PSY397H1 F

Biological Rhythms

Fall 2024 Syllabus

Course Meetings

PSY397H1 F

Section	Day & Time	Delivery Mode & Location
LEC0101	Tuesday, 11:00 AM - 1:00 PM Wednesday, 11:00 AM - 12:00 PM	In Person: UC 85 In Person: SS 1084

Refer to ACORN for the most up-to-date information about the location of the course meetings.

Course Contacts

Instructor: Professor Martin Ralph
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Course Overview

Daily, monthly, annual and other rhythms and methods of measuring them. Behavioural and physiological aspects of biological clocks. The importance of rhythms in experimental design, in research on brain function, in affective disorders, and the use animals make of rhythms in migration and other behaviours.

Daily, monthly, annual and other rhythms and methods of measuring them. Behavioural and physiological aspects of biological clocks. The importance of rhythms in experimental design, in research on brain function, in affective disorders, and the use animals make of rhythms in migration and other behaviours. Structure and function of biological clocks at various levels of biological organization. Anatomy of circadian and seasonal systems across the phylogenetic tree. History of chronobiology with discussions of major discoveries.

Course Learning Outcomes

Students will learn about how biological clocks are put together by nature. They will understand how scientific hypotheses are derived and the logical approaches that are made in designing

experiments to test those hypotheses. Using biological rhythms as a model field, students will learn how ideas were formulated, and how four factors come together to create breakthroughs in this and any other field (opportunity, awareness, knowledge, motivation, creativity, and serendipity). They will learn how the temporal dimension affects all other aspects of biological science.

Prerequisites: PSY201H1/ ECO220Y1/ EEB225H1/ GGR270H1/ IRW220H1/ POL222H1/ SOC202H1/ STA220H1/ STA238H1/ STA248H1/ STA288H1/ ECO220Y5/ PSY201H5/ STA215H5/ STA220H5/ PSYB07H3/ STAB22H3/ STAB23H3/ STAB57H3, ***and one of*** PSY260H1/ PSYB38H3 ***or*** PSY290H1/ PSY290H5/ PSYB64H3/ HMB200H1/ PSL300H1
Corequisites: None
Exclusions: None
Recommended Preparation: None
Credit Value: 0.5

The course requires a broad background in biological sciences. Biological timing involves everything from the molecular basis of rhythm generation to the effects of clocks and rhythmicity on human behavior, performance and health.

Marking Scheme

Assessment	Percent	Details	Due Date
Term test 1	25%	50 minute written test over course material up to and including September 18, 2024 Answers are written on the test form provided.	2024-09-24
Term test 2	30%	50 minute written test over course material up to and including material from September 24 to October 16, 2024 Answers are written on the test form provided.	2024-10-22
In-Person Final Exam	45%		Final Exam Period

Course Schedule

Week	Description
Week 1 Sept.	(*Function of clocks and other rhythmic organization in living organisms; discovery of circadian clocks; ubiquity of clocks across species and levels of biological organization*) 1. Pittendrigh, CS (1993) Temporal organization: reflections of a Darwinian clock-

