Sponsored Educational Materials

The Circadian Rhythms Issue

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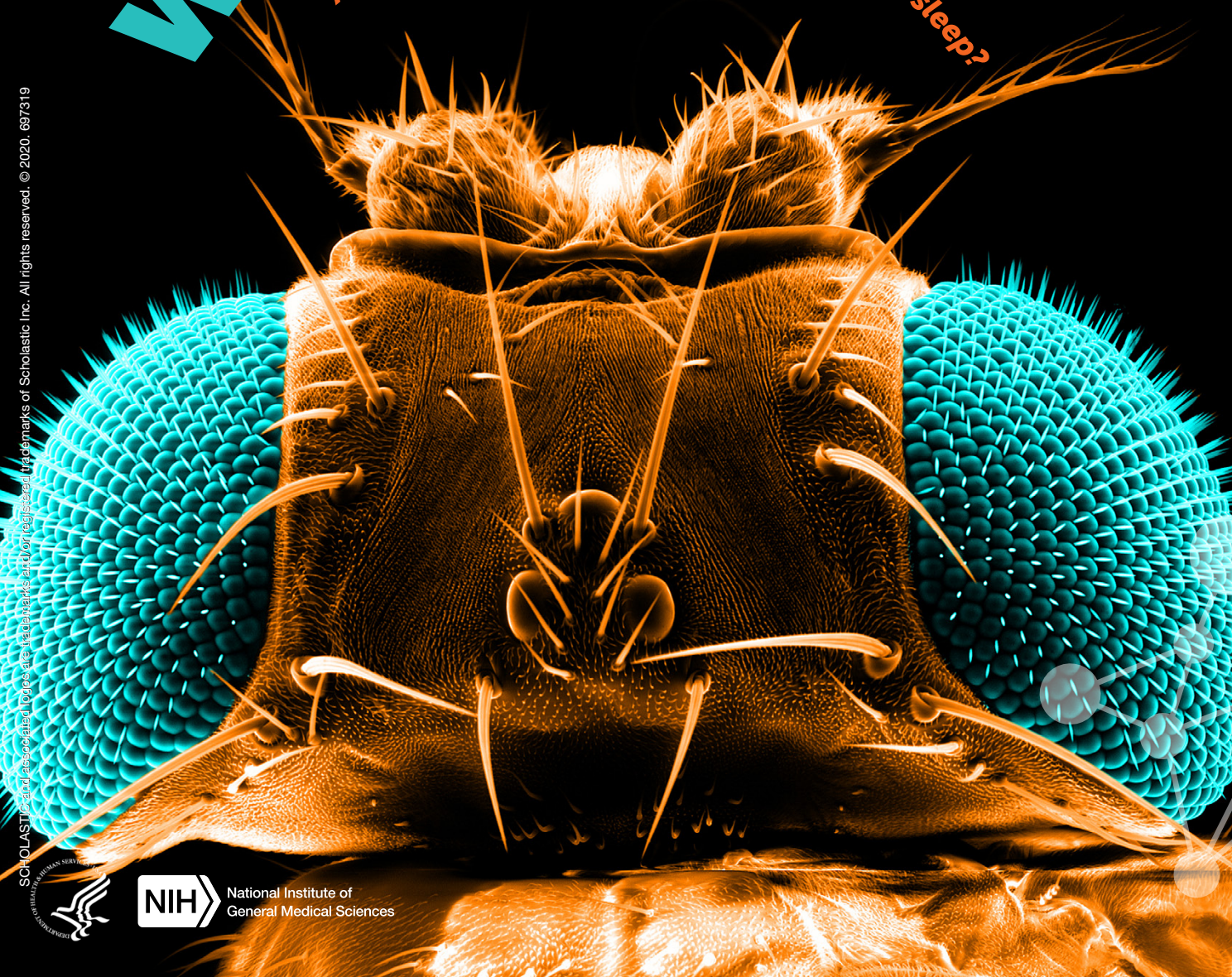
PATHWAYS

What is this?

And what does it have to do with how you sleep?

