Principles of Animal Physiology (Biology 329L)
Spring 2022

Synopsis

This course examines the physiological principles that guide animal life processes. Framed in an evolutionary context, processes ranging from respiration, circulation, neural control, movement, excretion and metabolism will be understood in terms of core principles that also apply to humans. Laboratories and lectures integrally examine fundamental physiological principles through hands-on investigations of animal physiology using research grade data acquisition systems and live animal, inquiry-based research.

Course goals

1) Assemble the core principles of animal physiology based on a foundation of evolution, physics and chemistry.
2) Connect basic and applied research to establish the broader relevance of animal physiology.
3) Create a continuous learning environment so that students and instructors are consistently aware of forward progress throughout the semester.

Note that this course holds both an W code and R code. This means that this is a writing-intensive and research-intensive course.

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Lecture location

French Family Sciences (FFSC) 4233
Tuesdays and Thursdays
10:15-11:30 AM

Laboratory location

073 Biological Sciences Building
Time and date are determined by section assignment.

Prerequisites

Biology 20 or 201L, Physics 141L, Chemistry 101DL

Laboratory topics and materials

Laboratories provide hands-on, investigative experience with live animal physiology. The two major investigations center on muscle physiology in live mussels and metabolic regulation in live adult zebrafish.

All lab sections meet in room 073 of Bio Sci. You do not need to buy anything for lab. We use digital lab notebooks (Microsoft OneNote) to provide all lab protocols and slide presentations, and to save and share data. Bringing your own laptop is advantageous to supplement the use of the lab computers.

This is an in-person lab course for which the default expectation is that students are physically present for lab, except under circumstances detailed in the section related to general course absences. If you have an excused absence, then it is required to communicate to lab staff and coordinate a makeup lab session. This must be done promptly and through the standard channels for absences at Duke (see course absences policies).

Lecture materials

Our official textbook is Hill et al. (2016) and we will provide readings to accompany lectures from this textbook. However, similar topics can be found in most college-level physiology textbooks, if you prefer a different style or format than found in Hill et al. (2016).

Hill, R.W., G. A. Wyse and M. Anderson. 2016. Animal Physiology, 4th Edition. Sinauer Associates, Sunderland, MA.
This text is available as casebound, looseleaf or ebook. It can be purchased from the Duke textbook store, online (e.g. amazon.com), Coursemart or NOOK (for the ebook) or from Sinauer's website directly (15% discount from list price for hardcopy books). Supplementary materials (e.g., flashcards, quizzes, etc.) to the textbook are located at: https://animalphys4e.sinauer.com/

The course's Sakai website hosts all additional readings and assignments.

Grading (subject to change – see Sakai for announcements of any changes)

1) Assessments: Class Assessments 32% + Cumulative Final Exam 21%
2) Analysis of Fundamentals (writing for the W code of the course) 32%
3) Lab Attendance and Participation 15%

Lecture attendance is required. Class assessments typically occur during class. Laboratory attendance and participation are required. For each unexcused, missed lab, up to 10 points are subtracted from final attendance/participation grade.

Class Assessments

Either at the start of each class or assigned outside of class on a weekly or twice-weekly basis, class assessments are comprised of several questions based on the previous class topic(s) and the assigned readings. Depending on the format of the particular class assessment, students will write down the answer on a piece of paper, fill out a multiple-choice form, or post to Gradescope and turn it in after about 5 minutes. When possible, students will discuss their answers in small groups or as a class.

In recognition of effort and attendance (for in-class assessments), simply turning in a reasonable (even if incorrect) answer will net one point. The remaining points will be achieved through correctly answering the question.

A small number of class assessments can be "retaken" through submission of a wonder paper. See Sakai for details.

Analysis of Fundamentals

Analysis of Fundamentals are short writing pieces (Builds) that connect the major concepts in the lectures to the ongoing research in the laboratory, and that ultimately connect to form the full research paper submitted at the end of the semester. The goal is to achieve facility with explaining and understanding the major course concepts and then to make concrete connections to your own and other published research investigations.

Each student will submit their own independent writing for these assignments, even though, in some cases, they will be reporting on lab research that was done collaboratively with another student. (Please see plagiarism section for further information about this expectation).