3,4	watcher. Annu Rev Physiol.1993;55:16-54. 2. Vitaterna, M. H., Takahashi, J. S., & Turek, F. W. (2001). Overview of circadian rhythms. *Alcohol Research & Health, 25*(2), 85-93. 3. Roenneberg T, Merrow M. (2005) Circadian clocks - the fall and rise of physiology. Nat Rev Mol Cell Biol.2005 Dec;6(12):965-71.
Week 2 Sept. 10,11	(*Basic mechanism of biological clocks; synchronization of clocks and other oscillators; environmental synchronizers and mechanisms of entrainment*) • Pittendrigh, C. S., & Daan, S. (1976). A Functional Analysis of Circadian Pacemakers in Nocturnal Rodents. IV. Entrainment: Pacemaker as Clock. *Journal of Comparative Physiology A*, *106*(3), 291-331. https://doi.org/10.1007/BF01417856. • Golombek, DA and Rosenstein, R (2010) The physiology of entrainment. *Physiol Rev* 90: 1063–1102 doi:10.1152/physrev.00009.2009. • Mrosovsky N, Salmon PA, Menaker M, Ralph MR. (1992) Nonphotic phase shifting in hamster clock mutants. *J Biol Rhythms*. 7(1):41-49
Week 3 Sept. 17,18	(*Discovery of the molecular circadian systems in representative species across the phylogenetic tree; conservation of circadian mechanisms within taxonomic kingdoms, evidence for separate derivation of clock mechanisms between kingdoms; adaptive significance of circadian mechanisms*) 1. Reppert, SM, Weaver, DR (2001) MOLECULAR ANALYSIS OFMAMMALIAN CIRCADIAN RHYTHMS *Rev. Physiol*. **63**:647–76. 2. Williams JA, Sehgal A. Molecular components of the circadian system in Drosophila. Annu Rev Physiol. 2001;63:729-55. doi: 10.1146/annurev.physiol.63.1.729. PMID: 11181974. 3. Hardin PE. (2011) Molecular genetic analysis of circadian timekeeping in Drosophila. *Adv Genet.* **74**:141-73. doi: 10.1016/B978-0-12-387690-4.00005-2. PMID: 21924977; PMCID: PMC4108082. 4. Lowrey PL & Takahashi JS (2011) Genetics of Circadian Rhythms in Mammalian Model Organisms. *Adv Genet*. **74**: 175–230. doi:10.1016/B978-0-12-387690-4.00006-4. 5. Tauber, E, Last, KS, Olive, PJW, Kyriacou, CP. (2004) Clock Gene Evolution and Functional Divergence. *J Biol Rhythms*, 19 445-458. 6. OUYANG, Y, ANDERSSON, CR, KONDO, T, GOLDEN, SS, JOHNSON, H (1998) Resonating circadian clocks enhance fitness in cyanobacteria *Natl. Acad. Sci. USA* **95**, 8660–8664. 7. Green CB, Takahashi JS, Bass J. The meter of metabolism. Cell. 2008 Sep 5;134(5):728-42. doi: 10.1016/j.cell.2008.08.022. 8. Ralph, MR, Menaker, M. A mutation of the circadian system in golden hamsters. 1988 Sep 2;241(4870):1225-7. doi: 10.1126/science.3413487. 9. **Vitaterna MH**, King DP, Chang AM, Kornhauser JM, Lowrey PL, McDonald JD, Dove WF, Pinto LH, Turek FW, **Takahashi JS.** Science. 1994 Apr 29;264(5159):719-25. doi: 10.1126/science.8171325.
Week 4	(*Comparing and contrasting the physiology and anatomy of circadian clocks across species; methods for identifying pacemakers; applying principles of entrainment*)

Sept. 24,25	1. Lundkvist, GB, Block, GD. (2005) Role of Neuronal Membrane Events in Circadian Rhythm Generation *METHODS IN ENZYMOLOGY*, VOL. 393:623-642. 2. Underwood, H, Steele, CT, Zivkovic, B (2001) Circadian Organization and the Role of the Pineal in Birds. *MICROSCOPY RESEARCH AND TECHNIQUE* 53:48–62. 3. Ralph MR, Foster RG, Davis FC, Menaker M. (1990) Transplanted suprachiasmatic nucleus determines circadian period. 1990 Feb 23;247(4945):975-8. doi: 10.1126/science.2305266.PMID: 2305266 4. Aronson BD, Bell-Pedersen D, Block GD, Bos NP, Dunlap JC, Eskin A, Garceau NY, Geusz ME, Johnson KA, Khalsa SB, et al. Circadian rhythms. Brain Res Brain Res Rev. 1993 Sep-Dec;18(3):315-33. doi: 10.1016/0165-0173(93)90015-r. PMID: 8401597. 5. Antle, MC, Silver, R (2005) Orchestrating time: arrangements of the brain circadian clock *TRENDS in Neurosciences*28. 6. Reppert, SM, Weaver, DR (2002) Coordination of circadian timing in mammals *NATURE* 418:935-941. 7. Page, TL (1982) Transplantation of the Cockroach Circadian Pacemaker. *Science* 216, 73-75.
Week 5 Oct. 1,2	(*Human chronobiology; ontogeny of circadian rhythms in human beings; clock dysfunction and physical and mental disorder; effects of chronic circadian misalignment or poor entrainment; significance of "chronotype"in health and performance;effects of daylight staving time*) 21. Haraszti RÁ, Ella K, Gyöngyösi N, Roenneberg T, Káldi K. (2014) Social jetlag negatively correlates with academic performance in undergraduates. Chronobiol Int. 2014 Jun;31(5):603-12. doi: 10.3109/07420528.2013.879164. 22. Roenneberg, T. (2015) Having trouble typing? What on earth is chronotype? *Biol. Rhythms* Dec;30(6):487-91. doi: 10.1177/0748730415603835. 23. Hahn C1, Cowell JM, Wiprzycka UJ, Goldstein D, Ralph M, Hasher L, Zelazo PD. (2012) Circadian rhythms in executive function during the transition to adolescence: the effect of synchrony between chronotype and time of day. Dev Sci.2012 May;15(3):408-16. doi:10.1111/j.1467-7687.2012.01137.x. Epub 2012 Feb 23. 24. Castillo-Ruiz A, Paul MJ, Schwartz WJ (2012) In search of a temporal niche: Social interactions. A. Kalsbeek, M. Merrow, T. Roenneberg and R. G. Foster (Eds.) *Progress in Brain Research*, Vol. 199 pp 267-280. Elsevier. 25. Chouvet, G et al. (1974) *Periodicite bicircadienne du cycle veille-sommeil dans des conditions hors du temps. Etude polygraphique*. *Electroenceph Clin Neurophysiol* **37**:367-380.
Week 6 Oct. 8,9	(*How organisms determine the time of year; length of day vs. circannual clocks;* *Article TBD*