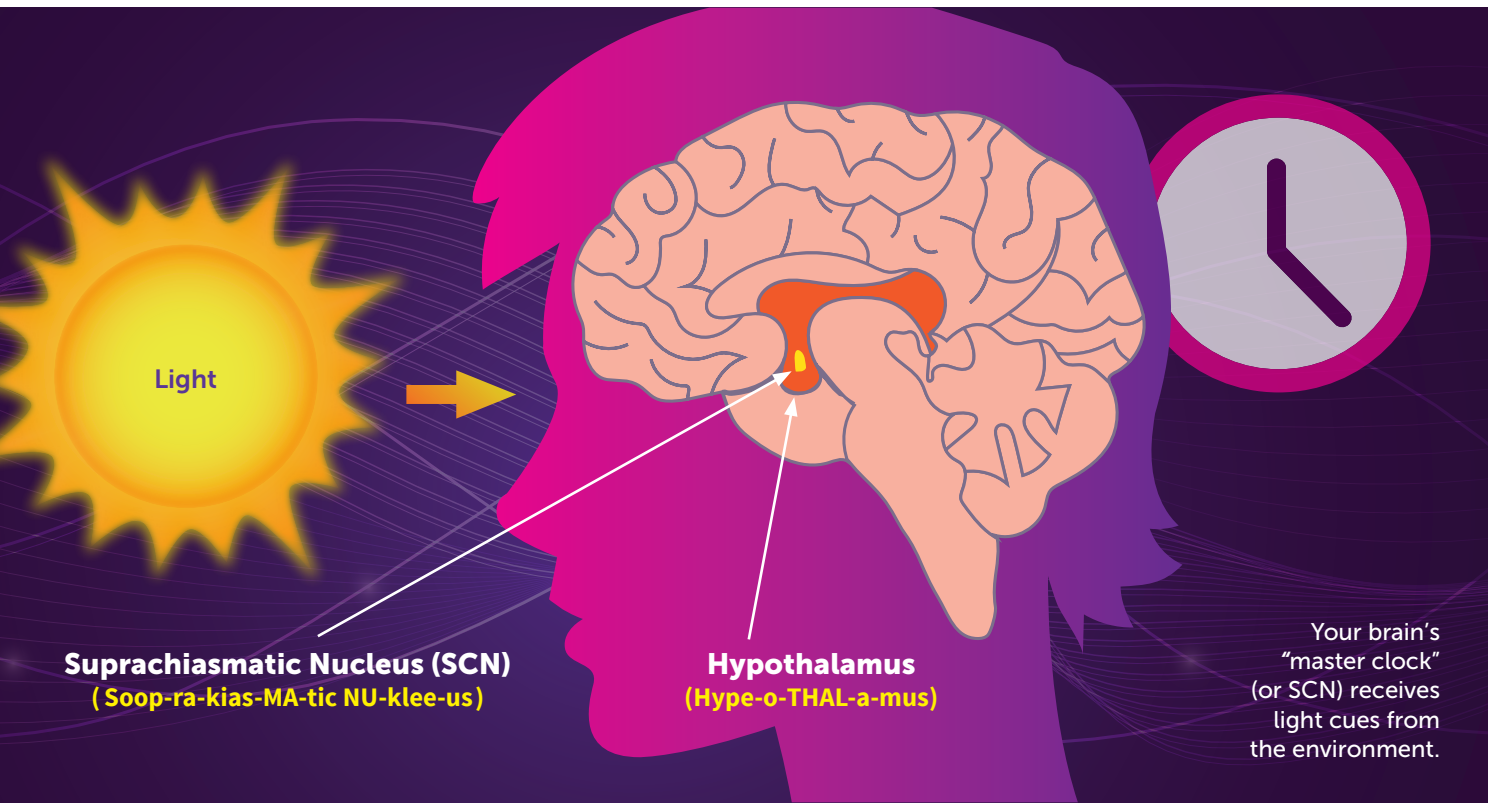
(Find out inside!)



NIH National Institute of General Medical Sciences

The Science of

What researchers are learning about the body's daily rhythms, and how they determine when you fall asleep, wake up, and more!



