

## **PHYSIOLOGICAL ECOLOGY**

In this course we will examine the physiological basis for the ways plants and animals have adapted to their environments. In the natural world timing is everything. Doing the wrong thing at the wrong time leads to extinction. Plants and animals synchronize the key events in their life cycles to cyclical changes in their environments. We will look at how they do this. We will examine how organisms detect environmental change and then the physiological mechanisms which underlie the adaptive responses that follow. Some adaptations involve exquisite timing mechanisms controlled by biological rhythms; others are triggered by the response of one organism to another (e.g. predators and prey, territoriality, plants and herbivores). Some adaptations are dramatic and occur over landscape scales (migration of waterfowl and shore birds, wildebeest on the Serengeti). Others are subtle and often go unnoticed. Some adaptations involve compromises or tradeoffs (sickle cell anemia and resistance to malaria) while others are triggered by major shifts in metabolism (hibernation in mammals, or migration of anadromous fish from salt water to fresh water during their spawning runs). It is intended that the scope of the course will be broad so that students may select topics from a variety of fields according to their interests.

The focus of the course is not simply to view physiology as we have come to understand it from studies on animals in cages or plants in growth chambers and greenhouses, but rather to examine how an organism's physiology changes as it adjusts to the different demands of its habitat. That is, we want to view an organism's physiology in the context of its environment and through an evolutionary lens.

### **COURSE OBJECTIVES:**

1. To become familiar with the biological literature and with on-line search strategies to access useful information from scientific data bases.
2. To develop good library research skills.
3. To acquire skills of critical data analysis.
4. To research and prepare effective oral presentations on topics of your choice.
5. To become acquainted with the fascinating discipline of physiological ecology.
6. To improve your formal writing skills.

### **ORAL PRESENTATIONS:**

The ability to effectively communicate one's ideas is the mark of an educated person. In science this skill is particularly important because data and information acquired by one scientist must be verified by others before it is accepted as part of the body of scientific knowledge. Scientists review and evaluate the merit of each others work. They communicate research findings to their colleagues by giving oral presentations at scientific meetings and by submitting manuscripts for publication in peer reviewed journals. Scientists attending professional meetings exchange information about their current research efforts often presenting their data before it has been published in the primary literature. The published papers in journals constitute the primary

literature. From the primary literature one or more authors may later assemble the results of many scientists into a reference book on a specific specific topic.

During the semester you will give two oral presentations to the class on topics in the field of physiological ecology. One of your topics should be plant-related and the other should be about an animal or a group of animals. Topics must be approved in advance by the instructor. The first presentation should be 15 minutes in length. The second presentation will be longer (25 minutes), and it should be more detailed in scope and involve more extensive preparation. Both presentations will be followed by a period of questions from the audience. During the first class meeting the dates for seminars will be assigned by drawing lots, and potential topics will be discussed. While it is not a requirement that you do so, you are encouraged to use Power Point to prepare your presentations.

As you conduct the research for your seminar, select a scientific paper which seems to be central to the theme you plan to develop. This will serve as a **focus paper** for the rest of the class since they will read it before hearing your presentation. This article should be from the primary literature, and ideally it should have been published within the last 10 years.<sup>1</sup> One photocopy of the article is to be placed on reserve in Reeves Library and another copy is to be given to the instructor **one week prior to the date the seminar is to be given**. At the same time you will give the instructor a typed abstract of your seminar (not to exceed 300 words). Duplicate enough copies (16) of your abstract so that you can distribute one copy to each member of the class one week before your presentation. It is important that your abstract and photocopied focus article be in on time. It is your responsibility to see that a copy of the article is on reserve in the library and in the hands of the instructor and other members of the class a full week before your talk.

#### CLASS PARTICIPATION:

It is your responsibility to come to class prepared to discuss the seminar topics. You have a standing, weekly assignment to go to the library and read the focus papers for each presentation. Prepare three (3) questions from the paper for the presenter, and bring them with you to class on the day the topic is to be discussed. You are also expected to ask questions about the oral presentation. Class participation makes up 20% of your grade, so it is an important component of the course.

