NSBRI TAP Classroom Activity

Title: **LIVING CLOCKS**

Grade Level: 5-8 and 9-12

Content Area: Science

National Science Content Standards:
Standard A. Science as Inquiry (Grades 5-8 & 9-12)
- Abilities necessary to do scientific inquiry

Standard C. Life Science
- Regulation and behavior (Grades 5-8)
- Behavior of organisms (Grades 9-12)

Standard E. Science and Technology (Grades 5-8 & 9-12)
- Understandings about science and technology

Behavioral Objectives:
- The students will make observations to determine if there is a pattern to the behavior/movement of a plant.
- The students will use scientific inquiry methods during field and/or laboratory investigations.

Lesson Objective:
- In this lesson the student will examine bean plants for examples of environmentally induced stimuli. Responses in organisms to external stimuli such as the presence or absence of light will be observed and recorded. These observations will lead to a discussion of circadian rhythms and how they are important to our lives and to the lives of astronauts as we prepare to go beyond low earth orbit.

Time:
- Five 45 minute periods; Three 90 minute block periods
  *Note: The time in this lesson is variable depending on how the teacher implements the lesson into their curriculum.

Materials:
1. Source of natural light
2. Plant(s) - bean family
3. Digital camera (not required)

*Note: If growing plants from seeds you will need small pots, potting soil, and bean seeds.

This lesson was developed by participants and staff of the Teacher Academy Project at Texas A&M University with support from the National Space Biomedical Research Institute through NASA NCC 9-58.

Procedure:

1. Grow young bean plants from seed or purchase plants from a greenhouse. Plants grown from seeds should have at least two leaves in addition to the cotyledons (fleshy seed leaves).

2. Place bean plants in a sunny window or under a grow light with a timer. Observe the leaves as early as possible in the morning and again later in the afternoon. It will be important not to move or turn the plants once observations begin. You may want to mark the location (with tape) of each plant and its orientation just in case. Notice whether the leaves are facing to the side or facing upward, and record your observations in the spaces below (if available a digital camera may also be used).

3. Once the pictures have been drawn or taken (usually the next day) have the students note the orientation of the large leaves. In particular the students should notice whether the leaves are extended outward or whether they are folded downward toward the stem.

4. Have them repeat the observation over three days.

Day 1

Early Morning	Afternoon
Time:	Time:

Day 2

Early Morning	Afternoon
Time:	Time:

Day 3

Early Morning	Afternoon
Time:	Time:

5. Move the bean plants to inside a cupboard or to a dim corner of the room. Record your observations as before over a three day time period.

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Day 1

Early Morning	Afternoon
Time:	Time:

Day 2

Early Morning	Afternoon
Time:	Time:

Day 3

Early Morning	Afternoon
Time:	Time:

6. Write a paragraph describing both sets of your observations on a separate sheet of paper.

Reference: From Outerspace to Innerspace/Sleep and Daily Rhythms (2000). Baylor College of Medicine. Available online at: http://www.nsbri.org/Education/TG/TG_Sleep.pdf

Extension:

- Sleepy Time-Students will collect data on their own sleep patterns. Lesson found online at: http://www.nsbri.org/Education/TG1_Act3.pdf

Resources:

From Outerspace to Innerspace Sleep and Daily Rhythms, 2000, Baylor College of Medicine. Available online at: http://www.nsbri.org/Education/TG/TG_Sleep.pdf

Portions of the background information were obtained from a article that appeared at the following website: http://www.nsbri.org/NewsPublicOut/Release.epl?r=25

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Background Information:

Most living things behave predictably in cycles of about 24 hours, similar to the period of the Earth's rotation. These cycles are referred to as *circadian,* from the Latin words for "about" *(circa)* and "day" *(dies).*

There are many easily recognized behavioral rhythms in nature. Well-known examples include the flowering of morning glories at dawn and the hunting routines of owls at night. These behaviors are governed by internal mechanisms, often referred to as "biological clocks," within the cells of the living organisms. When a biological clock runs on a 24-hour cycle, it also can be called a circadian clock.

Virtually all human body functions such as waking and sleeping, body temperature (lower in the morning just after waking, higher in the afternoon), secretion of some hormones, and urine production, are governed by circadian clocks. These changes occur regularly over intervals of 24 hours without cues from the environment. Researchers once thought, without cues from the environment, the human circadian clock eventually would drift into a slightly longer cycle of about 25 hours. More recent research has shown, however, that the free-running period of the human clock is just slightly over 24 hours in both young and older adults. The human internal clock fails to adapt to non-24-hour days and that fact takes its toll on astronauts, international travelers and shift workers.

