

## BIOLOGY 865.3 – Physiological Toxicology

**Instructor:** Dr. Som Niyogi  
Dept. of Biology  
Office: CSRB 120.4  
Ph: 966-4453  
Email: [som.niyogi@usask.ca](mailto:som.niyogi@usask.ca)

**Schedule:** 2022 Fall Term (Term I)

**Class Time:** Tuesday & Friday (10 am-12 pm; October 21-December 2)

**Classroom:** To be announced later.

**Website:** via PAWS/CANVAS

### **Course Description:**

This course will examine the fundamental aspects of how aquatic animals (fish and invertebrates) function and respond when exposed to both natural and anthropogenic stressors such as environmental contaminants. The primary emphasis will be placed on understanding the physiological processes by which aquatic animals acclimate/adapt to a challenging environment as well as the physiological alterations induced by the stressors that lead to the onset of toxicity. To this end, students will explore whether the interactions of natural and anthropogenic stressors lead to antagonistic or synergistic toxic effects in aquatic animals. The course also focuses on understanding how such knowledge can be used for regulatory decision-making in order to protect aquatic ecosystems. The natural and anthropogenic stress factors that will be discussed in this course include hypoxia, temperature variations (global warming), acidification, salinity, natural organic matter, nitrogenous pollutants, and inorganic, organic and emerging contaminants.

### **Treaty Acknowledgement:**

As we engage in in-person Teaching and Learning, we would like to acknowledge that the Saskatoon campus of the University of Saskatchewan is on *Treaty Six Territory* and the *Homeland of the Métis*. We pay our respect to the First Nation and Métis ancestors of this place and reaffirm our relationship with one another. We would also like to recognize that some may be attending this course from other traditional Indigenous lands. We ask that you take a moment to make your own Land Acknowledgement to the peoples of those lands. In doing so, we are actively participating in reconciliation as we navigate our time in this course, learning and supporting each other.

### **Learning Outcomes:**

Upon completion of this course, students will be able to:

1. Explain the mechanisms by which various natural and anthropogenic stressors cause adverse physiological effects in aquatic animals.
2. Identify scenarios where the interactions of environmental stressors may lead to antagonistic and synergistic toxicity in aquatic ecosystems.

3. Understand how the knowledge of comparative physiology and toxicology can be used for environmental regulations.
4. Demonstrate critical thinking, analytical and scientific communication skills.

**Prerequisites:** Animal physiology and environmental toxicology at the undergraduate level and/or permission of the instructor.

**Course Format:**

This course will be structured around 2 weekly classes of 2 hours for 6 weeks. The instructor will introduce each topic outlined below (see lecture schedule) to the students. This will be followed by students presenting original research articles on the same topic for group discussion. The instructor will choose the original research articles to be presented orally by the students using the Microsoft PowerPoint format. These articles will represent research conducted within the last 5-6 years, and expose students to the most up-to-date knowledge and/or discoveries on any chosen topic of discussion. The group discussion will be guided by the instructor, and students not presenting will be required to facilitate the discussion with questions directed to the presenter.

**Instructor Profile:**

Dr. Niyogi is a professor in the Department of Biology, and is also an associate faculty member of the Toxicology Program. He holds advanced degrees in biological sciences (MSc, PhD), and teaches and conducts research in the general area of environmental physiology and toxicology.

**Learning and Teaching Context:**

We are offering BIOL 865 in-person while the pandemic continues. We are passing through an extremely difficult time for many people, with trauma and loss experienced by many in our University community and beyond. Please note that it is a period of ongoing change and some may find it challenging to cope with, thus we expect students in the course should interact with empathy and care.

**Important guidelines for this term:**

During this term, it is important that we undertake in-person elements of this class safely. In order to do this, the university has developed a set of expectations and safety protocols that all students must adhere to if they are to engage in in-person activity.

**Throughout the term:**

**Protect the pack:** Right now, the impact of student choices and activities when not on campus cannot be separated from time spent on campus. In order to “protect the pack”, the university is asking all students who are doing in-person work to be mindful and do whatever possible to lower the risk that you will contract COVID-19 and bring it onto campus.