#### VIDEO TAPING OF SEMINAR PRESENTATIONS:

One of the most effective ways to evaluate your presence before an audience is to see a video tape of your own presentation. This will give you an opportunity to see yourself after the seminar. Your first seminar will be video taped by the Media Center staff. It is your responsibility to make an appointment with the Media Center staff to view your presentation during the week after it is given. The Media Center generally will burn a CD or DVD for you for this purpose, and you can view it on your own computer.

#### SEMESTER SCHEDULE:

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<sup>1</sup> Some of the seminal papers or classic citations for your topic may be more than 10 years old. Generally, however, it is preferable to utilize more current literature unless you feel there is a compelling reason to do otherwise. Check with the instructor if you are in doubt.

A semester schedule including meeting dates, seminar topics, and assignments will be distributed in the second week of classes.

CRITERIA FOR EVALUATING SEMINAR PRESENTATIONS:

1. Were the abstract and focus paper turned in on time?
2. Is there a central theme developed through the presentation?
3. Is the focus paper selected by the speaker representative of the topic and does it focus on the theme?
4. Does the presentation indicate that the speaker has thoroughly researched the topic and has command of the literature?
5. Is the speaker neatly dressed?
6. Delivery of the presentation:
  - A. Is there an introduction?
  - B. Are the data clearly presented? Do they illustrate the points being made?
  - C. Is the theme cohesive? Does the speaker ramble?
  - D. Did the speaker analyze the data correctly?
  - E. Was the use of visual aids effective?
    - (1) Are figures and tables **properly labeled** (i.e. conspicuous titles, axes labeled and supplied with appropriate units)?
    - (2) Is the amount of data presented adequate for the points being made?
    - (3) Do PowerPoint slides or overhead transparencies have too much data so that they appear crowded and difficult to read, or has the speaker obviously taken care to make the data easy for the audience to understand? **This is especially important to a good seminar presentation.**
    - (4) Are visual aids used to illustrate points, or just to consume time and “get the speaker through?”
    - (5) Are PowerPoint slides or transparencies left on the screen long enough for the audience to grasp their contents, or are they removed too quickly due to the speaker’s nervousness? **Another important point.**

## F. The speaker's demeanor:

- (1) Did the speaker maintain eye contact with the audience, or was the presentation read from a script?
- (2) Was the delivery smooth or jerky?
- (3) Were gestures used effectively, or were they distracting?
- (4) Posture. Did the speaker stand up straight, or lean over the lectern or against the blackboard?

## G. Response to questions:

- (1) How did the speaker handle himself/herself under fire (i.e. response to questions from the audience)?
  - (2) Were answers logical and analytical?
  - (3) Were questions answered directly, or did the speaker "beat around the bush?"
7. Was there a summary? Did it focus audience attention on the major points made during the presentation. **A summary is important.**

RESEARCH PAPER INSTRUCTIONS:

The research paper should be a major library research project, and as a result, it should be substantial in character.<sup>2</sup> Plan to write your paper on your first seminar presentation topic. You should keep in mind that toward the end of the semester course assignments and deadlines begin to pile up, so there is merit to writing a paper before the end-of-term chaos sets in. In fact, it is unreasonable to assume that you can write a good paper by waiting to end of the semester. Because it represents a substantial part of the semester grade, you should work on it continuously through the term.

The paper should summarize the current status of our understanding about your topic. **The paper must be written in college-level English.** Papers not meeting this standard will be returned ungraded to be rewritten.<sup>3</sup> Pay particular attention to spelling, grammar, and syntax. The paper should be written in a **critical** and **analytical** manner. As you work your way through the reference materials for your topic, ask yourself what important issues are unresolved. Where are the gaps in our knowledge about this topic? What issues should we know more about? What specific questions do you think should be answered? Keep a pad of paper by your side and list these questions or issues as you identify them. You will use them later.

When you construct the narrative for your paper, devote the last section of the paper to the specific questions you want to answer and describe how you propose to answer them. You can title this section “Unresolved Problems” or “Strategies to Address Unanswered Questions.” I am asking you here to **go beyond** simply recounting what you have read by making value judgements about what additional work needs to be done, and by explaining how you would go about doing it. In short, I am asking you to think scientifically. What experiments need to be done? How would you set them up? Lay out the rationale for them. What are your controls? How would you interpret the results from your experiments. I want you to identify interesting, unanswered questions and then show your reader how you propose to address them experimentally.

