What makes me tick...tock?

Circadian rhythms, genetics, and health

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

I. Overview:
This lesson focuses on the circadian rhythm and its connection to humans. Students analyze the average results of their sleepiness scales started in Lesson 1 and compare it to others in the class. They 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.

Connections to the Driving Question
In order to truly understand what makes us “tick,” it is important to discover what happens when something is disrupted. This lesson encourages students to discuss what can happen when our “tick” is no longer in its normal rhythm. It even asks students to address possible solutions that can keep the rhythm consistent within certain work and environmental conditions.

Connections to the Previous Lesson
In the previous lesson, students examined how light exposure can change the circadian rhythms of humans and other animals. Now, they look at adverse complications of circadian rhythm disruptions on human health, focusing on humans with occupations that lead to abnormal light exposure.

II. Standards/Benchmarks

National Education Science Standards

Content Standard A: Understandings about Scientific Inquiry
- Results of scientific inquiry-new knowledge and methods-emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation. (9-12 A: 2/6)

Content Standard C: The Behavior of Organisms
- Organisms have behavioral responses to internal changes and external stimuli. Responses to external stimuli can result from interactions with the organism’s own species and others, as well as environmental changes; these responses can either be innate or learned. The broad patterns
of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. (9-12 C: 6/2)

- Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology. (9-12 C: 6/4)

Content Standard E: Understandings about Science and Technology
- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering. (9-12 E: 1/3)

Content Standard F: Personal and Community Health
- Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms—sensory, motor, emotional, social, and technological—that can reduce and modify hazards. (9-12 F: 1/1)

Benchmarks of Science Literacy

The Nature of Science: The Scientific Enterprise
- Progress in science and invention depends heavily on what else is happening in society. 1C/H3a
- Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. 1C/H6ab

The Human Organism: Physical Health
- Conditions now are very different from the conditions in which the species evolved. But some of the differences may not be good for human health. 6E/H3b

III. Learning Objectives

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<th>Learning Goals</th>
<th>Assessment Criteria</th>
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<td>Relate students’ new knowledge to real situations in order to address problems</td>
<td>Students develop projects, posters or presentations that inform the public of potential solutions and suggestions to prevent negative health consequences with circadian rhythm disruptions in miners, pilots/stewardesses, and other shift workers (specifically emergency workers).</td>
<td>Throughout</td>
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<td>Articulate the effects that shift work and the disruption of circadian rhythms can have on</td>
<td>Using the readings and ideas that they have gained from previous lessons, students describe how circadian rhythm disruptions can</td>
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health and performance  have a variety of consequences on health, such as anxiety, depression, weight gain/loss, heart conditions, etc., and can result in poorer performance and focus at work and in life.

Interpret the Sleepiness Scale and explain theirs and others’ sleep-wake cycles  Students interpret their Sleepiness Scales, with their highest level of sleepiness at 10 and their lowest level of sleepiness at 1, determining at what points in the day they are the most tired and most awake. They also relate their findings based on the activities of a certain day (drinking caffeine, sleeping in, waking up early, staying up late, etc.) and how these external factors may have caused them to be more or less sleepy on a certain day. The students also analyze others’ sleep wake cycles, the family members they chose in Lesson 1, to compare/contrast their sleepiness scales to their own.

Explain if their sleep-wake cycle may posit any health problems by looking at the data they compiled throughout the unit  After reviewing their Sleepiness Scales, students determine if their sleep-wake cycles are conducive for optimal school performance and health. They should use evidence from Lessons 1-6 to support their explanation.

V. Adaptation/Accommodations
This lesson could be adapted to include any type of presentation that students wish. The number of occupations that are evaluated and researched in the first activity may also be altered to accommodate different classes. Occupations that are relevant to the time may be added along with jobs that are relevant to the specific area that the students live in. The PDF resources with the lesson materials are available as suggestions.

If time does not allow for it, the project aspect of this lesson may be removed. However, it is important that a thorough discussion take place so that students have the opportunity to learn from one another and the articles that they read. As another option, students could be asked to complete their project on their own time.
VI. Timeframe for activity

Opening of Lesson
• Discussion on homework, “Are Night Shifts Bad for You?” – 5-10 minutes

Main activity
• Activity 1: What are the effects of circadian rhythm disruptions? – 1.5 days
• Activity 2: What do the workers’ Sleepiness Scales tell us? – 15 minutes
• Activity 3: What does my Sleepiness Scale tell me? – 30 minutes

Conclusion of Lesson
• Wrap-Up Discussion – 10 minutes

VII. Advance prep and materials

Activity 1: What are the effects of circadian rhythm disruptions?

