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**FW405 – FISH PHYSIOLOGY (3 CREDITS)**  
**FW605 – ADVANCED PHYSIOLOGICAL ECOLOGY OF FISHES (4 CREDITS)**  
**COURSE OUTLINE – SPRING 2020**

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I.	Lecture:	Time:	Place:
		Monday 12:00 – 12:50 p.m.	132 Wagar
		Wednesday 12:00 – 12:50 p.m.	132 Wagar
	Laboratory	Tuesday 2:00 – 4:40 p.m.	132 Wagar / Foothills Fisheries Laboratory <sup>1</sup>
	Recitation	Friday 12:00 – 12:50 p.m.	106 Natural Resources Bldg.

Instructor: Dr. Chris A. Myrick 235 Wagar 491-5657  
Chris.Myrick@colostate.edu  
Office hours: Mon. 1 - 2 PM, Wed. 12 – 1 PM, or by appointment

## II. Required Materials

- ~~Fishes: An Introduction to Ichthyology, 5th edition (at CSU bookstore)~~ (see recommended materials)
- 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).

## III. Recommended Materials

- Fishes: An Introduction to Ichthyology, 5th edition (at CSU bookstore). The necessary chapters may end up on course reserve.
- 3-ring binder (for handouts + readings)
- Flash drive

## IV. Grading Policy

Exam 1 (2/24/20)	(15%)
Exam 2 (4/6/20)	(15%)
Final Exam (5/11/20, 11:50 AM)	(25%)
Laboratory reports & problem sets	(20%)
Laboratory preparation & performance	(10%)
Term Project (Lecture)	(15%)
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Total	(100%)

Students will be assigned a letter grade at the end of the course based on their total score. The instructor assigns +/- grades.

**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 by 5 PM on the specified due date. You may turn them in directly to the instructor or the teaching assistant, or you may turn them in to the FWCB department office (ask the administrative staff to record the date and time on your assignment so that you are not penalized for turning them in late). Late assignments**

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<sup>1</sup> The map to the Foothills Fisheries Laboratory (on the CSU Foothills Campus) is available on Canvas.

**will be penalized by 10% per weekday for the first 5 weekdays—after that point, they will be worth a maximum of 50% of the original value.**

**V. Student Disability Accommodations**

If you are a student who will need accommodations in this class due to a disability or chronic health condition, I will need an accommodation letter from the Student Disability Center (SDC) before they are implemented. Please meet with me during my office hours to give me the letter and/or to further discuss your needs.

If you do not already have these letters, please contact the SDC as soon as possible to initiate the accommodation process. The SDC is located in room 121 of the TILT building. Contact them at 970-491-6385 or visit [www.disabilitycenter.colostate.edu](http://www.disabilitycenter.colostate.edu).<sup>2</sup>

**VI. Office Hours**

Mon. 1 - 2 PM, Wed. 12 – 1 PM, or by appointment

**VII. 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.

**VIII. 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

**IX. Prerequisites**

FW300 or BZ214 or equivalent

**X. 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>.

**XI. Academic Integrity<sup>3</sup>**

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:

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<sup>2</sup> Information provided from: <https://disabilitycenter.colostate.edu/info-for-faculty/>

<sup>3</sup> Dr. Greg Dickinson, CSU, developed the Academic Integrity statement used here and gives permission for other CSU instructors to use parts or all this statement in their own syllabi.

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 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 works 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.

