What makes me tick...tock?
Circadian rhythms, genetics, and health

Teachers who use our materials say that students think this is one of our most engaging units! Through the context of sleep, students examine how genes and proteins affect behavior using interactive hands-on and computer activities. Environmental effects on behavior and gene expression are introduced through a game based on the cutting-edge research of epigenetics. Full of real-world examples of altered sleep cycles such as jet-lag and shift work, this unit includes a student-driven investigative case study and summative debate in which students prepare scientific arguments based on what they have learned.

This unit is connected to basic science research being done by Dr. Megan Mahoney and members of her laboratory.

Unit Summary: 📕 "What makes me tick...tock?" Lesson Descriptions PDF

Lesson 1: What is a circadian rhythm?

In this introductory lesson to the unit, students conduct an in-class survey to learn about the circadian rhythms and biological clocks of their peers. Using this survey, students identify the owls and the larks in their classroom. In addition, students look at two different Sleepiness Scales as a whole class and interpret the sleep-wake cycles of two people, looking at their sleepiness scales. In addition, they write or draw what they currently know about circadian rhythms and generate questions related to what they would like to know or learn about biological rhythmicity. The students will confirm or refute their ideas based on knowledge gained through a variety of activities and readings in later lessons of the unit. At the end of the lesson, they learn about some concepts related to circadian rhythms as they watch a video about Michel Siffre, a French scientist who studied his own circadian rhythm.

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Lesson 2: Why do scientists study fruit flies to understand what makes us "tick"?

Following the introduction of basic principles and key terminology of circadian rhythmicity in Lesson 1, this lesson begins with students discussing model organisms and how scientists use them; Drosophila melanogaster is used as a model for the study of circadian rhythms. Students use several NetLogo simulations to examine how light, temperature, and genetic mutations can affect a fly's behavior. Students make connections between these simulations and their own circadian rhythms, developing models throughout the lesson of how three different factors (light, temperature, and genetic mutations) can affect both the flies' activity levels and their own throughout the day.
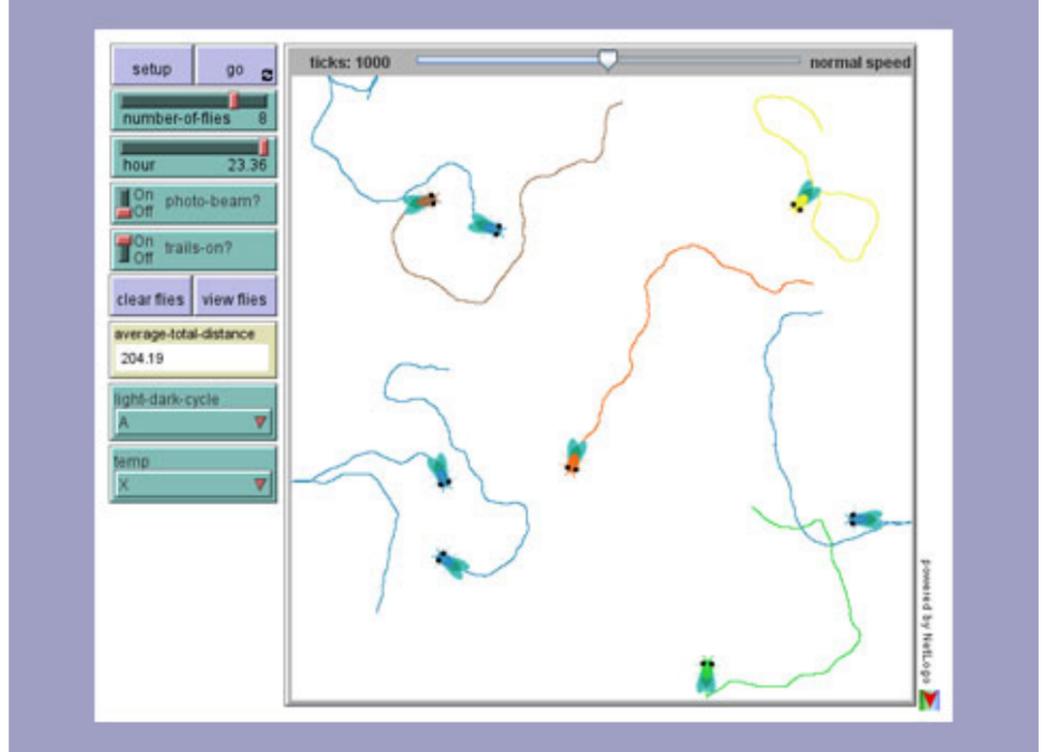
A possible extension to using these NetLogo models is to have students design and carry out their own fly experiment looking at how light affects fly activity. In this extension lesson, students use what they have learned through the NetLogo manipulations to develop hypotheses for the effects of specific light manipulations on the circadian activities of small fly populations. Students design and implement the initial phases of an experiment capable of testing their hypotheses. Data are collected over several days and then analyzed. Using these data and information learned from the NetLogo models, students develop an explanation using the claim, evidence, and reasoning framework that links back to their hypothesis.

