Bio 4030--Biological Clocks **Spring 2011**

Instructor: Erik Herzog **Teaching assistants:** Cory Lewis and Cameron Chiang

Lecture: Tues., Thurs. 8:30 -10:00 a.m. Rebstock 322
Office hours: TBA

Overview

Biological clocks are the endogenous oscillators that coordinate physiological and behavioral rhythms in nearly all organisms. This course examines how these rhythms are generated and regulated at the molecular, cellular and systems levels. We will cover the relevance of biological timing to the ecology and health of everything from protozoans to plants to people.

Objectives

Students in Biological Clocks should have four major objectives: 1) to learn about the molecules, cells, and systems of biological timing systems, 2) to master reading scientific literature with a critical eye and 3) to execute and interpret an experiment on human biological rhythms and 4) to contribute to public understanding of biological timing.

Course materials: All readings, slides from lectures and assignments will be posted online.

Readings: You will be asked to read book chapters, review articles and the primary literature.

Critiques: Written assignments follow lectures and readings to prepare you for exams and train you to evaluate the primary literature.

Problem sets: These short assignments challenge you to apply quantitative analyses and modeling to understand the basis for biological timing.

Experiment: You will collect data on your own biological rhythms.

Outline and Brief Communication: You will prepare a one-figure, one-page report comparing and interpreting original data from the class experiment.

Wiki: You will edit two Wikipedia entries related to biological timing.

Participation: Much of the material will be covered only in lecture. Your participation in class is valued. In addition, you are encouraged to report briefly on relevant news or seminars related to biological timing.

Grading:

Assignments	**% of total**
8 best critiques (15 points each)	15
2 Exams (100 points each)	25
3 Wiki edits (50 points each)	19
Outline (35 pts)	4
Brief Communication (100 points)	6
Participation (125 points)	16
5 Problem sets (25 points each)	16
Total 805 points	100

Date		Lecture	Assignments due (points)
1	1/18	A brief history of time as a biological variable	
2	1/20	Biological clocks, constant conditions, model systems	HW1 (15)
3	1/25	**ENTRAINMENT THEORY** …phase response curves	HW2 (15)
4	1/27	Intro to Class Experiment (by Cory Lewis and Cameron Chiang)	
5	2/1	… dawn to dusk and jet lag	PS1 (25) + HW3 (15)
6	2/3	… a clock for all seasons	
7	2/8	**PHYSIOLOGY OF CIRCADIAN SYSTEMS** … in plants: light perception, pacemakers & outputs	PS2 (25) + HW4 (15)
8	2/10	… in molluscs: light perception, pacemakers, outputs	HW5 (15)
9	2/15	… in arthropods: light perception, pacemakers, outputs	
10	2/17	… in mammals: light perception, pacemakers and outputs	HW6 (15)
	2/22	**Exam I (Covers material through 2/15)*	Exam I (100)
11	2/24	… in mammals: multioscillators and single cell pacemakers	
12	3/1	Analyses of periodic data; *Enter experiment data in NSLC*	
13	3/3	**CELLULAR AND MOLECULAR BASIS OF CIRCADIAN TIMING** ... in *Drosophila* and mammals: pacemakers	
14	3/8	…in mammals: light perception	HW7 (15)
15	3/10	…in *Drosophila*: light perception & outputs (by Dr. Paul Taghert)	HW8 (15) + Outline (35)
	3/14	*Spring Break*	
16	3/22	… in fungi & plants: light perception, pacemakers, and more outputs	HW9 (15)
17	3/24	… in protists: light perception, pacemakers, and more outputs	Wiki Preferences (60)
18	3/29	**MODELING CIRCADIAN CLOCKS** …from parameters to a jet lag simulation	Brief Communication (50)
19	3/31	…from molecules to predicting mutant behavior	HW10 (15)
20	4/5	**CLOCK USES** …Adaptive Significance	PS3 (25)
21	4/7	…Photoperiodism in plants and animals	PS4 (25)
22	4/12	…Sleep: from flies to people (by Dr. Paul Shaw)	
23	4/14	…Clocks and metabolism (by Dr. Shin-Ichiro Imai)	Wiki1 (50)
	4/19	**Exam II (Covers material through 4/14)*	
24	4/21	**OTHER BIOLOGICAL CLOCKS** …tidal, lunar, circannual rhythms	Wiki2 (50)
25	4/26	**WHEN CLOCKS BREAK** …Shift work, arrhythmia, dysrhythmia & depression	PS5 (25)
26	4/28	**CLOCK REPAIR** …Chronotherapy and melatonin madness (Case studies)	Wiki3 (50)