#### **XII. Lecture & Lab Schedule (subject to modification)**

<b>Lecture, Lab or Recitation number</b>	<b>Date</b>	<b>Lecture or Lab Topic</b>	<b>LOCATION or READINGS</b> plain = required   <i>Italic = suggested background</i>
1	22-Jan	Course introduction: characteristics of aquatic environments	
2	27-Jan	Fish anatomy; Anaerobic metabolism	<i>Moyle &amp; Cech - Ch.3</i>
Rec. 1	28-Jan	Discussion of fish physiology research techniques, standards, and development, and of the term project	<b>132 Wagar</b>
3	29-Jan	No class (Foothills Campus Parking Meeting)	

4	3-Feb	Aerobic metabolism - measurement	Cech, J. J., Jr. 1990. <i>Respirometry</i> . Pages 335-362 in C. B. Schreck, and P. B. Moyle, editors. <i>Methods for Fish Biology</i> . American Fisheries Society, Bethesda.
Lab 1.1	4-Feb	Start growth study with burbot (Expt. 1)	<b>FFL</b>
5	5-Feb	Aerobic metabolism; energetics - adaptations to temperature; intraspecific variability	<i>Moyle &amp; Cech - Ch.3</i>
6	10-Feb	Respiration: adaptations to hypoxia; exercise effects	<i>Moyle and Cech - Ch. 3</i>
Lab 2	11-Feb	Investigation of temperature effects on burbot respiration and aerobic metabolism (Expt. 2)	<b>FFL</b>
7	12-Feb	Respiration: respiratory structures	<i>Moyle &amp; Cech - Ch.3</i>
8	17-Feb	Gill structure; aquatic gas dynamics (may be online)	<i>Moyle &amp; Cech - Ch.3</i>
Rec. 2	18-Feb	Discussion of papers (1,2)	<b>132 Wagar</b>
9	19-Feb	Gill ventilation; review session	<i>Moyle &amp; Cech - Ch.3;</i> <i>Evans - Ch.5 (111-118)</i>
-	<b>24-Feb</b>	<b>Exam 1: Covers lectures, concepts from lab, and readings</b>	
	<b>25-Feb</b>	CO/WY & UT Chapter of the American Fisheries Society Meeting	
-	26-Feb		
10	2-Mar	Thermoregulation	<i>Moyle &amp; Cech - Ch.5;</i> <i>Evans - Ch.1 (3-4; 11-12)</i>
Lab 3	3-Mar	Heat exchanger experiment - benefits of counter-current flow	<b>FFL</b>
11	4-Mar	Fish blood and hemoglobin function	<i>Moyle &amp; Cech - Ch.4;</i> <i>Evans - Ch. 5 (101-111)</i>
12	9-Mar	Fish hemoglobins: characteristics (may be online)	<i>Moyle &amp; Cech - Ch.4;</i> <i>Evans - Ch.6 (129-156)</i>
Rec. 3	10-Mar	Discussion of your term projects	<b>132 Wagar</b>
13	11-Mar	Cardiovascular system; circulation	<i>Moyle &amp; Cech - Ch.4;</i> <i>Evans - Ch.6 (129-156)</i>
-	16-Mar	Spring Break	
-	18-Mar		
14	23-Mar	Growth: temperature, ration, strain and size effects	<i>Moyle &amp; Cech - Ch.8;</i> <i>Evans - Ch.4 (65-91)</i>
Lab 1.2	24-Mar	Conclusion of growth study	<b>FFL</b>

