University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Physiological Ecology of Animals

3 Credits

MEES 482/682 Spring 2019

Course Objectives / Overview

Pre-requisite: Undergraduate class in Ecology

Environmental changes that are expressed at the population level are ultimately rooted in responses of their constituent individuals to those changes. Knowing how individuals "work" is thus important to having a thorough appreciations for ecological processes. In this class we will use a thermodynamic/bioenergetic framework to examine some key physiological processes in animals. The course follows a path from underlying physical and biological theory, through discussion of specific physiological functions and their expression under different conditions, to viewing integrated physiological functions in the context of the individual's energy budget, and finally using physiology and energetics to understand ecological patterns. This course evaluates environmental changes, such as those associated with climate change and other anthropogenic impacts, from the perspective of influences on animal functions that underlie fitness and thus the ecology of the species and their communities. Aquatic and terrestrial animals are considered, although most emphasis is placed on aquatic and semi-aquatic species.

The goal is to provide students with a perspective on animal ecology based upon the relationships of individuals with abiotic and biotic characteristics of their environments. Through evaluating physiological and autecological properties of individuals, students will gain an appreciation of the mechanistic basis for higher-order ecological phenomena operating at the population-, community-, and ecosystem levels.

Expected Learning Outcomes

1. Students will gain an appreciation of physiological and bioenergetic processes as they relate to environmental conditions.

2. They will understand the impacts of major abiotic stressors (temperature, salinity/water hardness, water quality, contaminants) on integrated functions (physiological, behavioral) that may entail fitness costs, including thermal responses, osmotic exchange, feeding and assimilation efficiencies, gas exchange, and excretion.

3. Functional responses to stressors will be evaluated with respect to influences on energy allocation among maintenance and production

INSTRUCTOR DETAILS:
Christopher Rowe
rowe@umces.edu
410 326 7227

CLASS MEETING DETAILS:
Dates: Mon, Wed

Times: 8:30 – 10:00 a.m.

Originating Site: Chesapeake Biological Laboratory

IVN bridge number: (*******)

Phone call in number: (***)

Room phone number:(*****)

COURSE TYPE:
Check all that apply
☐ Foundation
☐ Professional Development
☐ Issue Study Group
☐ Seminar
☒ Elective

Prerequisites
Undergraduate Ecology class

Teaching Assistant
N/A

pathways.

4. Ultimately the students will be able to view bioenergetic underpinnings of population and community-level processes from the perspective of direct environmental influences on functional attributes of the individuals.

Course Assessment / Grading

Grades will be assigned based on the scores obtained on three in-class examinations, an in-class presentation, class participation, and a final term paper (600-level students only).

1. **Final Presentations**: All students (MEES 482 and 682) will give a final presentation (12 min + 3 min for questions). For MEES 682 students, this talk will address the topic of your term paper. MEES 482 students can choose a relevant topic of interest. A brief overview of the topic for your term paper and/or presentation is due by Session 21. This overview can be as brief as a single paragraph, as long as it informs me of what you will address and how it relates to the topic of this course. I will then let you know if the topic is sufficient or I will provide recommendations for changes.

Presentation format = Your job is to educate the audience (including me!) about a topic of your choice in environmental science or ecology that reflects the ecophysiological traits of individuals from the perspective of environmental effects on individuals, or the role of individual responses to environmental conditions on ecological systems (populations, communities, ecosystems). Past examples are listed below (#3).

Suggested strategy – Choose a topic that you're interested in and is ecological/environmental in nature. Do a literature search to learn more about it. Armed with this knowledge, prepare a 12 minute presentation to teach us about the phenomenon and why it's important. Refer to topics discussed in class. The goal is for you to unleash your power to share knowledge and to educate others based upon your understanding of animal ecophysiology.

2. Term Papers: Term papers (less than 15 pp double spaced) are required for all MEES 682 students. They will be due on the first day of Final Exams week. Term papers will address a topic of your choice that specifically relates to the interactions between individuals and their environment based on physiological properties or processes.

The paper should be in the format of an "overview" or "perspective" paper which is informative and well referenced, ands leaves the reader with a greater overall appreciation for the topic and the research that underpins it. I have posted one of my papers of this type (Rowe 2008 Bioscience 58:623-631) on Moodle (week 1) that may be useful as an

example..

Remember, you are responsible for educating the reader about the topic, as you are the expert (having read the literature) and the topic is likely new to the audience. Please do not just turn in a copy of your thesis proposal. That's not an effective way to succeed in the class. Term papers must be formatted following the criteria set forth by the research journal of your choice. Follow their "instructions to authors."

3. Examples of Topics for Talks and Term Papers: Below is a list of some topics that have been addressed by previous students.

