
FW405 – FISH PHYSIOLOGY (3 CREDITS)
COURSE OUTLINE – SPRING 2015

I.	Lecture:	Time:	Place:
		Monday 12:10 – 1:00 p.m.	132 Wagar
		Wednesday 12:10 – 1:00 p.m.	132 Wagar
	Laboratory	Tuesday 2:10 – 4:50 p.m.	132 Wagar / Foothills Fisheries Laboratory ¹
	Instructor:	Dr. Chris A. Myrick 235 Wagar 491-5657 Chris.Myrick@colostate.edu	
		Office hours: 2:00 – 3:00 p.m., Monday and Wednesday, or by appointment	

II. **Required Materials**

- Fishes: An Introduction to Ichthyology, 5th edition (at CSU bookstore).
- Supplemental readings (the journal articles listed at the end of the syllabus are required readings; papers 1-2 are testable for Exam 1, papers 3 and 4 are testable on Exam 2, and papers 5 and 6 are testable on Exam 3).
- CNR computer account

III. **Recommended Materials**

- 3-ring binder (for handouts + readings)
- Flash drive

IV. **Grading Policy**

Exam 1	(15%)
Exam 2	(15%)
Final Exam	(25%)
Laboratory reports & problem sets	(20%)
Laboratory preparation & performance	(10%)
Term Paper (research proposal)	(15%)
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Total	(100%)

Course grades will be determined using the scale below. Final grades may be adjusted to reflect overall class performance. The instructor reserves the right to use +/- grading.

A =	90% or more of total points
B =	Between 80 and 89% of the total points
C =	Between 70 and 79% of the total points
D =	Between 60 and 69% of the total points
F =	Less than 60% of the total points

No makeup exams or exercises will be given. If you miss an exam I must approve a valid excuse from you before the exam begins or you will get a zero. You may call my office (491-5657) in an emergency and leave a message on my answering machine. All assignments are due at the start of the class period on the specified due date. Assignments turned in after the start of the class period will be penalized by 10% per

¹ The map to the Foothills Fisheries Laboratory (on the CSU Foothills Campus) is on page 5. Please park in the lot on the S. side of Rampart Rd., immediately adjacent to the gate leading to the building.

weekday for the first 7 weekdays after the due date. After this point, assignments will be worth a maximum of 30% of their original value.

V. **Office Hours**

Chris Myrick – Monday & Wednesday, 1:30 – 2:30 PM, or by appointment.

VI. **Course Description**

Physiological ecology of fishes, focusing on the diverse range of functional adaptations and adjustments that fishes use to cope with various environmental and physiological states. The course will cover bioenergetics, respiration, blood chemistry and function, muscle function and locomotion, buoyancy regulation, thermoregulation, nutrition, reproduction, growth, and osmoregulation.

VII. **Course Goals**

1. To provide students with an understanding of physiological processes in fishes.
2. To assist students in understanding how fishes adapt and respond to various environmental and physiological challenges. It is anticipated that this course will provide linkages to existing FW courses, especially in the area of proximate organism-environment relationships.
3. To provide students with practical experience in making measurements on fishes related to their physiological ecology.
4. To provide students with experience in writing professional-quality research proposals and reports based on laboratory experiments

VIII. **Prerequisites**

FW300 or BZ214 or equivalent

IX. **Course Home Page**

A number of course files (supplemental readings, data sets, laboratory handouts) will be posted on the course Canvas website – you will need to login here: <http://help.canvas.colostate.edu/login.aspx>.

X. **Academic Integrity²**

We take academic integrity seriously. At minimum, academic integrity means that no one will use another's work as their own. The CSU writing center defines plagiarism this way:

Plagiarism is the unauthorized or unacknowledged use of another person's academic or scholarly work. Done on purpose, it is cheating. Done accidentally, it is no less serious. Regardless of how it occurs, plagiarism is a theft of intellectual property and a violation of an ironclad rule demanding "credit be given where credit is due."

Source: (Writing Guides: Understanding Plagiarism.

<http://writing.colostate.edu/guides/researchsources/understandingplagiarism/plagiarismoverview.cfm>.

If you plagiarize in your work you could lose credit for the plagiarized work, fail the assignment, or fail the course. Plagiarism could result in expulsion from the university. Each instance of

² Dr. Greg Dickinson, CSU, developed the Academic Integrity statement used here and gives permission for other CSU instructors to use parts or all of this statement in their own syllabi.

plagiarism, classroom cheating, and other types of academic dishonesty will be addressed according to the principles published in the CSU General Catalog (see page seven, column two: <http://www.catalog.colostate.edu/FrontPDF/1.6POLICIES1112f.pdf>).

