

-Group presentations

Students will be randomly assigned into small groups (2-3 students) and will explore evodevo questions regarding animal diversity. Each group chooses a scientific question and prepare a presentation that shows how to approach the question. Each group will provide 10-15 minute presentations followed by 5 minutes Q&A session. The details of presentation style and score criteria will be provided in classes.

Information for Student-Wellness Services:

Just In Case Web App (<http://codu.co/cee05e>)

Access helpful mental health information and resources for yourself or a friend in a mental health crisis on your smartphone or tablet and easily contact CAPS or RUPD.

Counseling, ADAP & Psychiatric Services (CAPS)

(848) 932-7884 / 17 Senior Street, New Brunswick, NJ 08901/ rhscaps.rutgers.edu/

CAPS is a University mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professional within Rutgers Health services to support students' efforts to succeed at Rutgers University. CAPS offers a variety of services that include: individual therapy, group therapy and workshops, crisis intervention, referral to specialists in the community and consultation and collaboration with campus partners.

Violence Prevention & Victim Assistance (VPVA)

(848) 932-1181 / 3 Bartlett Street, New Brunswick, NJ 08901 / vpva.rutgers.edu/

The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling and advocacy for victims of sexual and relationship violence and stalking to students, staff and faculty. To reach staff during office hours when the university is open or to reach an advocate after hours, call 848-932-1181.

Disability Services

(848) 445-6800 / Lucy Stone Hall, Suite A145, Livingston Campus, 54 Joyce Kilmer Avenue, Piscataway, NJ 08854 (<https://ods.rutgers.edu/>)

The Office of Disability Services works with students with a documented disability to determine the eligibility of reasonable accommodations, facilitates and coordinates those accommodations when applicable, and lastly engages with the Rutgers community at large to provide and connect students to appropriate resources.

Scarlet Listeners

(732) 247-5555 / <http://www.scarletlisteners.com/>

Free and confidential peer counseling and referral hotline, providing a comforting and supportive safe space.

Schedule

Schedules are subject to changes due to school closings, class progress, etc. Any updated syllabi will be posted on Sakai.

#	Date	Day	Time	Topic/Activities	Assignments <u>BEFORE CLASS</u>
1	Jan. 19	Tuesday	12:00-1:20PM	Opening - 400 million years of vertebrate evolution	
2	Jan. 22	Friday	12:00-1:20PM	Craniofacial: the origin and basic anatomy of the skull in early vertebrates (Anatomy)	<i>Pre-reading: Chapter7 of Vertebrates (p240-253)</i>
3	Jan. 26	Tuesday	12:00-1:20PM	Craniofacial: the general trends of cranial evolution in vertebrates (Anatomy)	<i>Pre-reading: Chapter7 of Vertebrates (p254-265)</i>
4	Jan. 29	Friday	12:00-1:20PM	Craniofacial: the enigma of the cell origins (EvoDevo)	<i>Pre-reading: p464-480 of Developmental Biology</i>
5	Feb. 2	Tuesday	12:00-1:20PM	Craniofacial: the genetic mechanisms of skull diversity – fish, chimp, human (Genomics)	<i>Pre-reading: scientific articles and some copy of textbooks will be uploaded in Sakai</i>
6	Feb. 5	Friday	12:00-1:20PM	Appendage: hands of fish, whale, and bat (Anatomy)	<i>Pre-reading: Chapter9 of Vertebrates (p325-346, but skip from “Pectoral girdle” of p336 to “Pelvic girdle” of p339 and also Fig.9.19-9.22)</i>
7	Feb. 9	Tuesday	12:00-1:20PM	Appendage: development of fins and limbs (EvoDevo)	<i>Pre-reading: Chapter19, Developmental Biology (p613-627)</i>
8	Feb. 12	Friday	12:00-1:20PM	Appendage: genetic basis for striking adaptations (Genomics)	<i>Pre-reading: Chapter19, Developmental Biology (p635-646), scientific articles will be uploaded in Sakai</i>
9	Feb. 16	Tuesday	12:00-1:20PM	Exam 1 (Craniofacial & Appendage)	
10	Feb. 19	Friday	12:00-1:20PM	Musculature: from simple to complex - how can birds fly? (Anatomy)	<i>Pre-reading: Chapter10 of Vertebrates (Fig.10.18&10.20 and p394-410, Skip all TABLEs and BOX essay)</i>