Your brain's "master clock" (or SCN) receives light cues from the environment.

What makes you drift off to sleep at around the same time every night? Why do you usually feel a snack attack coming on in the late afternoon? The answer: your circadian rhythms. You can't see them or feel them, but all humans have circadian rhythms—and so do most living things, including animals, plants, and even fruit flies! Circadian rhythms are powerful: They control physical, mental, and behavioral changes that you experience over the course of a 24-hour day.

What's driving those circadian rhythms? Bodily clocks! Humans have a "master clock" in the brain. This master clock, called the suprachiasmatic nucleus (SCN), contains about 20,000 nerve cells called neurons. It's located in a small, powerful region of the brain called the hypothalamus. The SCN receives direct messages about when it's light and dark from the sensory receptors in your eyes. It then communicates this info to the rest of the brain and cells in the body. "These SCN neurons in our brain are like clocks that keep track of the time of day, and help synchronize our bodies with the daily rhythms that occur as the Earth rotates on its axis every 24 hours," explains **Dan Cavanaugh, Ph.D.**, assistant professor at Loyola University Chicago. "It's why we get sleepy or wake up at particular times."

The time that your body likes to go to sleep, which is called your chronotype (think of it as your sleep personality), can change. "Research

Sleep

shows that as you enter your teenage years, it's normal to become more of a night owl, which means you want to stay up later," says **Carrie Partch, Ph.D.**, associate professor at the University of California, Santa Cruz. This shift is caused by the normal hormonal changes that happen during puberty. For example, in teens, the levels of melatonin, a sleep-inducing hormone, also rise later in the day than they do in kids and adults. Girls typically start puberty earlier, and some studies suggest they begin shifting toward a late-night chronotype about a year sooner than boys do. "In your early twenties, though, your hormones start to settle, and that urge to stay up later goes away," says Partch.

And circadian rhythms affect more than just your sleep-wake cycle. They can impact other important functions in your body. "Scientists know that we have a master clock in our brains, but we're only beginning to appreciate how widespread these clocks are," says **Swathi Yadlapalli, Ph.D.**, assistant professor at the University of Michigan. "Recent studies show that almost every cell in the human body has a circadian clock, so there are clocks in most of our organs: the liver, intestines, lungs, skin, and more." Irregular rhythms can cause health conditions like sleep disorders, obesity, and diabetes.

Light Effects

Your internal clock is amazingly reliable. But there is one major factor that could make it go off-kilter: changing your exposure to light. You've probably heard the term "jet lag." If someone travels a long distance to another time zone, they may feel groggy all day. That's because their internal clock isn't lined up with the light and dark cues in their new environment. People who work at night—like nurses and nighttime security guards—also have a hard time getting their circadian clocks to match up with their outside world. Their internal clock, which takes its cues from daytime light, makes it hard for them to stay asleep, even if they're tired.

The Phone Factor

Scientists have found that using blue-light-emitting devices like smartphones at night can mess up your internal clock in the same way. "Even though it's not from the sun, the light from a phone tells your internal clock that it's daytime, even at 10 or 11 p.m.," says Partch. The clock confusion can also drag down your energy levels, make you feel crabby, and impair your judgment.

Teens need eight to 10 hours of sleep a night. You might think you're doing a smart thing by "catching up" with a 12-hour sleep binge on the weekend, but you're only throwing off your circadian rhythms. The best strategy is to go to bed and get up at the same time every day, even on weekends, and turn off your devices 30 minutes before bedtime.

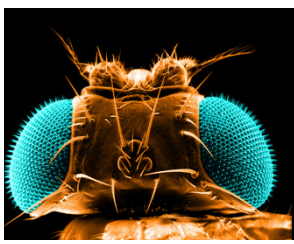
SCIENCE ALL-STARS

Ever wonder what it would be like to win a Nobel Prize? In 2017, scientists Jeffrey C. Hall, Michael Rosbash, and Michael W. Young won the prestigious honor for their circadian rhythms research. By studying Drosophila, aka fruit flies, which have a very similar genetic makeup to humans, they isolated a gene that helps control the body's clock. The scientists showed that the gene produces a protein, PER, that builds up in cells overnight, then breaks down during the day. This process can affect when you sleep, how sharply your brain functions, and more.