READING ASSIGNMENTS

Readings provide essential and supplemental information. Try to read prior to lecture.

#	Date	Reading
	1/18	
1	1/20	Chapt. 1, The Clocks that Time Us, Moore-Ede, MC, Sulzman, FM and Fuller, CA (1982) Harvard University Press, Cambridge, MA. BOOK CHAPTER
2	1/25	R. Y. Moore. Circadian rhythms: basic neurobiology and clinical applications (1997) *Annual Review of Medicine* 48:253-266. REVIEW ARTICLE
3	1/27	S. Daan & C. S. Pittendrigh (1976a) A Functional Analysis of Circadian Pacemakers in Nocturnal Rodents: II. The Variability of Phase Response Curves. *J. Comp. Physiol. [A]* 106:253-266
4	2/1	C. S. Pittendrigh & S. Daan (1976c) A functional analysis of circadian pacemakers in nocturnal rodents.V. Pacemaker structure: a clock for all seasons. *J.Comp.Physiol. [A]* 106:333-355.
	2/3	
5	2/8	S. C. Thain, A. Hall, and A. J. Millar (2000) Functional independence of circadian clocks that regulate plant gene expression. *Curr.Biol*. 10:951-956
	2/10	
6	2/15	A. M. Handler and R. J. Konopka (1979) Transplantation of a circadian pacemaker in Drosophila. *Nature* 279:236-238.
7	2/17	M. Menaker (1968) Extraretinal light perception in the sparrow. I. Entrainment of the biological clock. *Proc.Natl.Acad.Sci.* 59:414-421.
	2/22	
8	2/24	M. R. Ralph, R. G. Foster, F. C. Davis, and M. Menaker. (1990) Transplanted suprachiasmatic nucleus determines circadian period. *Science* 247:975-978.
	3/1	
9	3/3	P.E. Hardin, J.C. Hall and M. Rosbash (1990) Feedback of the Drosophila period gene product on circadian cycling of its messenger RNA levels. *Nature* 343:536-40.
10	3/8	Panda S, Provencio I, Tu DC, Pires SS, Rollag MD, Castrucci AM, Pletcher MT, Sato TK, Wiltshire T, Andahazy M, Kay SA, Van Gelder RN, Hogenesch JB (2003) Melanopsin is required for non-image-forming photic responses in blind mice. *Science* 301: 525-7
11	3/10	S. C. Renn, J. H. Park, M. Rosbash, J. C. Hall, and P. H. Taghert (1999) A pdf neuropeptide gene mutation and ablation of PDF neurons each cause severe abnormalities of behavioral circadian rhythms in Drosophila. *Cell* 99:791-802.
	3/14	Start viewing potential wiki sites.
12	3/22	J.C. Dunlap (1999) Molecular bases for circadian clocks. *Cell* 96:271-290.
13	3/24	Nakajima, M et al. (2005) Reconstitution of circadian oscillation of cyanobacterial KaiC phosphorylation in vitro. *Science* 308:414-5.
	3/29	
14	3/31	Goldbeter A. (2002) Computational approaches to cellular rhythms.Nature. 420:238-45.
	4/5	
	4/7	
	4/12	
	4/14	
15	4/19	Ramsey KM, Yoshino J, Brace CS, Abrassart D, Kobayashi Y, Marcheva B, Hong HK, Chong JL, Buhr ED, Lee C, Takahashi JS, Imai S, Bass J (2009) Circadian clock feedback cycle through NAMPT-mediated NAD+ biosynthesis. *Science* 324:651-4.
	4/21	
	4/26	
	4/28	