**Know what is required and expected of you:** One of the critical lessons learned in dealing with COVID-19 is knowing that situations can change and we must be flexible and ready to adjust our safety protocols. Instead of listing all of the relevant information in your course outline, the university has created [a webpage](#) where all up-to-date information around returning to campus is listed. **You are responsible** for **regularly** checking the health and safety guidelines <https://covid19.usask.ca/about/safety.php#Expectations> and knowing what is expected of you throughout the fall term.

**Follow all guidance:** Students are expected to follow all guidance provided by the University's Pandemic Recovery/Response Team (PRT), College/Department, professors, lab instructors, TAs, and any other staff member involved in the in-person academic program activities (e.g., Protective Services, Safety Resources).

**Key channels of communication:** If there is a need for the class to pause meeting in-person for a period of time you will be notified. If this occurs, you will be provided with detailed information on what you will need to do in place of the in-person class sessions via Course CANVAS.

### **Lecture Schedule and Study Materials:**

The details of the weekly lecture schedule and study materials for each specified topic are listed below. The study materials listed below will introduce students to the basic concepts and principles of any given topic of discussion. Please note that the original research articles to be used for class presentation will be selected by the instructor a week prior to each class.

#### **Week 1 (Oct. 18). Introduction to the course**

##### **Week 1 (Oct. 21).**

Topic: Hypoxia: Mechanisms of adaptation, toxic consequences, and interactions with contaminants

Readings:

Pollock, M.S., Clarke, L.M.J., Dube, M.G. 2007. The effects of hypoxia on fishes: from ecological relevance to physiological effects. *Environ. Rev.* 15: 1-14.

Xiao, W. 2015. The hypoxia signalling pathway and hypoxic adaptation in fishes. *Sci. China Life Sci.* 58: 148-155.

##### **Week 2 (Oct. 25).**

Topic: Temperature variations/global warming: Physiological consequences, interactions with contaminants

Readings:

McBryan, T.L., Anttila, K., Healy, T.M., Schulte, P.M. 2013. Responses to temperature and hypoxia as interacting stressors in fish: Implications for adaptation to environmental change. *Integr. Comp. Biol.* 53: 648-659.

Manciocco, A., Calamandrei, G., Alleva, E. 2014. Global warming and environmental contaminants in aquatic organisms: the need of the etho-toxicology research. *Chemosphere* 100: 1-7.

**Week 2 (Oct. 28).**

Topic: Acidification: Physiological consequences, and implications of interactions with contaminants

Readings:

Kwong, R.W., Kumai, Y., Perry, S.F. 2014. The physiology of fish at low pH: the zebrafish as a model system. *Journal of Experimental Biology*. 217: 651-662.

Nikinmaa, M. 2013. Climate change and ocean acidification – Interactions with aquatic toxicology. *Aquat. Toxicol.* 126: 365-372.

**Week 3 (Nov. 1).**

Topic: Salinity: Physiological responses, and implications for aquatic toxicology

Readings:

Gonzalez, R.J. 2011. The physiology of hyper-salinity tolerance in teleost fish: a review. *Journal of Comparative Physiology*. 182B: 321-329.

Cañedo-Argüelles, M., Kefford, B.J., Piscart, C., Prat, N., Schäfer, R.B., Schulz, C.J. 2013. Salinisation of rivers: An urgent ecological issue. *Environ. Pollut.* 173: 157-167.

**Week 3 (Nov. 4).**

Topic: Chronic exposure to nitrogenous pollutants (Ammonia): Physiological consequences & interactions with other stressors

Readings:

Camargo, J.A., Alonso, A. 2006. Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. *Environment International* 831-849.

Yuen, K.P., Chew, S.F. 2010. Ammonia production, excretion, toxicity, and defense in fish: a review. *Frontiers in Physiology*, Vol. 1: Article 134.

**No classes on Nov. 8 and Nov. 11 (Fall Midterm Break)**

**Week 4 (Nov. 15).**

Topic: Natural Organic Matter (NOM): Physiological effects, and influence on the bioavailability and toxicity of contaminants

Readings:

Steinberg, C.E.W., et al. 2006. Dissolved humic substances - ecological driving forces from the individual to the ecosystem level? *Freshwater Biol.* 51: 1189-1210.

Al-Reasi, H.A., Wood, C.M., Smith, D.S. 2011. Physicochemical and spectroscopic properties of natural organic matter (NOM) from various sources and implications for ameliorative effects on metal toxicity to aquatic biota. *Aquatic Toxicology*. 103: 179-190.