In the text of your paper you must document statements with literature citations. You may do this by number or by author’s last name and date. In scientific writing documentation is necessary so that your reader can find the sources of the information to which you refer. Assemble your citations at the end of the paper, alphabetically by first author’s last name according to the format on page 7. Note that this is not a bibliography of reference works which you consulted, but rather a list of specific papers from the primary literature and reference texts which you have cited directly in the text of your paper. Follow the prescribed literature citation format carefully.

#### GRADING:

Grades will be based on your seminar presentations, class participation, a written paper, and other library assignments. Unannounced quizzes may be given at any time during the semester on reading materials for the seminars for any given day.

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<sup>2</sup> Approximately 20-25 typewritten pages with normal margins in 12 point font. Statements referring directly or indirectly to scientific research must be properly documented with literature citations.

<sup>3</sup> Not a good thing at the end of the semester when you have 10<sup>6</sup> things to do.

Seminar presentations (Short seminar 10%, Major seminar 25%)	35%
Class participation	20%
Research Paper	40%
Quizzes	5%

#### TIME LINE FOR WRITING YOUR PAPER

Put these dates into your datebook calendar. It is important to stay on target with the progress of your paper. Since this is a major undertaking and involves a substantial amount of library research time, it is unlikely you will do well on it if you put it off until late in the semester.

<u>Date</u>	<u>Items Due</u>
Tue. 6 Sept.	Selection of first seminar topic
Thurs. 29 Sept.	<ol style="list-style-type: none"> <li>1. Paper outline</li> <li>2. List of literature citations and reference texts you plan to use</li> <li>3. Photocopies of all journal articles you have received through interlibrary loan.</li> </ol>
Tue. 18 Oct.	<ol style="list-style-type: none"> <li>1. Expanded outline.</li> <li>2. Rough draft</li> <li>3. A list of the gaps in our knowledge (i.e. unanswered questions) which you have identified about the topic.</li> <li>4. Photocopies of all journal articles you are using</li> </ol>
Thurs. 10 Nov.	Second draft (this is a <b><u>firm</u></b> deadline)
Tue. 6 Dec.	Paper due

#### HOW TO CITE LITERATURE IN YOUR PAPER:

##### Literature Cited

##### **For journal articles:**

Berback, J.T. 2011. Elevated rates of tree collisions by high-flying toucans in a Peruvian rain forest associated with increased dietary intake of *Erythroxylum coca*. *Ecology*. 102: 76-85.

Bernier, S.C. 1902. An initial study of the adaptive strategies of the green iguana. I. Swan-diving from tall trees, it only hurts for a while. *Journal of Herpetology*. 26: 243-249.

Chedraoui, P.A. and J.P. Deutsch. 1945. Pollination failure in tropical vines affected by hummingbird intoxication and its correlation with the period of party activity by the birds during the previous night. *Ecological Monographs*. 26: 89-103.

Galasso, A. 2006. Why bats fly into walls. *Collision Science*. 16: 2017-2023.

Harris, J.L., J.F. Ibrahim, and J.K. Jordan. 1992. How to enjoy termite ecology while they eat you out of house and home. *Journal of Irreproducible Results*. 54: 22-47.

**For a chapter or an article in a reference book:**

Koelbel, M.R., M.C. Kopp, and T.A. Layng. 2007. Migratory tropical birds flying at low altitudes have difficulty discriminating between open windows and closed ones. In: M.J. Lefanto and A.M. Meola. *Fun and games with migratory birds*. Macmillian Publishing Co, Inc., New York. pp. 223-227.

Scalia, L.P. and S.M. Smith. 2000. A new paradigm: the sloth and the hare. In: J.C. West and S.A. Wursta. *Winning is everything*. Bench Press, Inc. Bogota. pp. 235-253.

## Suggestions for Seminar Topics in Physiological Ecology<sup>4</sup>

### Animal Topics:

Fish

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<sup>4</sup> Other topics are possible, but you should discuss them with the instructor before beginning your literature search.

