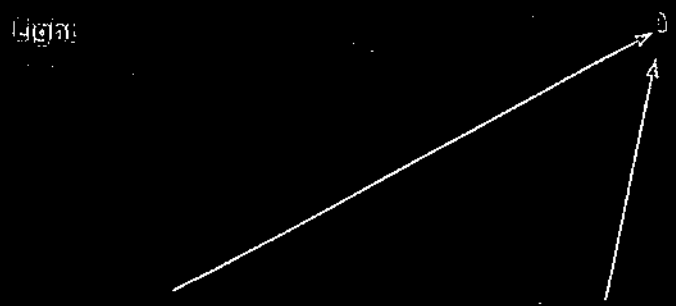
The Science of

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.

Activity

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

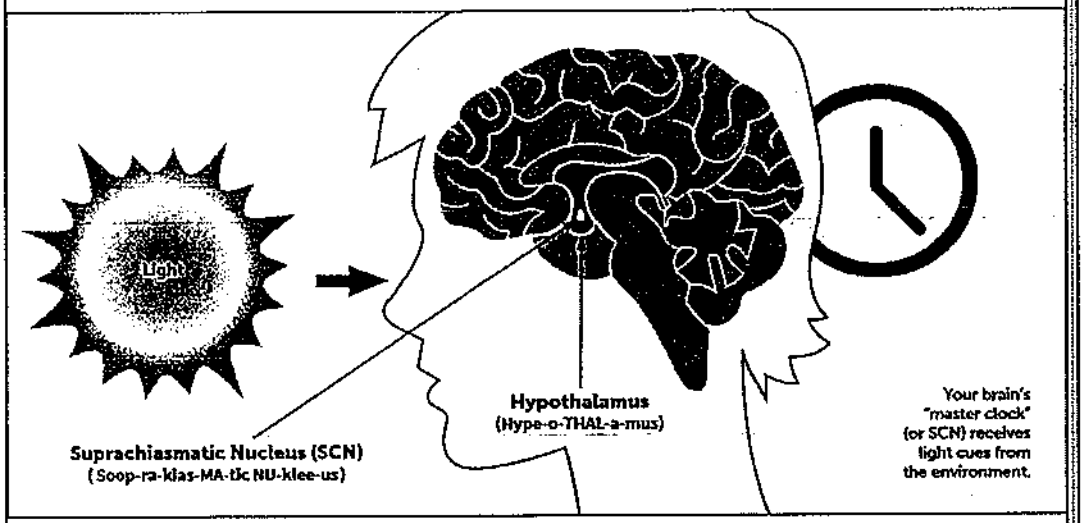
- Hook/get reader's attention (e.g., introduce a stat or a question)
- Explain your chosen topic
- State your position

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.

Keep a Sleep Diary

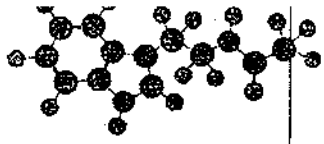
Name _____

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.

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.

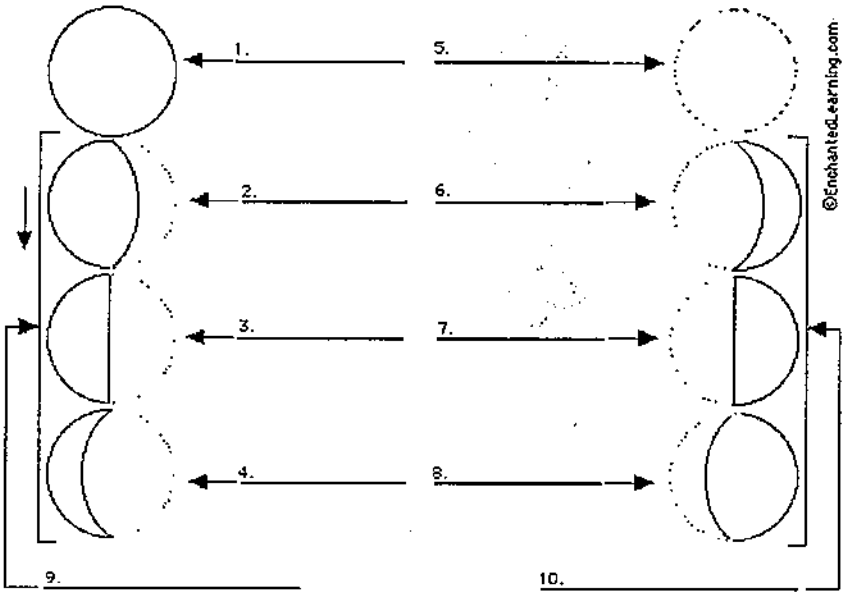
6 **Direct** students to use their data to create a persuasive argument about how either they or their school can use the science of circadian rhythms to improve health and wellness. Consider offering students a choice of how to show their work: essay, infographic, video, slides, or a short talk to the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