Week 7 Oct. 15,16	(*Non-SCN clocks in mammals; clocks that don't use the canonical clock genes; post-translational oscillators; dopamine-dependent systems*) 1. Stephan FK. (2002) The "other" circadian system: food as a Zeitgeber. *J Biol Rhythms*. Aug;17(4):284-92. 2. Honma K1, Honma S. (2009) The SCN-independent clocks, methamphetamine and food restriction. Eur J Neurosci. Nov;30(9):1707-17. doi: 10.1111/j.1460-9568.2009.06976.x. Epub 2009 Oct 28. 3. Coward, D., Cain, S. and Ralph, M. R. (2001) A circadian rhythm in mice that is unaffected by the period mutation at *clock*. *Rhythm Res.* **32**: 233-242. 4. Taufique SKT, Ehichioya DE, Pendergast JS and Yamazaki S. Genetics and functional significance of the understudied methamphetamine sensitive circadian oscillator (MASCO) [version 1; peer review: 2 approved] F1000Research 2022, 11:1018 https://doi.org/10.12688/f1000research.125432.1
Week 8 Oct. 22,23	Non-circadian biological clocks: tidal, lunar, annual, ultradian rhythms. Readings TBA
Week 9 Nov. 5,6	(*time memory; anticipation of significant events*) 21. Mulder CK, Gerkema MP & Van der Zee1 (2013) Circadian clocks and memory: time-place learning. *Front. Mol. Neurosci*. https://doi.org/10.3389/fnmol.2013.00008. 22. Ralph MR, Ko CH, Antoniadis EA, Seco P, Irani F, Presta C, McDonald RJ. (2002) The significance of circadian phase for performance on a reward-based learning task in hamsters. *Behav Brain Res.* Oct 17;136(1):179-84. 23. Cain SW, Yoon J, Shrestha TC, Ralph MR (2014) Retention of a 24-hour time memory in Syrian hamsters carrying the 20-hour short circadian period mutation in casein kinase-1ε (ck1εtau/tau). *Neurobiol Learn Mem.* 114C:171-177. doi: 10.1016/j.nlm.2014.06.004. 24. Cain, SW, Rawashdeh, OA, Siu, M, Kim, SC & Ralph, MR. (2017) Dopamine dependent setting of a circadian oscillator underlying the memory for time of day. *Neurobiol Learn Mem.*141:78–83.27.
Week 10 Nov. 12,13	(*Using the Sun and other celestial objects to determine direction*) Readings TBD
Week 11 Nov. 19,20	(*Circadian dysfunction and chronic, non-communicable disease; circadian disruption and aging; heart disease, diabetes, metabolic syndrome; relationship between circadian rhythms and metabolism*) Readings TBD

Week 12 Nov. 26,27	(*Conceptual and mathematical modelling of circadian patterns over time; potential for diagnostic tools for prevalent disorders; using models to predict disorder over the the lifespan, inform diagnosis, and validated successful treatment; efforts to design sleep and rhythm friendly environments; recognizing temporal restrictions on life in space and other planets*) Readings TBD

Policies & Statements

Make-Up Tests

A missed term test can be made up within 1-week of the scheduled test date. Make up tests must be scheduled with the TA, who will administer the test at a time an location to be determined. If a term test is missed without a make up, the second test and the final exam will be re-weighted so that the other test is 33%, and the final test is 67% of the final submitted mark.