Migration of anadromous fish

Ecophysiology of sex change (“piscatorial transvestites”)

Schooling behavior

Ecophysiology of breeding (e.g. anadromous fish)

\*The icefish has no hemoglobin? Where did it get its antifreeze?

Amphibians and reptiles

Thermal regulation

Cutaneous respiration in amphibians

Amphibian decline

\*\*Poison dart frogs (toxin acquisition, mimicry, life cycle and natural history)

Birds

\*Bird migration: triggers, orientation, etc.

\*Ecophysiology of hummingbirds (metabolism, resource partitioning, sexual dimorphism, hitchhiking mites, etc.)

Insect ecophysiology

\*Pheromonal communication, nestmate recruitment

\*Honeybees dance and shake their boodles.

\*\*Leaf cutter ants

\*\*Termites, army ants

\*\*Dung beetles and their ecological adaptations

How herbivorous insects deal with plant toxins

Physiological basis for defensive strategies insects use to avoid predation

\*Fig wasps and their trees

Mollusks

Zebra mussels

Cone snails and their toxins

Mammals

Thermal regulation (e.g. polar bears, black bears, arctic ground squirrels)

Torpor, estivation

Delayed implantation in bears

Physiology of diving in seals, whales, penguins, loons

\*Scent marking, territoriality, the physiology of aggression

Physiology of hibernation: adaptive values, underlying mechanisms, triggers

\*\*Echolocation in bats

Stress in baboons, hormone levels, rank in the troop and the relevance for humans

Survival in deserts

Water economy of desert tortoises, camels

Physiological adaptations: camels, kangaroo rats, rattlesnakes

Plant Topics:

Adaptations to high-light and low-light habitats

Physiological ecotypes (e.g. altitudinal, edaphic, photoperiodic)

Induced plant defences against insect herbivores:

Elicitors in insect saliva

\*\*Jasmonic acid as an activator of defense responses

Protease inhibitors

\*\*Ecological roles of plant volatiles as signaling molecules (e.g. “talking trees,” recruitment



of herbivore predators: “*The enemy of my enemy is my friend,*” pollinator recruitment, seed and fruit dispersal)

\*\*Myrmecophytes (ant plants): *Cordia, Triplaris, Acacia, Cecropia, Duroia, Macaranga*

\*Mycorrhizae – A fungus and a root fell in love.

Nitrogen fixation (in legume root nodules, on the phyllosphere of tropical plants)

Roles of phytochrome: adaptations to changes in spectral quality, seed germination, sleep

Movements, flowering, dormancy

\*Circadian rhythms (ecological roles in flowering, onset of dormancy, leaf movements)

Photoperiodic control of flowering

Photosynthesis

C<sub>3</sub> and C<sub>4</sub> species distribution

Photosynthetic adaptations to different spectral environments

\*\*CAM in arid zone plants

\*CAM in epiphytes

Adaptations to desert environments (succulence, desert ephemerals, drought-induced leaf abscission, subirrigated plants)

Halophytes – Pass the salt please!

Hydrophytes

Ecophysiology of pollination

\*Ecology of seeds (dormancy, dispersal, germination)

Allelopathic interactions between plants

Thermophilic algae

Ecophysiology of woody plants living at treeline

Ecophysiology of epiphytic plants (bromeliads, orchids): nutrition, water relations, interactions with animals (e.g. poison dart frogs in bromeliads)

Adaptations of plants to alpine and arctic tundra

Cold hardiness: Why are some plants able to develop cold hardiness while other cannot?

\*Physiological ecology of parasitic, achlorophyllous flowering plants (mistletoes, dodders, broomrapes, beech drops, oak drops)

## Reference Texts

The reference texts below may be helpful when preparing your seminars and papers. The list is not a complete one, but it will get you started. Two of the texts are particularly good in covering basic elements of the discipline. For plant topics, you can consult the fourth edition of Taiz and Zeiger’s book **Plant Physiology** (2006). For animal topics, a good place to review basic concepts is Moyes and Schulte’s book **Principles of Animal Physiology** (2006). Both books cover the fundamentals of physiology very well in their respective disciplines. These texts are representative of a much larger collection of good references in Reeves Library. You can ferret out the others for yourself.