**Week 4 (Nov. 18).**

Topic: Behavioral effects of contaminants in aquatic organisms: regulatory perspectives

Readings:

Hong, X., Zha, J. 2019. Fish behaviour: A promising model for aquatic toxicology research. *Science of the Total Environment*. 686: 311-321.

Ford, A.T, P., et al. 2021. The role of behavioral ecotoxicology in environmental protection. *Environmental Science & Technology* 55: 5620-5628.

**Week 5 (Nov. 22).**

Topic: Chronic exposure to inorganic contaminants (metals/metalloids): Mechanisms of uptake and physiological consequences

Readings:

Bury, N., Walker, P.A., Glover, C.N. 2003. Nutritive metal uptake in teleost fish. *J. Experiment. Biol.* 206: 11-23.

Wang, W.X., Meng, J., Weng, N. 2018. Trace metals in oysters: molecular and cellular mechanisms and ecotoxicological impacts. *Environ. Sci.: processes Impacts* 20: 892-912.

**Week 5 (Nov. 25).**

Topic: Chronic exposure to organic contaminants: mechanisms of toxicity, and physiological consequences

Readings:

Malaj, E., et al. 2014. Organic chemicals jeopardize the health of freshwater ecosystems on the continental scale. *PNAS* 111: 9549-9554.

Vasseur, P., Cossu-Leguille, C. 2006. Linking molecular interactions to consequent effects of persistent organic pollutants (POPs) upon populations. *Chemosphere* 62: 1033-1042.

**Week 6 (Nov. 29).**

Topic: Interactive effects of contaminants in mixture: physiological mechanisms and toxicity

Readings:

Cedergreen, C. 2014. Quantifying synergy: A systemic review of mixture toxicity studies within environmental toxicology. *PLOS One* 9: e96580 (1-12).

Gauthier, P.T., Norwood, W.P., Prepas, E.E., Pyle, G.G. 2014. Metal-PAH mixtures in the aquatic environment: A review of co-toxic mechanisms leading to more-than-additive outcomes. *Aquatic Toxicology*. 154: 253-269.

**Week 6 (Dec. 2).**

Topic: Applying comparative physiology to environmental regulation: The Biotic Ligand Model Approach

Readings:

Niyogi, S., Wood, C.M. 2004. Biotic Ligand Model, a flexible tool for developing site-specific water quality guidelines for metals. *Environ. Sci. Technol.* 38: 6177-6192.

Santore, R.C., Ryan, A.C. 2015. Development and application of a multimetal multibiotic ligand model for assessing aquatic toxicity of metal mixtures. *Environ. Toxicol. Chem.* 34: 777-787.

**Required Resources:** No textbooks are required.

**Grading Scheme:**

Oral presentations of original research articles	50%
Participation in group discussion	10%
Final Exam	40%

All sections mentioned above are essential requirements of this course. A student who will fail to fulfil any one of the requirements will be graded incomplete.

A student who will miss any designated oral presentation assignments must contact the instructor, in person or by e-mail, within 3 working days, in order to present the necessary documentation explaining the reason for being unable to meet the requirement. Otherwise, a grade of zero will be assigned for the missed assignment.

**Final Exam Scheduling:** Final examinations will be scheduled during the Fall examination period; students should therefore avoid making prior travel, employment, or other commitments for this period.

**Assessments:****Evaluation scheme to be used for assessing oral presentations in the class**

Each presentation will be graded out of 10 marks

**Introduction: (1 Mark)**

- Title of the article was presented
- Outlined content of the presentation
- Stated the general purpose and context of the study

**Content of the presentation: (5 Mark)**

- Arranged and discussed the content in a systematic and organized manner
- Logical progression from description of background information to formulated research objectives/questions
- Presented sufficient theoretical and/or empirical background information for the proposed study
- Clear statement of research objectives/hypotheses/questions
- Described experimental design, methodology and results in sufficient details for audience to understand
- Adequately explained complex ideas, concepts and data while discussing the experimental results
- Provided a critique of the article: strengths and weaknesses of the study (e.g., research objectives, methodologies, experimental designs, data analysis including statistics, discussion of the experimental results, and writing)