Religious Accommodations

As a student at the University of Toronto, you are part of a diverse community that welcomes and includes students and faculty from a wide range of cultural and religious traditions. For my part, I will make every reasonable effort to avoid scheduling tests, examinations, or other compulsory activities on religious holy days not captured by statutory holidays. Further to University Policy, if you anticipate being absent from class or missing a major course activity (such as a test or in-class assignment) due to a religious observance, please let me know as early in the course as possible, and with sufficient notice (at least two to three weeks), so that we can work together to make alternate arrangements.

Students with Disabilities or Accommodation Requirements

Students with diverse learning styles and needs are welcome in this course. If you have an acute or ongoing disability issue or accommodation need, you should register with Accessibility Services (AS) at the beginning of the academic year by visiting https://studentlife.utoronto.ca/department/accessibility-services/. Without registration, you will not be able to verify your situation with your instructors, and instructors will not be advised about your accommodation needs. AS will assess your situation, develop an accommodation plan with you, and support you in requesting accommodation for your course work. Remember that the process of accommodation is private: AS will not share details of your needs or condition with any instructor, and your instructors will not reveal that you are registered with AS.

Academic Integrity

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters

(https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019). If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, please reach out to me. Note that you are expected to seek out additional information on academic integrity from me or from other institutional resources. For example, to learn more about how to cite and use source material appropriately and for other writing support, see the U of T writing support website at http://www.writing.utoronto.ca. Consult the Code of Behaviour on Academic Matters for a complete outline of the University's policy and expectations. For more information, please see A&S Student Academic Integrity (https://www.artsci.utoronto.ca/current/academic-advising-and-support/student-academic-integrity) and the University of Toronto Website on Academic Integrity (https://www.academicintegrity.utoronto.ca).

Specific Medical Circumstances

If you become ill and it affects your ability to do your academic work, consult me right away. Normally, I will ask you for documentation in support of your specific medical circumstances. This documentation can be an Absence Declaration (via ACORN) or the University's Verification of Student Illness or Injury (VOI) form. The VOI indicates the impact and severity of the illness, while protecting your privacy about the details of the nature of the illness. If you cannot submit a VOI due to limits on terms of use, you can submit a different form (like a letter from a doctor), as long as it is an original document, and it contains the same information as the VOI (including dates, academic impact, practitioner's signature, phone and registration number). For more information on the VOI, please see http://www.illnessverification.utoronto.ca. For information on Absence Declaration Tool for A&S students, please see https://www.artsci.utoronto.ca/absence. If you get a concussion, break your hand, or suffer some other acute injury, you should register with Accessibility Services as soon as possible.

Accommodation for Personal Reasons

There may be times when you are unable to complete course work on time due to non-medical reasons. If you have concerns, speak to me or to an advisor in your College Registrar's office; they can help you to decide if you want to request an extension or other forms of academic consideration. They may be able to email your instructors directly to provide a College Registrar's letter of support and connect you with other helpful resources on campus.

Recording Lectures (by Student)

Audio recording by students is permitted, but video recording is not due to it being intrusive. A video recording of the lecture will be provided, if possible, but cannot be guaranteed. Recordings are for study purposes only and cannot be published nor passed on to a third party.

Course Materials, including lecture notes

Course materials are provided for the exclusive use of enrolled students. These materials should not be reposted, shared, put in the public domain, or otherwise distributed without the explicit permission of the instructor. These materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by

copyright. Students violating these policies will be subject to disciplinary actions under the Code of Student Conduct.

Equity, Diversity and Inclusion

- The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. U of T does not condone discrimination or harassment against any persons or communities.

Video Recording and Sharing (Download Permissible; Re-use Prohibited)

This course, including your participation, will be recorded on video and will be available to students in the course for viewing remotely and after each session.

Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by copyright. In this course, you are permitted to download session videos and materials for your own academic use, but you should not copy, share, or use them for any other purpose without the explicit permission of the instructor.

For questions about the recording and use of videos in which you appear, please contact your instructor.

Departmental Guidance for Undergraduate Students in Psychology

The Department of Psychology recognizes that, as a student, you may experience disruptions to your learning that are out of your control, and that there may be circumstances when you need extra support. Accordingly, the department has provided a helpful guide to clarify your and your instructor's responsibilities when navigating these situations. This guide consolidates Arts & Science Policies for undergraduate students in one place for your convenience. As an instructor in the department, I will frequently consult with these recommendations when providing you with support, and I recommend that you also consult it to learn more about your rights and responsibilities before reaching out to me.