According to Dr. Kenneth Wright, an instructor in medicine at Harvard Medical School and associate neuroscientist and director of the Fatigue Countermeasures Research Program in the Division of Sleep Medicine at Brigham and Women's Hospital (BWH), "Due to the shuttle orbit, astronauts often experience days that are less than 24 hours. Many experience sleep difficulties, averaging only about six hours of sleep a day in contrast to the seven or eight hours they get on the ground. This can lead to increased risk of accidents due to fatigue and sleepiness."

In NSBRI and NASA funded study conducted at Brigham Women’s Hospital in Boston, Wright and colleagues evaluated how people's internal clocks were affected by exposure to 23.5, 24 and 24.5 hour days. Shuttle missions typically operate on 23.5 hour days, and astronauts exploring Mars would experience a 24.65 hour day.

"Adapting to these different day lengths is critical to mission success," said Wright, a Boston researcher on the National Space Biomedical Research Institute's human performance team. Since spacecraft are dimly lit, study participants at BWH were exposed to low-level daytime lighting equivalent to candlelight. All groups were placed on a fixed work/rest schedule. Melatonin, a hormone that regulates the body's sleep activities was evaluated to determine how participants adapted to the various day lengths. In a normal day/night sleep cycle, melatonin levels will rise about two hours before sleep to signal the body to prepare for sleep. The levels are high during sleep and low during the day. The findings appeared in the Nov. 20 edition of the Proceedings of the National Academy of Science.

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"Light exposure is the strongest cue for our internal clock. However, participants on the 24-hour day fixed work/rest schedule were able to maintain the appropriate melatonin cycles for sleep even in the dim light," Wright said. "Their internal clocks kept time with the day. The groups experiencing the shorter or longer days did not adapt."

In the other groups, melatonin levels lost the normal cycle. Levels were high when the participants were awake and low when they were trying to sleep. This factor made it difficult to sleep at the scheduled time. According to Dr. Wright, "This problem with the melatonin cycle occurs during jet lag and in people working on night shifts, in effect, astronauts on shortened days are experiencing jet lag in space." Dr. Wright goes on to say, "People with advanced sleep phase syndrome typically have difficulty staying awake after 5 p.m. and will wake up in the early hours. Another disorder impacts people the opposite way, leaving them unable to sleep until early morning and making it hard to be awake during traditional work hours. For these patients, a treatment to adjust the internal clock would make a big difference in work and home life."

The NSBRI human performance factors team is working to develop a remedy, or countermeasure, to help people adapt to various day lengths. While this solution is essential to prepare astronauts for exploration missions beyond low-Earth orbit, it will also have practical implications on Earth. In addition to jet lag and shift-work adaptation, it will be useful for certain sleep rhythm disorders.

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Student Assessment (Student Copy)

Title: **LIVING CLOCKS**

1. Describe the behavior/function the plant exhibited.
2. Compare the plant's behavior to a circadian cycle.
3. What is a circadian cycle? Give an example.
4. Many body functions are governed by the circadian cycle. Name two:
5. What is the name of the hormone that controls sleep? What is its concentration in a normal person in the day and night?
6. Name two common conditions associated with irregular sleep cycles.

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Student Assessment

Title: **LIVING CLOCKS**

1. Describe the behavior/function the plant exhibited.

   Ans. During early morning the leaves should be droopy. As the day goes on and light becomes more intense the leaves should rise. This is in response to increased metabolic activity during the day.

2. Compare the plant's behavior to a circadian cycle.

   Ans. The plants are going through a sleep cycle. In the evening there is no sunlight to drive photosynthesis; therefore, the plant does not need to produce food for energy and "sleeps". When the sun is out the leaves orient themselves in a "wakeup" posture and begin the day producing food, the plant is ready for work.

3. What is a circadian cycle? Give an example.

   Ans. A cycle of about 24 hours similar to the Earth's rotation.
   Examples - Flowering of morning glories, body temperature, hunting routines of owls, etc.

4. Many body functions are governed by the circadian cycle. Name two:

   Ans. Waking and sleeping, body temperature (lower in the morning just after waking, higher in the afternoon), secretion of some hormones, and urine production.

5. What is the name of the hormone that controls sleep? What is its concentration in a normal person in the day and night?

   Ans. Melatonin. The levels of melatonin remain high until morning when a decrease signals awakening.

6. Name two common conditions associated with irregular sleep cycles.

   Ans. Jet lag-occurs when a person travels across time zones. Shift work adaptation-shift workers do not always work on a daytime schedule, they may work during the night, which can cause them to become out of synchronization with their circadian rhythm.

Group Presentation:
Once the students have concluded their investigations have each group present its observations to the class. Students should be able to describe the behavior/function that they observed.

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