"Osmoregulation in bull sharks allows occupation of freshwater habitats where they may endanger humans"

"Relationships between prey quality and fitness of blue fin tuna of the western North Atlantic Stock"

"Potential effects of ocean acidification on metabolism and growth of Arctic bivalves."

"Effects of a changing climate on larval development of the deep-sea red crab"

"The effect of adult migration on energetic investment in, and health of, offspring in shore birds"

"Are lungless salamanders evolutionarily equipped to escape the effects of climate warming?"

"Physiological effects of global warming and ocean acidification on marine invertebrates and their life histories"

"Respiration and osmoregulation in blue crabs in response to environmental conditions"

4. Grading:
There are 3 in-class, short-answer format exams. Exams are open-notes and reflect content discussed in class as well as Assigned Readings. I will only count the top 2 scores from the 3 exams toward your final grade. Therefore, I do not give make-up exams. If you miss an exam, that one will be dropped.

Grading breakdown:

A. MEES 482 students:

Exams (best 2 scores of 3 exams) = 75 % of final grade
Presentation = 25 % of final grade

Borderline grades will be determined based upon class participation.

B. MEES 682 students:

Exams (best 2 scores of 3 exams) = 50 % of final grade
Presentation = 25 % of final grade
Term paper = 25 % of final grade

Borderline grades will be determined based upon class participation.

Tentative Weekly Course Schedule

Session	Topic
1 – Jan 16	Course Introduction
2 – Jan 21	Thermodynamics, Life Histories, Adaptation I 1. Energy and the Laws of Thermodynamics 2. Adaptation, Plasticity 3. Life History Strategies/Patterns
3 – Jan 23	Thermodynamics, Life Histories, Adaptation II 1. Life Histories and Resource Allocation 2. Tradeoffs – Costs of Reproduction 3. Tradeoffs – Offspring Size/Quality vs. Offspring Number 4. Contrasting Life History Patterns 5. Non-genetic Maternal Effects
4 – Jan 28	Cellular Processes and Energy 1. Chemical Reactions – Enzymes 2. Metabolism and Metabolic Substrates 3. Cellular Work
5 – Jan 30	Allometry and Scaling; Introduction to Bioenergetics 1. Allometric Relationships 2. Size and Physiology – Universal Relationships? 3. Bioenergetics – Allocation Pathways
6 – Feb 4	Osmotic Exchange, Aquatic Organisms 1. Body Chemistry Homeostasis 2. Osmo-Conformers and -Regulators 3. Colligative Properties 4. Osmotic Challenges in Marine, Estuarine, and Freshwater Habitats 5. Osmotic Tolerance 6. Osmotic Regulation – Freshwater vs. Saltwater Fish
7 – Feb 6	*Guest Lecture* - Dr. Carys Mitchelmore - Endocrinology
8 – Feb 11	Osmotic Exchange, Aquatic (continued) and Terrestrial Organisms 1. Osmotic Fluxes 2. Energetics of Osmoregulation 3. Terrestrial Animals – Distinct Constraints
9 – Feb 13	Osmotic Exchange, Terrestrial Organisms 1. Water Income 2. Water Loss 3. Urinary Excretion and Water Conservation 4. Adaptations for Terrestrial Reproduction – The Amniotic Egg

10 – Feb 18	Thermal Physiology I - Poikilotherms/Ectotherms 1. Different Types of "-thermy" 2. Limits – Thermal Tolerance 3. Effects of Temperature between Lethal Limits 4. Acclimation and Acclimatization
11 – Feb 20	**EXAM 1 - Thermodynamics through Osmotic Exchange**
12 – Feb 25	Thermal Physiology I – continued 5. How Does Heat Kill? 6. Physiological Mechanisms for Living at Different Temperatures 7. Thermal Physiology and Animal Ecology
13 – Feb 27	Thermal Physiology II - Homeotherms/Endotherms 1. The Physics of Heat Exchange 2. Physiology, Environment, and Heat Exchange 3. Physiological Heat Production 4. Hibernation, Aestivation, Torpor 5. Intermediate forms of Homeothermy
14 – Mar 4	Excretion, Gas Exchange I 1. Nitrogenous Wastes 2. Gas Exchange -- Physical Factors 3. The Complexities of CO_2 in Aquatic Systems 4. The Haldane, Bohr, and Root Effects
15 – Mar 6	Gas Exchange II 1. Respiratory Physiology – Aquatic Animals 2. Optimizing Gas Exchange 3. Physiological Requirements and Ecological Consequences 4. Respiratory Physiology – Terrestrial Animals
Spring Break March 11 - 15	
16 - Mar 18	*Guest Lecture* - Dr. Ryan Woodland - Trophic Relationships
17 – Mar 20	Feeding and Nutrition I 1. Overview of Energy Dynamics of Individuals – The Energy Budget 2. Ingestion/Consumption 3. Metabolic Substrates – Carbohydrates, Fats, Proteins 4. Resource Acquisition and Energy Assimilation 5. Losses – Fecal Loss
18 – Mar 25	Feeding and Nutrition II 1. The Cost of Feeding – Specific Dynamic Action 2. Starvation 3. Nutrients and Micronutrients 4. Influences on Feeding or Assimilation 5. "Time is Money" and "There's No Such Thing as a Free Lunch"
19 – Mar 27	**EXAM 2 - Thermal Physiol. through Trophic Relationships**