Attendance/participation

1. Collaborate and cooperate with fellow classmates during group efforts during discussion, lecture, or laboratory sections.
2. Ask questions, stimulate small-group discussion, and engage in the class. If you are shy, then attend office hours and demonstrate your engagement with the material in that one-on-one setting.
3. Contribute to the Slack workspace through posts in various channels such as by offering ideas/help to fellow students or responding to prompts about connections to literature, videos, or sites outside the class.
4. Focus on the lecture, discussion, or lab. *Teaching staff will ask you to leave if you are texting, chatting on the cellphone, surfing the web, or succumbing to other distractions. There are no make-up opportunities in these cases and the participation score for that day will be a zero.*

How participation is graded:

100%: excellent attendance, superior and meaningful contributions during class, lab and office hours, attentive and respectful
90%: excellent attendance, regular and meaningful contributions in lab, class, and office hours, attentive and respectful
80%: very good attendance, some contributions in lab, class or office hours, attentive and respectful
70%: good attendance, some or few contributions in lab, class or office hours, inattentive or disrespectful
60% and below: poor attendance, few or no contributions, inattentive or disrespectful

Late assignments

For each hour that an assignment is late, the grade drops by 10%. If an assignment is due at the start of class, and the student arrives 5 minutes late to class and turns it in, then 10% will be removed from the assignment grade.

Attendance/absences

Laboratory and lecture attendance and participation are required.

For each unexcused missed lab or an excused missed lab that is not made up during a makeup session, up to 10 points are subtracted from final laboratory attendance/participation grade.

We will accommodate absences per Duke University policy. Please ***communicate*** with us and with your academic Dean as issues arise. Make-up work will not be accepted for unexcused absences.

Forms and more information are found here:
https://trinity.duke.edu/undergraduate/academic-policies/class-attendance-and-missed-work

For varsity sports related absences, an official letter (NOVAP) containing the schedule of athletic competitions MUST be turned in during the first week of classes. NOVAPs will not be accepted after the first week.

Duke's official policy for illnesses is described here:
http://trinity.duke.edu/undergraduate/academic-policies/illness
STINF is only to be used for conditions such as "influenza, migraine, sinus infection, and strep throat" and must be submitted within 48 hours of the onset of the illness. "You will only use the STINF for reasons related to your health and then only if your illness is truly incapacitating but not for minor inconveniences such as colds and normal headaches." Abuse of the STINF policy is considered academic misconduct and will be directed to the Dean. Academic Deans monitor STINF submissions.

Plagiarism and academic dishonesty

Duke's Community Standard defines plagiarism as follows:
"Plagiarism occurs when a student, with intent to deceive or with reckless disregard for proper scholarly procedures, presents any information, ideas or phrasing of another as if they were his/her own and/or does not give appropriate credit to the original source. Proper scholarly procedures require that all quoted material be identified by quotation marks or indentation on the page, and the source of information and ideas, if from another, must be identified and be attributed to that source. Students are responsible for learning proper scholarly procedures."

Plagiarism or any other form of cheating will result in failure for the assignment and possibly the course. See detailed policies for individual assignments below.

Course staff identify plagiarism through direct reading of assignments, web-based searches, and plagiarism scanning software implemented through Gradescope or other automated platforms supported by Duke University.

Analysis of Fundamentals policy: Plagiarism or related academic dishonesty for any individual Build assignment (Analysis of Fundamentals) will result in failure for the entire Analysis of Fundamentals grade in the course. That means a 0% for the entire Analysis of Fundamentals category, nullifying 32% of the final course grade.

Class assessments policy: Cheating on any individual assessment will lead to a 0% assigned to the entire Assessment category, nullifying 32% of the final course grade.

Final exam policy: Cheating on the final exam will lead to a 0% assigned to the entire Assessments category, nullifying 53% of the final course grade.

All cases will be reported to the Office of Student Conduct and handled according to their rules and guidelines.

We do not accept Faculty Student Resolutions in this course.

These are not platitudes. We have failed more than 17 students for plagiarism and multiple students have been subjected to administrative action, including being asked to leave the university.
Worried that you just don't quite get it? Take the self-test at this website:
https://plagiarism.duke.edu/def/

Finally, it is important for all students to understand Duke's policy on academic dishonesty for individual courses. This syllabus is the contract and statement of policy that applies to all students who choose to enroll in the course. By taking this course, you have agreed to all stated policies in this syllabus. If you do not wish to abide by these policies, the only option is to not enroll in this class.

APPROXIMATE COURSE TOPICS AND SCHEDULE
(see Sakai for updates)

Humans are animals

Establish the distinction between proximate and ultimate causation in physiology.
Connect basic and applied animal physiology research through case analysis.
Understand the goals, scope, and framework of this course.

