

## Department of Biology Course Outline

### SC/BIOL 4310, Physiology of Circadian Timing FALL 2024

#### Course Description

This course examines the mechanism by which cells generate 24h (circadian) rhythms, how the numerous sites of these cells are coordinated by nerves and hormones and the critical roles of human circadian clocks in health and diseases. Three lecture hours per week. One term. Three credits.

#### Prerequisites

SC/BIOL 2020 4.00 or SC/BIOL 2020 3.0; SC/BIOL 2021 4.00 or SC/BIOL 2021 3.0; SC/BIOL 3060 4.0.

#### Technical Requirements

You must have access to reliable high-speed internet connection (wi-fi) and a computer to take this course, including access to audio (including microphone) and a web cam. Some aspects of the course will involve video conferencing software (e.g. Zoom). Reliable access to eClass and ability to stream videos from eClass are required.

#### Course Instructors and Contact Information

**Course Director:** Dr. Michael Cardinal-Aucoin (he/him)

**Email:** [mdca@yorku.ca](mailto:mdca@yorku.ca)

**Office hours:** email to schedule appointment in advance

#### Land Acknowledgement

York University recognizes that many Indigenous Nations have longstanding relationships with the territories upon which York University campuses are located that precede the establishment of York University. York University acknowledges its presence on the traditional territory of many Indigenous Nations. The area known as Tkaronto has been care taken by the Anishinabek Nation, the Haudenosaunee Confederacy, and the Huron-Wendat. It is now home to many First Nation, Inuit, and Métis communities. We acknowledge the current treaty holders, the Mississaugas of the Credit First Nation. This territory is subject of the Dish with One Spoon Wampum Belt Covenant, an agreement to peaceably share and care for the Great Lakes region.

#### Schedule

TR 5:30-7:00pm (EST) DB 005

- We may sometimes meet via Zoom (link provided on eClass).
- This course will be delivered using a hybrid approach that combines synchronous class meetings and lectures during the scheduled lecture period with asynchronous components to be completed independently.

Evaluation			
Component	Date	Value	
<b>Term tests (online via eClass)</b>			
Midterm Test (Units I, II, and III)	Thursday Oct. 24	=25%	} =55%
Final Test (Units IV, V, and VI)	During exam period	=30%	
<b>Assignments</b>			
Assignment 1: Exploring Circadian Rhythms	due Sept. 20	=5%	} =35%
Assignment 2: Building the Molecular Clockwork	due Oct. 25	=5%	
Assignment 3: Circadian Journal	due Dec. 3	=25%	
<b>Discussion Forums</b>			
Introduction Forum	Sept. 4 – Sept. 15	=1%	} =10%
Forum 1	Sept. 16 – Oct. 13	=4.5%	
Forum 2	Oct. 21 – Nov. 24	=4.5%	
<b>Total</b>			=100%

**Important Dates**  
 See Evaluation section above.

➤ **NOTE:** For additional important dates such as holidays, refer to the “Important Dates” section of the Registrar’s Website at <https://registrar.yorku.ca/enrol/dates>.

**Resources**

Foster, R.G. and Kreitzman, L. (2017) Circadian Rhythms: A Very Short Introduction. Oxford University Press; Oxford, UK.

➤ Readings will be assigned from Foster and Kreitzman and recent review articles. The articles will be made available on the course eClass page.

**Learning Outcomes**

Upon successful completion of this course, students should be able to:

- understand the nature and characteristic properties of circadian rhythms,
- compare the circadian organization of diverse organisms at the molecular, cellular, and physiological levels, and
- appreciate the integral regulatory role played by the circadian timing system in the physiology of organisms and its important contribution to human health and disease.

**Course Content**

**EXPANDED COURSE DESCRIPTION:**

Life evolved in a cyclical environment alternating between the freezing darkness of night and the searing radiation of day. Early nucleated cells evolved the ability to time their various activities to occur in the most appropriate portion of daily and seasonal cycles. These cellular biological "clocks" are retained in modern organisms where they coordinate both cellular and physiological activities which are expressed in the whole organism as overt rhythms ranging from hormone secretion rhythms to sleep-wake (activity) rhythms. Interactions between the component "clocks" of an organism, mediated primarily by nerves and hormones, lead to

internal temporal organization of events within it. The fundamental cellular and physiological mechanisms of biological clocks were developed in key animal model systems such as bacteria, molluscs, and insects and later applied to mammals and humans. Molecular clocks are now known in nearly all human tissues; new research reveals their importance in synchronizing the functions of various tissues with each other, to produce coordinated functioning of the various body parts. Clocks are master coordinators of physiology.