15	25-Mar	Growth II: compensatory growth; counter-gradient variation	<i>Moyle &amp; Cech - Ch.8;</i> <i>Evans - Ch.4 (65-91)</i>
16	30-Mar	Circulation; cardiovascular dynamics	<i>Moyle &amp; Cech - Ch.4;</i> <i>Evans - Ch.6 (129-156)</i>
Rec. 4	31-Mar	Discussion of papers (3,4)	<b>132 Wagar</b>
17	1-Apr	Feeding kinematics; review session	
-	<b>6-Apr</b>	<b>Exam 2: Covers lectures since exam 1, lab concepts, and readings</b>	
Rec. 5	7-Apr	Topic TBD	<b>132 Wagar</b>
18	8-Apr	Nutrition; feeding energetics	<i>Moyle &amp; Cech - Ch.7;</i> <i>Evans - Ch.3 (43-60)</i>
19	13-Apr	Buoyancy & swimbladder function	<i>Moyle &amp; Cech - Ch.5;</i> <i>Evans - Ch.2 (25-40)</i>
Rec. 6	14-Apr	Discussion of term project progress	<b>132 Wagar</b>
20	15-Apr	Muscle function	<i>Moyle and Cech - Ch.2</i>
21	20-Apr	Locomotion	<i>Moyle &amp; Cech - Ch.2;</i> <i>Evans - Ch.1 (3-20)</i>
Lab 4	21-Apr	Comparative kinematics of burbot and fathead minnows	FFL
22	22-Apr	Reproduction: environmental effects; development	<i>Moyle &amp; Cech - Ch.9;</i> <i>Evans - Ch.18 (465-483)</i>
23	27-Apr	Osmoregulation: ionic regulation; salmonid smoltification	<i>Moyle &amp; Cech - Ch.6;</i> <i>Evans - Ch.7 (157-172)</i>
Lab 5	28-Apr	Hematology rainbow trout and burbot (tentative)	FFL
24	29-Apr	Stress & acid-base balance: effects of environmental acidification, exercise, hypoxia.	<i>Moyle &amp; Cech - Ch.6;</i> <i>Evans - Ch.8 (177-192)</i>
25	4-May	Tolerance of extreme temperatures: freezing resistance; heat resistance; intraspecific variation; acclimation effects	<i>Moyle and Cech - Ch.6</i>
Rec. 6	5-May	Ultimate Fish Presentations & Discussion of lab data	132 Wagar
26	6-May	Physiology of fish disease	
	<b>11-May</b>	<b>Final Exam: 11:50 AM - 1:50 PM Cumulative (know it all)</b>	

### XIII. 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)**

**Lab locations:** Laboratory sessions will either be held at the Foothills Fisheries Laboratory (see map on Canvas), 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:** Students will prepare 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.

#### XIV. Term Project – Designing the Ultimate Fish

**Objective:** To allow students to use their knowledge of fish physiology to design the “ultimate fish”, a species that will have the ability to survive a specific set of environmental conditions. more information on this will be provided during the class.

#### XV. Required Journal Articles

Exam 1	1	Rodrigo Fortes, S., K. Heubel, S. Marie-Victoria, and J. Borcharding. 2019. Have a break or keep going - behavioral and metabolic overwintering strategies of two invasive species of the river Rhine, Germany. <i>Environmental Biology of Fishes</i> 102(8):1057-1068.
	2	Jew, C. J., N. C. Wegner, Y. Yanagitsuru, M. Tresguerres, and J. B. Graham. 2013. Atmospheric Oxygen Levels Affect Mudskipper Terrestrial Performance: Implications for Early Tetrapods. <i>Integrative and Comparative Biology</i> 53(2):248-257.
Exam 2	3	Newbold, L. R., X. Shi, Y. Hou, D. Han, and P. S. Kemp. 2016. Swimming performance and behaviour of bighead carp ( <i>Hypophthalmichthys nobilis</i> ): Application to fish passage and exclusion criteria. <i>Ecological Engineering</i> 95:690-698.
	4	Gutierre, S. M. M., P. J. Schofield, and V. Prodocimo. 2016. Salinity and temperature tolerance of an emergent alien species, the Amazon fish <i>Astronotus ocellatus</i> . <i>Hydrobiologia</i> 777(1):21-31.
Final Exam	5	Wang, J., B. Li, J. Ma, S. Wang, B. Huang, Y. Sun, and L. Zhang. 2017. Optimum dietary protein to lipid ratio for Starry flounder ( <i>Platichthys stellatus</i> ). <i>Aquaculture Research</i> 48(1):189-201.
	6	Anderson, D. A., and F. S. Scharf. 2014. The effect of variable winter severity on size-dependent overwinter mortality caused by acute thermal stress in juvenile red drum ( <i>Sciaenops ocellatus</i> ). <i>ICES Journal of Marine Science</i> 71(4):1010-1021.