Materials:
• A basic explanation of circadian rhythms and aspects that can affect it, "U3_L6_Reading_Circadian_Rhythms_General.docx" (one copy/group).
• Research Articles (only one copy of each article is needed per group)
  o Set 1: Possible articles for trapped miners
    ▪ "U3_L6_Reading_Miners-PsychologyToday.docx"
    ▪ "U3_L6_Reading_Miners-Newsweek.docx"
    ▪ "U3_L6_Reading_Miners-EHSToday.docx"
    ▪ "U3_L6_Reading_Miners-CNN.docx"
  o Set 2: Possible articles on flight crews (pilots and flight attendants) and circadian rhythm disruptions
    ▪ "U3_L6_Reading_Flight-FedAvAdmin (pilots)"
    ▪ "U3_L6_Reading_Flight-Stauss (pilots)"
    ▪ "U3_L6_Reading_Flight-NIOSH (flight attendants)"
  o Set 3: Possible articles for shift work
    ▪ "U3_L6_Reading_ShiftWork-Kuhn"
    ▪ "U3_L6_Reading_ShiftWork-PublicHealth (nurses)"
    ▪ "U3_L6_Reading_ShiftWork-HealthCommunities (general)"
• Copies of the student worksheet ("U3_L6_StudentSheet_GroupPresentationGuide.docx") for each student in the classroom.
• Posters, paper, computer, books, etc. (a wide range of materials and media)

Activity 2: What do the workers’ Sleepiness Scales look like?
Materials:
- A copy of the Worker Sleepiness Scale worksheet 
  (U3_L6_StudentSheet_WorkerSleepinessScale.docx) for each student.

Activity 3: What does my Sleepiness Scale tell me?

Materials:
- Sleepiness Graphs that students have been plotting their data on throughout the unit.
- A copy of the Sleepiness Profile worksheet (U3_L6_StudentSheet_SleepinessProfile.docx) for each student.

Preparation:
- At the beginning of the unit (refer to Lesson 1) students were asked to plot their sleepiness data three times a week. They have also been asked to collect data from a member of their family (parents or siblings). All of this information will be needed for this activity so that they can look for patterns and differences.

Homework and Assessments

Materials
- Group Presentation Guide, U3_L6_StudentSheet_GroupPresentationGuide.docx
- Worker Sleepiness Scale, U3_L6_StudentSheet_WorkerSleepinessScale.docx
- Sleepiness Profile, U3_L6_StudentSheet_SleepinessProfile.docx
- Homework Reading on why DNA isn’t your destiny, U3_L6_Homework_TIMEmagazine.docx
- Homework Reading on Mental Illness switching on and off, U3_L6_Homework_DiscoverMagazine.docx

Preparation
- When assembling this homework, page one of the homework questions should precede the article. The second page of questions should follow the article. The homework should be compiled this way because it is designed to first ask the students what they know about genetics. The follow-up questions ask how the article has changed their view of genetics/epigenetics.
VIII. Lesson Implementation

Opening of Lesson:
The homework assigned at the end of Lesson 5, Are Night Shifts Bad for You?, introduces the concept that circadian rhythm disruptions in certain occupations can have health consequences. It shows how humans’ lives are impacted by their circadian rhythms. As a review of the homework, ask students some questions such as the ones that follow:

- What new concepts were introduced in this reading?
- What types of health concerns were mentioned within the article?
- Were there any ideas that you found particularly interesting?
- Why is it important to know about complications associated with circadian rhythms? (in relation to learning more about them)
- What are some issues that need to be considered with this research? (ex: more research needs to be done, other factors may be playing a large role, etc.)
- Have you heard or read of any health concerns related to circadian rhythm disruptions in the media?

Main Part of Lesson

Activity 1: What are the effects of circadian rhythm disruptions?
Ask students the following questions to get them thinking about what happens when circadian rhythms are disrupted:

- What are some occupations that can alter natural circadian rhythms?
- In what ways are circadian rhythms affected in these examples?
- What impact do you think this disruption could have on lifestyle and/or health?