Of course, academic integrity means more than just avoiding plagiarism. It also involves doing your own reading and studying. It includes regular class attendance, careful consideration of all class materials, and engagement with the class and your fellow students. Academic integrity lies at the core of our common goal: to create an intellectually honest and rigorous community. Because academic integrity, and the personal and social integrity of which academic integrity is an integral part, is so central to our mission as students, teachers, scholars, and citizens, we will ask to you sign the CSU Honor Pledge as part of completing the research proposal project. **While you will not be required to sign the honor pledge, we will ask each of you to write and sign the following statement on your term paper.**

"I have not given, received, or used any unauthorized assistance."

In-Class Behavior

Dr. Myrick, the guest lecturers, and his graduate students work hard to provide you with a high-quality educational experience. In-class disturbances, such as ringing cell phones, detract from that experience and we consider them highly disruptive and disrespectful. Therefore, you are asked to **turn off** your cell phone before the start of any lecture or laboratory session. If your phone does ring during class, you will be asked to leave the room for the remainder of that class period. Any other in-class behavior that is deemed unacceptable or distracting to your fellow students will also result in your being asked to leave the class for the remainder of that period.

XI. Lecture Schedule (subject to modification)

Lec. No.	Date	Lecture Topic	READINGS plain = required <i>Italic = suggested background</i>
1	21-Jan	Course introduction: characteristics of aquatic environments [online]	
2	26-Jan	Fish anatomy; Anaerobic metabolism	Moyle & Cech - Ch.3
3	28-Jan	Aerobic metabolism; energetics - adaptations to temperature; intraspecific variability	Moyle & Cech - Ch.3
4	2-Feb	Aerobic metabolism - measurement	Cech, J. J., Jr. 1990. Respirometry. Pages 335-362 in C. B. Schreck, and P. B. Moyle, editors. <i>Methods for Fish Biology</i> . American Fisheries Society, Bethesda.
5	4-Feb	Respiration	Moyle & Cech - Ch.3; <i>Evans - Ch.1 (8-9)</i>
6	9-Feb	Respiration: adaptations to hypoxia; exercise effects	Moyle and Cech - Ch. 3
7	11-Feb	Respiration: respiratory structures	Moyle & Cech - Ch.3
8	16-Feb	Gill structure; aquatic gas dynamics	Moyle & Cech - Ch.3
9	18-Feb	Gill ventilation; review session	Moyle & Cech - Ch.3; <i>Evans - Ch.5 (111-118)</i>
-	23-Feb	Exam 1: Covers lectures, concepts from lab, and readings	

-	25-Feb	Colorado - Wyoming Chapter of the American Fisheries Society Meeting No class, but you are encouraged to attend this local meeting	
10	2-Mar	Fish blood and hemoglobin function	Moyle & Cech - Ch.4; <i>Evans - Ch. 5 (101-111)</i>
11	4-Mar	Fish hemoglobins: characteristics	Moyle & Cech - Ch.4; <i>Evans - Ch.6 (129-156)</i>
12	9-Mar	Cardiovascular system; circulation	Moyle & Cech - Ch.4; <i>Evans - Ch.6 (129-156)</i>
13	11-Mar	Circulation; cardiovascular dynamics	Moyle & Cech - Ch.4; <i>Evans - Ch.6 (129-156)</i>
-	16-Mar	Spring Break	
-	18-Mar		
14	23-Mar	Growth: temperature, ration, strain and size effects	Moyle & Cech - Ch.8; <i>Evans - Ch.4 (65-91)</i>
15	25-Mar	Growth II: compensatory growth; counter-gradient variation	Moyle & Cech - Ch.8; <i>Evans - Ch.4 (65-91)</i>
16	30-Mar	Thermoregulation	Moyle & Cech - Ch.5; <i>Evans - Ch.1 (3-4; 11-12)</i>
17	1-Apr	Feeding kinematics; review session	
-	6-Apr	Exam 2: Covers lectures since exam 1, lab concepts, and readings	
18	8-Apr	Nutrition; feeding energetics	Moyle & Cech – Ch.7; <i>Evans - Ch.3 (43-60)</i>
19	13-Apr	Buoyancy & swimbladder function	Moyle & Cech - Ch.5; <i>Evans - Ch.2 (25-40)</i>
20	15-Apr	Muscle function	Moyle and Cech - Ch.2
21	20-Apr	Locomotion	Moyle & Cech - Ch.2; <i>Evans - Ch.1 (3-20)</i>
22	22-Apr	Reproduction: environmental effects; development	Moyle & Cech - Ch.9; <i>Evans - Ch.18 (465-483)</i>
23	27-Apr	Osmoregulation: ionic regulation; salmonid smoltification	Moyle & Cech - Ch.6; <i>Evans - Ch.7 (157-172)</i>
24	29-Apr	Stress & acid-base balance: effects of environmental acidification, exercise, hypoxia.	Moyle & Cech - Ch.6; <i>Evans - Ch.8 (177-192)</i>
25	4-May	Tolerance of extreme temperatures: freezing resistance; heat resistance; intraspecific variation; acclimation effects	Moyle and Cech – Ch.6
-	6-May	Proposal Presentations & Review Session	
	13-May	Final Exam: 7:30 AM - 9:30 AM Cumulative	