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

Name _____

Identifying Phases of the Moon I

Waxing Crescent – A little part of the moon's right side is lit. ***Full Moon*** – The moon's entire disk is lit because the Earth is between the sun and the moon. ***Waxing Gibbous*** – About $\frac{3}{4}^{th}$ of the right side moon's disk is lit. ***1st Quarter*** – The right half of the moon's disk is lit. ***Waxing*** – Getting larger.	***New Moon*** – The moon's disk facing us is dark because the moon is between the sun and the Earth. ***Last Quarter*** – The left half of the moon's disk is lit. ***Waning Crescent*** – A little part of the moon's left side is lit. ***Waning Gibbous*** – About $\frac{3}{4}^{th}$ of the left side moon's disk is lit. ***Waning*** – Getting smaller.



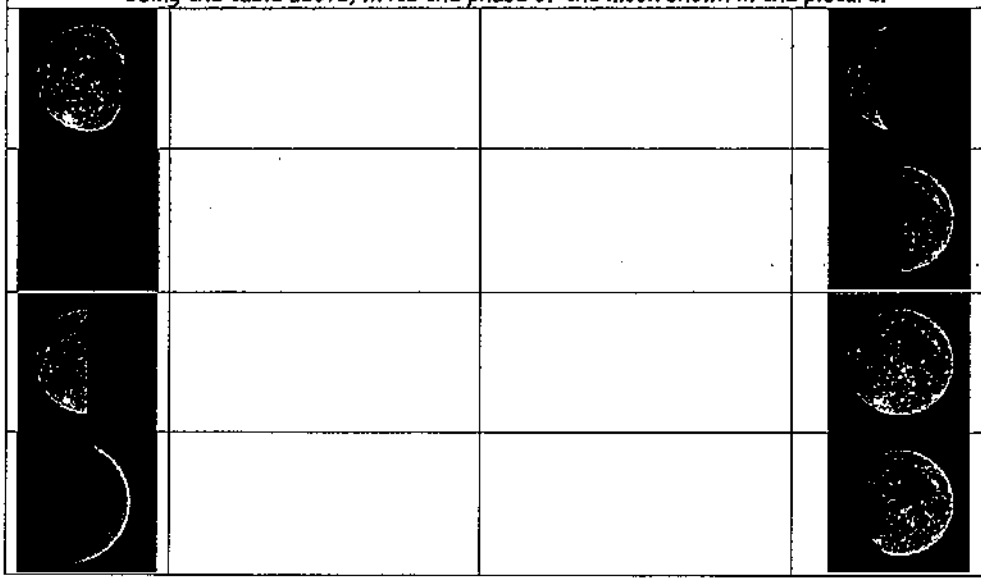
Are Moons 1-4 waxing or waning?

Are Moons 5-8 waxing or waning?