The analysis of human biological clocks has made extraordinarily rapid advances in recent years at the levels of physiology and cell and molecular biology. Human clocks are critical factors in the development of cancers, heart attacks, diabetes, and a host of other diseases. This knowledge is creating profound changes in numerous medical practices. The subject has acquired a prominence in public awareness (rhythms in human performance, shift-work, jet-lag, etc.). In medicine, treatment of many diseases has been revolutionized by precise timing of administration of medications. Numerous disorders are now recognized as due to malfunctions of human biological "clocks" and are treated by the new techniques of "chronotherapy". Others are simply natural variants of timekeeping genes in humans (e.g. 'larks' and 'owls'). We will discuss the need for education of society in general regarding the serious dangers to human health of requiring people to adopt work schedules or lifestyles that defy their biological clockwork.

The course will emphasize the physiological mechanisms underlying biological clocks but will also discuss the subject at the level of its cellular and molecular mechanisms and its human and medical implications. Therefore, the course crosses a number of the conventional disciplinary boundaries within biology.

### **Short Course Lecture Outline**

Central concepts and properties of circadian clocks  
 How a cell keeps time; subcellular mechanisms of generation of circadian rhythm  
 Invertebrate model systems that showed circadian clocks control all physiology by nerves and hormones

#### **Midterm Test**

Vertebrate circadian clocks  
 The 'master clock' in the brain of mammals, including humans  
 Clocks outside the brain and their interactions with it  
 Human and medical implications

#### **Final Test**

### **LECTURE SCHEDULE**

(Subject to Change)

#### **I. Basic Concepts and Properties of Circadian Clocks**

Origin and nature of periodicities in the environment.  
 The solar day cycle as a formative factor in the origin of life.  
 Evolutionary origin and adaptive significance of circadian clocks.

Circadian rhythms in whole organisms.

Properties and evidence of endogenous nature.  
 Definitions: 'circadian clock' and related terminology.

Circadian rhythms in populations. Circadian gating: *Drosophila* eclosion rhythm.

Mechanism of synchronization of clocks with environmental signals i.e. Entrainment.

The phase response curve. Pacemakers and slaves.

Importance of both 'dawn' and 'dusk': use of 'skeleton' photoperiods.

Entrainment to temperature cycles.

Conflict between Zeitgebers.

## II. Molecular Bases of Circadian Rhythms

Circadian clocks in single celled eukaryotes: one or more clocks in a cell?

The molecular mechanism of circadian timing in *Drosophila* and mammals.

Clock gene products and transcription regulators: the transcription/translation oscillator (TTFL).

A complete cellular clock needs many post-translational factors: circadian cycling of  $K^+$ ,  $Ca^{2+}$ , ATP, cAMP, phosphorylases, phosphatases, redox.

## III. Circadian Systems of Invertebrate Model Organisms

Structure and function of clocks in the brain and other tissues. Multiple clocks are connected together into timekeeping systems. Concepts discovered in insects are applied to mammals.

Molluscs:

Molluscan eye clock: the simple neuronal clock that foreshadowed the SCN.

Insects:

Insect neuroendocrine clocks: a model multi-oscillator system of mammals.

Neuroarchitecture of the clockwork in the brain and how it controls rhythms in behaviour and rhythmic release of hormones.

Hormones as 'messengers of time'.

Discovery of oscillator cells in various tissues (peripheral oscillators) of insect models: evidence of hormones and nerves in driving these oscillators and their role in the broader circadian system.

Clocks in populations: bees and butterflies.

## Midterm Test (Units I, II, and III)

## IV: Circadian Systems of Vertebrate Model Organisms

Fish: An intermediate between insects and mammals

Birds: Pineal gland as pacemaker and roles of melatonin.

## IV: Mammalian Circadian Clocks

Mammals (including humans):

The suprachiasmatic nucleus (SCN) in the brain of humans and other mammals.

Mechanisms of rhythm generation by SCN cells.

Circadian photoreceptors in the eye; melatonin.

Melatonin and circadian timing.

Interaction of SCN with clocks in the retina and the pineal gland (melatonin).