Explain to students that they are going to use the news and journal articles to research humans and circadian rhythm disruptions. They will use this information and work together to create a presentation to display what they have learned from their group research. They will be required to present to the rest of the class but how they present will be up to them. Potential ideas/suggestions for their presentation are: newspaper article, public service announcement, comic, play, news episode, mock legislation, podcast, or a letter to someone relevant.

Separate students into groups of 4 students. Each group should be given one of three different sets of articles to discuss (other groups can be created as appropriate). Each set of articles evaluates an occupation that is related to circadian rhythm disruptions.

- Set 1: focuses on miners
- Set 2: focuses on pilots/stewardesses
- Set 3: focuses on shift workers, specifically emergency staff
In groups, have students read the articles and discuss key ideas and topics included in each one. They will use these articles (in combination with the information gained from the Mahoney video) as a starting point to research the health and behavior consequences of jobs that disrupt circadian rhythms. Through their research students will identify possible solutions to avoid the problems presented in the article (ex: special circadian lights could be used for miners who are trapped).

Students need to be aware that they will be responsible for presenting:

- The occupation
- Why it is considered a circadian rhythm disruption
- Health and behavior consequences
- How to alleviate the disruption (but still continue to work in the field)

As a research support, a worksheet (U3_L6_StudentSheet_GroupPresentationGuide.docx) is provided to help guide the students by giving direction to their conversations and research.

Before reading, students should add a couple questions of their own to the “Additional Questions” section of the worksheet. Then as they are reading, they should answer the “Questions you are asked to consider” and any of their own questions that the articles may answer or give information for. This column could also be used to jot down additional main points that are relevant for the presentation. In the “Connections to the Presentation” section, students should record the type of presentation that they think is appropriate for their topic and should brainstorm ideas for how they want to include the critical information.

Allow students to begin their research. While they are researching, students should begin to plan their presentation and how the information can be used in it. They will work on preparing their presentation and should be given a due date to help keep them on track.

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**Teacher Content Knowledge**

It is important to make sure that students understand some distinguishing concepts of the occupations that they have done research on.

- Shift workers work different times each day and sometimes work 5 days on and 2 days off, for example. During this time, their sleep schedules are not kept consistent. For example, they may work the same time for a certain number of days and then go back to a “normal” schedule during the days that they do not have to work. This change can have detrimental effects in addition to the differences in light/dark cycles that they may encounter.

- Flight crews can have disruptions of their circadian rhythms because they often work at different times throughout the 24-hour day. In addition to that, though, they are traveling across time zones and suffer from jet lag. This contributes to the disruptions in circadian rhythms in these professionals.
The miners that were trapped had disruptions in their sleep-wake cycle and their light-dark cycles because they were underground for so long. Even though they began to organize their sleep and activity patterns, this still had an impact on their well-being. For many of the workers, circadian rhythm issues persisted for some time after they were removed from the mine.

Allow students to present their information to the rest of the class. The purpose of presenting to the class is to help connect all of the ideas in the different articles. As students present, have their classmates identify key similarities and differences across the three groups. Have a discussion of common themes or ideas that were found throughout all of the occupations.

In order to help support this discussion, ask students:

- How does the circadian rhythm get disrupted in each of these occupations?
- What patterns did you notice in all of the presentations? Differences?
- Were there any health consequences that seemed to appear in multiple presentations? Performance disruptions?
- What were some practical solutions that your classmates mentioned to help avoid circadian rhythm disruptions?
  - Do you think this would be successful? Why or why not?

This will lead to a concluding discussion about what students have learned about human circadian rhythms and the negative impacts that can occur if they are repetitively altered.

**Activity 2: What would a shift worker, flight crew, or miner’s Sleepiness Scale look like?**

Explain to students that they will make a Sleepiness Scale for the workers that they just researched (flight crew, shift worker, or miner). The Sleepiness Scale predictions will be based on various facts that they have discovered during their research.

Have each student create their own scale for the group that they researched using the template handout (*U3_L6_StudentSheet_WorkerSleepinessScale.docx*). After students create their individual scale, allow students to compare scales within their group. Each scale does not have to look exactly the same. In fact, most likely they will not since, for example, many shift workers have hours that vary from one another. Students should try to predict the scales and be able to support why there are increases/decreases in sleepiness at certain points.