**Clarity of the Presentation: (2 Mark)**

- Defined new terms, concepts/principles
- Visual aids were organized, and easy to follow
- Summarized main ideas to provide a “take home” message

**Presentation Style: (2 Mark)**

- Used good diction
- Used voice modulation for variety/emphasis
- Speech filters (e.g., ok, umm., basically) were not too distracting
- Spoke with a good flow (not too fast or too slow)
- Ability to deliver material without reference to notes
- Established eye contact – talked to the class, not to the screen
- Received questions enthusiastically and answered them in a direct/straightforward manner (evasive or ambiguous answers should be avoided)

**Evaluation scheme to be used for the Final Exam**

Final exam will constitute a 3 hour open book written exam. Students will be asked to answer questions which will test their conceptual understanding of how different environmental stressor and their interactions affect the physiology of aquatic animals. They will be required to discuss the relevant case studies presented in the class in support of their answer.

**Grading System:**

The following describes the relationship between literal descriptors and percentage scores for courses in the College of Graduate Studies and Research:

**Exceptional (90-100)** A superior performance with consistent evidence of

- a comprehensive, incisive grasp of the subject matter;
- an ability to make insightful critical evaluation of the material given;
- an exceptional capacity for original, creative and/or logical thinking;
- an excellent ability to organize, to analyse, to synthesize, to integrate ideas, and to express thoughts fluently.

**Excellent (80-90)** An excellent performance with strong evidence of

- a comprehensive grasp of the subject matter;
- an ability to make sound critical evaluation of the material given;
- a very good capacity for original, creative and/or logical thinking;
- an excellent ability to organize, to analyse, to synthesize, to integrate ideas, and to express thoughts fluently.

**Good (70-79)** A good performance with evidence of

- a substantial knowledge of the subject matter;
- a good understanding of the relevant issues and a good familiarity with the relevant literature and techniques;
- some capacity for original, creative and/or logical thinking;
- a good ability to organize, to analyse and to examine the subject material in a critical and constructive manner.

**Poor (60-69)** A generally satisfactory and intellectually adequate performance with evidence of

- a basic grasp of the subject material;
- some understanding of the relevant issues;
- some familiarity with the relevant literature and techniques;
- some ability to develop solutions to moderately difficult problems related to the subject material;
- some ability to examine the material in a critical and analytical manner.

**Failure (<60)** An unacceptable performance.

### **Recording of the Course:**

**All lectures and presentations will be recorded for the purpose of allowing students and the instructor to review them later again, when required.** These recordings will be retained for one year and then destroyed. **Students are not allowed to record any aspect of this course, except with the permission of the instructors or as provided for by arrangements with Access and Equity Services. Any recording made under these provisions is to only be used for the personal learning of the student who made the recording.** For questions about recording and use of sessions in which you have participated, including any concerns related to your privacy, please contact your instructor.

### **Copyright:**

Course materials are provided to you based on your registration in the class, and anything created by your instructors is their intellectual property, unless materials are designated as open education resources. Copyright-protected material includes exams, Power-Point/PDF slides and other course notes. Additionally, other copyright-protected materials created by textbook publishers and authors may be provided to you based on license terms and educational exceptions in the Canadian Copyright Act.

**Before you copy or distribute others' copyright-protected materials, please ensure that your use of the materials is covered under the University's Fair Dealing**

**Copyright Guidelines at:** <https://library.usask.ca/copyright/general-information/fair-dealing-guidelines.php>

For example, posting others' copyright-protected materials on the open web is not covered under the University's Fair Dealing Copyright Guidelines, and doing so requires permission from the copyright holder. For more information about copyright, please visit: <https://library.usask.ca/copyright/index.php> where there is information for students available at <https://library.usask.ca/copyright/students/rights.php>, or contact the University's Copyright Coordinator at: [copyright.coordinator@usask.ca](mailto:copyright.coordinator@usask.ca) or 306-966-8817.

### **Academic Integrity:**

The University of Saskatchewan is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding

academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Student Conduct & Appeals section of the University Secretary's Website and avoid any behavior that could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

### **Prepare for Integrity**

Students are expected to act with academic integrity.