Peripheral oscillators in diverse mammalian tissues including:

Adrenal gland clock and corticosteroid rhythms as 'messengers of time'.

Food entrainable oscillator: relation to diabetes, heart attacks etc.

Development and aging of clocks.  
 Why clocks are everywhere and how they are coordinated together.  
 The emerging concept that networks of circadian clocks coordinate the timing of activities in diverse tissues by timing nervous activity and release of hormones.

**VI. Health and Medical Implications of Circadian Clocks**

Health problems resulting from ignoring your clocks.  
 Diseases related/caused by circadian defects: cancers, heart attacks, diabetes etc.  
 Jet-lag, shift-work.  
 Psychiatric disorders (depression etc.), sleep disorders and ‘SAD’.  
 ‘Night owls’, ‘larks’ and natural clock mutations in humans.  
 Interaction of symbiotic clocks and host clocks (e.g. gut microbiota, parasites, etc.)  
 City light pollution at night and cancers.  
 Chronotherapy and chronopharmacology

**Final Test (Units IV, V, and VI)**

**Experiential Education and E-Learning**

- This course will be delivered using a hybrid approach that combines synchronous class meetings and lectures during the scheduled lecture period with asynchronous components to be completed independently.
- This course includes several experiential components culminating in a final assignment in which students observe and collect data related to their own circadian rhythms.

**Other Information**

**Learning Environment**

Everyone learns more effectively in a respectful, safe, and equitable learning environment free from discrimination or harassment. I invite you to work with me to create a classroom space—both real and virtual—that fosters and promotes values of human dignity, equity, non-discrimination and respect for diversity. These values and practices are in accord with York Universities policies on equity and inclusion promoted by the Centre for Human Rights, Equity and Inclusion (<https://rights.info.yorku.ca/>). Please feel free to discuss with me any questions or concerns you have about equity in our classroom or in the Lakehead community. If I cannot answer your questions or help you address your concerns, I encourage you to contact the Centre for Human Rights, Equity and Inclusion Human Rights and Equity (<https://rights.info.yorku.ca/contact-us/>).

**Behaviour and Conduct**

- Students are expected to ensure that the classroom and laboratory learning environments are inclusive, respectful, peaceful, and safe.
- Interactions and relationships with instructors and other students (in person, online, in email, etc.) within the academic context should be professional and characterized by integrity, courtesy and mutual respect.
- Lectures should be interactive - please get engaged in the material and ask as well as answer questions!

- I fully encourage a reduction in the use of paper but if you bring your laptop to take notes, please refrain from using the internet in class (otherwise you will be banned from bringing your computer).
- Please be considerate in lectures and refrain from talking as it will disturb the learning environment.
- For your benefit and the benefit of students around you, turn your phone off to ensure it does not ring during lecture and to avoid the urge to text or you may be asked to leave the lecture hall.
- Students are expected to attend all lectures and labs.
- Recording devices of any kind are not permitted to be used in lectures.

### **Email Policies and Etiquette**

I will try to respond to email within two working days, but this is not always possible as there are many students and only 1 professor. I may also answer your question in the next class meeting if appropriate. Questions and answers that I deem of interest to the entire class may be posted (anonymously) on eClass or sent via course announcements if urgent. Emails that do not meet the requirements below will not be answered:

- Use your @my.yorku.ca email address when emailing instructors and others within the university. Email from other sources may be filtered out and not reach the intended recipient.
- SUBJECT LINE - Include the course code, and a brief indication of topic.
- Lecture email example: BIOL 4310 – question regarding TTFL
- Include your NAME and STUDENT NUMBER at the end of each email. I work with many students and this facilitates my ability to help you.

### **Course Policies**

**Term Test Policies:** Term tests will consist of a variety of question types including multiple choice, mix-and-match, true/false, diagrams, and short answer. Term tests are non-cumulative, but it should be understood that material covered prior to the test may be included indirectly if it is essential to the understanding of the topics being tested. All term tests will be written online via the course eClass page. More detailed instructions will be provided.

A student who misses a term test will receive a zero. Exceptions to this policy may be granted at the discretion of the course director if either a medical or family emergency occurs and documentation is provided. Failure to make contact within 48 hrs. will result in a forfeiture of any opportunity to do a re-write. In the event of a missed term exam the value of the exam will be redistributed to the next term test.