Photo: The Nobel Prize Medal is a registered trademark of the Nobel Foundation

The Mystery Cover Image

Say hello to Drosophila, otherwise known as a fruit fly. See the "Science All-Stars" section to learn how these research organisms have helped us decode circadian rhythms. The image shows its head and large, light-sensitive eyes.



Circadian rhythm comes from the Latin words *circa*, which means "around," and *diem* or *dies*, meaning "day." The study of circadian rhythms is called chronobiology.

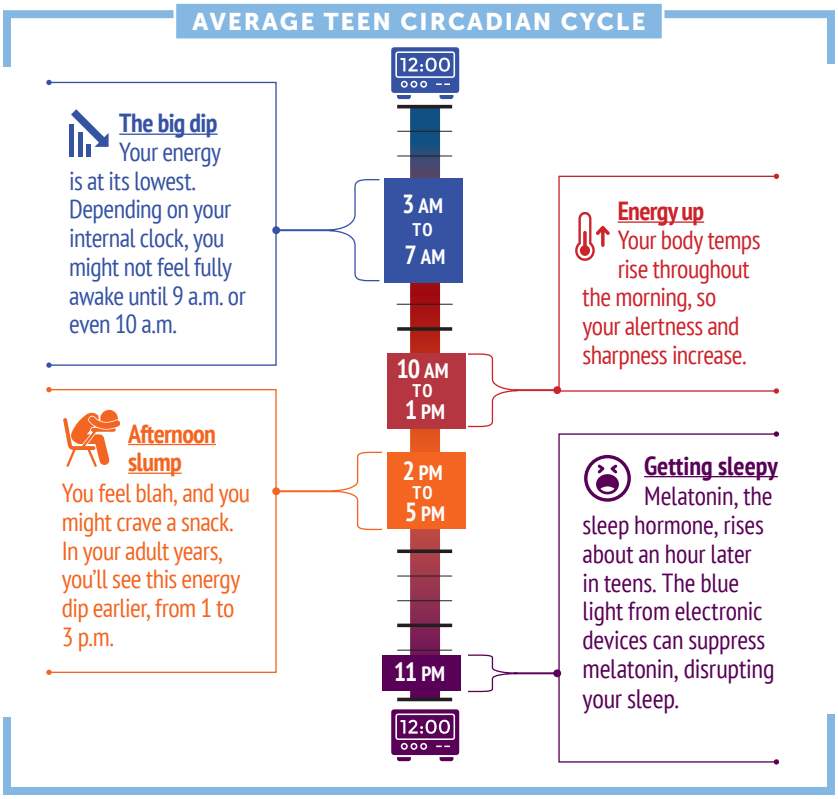
Should Teens Be Allowed to Sleep In?

Some school districts are saying yes to improve students' health.

Your phone alarm goes off and you've got to drag yourself out of bed to get ready for school. Ugh. If you feel like climbing back under the covers, it's probably not your fault: Many teenagers' circadian clocks aren't ready to solve algebra problems before 8 a.m. —and science backs this up.

When Seattle, Washington, switched its school start time from 7:50 a.m. to 8:45 a.m., students got more sleep and better grades, according to researchers at the University of Washington and Salk Institute for Biological Studies. In fact, California recently became the first state to ban high school start times before 8:30 a.m. Middle school can't begin until 8 a.m.

Check out the graphic at right to see what a body clock looks like on school days for the typical teenager.



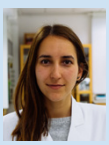
In the Spotlight Early-Career Scientists

Dustin Ernst, Ph.D., postdoctoral fellow at the University of California, San Diego

What sparked your interest in science? In middle school, I had a very enthusiastic teacher who showed me how much fun science can be. I really enjoyed setting up experiments and working with my hands.

What research are you doing now? I'm investigating how circadian rhythms controlled by biological clocks help microbes survive and reproduce. The biological clock found in the microbe I work with is different than the human biological clock. But the underlying principles are similar, so our research may help us discover how biological clocks influence human health.