Plant-Related References:

Alvim, Paulo de T. and Theodore T. Kozlowski. 1977. **Ecophysiology of Tropical Crops**. Academic Press.

Bazzaz, F.A. 1996. **Plants in Changing Environments: Linking Physiological, Population, and Community Ecology**. Cambridge University Press.

Caldwell, Martyn and Robert W. Pearcy. 1994. **Exploitation of Environmental Heterogeneity by Plants: Ecophysiological Processes Above and Below Ground**. Academic Press.

Chapin, Francis S. 1992. **Arctic Ecosystems in a Changing Climate: An Ecophysiological Perspective**. Academic Press.

Fitter, Alastair H. and Robert K. Hay. 2001. **Environmental Physiology of Plants**. Third Edition. Academic Press.

Kozlowski, Thomas T. 1991. **The Physiological Ecology of Woody Plants**. Academic Press.

Lambers, Hans. **Plant Physiological Ecology**.

Larcher, Walter. 1975. **Physiological Plant Ecology**. Springer-Verlag.

Levitt, Jacob. 1980. **Responses of Plants to Environmental Stresses**. Academic Press.

Lowman, Margaret and Nalini Nadkarni. 1995. **Forest Canopies**. Academic Press.

Luttge, Ulrich. 1977. **Physiological Ecology of Tropical Plants**. Springer-Verlag.

Nobel, Park. **Physiochemical and Environmental Plant Physiology**. Third Edition.

Pearcy, Robert W. 1989. **Plant Physiological Ecology: Field Methods and Instrumentation**. Chapman and Hall.

Mooney, Harold A., William E. Winner, and Eva I. Pell. 1991. **Response of Plants to Multiple Stresses**. Academic Press.

Mulkey, S.S., R.L. Chazdon, and A.P. Smith. 1966. **Tropical Forest Plant Ecophysiology**. Chapman and Hall.

Sage, Rowan F. and Russell K. Monson. 1999. **C<sub>4</sub> Plant Biology**. Academic Press.

Sharkey, Thomas D., Elizabeth Holland, and Harold A. Mooney. 1991. **Trace Gas Emissions by Plants**. Academic Press.

Smith, William K. and Thomas M. Hinckley. 1995. **Ecophysiology of Coniferous Forests**. Academic Press.

Swaine, M.D. 1966. **The Ecology of Tropical Forest Seedlings**. Parthenon Publishing Group.

Taiz, Lincoln and Eduardo Zeiger. 2006. **Plant Physiology**. Sinauer Associates, Inc. Fourth Edition.

Turner, I.M. 2001. **The Ecology of Trees in the Tropical Rain Forest**. Cambridge University Press.

Tranquillini, Walter. 1979. **Physiological Ecology of the Alpine Timberline: Tree Existence at High Altitudes with Special Reference to the European Alps**. Springer-Verlag.

Wallace, J.W. and R.L. (Eds). 1976. **Biochemical Interaction Between Plants and Insects**. Vol 10: Recent Advances in Phytochemistry. Plenum Press.

Animal-Related References:

Abrahamson, W.G. (Ed.) 1989. **Plant-Animal Interactions**. McGraw-Hill.

Agosta, William. 1997. **Bombardier Beetles and Fever Trees: A Close-Up Look at Chemical Warfare and Signals in Animals and Plants**. Perseus Books.

Bradshaw, Don. 2003. **Vertebrate Ecophysiology**. Cambridge University Press.

Eisner, Thomas. 2003. **For Love of Insects**. Harvard University Press.

Eisner, Thomas and Jerrold Meinwald. 1995. **Chemical Ecology: The Chemistry of Biotic Interaction**. National Academy Press.

Feder, M.E. and W.W. Burggren. 1992. **Environmental Physiology of the Amphibians**. University of Chicago Press.

Hill, Richard, Gordon A. Wyse, and Margaret Anderson. 2004. **Animal Physiology**. Sinauer.

Hölldobler, Bert and Martin Lindauer (Eds.) 1985. **Experimental Behavioral Ecology and Sociobiology**.

Hölldobler, Bert and E.O. Wilson. 2009. **The Super-Organism**. W.W. Norton and Co.