20 – Apr 1	Maintenance and Activity - Respiratory Energetics 1. Allocation of Energy to Maintenance and Activity 2. Measures of Metabolic Rate 3. Activity Costs and Measurements 4. Metabolic Scope and Power 5. Respiratory Costs and Metabolic Substrates 6. Influences on Maintenance Expenditures
21 – Apr 3	Production I ***** Topics for Term Paper and Presentation Due*** 1. Allocation of Energy to Production 2. Quantifying Growth 3. Time – Astronomical and Physiological 4. Tradeoffs Involving Growth 5. Biotic and Abiotic Influences on Growth and Size 6. Energy Storage
22 – Apr 8	Production II 1. Allocation of Energy to Reproduction 2. Production and Activity 3. Production Tradeoffs 4. Allocation Priorities and Seasonal Cycles 5. A Competitive View of Allocation Pathways 6. Influences on Reproductive Investment 7. Production Efficiencies 8. Reproductive Modes 9. Reproduction Involves Multiple Allocation Pathways 10. Maternal Investment 11. Environmental Sex Determination 12. Example of Empirical Energy Budgets
23 – Apr 10	Chemical Warfare - Toxins and Venoms 1. Toxins vs. Venoms vs. Poisons 2. Tetrodotoxin 3. Venoms 4. Toxic Animals 5. Overview of the Variety of Venoms and Toxins in Biota
24 – Apr 15	Environmental Change and the Physiology/Ecology Nexus 1. Climate Change 2. Climate Warming and Ectotherm Responses 3. OCLTT – The "Oxygen- and Capacity-Limited Thermal Tolerance Hypothesis 4. Ocean Acidification – Physiology and Behavior 5. Climate Change is Now Part of the "Baseline"
25 – Apr 17	Case Study in Environmental Change and the Physiology/Ecology Nexus - Threats to Maryland's Diamondback Terrapin
26 – Apr 22	*Guest Lecture* - Dr. Carys Mitchelmore - Symbiosis

27 – Apr 24	Applied Energetics - Human and Environmental Systems 1. Questions in Applied Energetics 2. Energetics and Contaminants 3. Energetics and Invasive Species 4. Energetics of a Tribal Human Society
28 – Apr 29	**Student Presentations**
29 – May 1	**EXAM 3 – Feeding and Nutrition through end of course**
Finals week	**MEES 682 Term Papers Due** – Date to be announced

Required textbooks, reading and/or software or computer needs

There are no required text books for this class. I will assign readings from the primary literature from time to time throughout the semester. Sometimes we will discuss these in class, but often we won't. However, content from the assigned readings will be addressed in the exams, so *be sure to read them*.
Some texts that may be of interest:

McNab, B K. 2002. The Physiological Ecology of Vertebrates: A View from Energetics. Comstock Press.

Karasov, W.K., del Rio, C.M. 2007. Physiological Ecology: How Animals Process Energy, Nutrients, and Toxins. Princeton University Press.

Schmidt-Nielson, K. 1997. Animal Physiology: Adaptation and Environment, 5th Edition. Cambridge Press.

Sibly, R.M., Calow, P. 1986. Physiological Ecology of Animals: An Evolutionary Approach. Blackwell Press.

Kleiber, M. 1975. The Fire of Life: An Introduction to Animal Energetics. Krieger Publishing Co.

Cossins, A.R., Bowler, K. 1987. Temperature Biology of Animals. Chapman and Hall.

Brody, S., 1945. Bioenergetics and Growth, with Special Reference to the Efficiency Complex in Domestic Animals. Hafner Press.

Hochachka, P.W., Somero, G.N. 2002. Biochemical Adaptation: Mechanism and Process in Physiological Evolution. Oxford University Press.

Course Communication

Moodle, email

Resources

Course website: https://moodle.cbl.umces.edu/course/view.php?id=49

Campus Policies

The University of Maryland Center for Environmental Science has drafted and approved of various academic and research-related policies by which all students and faculty must abide.

Please visit http://www.umces.edu/consolidated-usm-and-umces-policies-and-procedures for a full list of campus-wide academic policies.

Course-Specific Policies and Expectations

There are no make-up exams. If you miss an exam, that one will be assigned a grade of zero. Since one exam score will be dropped from calculation of the final grade, the missed exam can be dropped. Missing two exams will result in a failing grade.