Any advice for students who want to become scientists? Look for classes that require problem-solving. Get as much lab experience as you can. Join a science club at your school, and get involved in activities that require creative, out-of-the-box thinking.



Filipa Rijo-Ferreira, Ph.D., postdoctoral associate, University of Texas Southwestern Medical Center

Did you like science as a kid? Yes! I've always been fascinated by biology and wildlife TV shows. In high school, I had the most amazing biology teachers. They were all women, and it was like, wow, they're all doing this—I could, too.

What do you hope to discover? I'm trying to find out if parasites, which cause devastating diseases, have a way to tell time—if a parasite has a clock. One of the major symptoms of the malaria disease is its periodic fevers that happen at very specific times of day, always in multiples of 24 hours—like a circadian clock. If parasites have a clock and you can disrupt that, you can control the infection.

How can students find out more about science careers? Get exposed to as many things as you can so you can see what most fascinates you. Be curious about the world around you. Be persistent.

Circadian Rhythms and Sleep

Launch a class-wide investigation into the science of sleep, and then have students investigate and track their own biological clocks.

Objective

Students will plan and carry out an investigation, then use their findings and additional research to write an evidence-based argument.

NGSS Standards

3. Planning and carrying out investigations

4. Analyzing and interpreting data

7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information

Time

Part A: 60 minutes

Part B: 60 minutes

Allow extra work periods for essay research and writing as necessary.

Materials

- *Pathways* magazine
- Keep a Sleep Diary activity sheet
- Organize Your Argument activity sheet
- Science of Sleep digital tool at scholastic.com/pathways/sleep
- Vocabulary list at scholastic.com/pathways

PART A

1 **Ask:** *What do humans spend about one-third of their lives doing?* Answer: sleeping. Poll the class to see if they are night owls or early birds? Ask if anyone has heard the term *circadian rhythms* and if they can guess what it means.

2 **Read** the following statements aloud and ask students to guess if they are true or false.

Our body's cycle of sleeping and waking every day is the only example of circadian rhythms in humans.

▶ **False.** The sleep-wake cycle is just one example of a circadian rhythm—the natural cycle of physical, mental, and behavioral changes that our bodies go through in a roughly 24-hour period.

The body has a "master clock" that controls circadian rhythms.

▶ **True.** It coordinates a set of biological clocks that regulate things like body temperature, hormone release, digestion, hunger regulation, and sleepiness throughout the day.

Teenagers need more sleep than adults.

▶ **True.** Teens need 8–10 hours of sleep every night. This gets harder during adolescence, when a teen's biological clock shifts, causing them to feel alert later at night, which can make it challenging to get the sleep they need.

3 **Hand out** the *Pathways* student magazine. Discuss the ways that researchers and scientists study sleep and circadian rhythms through observation, and how their research can positively affect our everyday lives (because all of us need sleep to stay healthy and happy!). Point out that students can play the role of scientist and researcher by using the same principles of observation to conduct their own sleep experiment.

4 **Hand out** the Keep a Sleep Diary activity sheet. Challenge students to observe their sleep rhythms for one week, then design a research question to test a beneficial sleep habit in a second week of observation. Sample research questions: How might my sleep/mood/energy levels be affected if I introduced: a "no blue light" rule two hours before bedtime; five minutes of natural light after I wake up; a meditation practice before bed; or 20 minutes of exercise in the morning? *Note: Afterward, you may wish to tell students that if a clear trend or conclusion did not emerge from their data, it may simply be because of the complexity of the factors influencing sleep, not due to a data collection error on the student's part.*

PART B

5 **Hand out** the Organize Your Argument activity sheet. Direct students to conduct research and combine it with their sleep diary findings. Use the digital interactive tool at **scholastic.com/pathways/sleep** as a research source.

6 **Direct** students to use their data to create a persuasive argument about how either they or their school can use the science of circadian rhythms to improve health and wellness. Consider offering students a choice of how to show their work: essay, infographic, video, slides, or a short talk to the class.

Extension: Students may wish to share their findings with administrators or plan a campaign in the school to share information with peers.