Wirth, R, H. Herz, R.J. Ryel and W. Beyschlag, and B. Hölldobler. 2003. **Herbivory of Leaf-Cutting Ants**. Springer-Verlag.

Kricher, John. 2011. **Tropical Ecology**. Princeton University Press.

- Louw, Gideon. 1993. **Physiological Animal Ecology**. Longman Scientific and Wiley.
- McNab, Brian K. 2002. **The Physiological Ecology of Vertebrates**. Cornell University Press.
- Moyes, Christopher D. and Patricia M. Schulte. 2006. **Principles of Animal Physiology**. Pearson Benjamin Cummings.
- Price, P.W. 1991. **Plant-Animal Interactions**. Wiley Interscience.
- Randall, David, Warren Burggren, and Kathleen French. 1997. **Animal Physiology: Mechanisms and Adaptations**. Fourth Edition. W.H. Freeman.
- Schmidt-Nielsen, Knut. 1007. **Animal Physiology: Adaptation and Environment**. Cambridge University Press.
- Sibly, Richard M. 1986. **Physiological Ecology of Animals: An Evolutionary Approach**. Blackwell Scientific.
- Kunz, Thomas H. and Fenton M. Brock. 2003. **Bat Ecology**. University of Chicago Press.
- Reynolds, John E. and Sentiel A. Rommel. 1999. **Biology of Marine Mammals**. Smithsonian Institution Press.
- Dunston, Nigel and Martyn L. Corman. 1998. **Behaviour and Ecology of Riparian Mammals**. Cambridge University Press.

#### SEMESTER SCHEDULE

Tue.	30 Aug.	Orientation, course objectives, discussion of topics
Thur.	1 Sept.	Physiological ecology, discussion of topics
Tue.	6 Sept.	Library session: online searching strategies (come to class a few minutes early)
Thur.	8 Sept.	Complete discussion of topics Finalize topics for first seminar.

Tue.	13 Sept.	Structuring your presentation. Presentation skills.
Thur.	15 Sept.	Paper critiques
Tue.	20 Sept.	Paper critiques
Thur.	22 Sept.	Paper critiques
Tue.	27 Sept.	Surprise
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Thur.	29 Sept.	Short seminars 1 & 2: Joey Ibrahim & Tim Layng Paper outline, literature citations, copies of journal articles due.
Tue.	4 Oct.	Short seminars 3 & 4: Samantha Smith & Mike Manion
Thur.	6 Oct.	Short seminars 5 & 6: Mike Lefanto & Meghan Kopp
Fri.	7 Oct.	Mid term
Sat. 8 Oct. – Tue. 11 Oct.		Fall Recess
Thur.	13 Oct.	Short seminars 7 & 8: Adam Galasso & Jackie West
Tue.	18 Oct.	Short seminars 9 & 10: Mark Koebel & Shane Bernier Rough draft, expanded outline, list of unanswered questions due.
Thur.	20 Oct.	Short seminars 11 & 12: Stephen Wursta & Kevin Jordan
Tue.	25 Oct.	Short seminars 13 & 14: Anna Meola & Jonathan Berback
Thur.	27 Oct.	Short seminars 15 & 16: Jared Deutsch & Louis Scalia

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Tue.	1 Nov.	Longer seminars 1 & 2: Joey Ebrahim & Tim Layng
Thur.	3 Nov.	Longer seminars 3 & 4: Samantha Smith & Mike Manion
Tue.	8 Nov.	Longer seminars 5 & 6: Mike Lefanto & Meghan Kopp
Thur.	10 Nov.	Longer seminars 7 & 8: Adam Galasso & Jackie West Second draft of paper due
Tue.	15 Nov.	Longer seminars 9 & 10: Mark Koebel & Shane Bernier
Thurs.	17 Nov.	Longer seminars 11 & 12: Stephen Wursta & Kevin Jordan
Tue. 22 Nov. – Sun. 27 Nov.		Thanksgiving Recess
Tue.	29 Nov.	Longer seminars 13 & 14: Anna Meola & Jonathan Berback
Thurs.	1 Dec.	Longer seminars 15 & 16: Jared Deutsch & Louis Scalia
Tue.	6 Dec.	Term paper due
Wed.	7 Dec.	Last day of classes