XII. Laboratory Exercises.

Objective: To acquaint each FW405/605 student with some of the instrumentation, techniques, and measurements currently used in fish physiological studies and to demonstrate/reinforce concepts covered in lectures.

Computer Introductions to Lab Exercises: When available, each student must preview the PowerPoint slide shows (available on course website) or lab handouts describing the laboratory exercises to gain admission to the lab. Slide shows or PowerPoint presentations will be uploaded the Monday before each lab exercise. Students will be quizzed on lab techniques at the start of each exercise.

Laboratory Preparation & Performance: A subjective score for each student's apparent laboratory preparation, logical thinking, and exercise-directed persistence for each laboratory exercise will be decided upon by the instructor at the end of each period. Familiarity with the laboratory handout sheet and slide show will result in higher scores.

Laboratory Schedule (timing and topics subject to modification)

Date	Lab Topic	Location	Report Due Date (by 5:00 p.m.)
27-Jan	Discussion of fish physiology research techniques, standards, and development, and of the research proposal.	132 Wagar	No report
3-Feb	Start growth study with fathead minnows (Expt. 1)	FFL	No report
10-Feb	Investigation of temperature effects on fathead minnow respiration and aerobic metabolism (Expt. 2)	FFL	24-Feb
17-Feb	Discussion of papers (1,2) & lab data	132 Wagar	No report
24-Feb	Colorado - Wyoming AFS Meeting - No Lab		
3-Mar	Investigation of the effects of temperature on fathead minnow swimming performance and kinematics (Expt. 3)	FFL	26-Mar
10-Mar	Investigation of temperature effects on startle responses of fathead minnows (Lab 4)	132 Wagar	24-Mar
17-Mar	Spring Break		
24-Mar	Discussion of papers (3,4) + lab data analyses	FFL	No report
31-Mar	Heat exchanger experiment - benefits of counter-current flow (Expt. 5)	FFL	No report (Exam 2 question)
7-Apr	Effects of feeding state on fathead minnow thermal preferences (Expt. 6)	FFL	21-Apr
14-Apr	Conclusion of growth study (Expt. 1)	FFL	28-Apr
21-Apr	Discussion of papers (5,6) + lab data	132 Wagar	No report

28-Apr	Comparative hematology of grass carp and rainbow trout (Expt. 7)	FFL	No report (final exam question)
5-May	Proposal Presentations & Discussion of lab data	132 Wagar	No report

Lab locations: Laboratory sessions will either be held at the Foothills Fisheries Laboratory (see map below), or at in 132 Wagar on the main CSU campus. See the lab schedule to determine where a particular week's laboratory session is being held.

Lab Reports: Five typed laboratory reports (following the Transactions of the American Fisheries Society citation and reference format –available at <http://afs.allenpress.com/fitr.pdf>) are required during the semester (due dates shown below) from each student. Students will receive more information on lab reports and their formats during the first discussion/lab meeting. Each report is worth 50 points.

1. Reports should address an “outside audience”, with the assumption that reader was not in the lab with you, but has some knowledge of fish physiology.
2. Reports should be **double-spaced** and should be **2-3 pages** in length (literature cited, figures, and tables do not count towards the total).
3. Reports should concisely cover the following areas:
 - a. Introduction (10 pts): This section should provide a summary of relevant background information, provide the experimental objectives, and provide a testable hypothesis with justification for why you chose that hypothesis.
 - b. Materials and methods (10 pts): This section provides a summary of the primary equipment and procedures. You may reference the laboratory handout for details, but be sure to include any changes from the handout's procedures as well as relevant details about experimental conditions, equipment, and possible sources of error.
 - c. Results and Discussion sections (25 pts): This section must include the following:
 - i. A summary of the data collected in either tabular or graphical format. **Do not** include the raw data, unless specifically directed to do so (Results section).
 - ii. A statement where you conclude that your results either support or reject the hypothesis stated in the Introduction (Results section).
 - iii. Samples of each type of calculation necessary (Results section), excluding those needed for conducting statistical tests (e.g., t-tests, ANOVAs, regression).
 - iv. An interpretation of your data, with inferences drawn from the primary literature, if necessary (Discussion section).
 - v. A discussion of the significance of your findings to the species in their ability to cope with environmental conditions (Discussion section).
 - d. Literature cited (5 pts): Each report must incorporate a **minimum** of 4 relevant citations from the primary literature. Be sure to follow the proper format (Transactions of the American Fisheries Society) for citations and references.