Keep a Sleep Diary

Name _____

Fill in data and observations about your sleep for five nights in a row (make sure to include one weekend night). Then, design a research question and hypothesis to test in Week 2.

	Sleep Diary	DAY 1 /	DAY 2 /	DAY 3 /	DAY 4 /	DAY 5 /
EVENING	**I consumed caffeine today.** (Examples: soda, chocolate, tea, coffee, sports/energy drink)					
	Morning					
	Afternoon					
	Evening					
	I exercised for 20 or more minutes.					
	Morning					
	Afternoon					
	Evening					
	I took a nap today. Y/N					
	I felt tired today. Y/N					
	Morning					
	Afternoon					
	Evening					
NIGHT	**My mood today: (G)** good **(O)** OK **(B)** bad					
	Activities I did 1–2 hours before bed: (Examples: took a shower, messaged with friends, watched a video, finished homework, read a book, etc.)					
	I went to bed at:	AM PM	AM PM	AM PM	AM PM	AM PM
MORNING	**I woke up this morning at:**	AM PM	AM PM	AM PM	AM PM	AM PM
	I got out of bed this morning at:	AM PM	AM PM	AM PM	AM PM	AM PM
	Falling asleep last night was: (**E**) easy; (**O**) OK; (**D**) difficult					
	I woke up during the night. Y/N					
	I slept for a total of _____ hours.					
	I woke up feeling: (R) refreshed; **(T)** a little tired; **(VT)** very tired					

Turn over this sheet to record additional details. For example: It was too hot to sleep; I stayed up late to finish a movie; I felt stressed before bedtime because I had a test the next day; etc.

Name _____

Organize Your Argument

Ready to use your sleep-diary data and research to craft a persuasive argument? Choose a prompt below. Then organize your position, claims, and evidence with this planner.

A. How should schools use the science of circadian rhythms to improve students' lives?

B. How will YOU apply the science of circadian rhythms to improve your life?

You might want to consider ideas like school start times; breaks for exercise, nutrition, stress relief, or rest; strategies and supports for flagging energy; homework expectations; scheduling of extra-curricular activities; and blue light from electronic devices.