- Students are encouraged to complete the Academic Integrity Tutorial to understand the fundamental values of academic integrity and how to be a responsible scholar and member of the USask community (tutorial link: <https://libguides.usask.ca/AcademicIntegrityTutorial>) .
- Students can access campus resources that support development of study skills, time and stress management, and ethical writing practices important for maintaining academic integrity and avoiding academic misconduct.

### **Responses to Misconduct**

Students are expected to be familiar with the academic misconduct regulations (<https://governance.usask.ca/student-conduct-appeals/academic-misconduct.php#About>).

- Definitions appear in Section II of the academic misconduct regulations.
- The academic misconduct regulations apply regardless of type of assessment or presence of supervision during assessment completion.
- Students are advised to ask for clarification as to the specific expectations and rules for assessments in all of their courses.
- Students are urged to avoid any behaviour that could result in suspicions of cheating, plagiarism, misrepresentation of facts. Students should note that posting copyrighted course materials (e.g., notes, questions, assignments or exams) to third party websites or services or other forum or media without permission is an academic or non-academic misconduct offense.

Non-academic offenses are dealt with under the [Standard of Student Conduct in NonAcademic Matters and Regulations and Procedures for Resolution of Complaints and Appeals](#).

### **Access and Equity Services (AES) for Students:**

Students who have disabilities (learning, medical, physical, or mental health) are strongly encouraged to register with Access and Equity Services (AES) if they have not already done so. Students who suspect they may have disabilities should contact AES for advice and referrals at any time. Those students who are registered with AES with mental health disabilities and who anticipate that they may have responses to certain course materials or topics, should discuss course content with their instructors prior to course add / drop dates. In order to access AES programs and supports, students must follow AES policy and procedures. For more information or advice, visit <https://students.usask.ca/health/centres/access-equity-services.php>, or contact AES at 306-966-7273 or [aes@usask.ca](mailto:aes@usask.ca).

Students registered with AES may request alternative arrangements for mid-term and final examinations. Students must arrange such accommodations through AES by the stated deadlines. Instructors shall provide the examinations for students who are being accommodated by the deadlines established by AES.

For information on AES services and remote learning please visit <https://updates.usask.ca/info/current/accessibility.php#AccessandEquityServices>

### **Student Supports:**

#### **Academic Help for Students**

The University Library offers a range of learning and academic support to assist USask undergrad and graduate students. For information on specific services, please see the Learning page on the Library website <https://library.usask.ca/support/learning.php>.

#### **Teaching, Learning and Student Experience**

Teaching, Learning and Student Experience (TLSE) provides developmental and support services and programs to students and the university community. For more information, see the students' website <http://students.usask.ca>.

#### **College Supports**

Students in Arts & Science are encouraged to contact the Undergraduate Student Office and/or the Trish Monture Centre for Success with any questions on how to choose a major; understand program requirements; choose courses; develop strategies to improve grades; understand university policies and procedures; overcome personal barriers; initiate pre-career inquiries; and identify career planning resources. Contact information is available at: (<http://artsandscience.usask.ca/undergraduate/advising/>)

#### **Financial Support**

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact Student Central (<https://students.usask.ca/student-central.php>).

#### **Aboriginal Students' Centre**

The Aboriginal Students' Centre (ASC) is dedicated to supporting Aboriginal student academic and personal success. The centre offers personal, social, cultural and some academic supports to Métis, First Nations, and Inuit students. The centre is also dedicated to intercultural education, bringing Aboriginal and non-Aboriginal students together to learn from, with and about one another in a respectful, inclusive and safe environment. Students are encouraged to visit the ASC's Facebook page (<https://www.facebook.com/aboriginalstudentscentre/>) to learn more.

#### **International Student and Study Abroad Centre**

The International Student and Study Abroad Centre (ISSAC) supports student success and facilitates international education experiences at USask and abroad. ISSAC is here to assist all international undergraduate, graduate, exchange and English as a Second

Language students in their transition to the University of Saskatchewan and to life in Canada. ISSAC offers advising and support on matters that affect international students and their families and on matters related to studying abroad as University of Saskatchewan students. Please visit [students.usask.ca](http://students.usask.ca) or [updates.usask.ca](http://updates.usask.ca) for more information.

#### Recommended Technology for Remote Learning

Students are reminded of the importance of having the appropriate technology for remote learning. The list of recommendations can be found at <https://students.usask.ca/remote-learning/tech-requirements.php>