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Lesson 3: How can genetics change your clock?

The goal of this lesson is to teach the students about how changes to circadian genes can have physiological effects that may or may not have circadian phenotypes. Students construct a physical model of a circadian gene, Period 2 (per2). Using this model, students explain how changes in the nucleic acid sequence can change protein structure and, ultimately, alter protein function.

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Lesson 4: Tick tock...Broken clock

In this lesson, students learn about the role played by DNA and proteins in the circadian cycle. Students also explore some of the scientific and diagnostic techniques used by doctors and researchers to diagnose and study circadian rhythm disorders. Using a case study format, students investigate the source of a fictional character's sleeping problems. Students are presented with information that they must utilize to progress through four "checkpoints" throughout the course of the lesson. Each checkpoint gives student groups access to additional information based on current research regarding the nature of the patient's sleep difficulties. The students, who act as case investigators, review records collected by a hospital case investigation team to help solve the young man's sleeping problems.

After completing all of the checkpoints in the order of their choosing, each group will regroup as possible "diagnoses" teams, where each group member gains in-depth knowledge of a possible diagnosis for the patient. Following this jigsaw, students return to their investigation teams to come to a final consensus on the patient's diagnosis.

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Lesson 5: How do environment and modern society influence our rhythms?

In this lesson, students apply what they have learned about circadian processes to issues relevant to human light exposure, species biology and ecology. Students use light meters to examine light exposure differences around their school to illustrate the possible

influences of habitat/workplace on light exposure. Students read and discuss a series of short articles that exemplify the interaction between environment and circadian rhythms. Students develop a scientific explanation to answer the question: Does environment influence circadian rhythms? Through these activities, students explore how cues from the environment entrain their biological daily clocks. In addition, they examine examples of how endogenous circadian clocks in different species have adapted over time to allow the species to survive in their light environment.

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Lesson 6: What happens to humans when normal rhythms are disrupted?

This lesson focuses on the circadian rhythm and its connection to humans. Students will analyze the average results of their sleepiness scale and compare it to others. They will examine multiple instances where circadian rhythms have an impact on real life scenarios in humans. This lesson will be applicable to the students' lives and will consist of topics that they are familiar with.

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Lesson 7: How can epigenetics change your clock?

The goal of this lesson is to teach students about how changes to circadian genes can have physiological effects that may or may not have circadian phenotypes. Using the period 2 gene sequence, students will play the Epigenome game to learn about how changing the secondary structure of DNA can up- or down-regulate expression of genes.

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Lesson 8: When should the school day begin?

During this lesson, students debate the most appropriate starting time of the school day using the relevant information learned throughout the unit as their evidence for claims they make. Students work in groups to create an argument for what they believe to be the best starting time for the school day, share their argument with the class in the form of a discussion/debate, and prepare a presentation to share their recommendation for school day starting time with a school administrator. Groups will be required to pull from knowledge they acquired from throughout the unit, including sleepiness scale data and experimental results, as well as information gathered from popular media and scientific journal articles, to formulate their argument.

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