Persuasive Argument Planner

Introduction

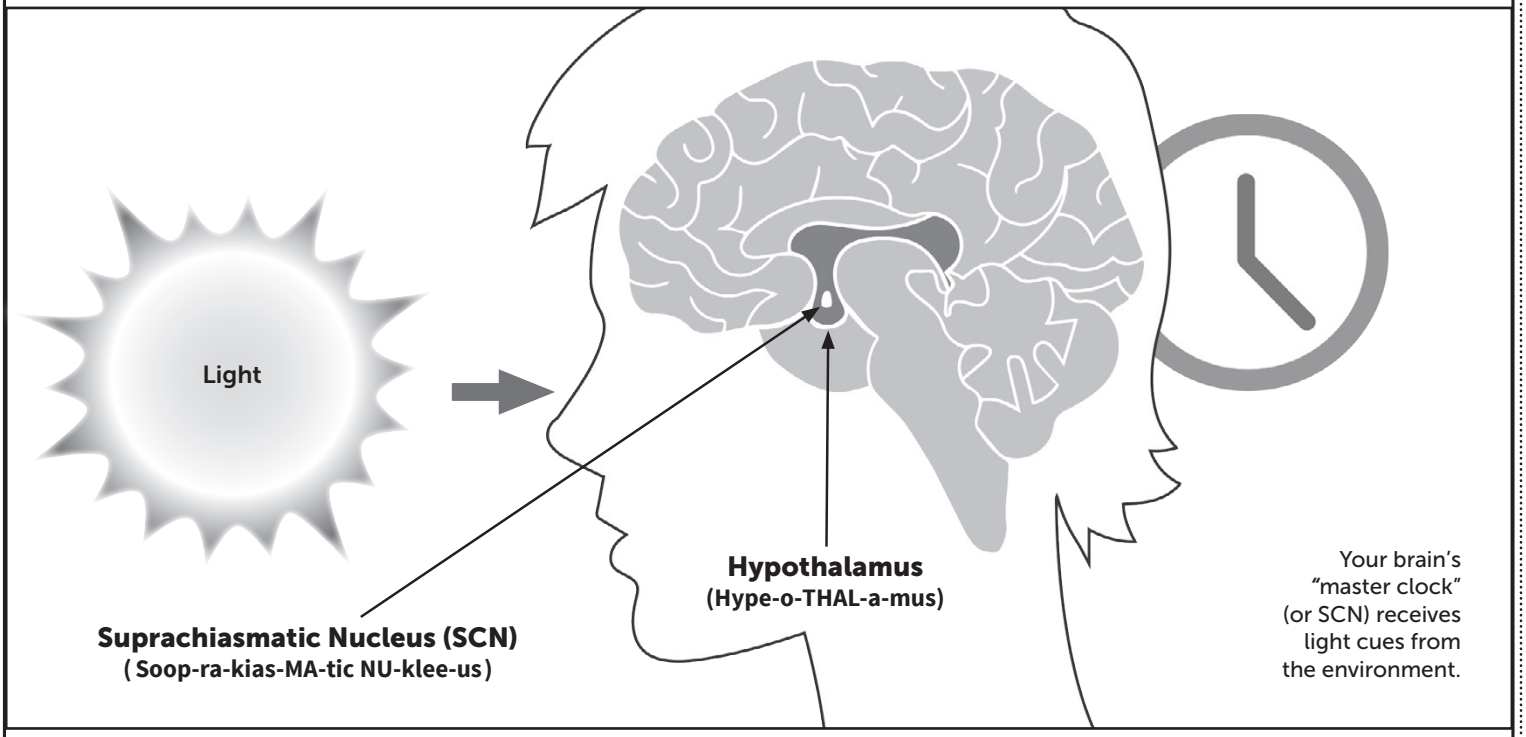
- Hook/get reader's attention (e.g., introduce a stat or a question)
- Explain your chosen topic
- State your position

Claims Craft two or more claims to support your position (your argument). For example: Schools should _____ because that would help students who _____ to _____.	**Claim 1**	**Claim 2**	**Claim 3**
Supporting Evidence Provide research, facts, and scientific findings to support each claim.			

Conclusion

- Restate your position
- Summarize your argument and supporting evidence
- Write a concluding statement and call to action

VOCABULARY LIST



biological clocks *(noun)*: an organism's innate timing devices. Most human cells and organs have a clock. Biological clocks produce circadian rhythms and regulate their timing.

caffeine *(noun)*: a chemical substance, found in products like coffee, tea, and cocoa, which stimulates your brain and body and makes you feel more awake and alert for a little while.

chronotype *(noun)*: the internal circadian rhythm of a person that influences the 24-hour cycle of sleep and activity (aka your "sleep personality," or when you like to go to sleep).

circadian rhythms *(noun)*: physical, mental, and behavioral changes that follow a 24-hour day-night cycle.

gene *(noun)*: a small section of DNA that contains the instructions for making a specific protein.

hypothalamus *(noun)*: a small area in the center of the human brain. It plays an important role in hormone production and helps to stimulate many important processes in the body.

jet lag *(noun)*: a disruption of a person's circadian rhythms from long-distance travel, causing extreme tiredness and other physical effects.

melatonin *(noun)*: a hormone in your body that plays a role in sleep. The production and release of melatonin in the brain is connected to the time of day, increasing when it is dark out and decreasing when it is light out.

neuron *(noun)*: a cell within the nervous system that transmits information to other nerve, muscle, or gland cells.

proteins *(noun)*: large, complex molecules that are essential for all life processes, playing a key role in the structure, function, and regulation of the body's tissues and organs.

sensory receptor *(noun)*: a nerve ending that reacts to a physical stimulus in the internal or external environment.

suprachiasmatic nucleus *(noun)*: a tiny region of the brain in the hypothalamus. It acts as the "master clock," controlling the clocks throughout the body and driving various circadian rhythms adapted to Earth's 24-hour day-night cycle.

synchronize *(verb)*: to occur at the same time.