### **Assignment Due Date Policies**

Assignment due dates are indicated in the course schedule and on the course Brightspace page. Assignments submitted past the due date will be deducted 10% each day for 5 days after which the student will receive a grade of 0%. Exceptions to this policy may be granted at the discretion of the course director if either a medical or family emergency occurs and documentation is provided. It is your responsibility to contact the course director.

**No Extra Credit:** There is no possibility of extra credit (i.e. doing extra work if you did not do well on something) to increase your mark either during the term or after the final exam. Anyone receiving a final course grade of 49% will **automatically** have their final exam re-graded.

## University Policies

### Academic Honesty and Integrity

York students are required to maintain the highest standards of academic honesty and they are subject to the Senate Policy on Academic Honesty (<http://secretariat-policies.info.yorku.ca/policies/academic-honesty-senate-policy-on/>). The Policy affirms the responsibility of faculty members to foster acceptable standards of academic conduct and of the student to abide by such standards.

There is also an academic integrity website with comprehensive information about academic honesty and how to find resources at York to help improve students' research and writing skills, and cope with University life. Students are expected to review the materials on the Academic Integrity website at - <http://www.yorku.ca/academicintegrity/>

### Access/Disability

York University is committed to principles of respect, inclusion and equality of all persons with disabilities across campus. The University provides services for students with disabilities (including physical, medical, learning and psychiatric disabilities) needing accommodation related to teaching and evaluation methods/materials. These services are made available to students in all Faculties and programs at York University.

Students in need of these services are asked to register with disability services as early as possible to ensure that appropriate academic accommodation can be provided with advance notice. You are encouraged to schedule a time early in the term to meet with each professor to discuss your accommodation needs. Please note that registering with disabilities services and discussing your needs with your professors is necessary to avoid any impediment to receiving the necessary academic accommodations to meet your needs.

Additional information is available at the following websites:

Counselling & Disability Services - <http://cds.info.yorku.ca/>

Counselling & Disability Services at Glendon - <http://www.glendon.yorku.ca/counselling/personal.html>

York Accessibility Hub - <http://accessibilityhub.info.yorku.ca/>

- ***Students are encouraged to contact their professor to discuss accommodation needs or any way in which they can help you succeed.***

### Ethics Review Process

York students are subject to the York University *Policy for the Ethics Review Process for Research Involving Human Participants*. In particular, students proposing to undertake research involving human participants (e.g., interviewing the director of a company or government agency, having students complete a questionnaire, etc.) are required to submit an *Application for Ethical Approval of Research Involving Human Participants* at least one month

before you plan to begin the research. If you are in doubt as to whether this requirement applies to you, contact your Course Director immediately.

### **Religious Observance Accommodation**

York University is committed to respecting the religious beliefs and practices of all members of the community, and making accommodations for observances of special significance to adherents. Should any of the dates specified in this syllabus for an in-class test or examination pose such a conflict for you, contact the Course Director within the first three weeks of class. Similarly, should an assignment to be completed in a lab, practicum placement, workshop, etc., scheduled later in the term pose such a conflict, contact the Course director immediately. Please note that to arrange an alternative date or time for an examination scheduled in the formal examination periods (December and April/May), students must complete an Examination Accommodation Form, which can be obtained from Student Client Services, Student Services Centre or online at <https://secure.students.yorku.ca/pdf/religious-accommodation-agreement-final-examinations.pdf> (PDF)

### **Student Conduct in Academic Situations**

Students and instructors are expected to maintain a professional relationship characterized by courtesy and mutual respect. Moreover, it is the responsibility of the instructor to maintain an appropriate academic atmosphere in the classroom and other academic settings, and the responsibility of the student to cooperate in that endeavour. Further, the instructor is the best person to decide, in the first instance, whether such an atmosphere is present in the class. The policy and procedures governing disruptive and/or harassing behaviour by students in academic situations is available at - <http://secretariat-policies.info.yorku.ca/policies/disruptive-andor-harassing-behaviour-in-academic-situations-senate-policy/>

### **Copyright Policy**

The materials (i.e. course notes, handouts, exams, etc.) in the BIOL 4310 (Physiology of Circadian Timing) course at York University are the sole property of the instructor, unless stated otherwise by the instructor. Online posting or selling of this material to third parties for distribution without permission is subject to Canadian Copyright law and is strictly prohibited.  
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