#	Date	Day	Time	Topic/Activities	Assignment Due?
11	Feb. 23	Tuesday	12:00-1:20PM	Musculature: canonical theory and contradiction (Development)	<i>Pre-reading: Chapter17 of Developmental Biology (Fig. 17.1, fig.17.2, and p560-571)</i>
12	Feb. 26	Friday	12:00-1:20PM	Musculature: secrets of electronic rays and turtles (Genomics and evodevo)	<i>Pre-reading: p575-578 of Developmental Biology, scientific articles will be uploaded in Sakai</i>
13	Mar. 2	Tuesday	12:00-1:20PM	Integument: scales, feathers, antlers (Anatomy)	<i>Pre-reading: Chapter6 of Vertebrates (p212-224)</i>
14	Mar. 5	Friday	12:00-1:20PM	Integument: developmental mechanisms of integumentary systems (Development)	<i>Pre-reading: p528-537 of Developmental Biology and scientific articles will be uploaded in Sakai</i>
15	Mar. 9	Tuesday	12:00-1:20PM	Integument: are scales and feathers homologous? (Evodevo & genomics)	<i>Pre-reading: scientific articles will be uploaded in Sakai</i>
16	Mar. 12	Friday	Exam2 (Musculature and Integument)	Exam2 (Musculature and Integument)	
17	Mar. 16	Tuesday	12:00-1:20PM	No lecture	Spring Break
18	Mar. 19	Friday	12:00-1:20PM	No lecture	Spring Break
19	Mar. 23	Tuesday	12:00-1:20PM	The nervous system: cranial nerves of sharks, snakes, and you (Anatomy)	<i>Pre-reading: Chapter16 of Vertebrates (p628-641)</i>
20	Mar. 26	Friday	12:00-1:20PM	The nervous system: Body trunk or appendage? (Development)	<i>Pre-reading: Figure16.2 of Vertebrate Kardong and p488-497 of Developmental Biology</i>
22	Mar. 30	Tuesday	12:00-1:20PM	The nervous system: dissecting evolutionary network of innervation (genomics)	<i>Pre-reading: p465-466 of Developmental Biology, and other scientific articles will be uploaded in Sakai</i>
23	Apr. 2	Friday	12:00-1:20PM	Explore evo devo questions – with group members and instructor	
#	Date	Day	Time	Topic/Activities	Assignment Due?

24	Apr. 6	Tuesday	12:00-1:20PM	Explore evo devo questions – with group members and instructor	
25	Apr. 9	Friday	12:00-1:20PM	No lecture (prep for presentation, <u>NO need for coming to a class room</u>)	
26	Apr. 13	Tuesday	12:00-1:20PM	No lecture (prep for presentation, <u>NO need for coming to a class room</u>)	

27	Apr. 16	Friday	12:00-1:20PM	No lecture (prep for presentation, <u>NO need for coming to a class room</u>)	
28	Apr. 20	Tuesday	12:00-1:20PM	Group presentation and discussion (1)	<i>Pre-reading: p635-645 of Developmental Biology (again!), and scientific articles will be uploaded in Sakai</i>
29	Apr. 23	Friday	12:00-1:20PM	Group presentation and discussion (2)	<i>Pre-reading: scientific articles will be uploaded in Sakai</i>

30	Apr. 27	Tuesday	12:00-1:20PM	Deep conservation: human hands, cuttlefish arms, and drosophila wing (EvoDevo)	<i>Pre-reading: scientific articles will be uploaded in Sakai</i>
31	Apr. 30	Friday	12:00-1:20PM	Deep conservation: Eyes of human, squid, and insects (Genomics)	
31	May. 4	Tuesday	12:00-1:20PM	Recap: remaining problems and future evodevo	
31	Mar.	Thursday	12:00-1:20PM	Final Exam (Nervous systems and deep conservation)	

Contents by topics

Craniofacial, Jan. 25 –

In class: Instructor will explain the general trends of craniofacial evolution and its underlying genetic mechanisms. The first and second weeks are for comparative anatomy of skulls, third week is for explaining developmental mechanisms of cranial bones, and the fourth week will be used for explaining genomics and genetics to understand craniofacial evolution. Particularly, the fourth week is used for discussing ways to integrate comparative anatomy, developmental biology, and genomics to answer evolutionary questions. Each class begins with a small quiz to confirm whether everyone is on board.

Appendage, Feb. 8 -

In class: Instructor will explain the origin and diversity of appendage and its underlying genetic mechanisms. These lectures contain multiple topics – fish fin-to-limb evolution and diversity of tetrapod limb such as the number of digits. The first week is for comparative anatomy of appendages (fish, amphibian, tetrapods etc.), second week is for explaining developmental mechanisms of appendages, and the third week will be used for explaining current understanding of appendage diversity by genomics and genetics. Each class begins with a small quiz to confirm whether everyone is on board.

Musculature, Feb. 22 -

In class: Instructor will explain the structures of vertebrate musculature system and their evolutionary diversity. The first week is for comparative anatomy of muscles (eye, appendages, body trunk etc.), second week is for explaining developmental mechanisms of musculature systems, and the third week will be used for explaining current understanding of muscular evolution by genomics and genetics. Each class begins with a small quiz to confirm whether everyone is on board.

Integument, Mar. 5 -

In class: Instructor will explain the structures of vertebrate integument system and their evolutionary diversity. The first week is for comparative anatomy of integument systems (scales, feathers etc.), second week is for explaining developmental mechanisms of integument systems, and the third week will be used for explaining current understanding of evolution of integument systems by genomics and genetics. Each class begins with small quiz to confirm whether everyone is on board.

The nervous system, Mar 26-

In class: Instructor will explain the structures of vertebrate nervous system and their evolutionary diversity. The first week is for comparative anatomy of cranial nervous systems, second week is for brain, third week is for explaining developmental mechanisms of nervous systems, and the fourth week will be used for explaining current understanding of evolution of nervous systems by genomics and genetics. Each class begins with a small quiz to confirm whether everyone is on board.

Deep conservation, Apr 5-

In class: Instructor will explain the deep origins of vertebrate body structures. Convergent evolution of bones, eyes, and appendages are particularly focused. The lectures will contain significant amount of discussion. Instructor and students will discuss how deep conservations have been tested and what should be done to test new hypothesis.