For the Sleepiness Scales for the miners, have students focus on miners in general as opposed to the trapped miners. They should be able to use information that they have gathered from other presentations and ideas that have been established throughout the whole unit to speculate.
Ask a couple students to explain their Sleepiness Scales to the rest of the class and give support and reasoning for why they look the way they do. Give other students in the class the opportunity to ask questions or disagree/agree.

Use this activity to lead into a discussion about the Sleepiness Scales that the students have been recording for the past couple weeks.

**Activity 3: What does my Sleepiness Scale tell me?**

Have students take out the data and graphs that they have collected and created throughout the unit using their own Sleepiness Scales.

Hand out the Sleepiness Profile document (*U3_L6_StudentSheet_SleepinessProfile.docx*) to the students. This handout will guide them as they analyze and interpret their sleepiness data. Ask students to look at their Sleepiness Scale Graphs and identify patterns or changes that occurred over the time that they collected the data.

Have students create a final graph which shows the *typical* times of the day during the week when they feel very awake or sleepy. Using this graph, have students compare their “typical sleepiness scale” to their friends’ and their parents’ or siblings’ graphs. In addition, they need to identify how their sleep-wake times correlates with the Sleepiness Graph. Through this comparison, they will identify if the times that they go to bed are the times when they are most sleepy. In addition they will identify if they get less sleep or feel more alert when they have a lot of caffeinated drinks.

After students identify patterns in their and their family members’ sleepiness data and write down their interpretations on their and their family members’ Sleepiness Profile, ask them to work in groups of 3-4 to compare their Sleepiness Profile and their family member’s Sleepiness Profile with their peers’.

After students work in groups to compare each others’ Sleepiness Profiles, have a whole class discussion. During the whole class discussion, ask students the following questions and record their answers on the board:

- What time of the day do you feel most awake and alert? Do your parents (or younger siblings) also feel most awake at the same time of the day?
- What are some of the differences and similarities among your sleepiness profiles and your peers’, parents’?
- Why do you think there are significant differences among your Sleepiness Profiles and your peers’, parents’?
- How many hours of sleep are you getting during the week and on the weekend?
- If you are typically sleeping during the day but are awake at night, what kind of a long term effect this might have in your body? (think about shift-workers and related health problems)
- How does your sleep-wake patterns relate to your peers’ data? Do you have similar circadian rhythms?
• How does your circadian rhythm relate to the recommended sleep-wake cycles for teens? How can you modify your habits to apply them in your life?
• What are some other patterns that you noted as you created your Sleepiness Profiles?

Continue by asking students how they would benefit from knowing the times that they feel sleepy or alert (as part of this discussion, have students suggest ways that they can organize their schedules accordingly; for the tasks that are demanding, they can do them when they are most alert, etc.).

If possible, allow students to present their findings by creating a PowerPoint presentation or using poster paper. Here are some ideas of information that they can present:

• Similarities and differences in my circadian rhythm and my peers’
• My sleep-wake cycle and how it may affect my health in the long run
• My sleep-wake cycle and what I can do to adjust it according to recommended sleep patterns for teens.
• My sleep-wake cycle versus the sleep-wake cycle of the group that I researched

**Conclusion of Lesson**

Explain the homework that will lead into Lesson 7, *How epigenetics can change your tick*. To do this, ask the students a few questions:

• What have you learned about circadian rhythms so far?
• What role does genetics have in circadian rhythms?
• How can circadian rhythms be changed?
• Do you think the environment (geography, working schedule, etc) can change circadian rhythm genes?

Following these questions, tell the students that they will be reading an article about how the genetic code does not always equal the phenotype (or measurable trait) in an individual. Hand out their homework reading, the *Time Magazine* article “Why Your DNA Isn’t Your Destiny” (*U3_L6_Homework_TIMEmagazine.docx*) or the *Discover Magazine* article “The Brain: The Switches That Can Turn Mental Illness On and Off” (*U3_L6_Homework_DiscoverMagazine.docx*) and answer the associated questions on the handout.

**Assessment**

The students will be assessed on their presentation and the information that is provided. They will also be evaluated on their participation in the discussion of the article and the formation of the Sleepiness Scale for the various occupations. Students’ evaluation, interpretation, and comparison of their own Sleepiness Scale should be assessed as well.