XIII. Term Project – Research Grant Proposal

Objective: To allow pairs of students to develop a better understanding of a specific topic area in the physiological ecology of fishes and to give students grant-writing experience. Note: If you

have written a paper for another course on a fish physiology topic, you *will not* be allowed to use the same topic for this course—your work is to be original.

1. Choose a partner and a broad topic area by February 6th.
2. Narrow your choice down to a more focused sub-topic and get approval from C. Myrick by February 13th (email your choice to Dr. Myrick).
3. Prepare a written outline (with at least 5 references from the primary literature) by March 6th (5 pts).
4. Prepare a double-spaced, typed proposal (6 – 10 pages long) by Friday, May 1st. Proposals are due by 5:00 PM that Friday. The proposal should address an experiment (or experiments) that you feel should be conducted to advance our knowledge in your topic area.
5. You may submit typed drafts to the instructor for comments—in fact this is strongly recommended. The deadline for submission of drafts is Friday, April 17th at 5:00 p.m.
6. The audience for this proposal is a mix of scientists (not necessarily fish physiologists) and administrators. Though you are not required to turn in a budget, assume that you cannot exceed a total project cost of \$1 million.
7. The proposal should follow the format (section headings) below:
 - a. *Research Question or Statement of the Problem*
 - b. *Background* information, ending with your hypotheses and objectives.
 - c. *Approach and Methods* (note: include appropriate statistical analyses)
 - d. *Justification*
 - e. *Literature Cited*
 - f. *CSU honor pledge (see section X of the syllabus)*
8. Proposals will be graded as follows (total of 90 pts):
 - a. Physiological relevance (20 pts)
 - b. Understanding of research area and background information (20 pts)
 - c. Originality and feasibility of research idea, methods, and analyses (20 pts)
 - d. Defense of research idea and justification, including its application to present knowledge (20 pts)
 - e. Readability, conciseness, and appearance (i.e., correct formatting, spelling, and grammar) (10 pts)
9. Each group shall prepare a 7-minute presentation on your research proposal for delivery during the last laboratory and lecture periods (Tuesday and Wednesday , May 5th and 6th; 10 pts). You may use slides, PowerPoint or overheads.

XIV. Required Journal Articles

Exam 1	1	Glover, D. C., DeVries, and R. A. Wright. 2012. Effects of temperature, salinity and body size on routine metabolism of coastal largemouth bass <i>Micropterus salmoides</i> . <i>Journal of Fish Biology</i> 81(5):1463-1478.
	2	Halpin, P. M., and K. L. M. Martin. 1999. Aerial respiration in the salt marsh fish <i>Fundulus heteroclitus</i> (Fundulidae). <i>Copeia</i> (3):743-748.
Exam 2	3	Holthe, E., E. Lund, B. Finstad, E. B. Thorstad, and R. S. McKinley. 2005. A fish selective obstacle to prevent dispersion of an unwanted fish species, based on leaping capabilities. <i>Fisheries Management and Ecology</i> 12(2):143–147.
	4	Herrera, M., C. Aragao, I. Hachero, I. Ruiz-Jarabo, L. Vargas-Chacoff, J. M. Mancera, and L. E. Conceicao. 2012. Physiological short-term response to sudden salinity change in the Senegalese sole (<i>Solea senegalensis</i>). <i>Fish Physiology and Biochemistry</i> 38(6):1741-1751.

Final Exam	5	Eliason, E. J., D. A. Higgs, and A. P. Farrell. 2007. Effect of isoenergetic diets with different protein and lipid content on the growth performance and heat increment of rainbow trout. <i>Aquaculture</i> 272(1-4):723-736.
	6	Recsetar, M. S., M. P. Zeigler, D. L. Ward, S. A. Bonar, and C. A. Caldwell. 2012. Relationship between fish size and upper thermal tolerance. <i>Transactions of the American Fisheries Society</i> 141(6):1433-1438.