Energy and flow

How does the principle of potential energy explain energetics in animal physiology – from cells to whole organisms?
What are the key features of cell membranes that allow the maintenance and generation of electrochemical gradients?
How are osmosis, active transport, secondary active transport, and electrochemical gradients combined to form a framework for the treatment of diarrheal diseases?

Electrical Beings

How do analogies to electrical wires inform understanding and analysis of neural signaling?
What are the key components that generate the major functions of a neuron?
How did neurons originate over evolutionary history?

Synapses and brains

What is a brain in terms of structure and function across animals?
How do synapses form the foundation of variable and precise neural control?
Why do scientists use particular model animal systems for understanding the nervous system?

Muscle building blocks

What are the key molecules involved in movement?
How is movement variability achieved through variation of the behavior, chemistry and organization of these molecules?
How do permeability and ion concentration guide and control muscle contractions?

Muscle performance

What underlying mechanisms explain isotonic and isometric contractions and the tradeoff between force and speed?
How do organisms accommodate variable muscle use through energy supplies?
How do muscles respond to and recover from exercise?

Powerful movement

How do animals maximize power with muscle?
How do animals circumvent muscle limitations to achieve power amplification?
Which therapeutic techniques are used for enhancing muscle-tendon efficiency?

Pumps and Tubes

How do the processes of small scale flow connect to large scale flow in the operation and function of circulatory systems?
What are some of the physical and physiological reasons for the evolutionary diversity of circulatory systems?
How do evolution and physics intersect in the development of hearts?

Gas Exchange

How do partial pressure and solubility work together to determine oxygen and carbon dioxide concentrations in blood or hemolymph?
What are the key mechanisms by which respiratory pigments facilitate oxygen uptake and release as well as carbon dioxide uptake and release?
How does oxygen affinity vary within and across species to accommodate varying environments?

Respiratory Systems

How is energy efficiency incorporated into the mechanisms of respiratory systems?

Why is counter current exchange a core component of efficiency in bulk flow physiological systems?

How have birds evolved extreme performance at high altitudes?

Water balance and homeostasis

What are the levels of internal environment involved in water/waste homeostasis?

How is homeostasis managed in different environments versus in animals that switch environments?

How do salmon physiologically switch between fresh and saltwater environments?

Excretion and kidneys

What are the key strategies for removing waste and what are the major wastes that need to be removed?

What does a kidney "do" and how?

What are the strategies for building kidney transplants and how does this relate to kidney structure and function?

Feedback, the endocrine system and the kidney

How do feedback mechanisms form the foundation of homeostasis?

How do hormones achieve specificity to particular regions of the body?

Which major feedback mechanisms are associated with the kidney and its multiple functions in homeostasis?

Metabolism

What is metabolism and how is it measured?

What is the relationship between metabolic rate and body size?

What is the effect of temperature on metabolism?

Temperature physiology

Who is Knut Schmidt-Nielsen and what were his contributions?

Which aspects of thermoregulation are exemplified in desert-tolerant camels?

How does the heat balance equation operate in cold v. hot environments?

Temperature physiology and climate change

How do performance curves give insight into the effects of temperature within and across species?

What are the effects of temperature in the thermal optimal ranges as opposed to the Pejus and critical temperature ranges?

What are the implications of global climate change for organisms from the tropics v. temperate zones?

Sensory systems as transducers

What is a sensory transducer and how does this compare to engineered transducers?

How is a stimulus turned into a neural signal?

How are sensory systems studied by biologists?

Which aspects of sensory systems provide useful information for human products?

Ears

What is an "ear" and what can it do?

How are ears built in animals?

How did the vertebrate ear evolve?

How have biology and engineering been combined to enhance impaired human hearing?

Stress

What is stress?

How is stress managed by the endocrine system, nervous system and immune system?

How do short term and long term time scales of stress differ in their outcome?

Stress research in an ecological context

What is stress in wild animals?

How are experimental analyses of stress performed in wild animals?

What are the major stressors in wild animals and how are they manifested through behavior and physiology?

Reproduction and endocrine disruptors

What are the levels of analysis for reproductive systems?
How do mammalian reproductive systems develop, mature, and differentiate between male and female?
How do endocrine disruptors impact animal reproductive systems and what are the major challenges in studying/assessing the impacts?

Sleep

What is sleep?
What are the major hypotheses for why animals sleep?
How are these hypotheses tested through multi-level physiological research?