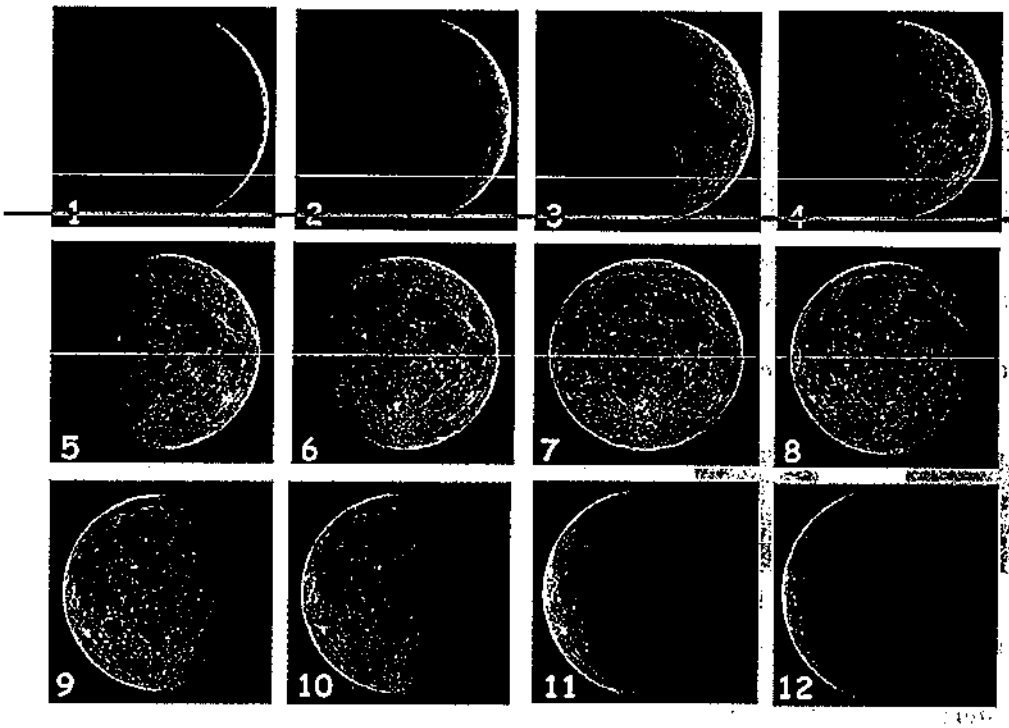
Identifying the Phases of the Moon II

Waxing Crescent – when we can see only a sliver of the moon's disk (*right*-hand side). ***Full Moon*** – when the moon's disk is light because the Earth is between the sun and the moon ***Waxing Gibbous*** – when we can see roughly three-quarters of the moon's disk (the *right* side of the moon is lit). ***First Quarter*** – can see one-half of the moon's disk (at First Quarter, you see the *right* half of the moon lit [this one-quarter of the entire moon's surface]).	***New Moon*** – when the moon's disk is dark (and invisible to us) because the moon is between the sun and the Earth ***Last/3rd Quarter*** – can see one-half of the moon's disk (at Last/3rd Quarter, you see the *left half* of the moon lit [this one-quarter of the entire moon's surface]). ***Waning Gibbous*** – when we can see roughly three-quarters of the moon's disk (the *left side* of the moon is lit). ***Waning Crescent*** – when we can see only a sliver of the moon's disk (*left*-hand side).

Using the table above, write the phase of the moon shown in the picture.



Identifying Phases of the Moon III



Using the pictures above, complete the worksheet.

Which image shows First Quarter? _____ Full? _____ Third Quarter? _____

Which images are crescents? _____ Gibbous? _____

Which images are waxing? _____ through _____

Which images are waning? _____ through _____

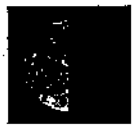
Identifying Phases of the Moon IV

For each of the diagrams below, ***identify the exact phase*** of each and then ***order*** the phases (1 thru 8) in sequence beginning with the New Moon as #1.

A

Phase:

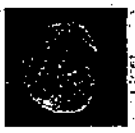
Order:



B

Phase:

Order:



C

Phase:

Order:

D

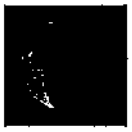
Phase:

Order:

E

Phase:

Order:



F

Phase:

Order:

G

Phase:

Order:

H

Phase:

Order:

Phases:

1. New Moon
2. Waxing Crescent
3. 1st Quarter
4. Waxing Gibbous
5. Full Moon
6. Waning Gibbous
7. Last Quarter
8. Waning Crescent

Matching Moon Phases

Read the description on the left and match it with the Moon phase on the right. Please put the letter of the Moon phase on the far left blank line and draw a line to the matching word.

Example:

1.__b__ The opposite of dark is...

a. gold b. light

_____ 1. The Moon is almost directly between the Sun and Earth (start of cycle).

_____ 2. The Moon is almost directly between the Sun and Earth (cycles starts again.

_____ 3. A bit of the Sunlit side of the Moon shows, with the Sunlit side being on the right.

_____ 4. Two weeks have passed since the new Moon. We see the entire face of the Moon shining.

_____ 5. The Moon is three-quarters of its way around Earth.

_____ 6. The Moon is a quarter of its way around Earth.

_____ 7. A bit of the Sunlit side of the Moon shows with the light side being on the left.

_____ 8. The Moon is between full Moon and last quarter

_____ 9. The Moon is increasing in light between a first quarter Moon and a full Moon.

_____ 10. The Moon is decreasing in light between a full Moon and a last quarter Moon.

a. Waning Gibbous Moon

b. Full Moon

c. New Moon

d. Waxing Crescent Moon

e. First Quarter Moon

f. Waxing Crescent Moon

g. Last/3rd Quarter Moon

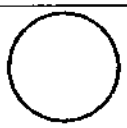
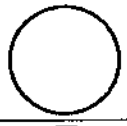
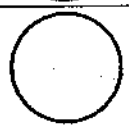
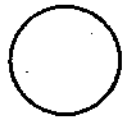
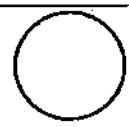
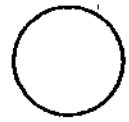
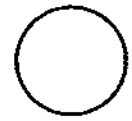
h. Waxing Gibbous Moon

i. Waning Gibbous Moon

j. New Moon

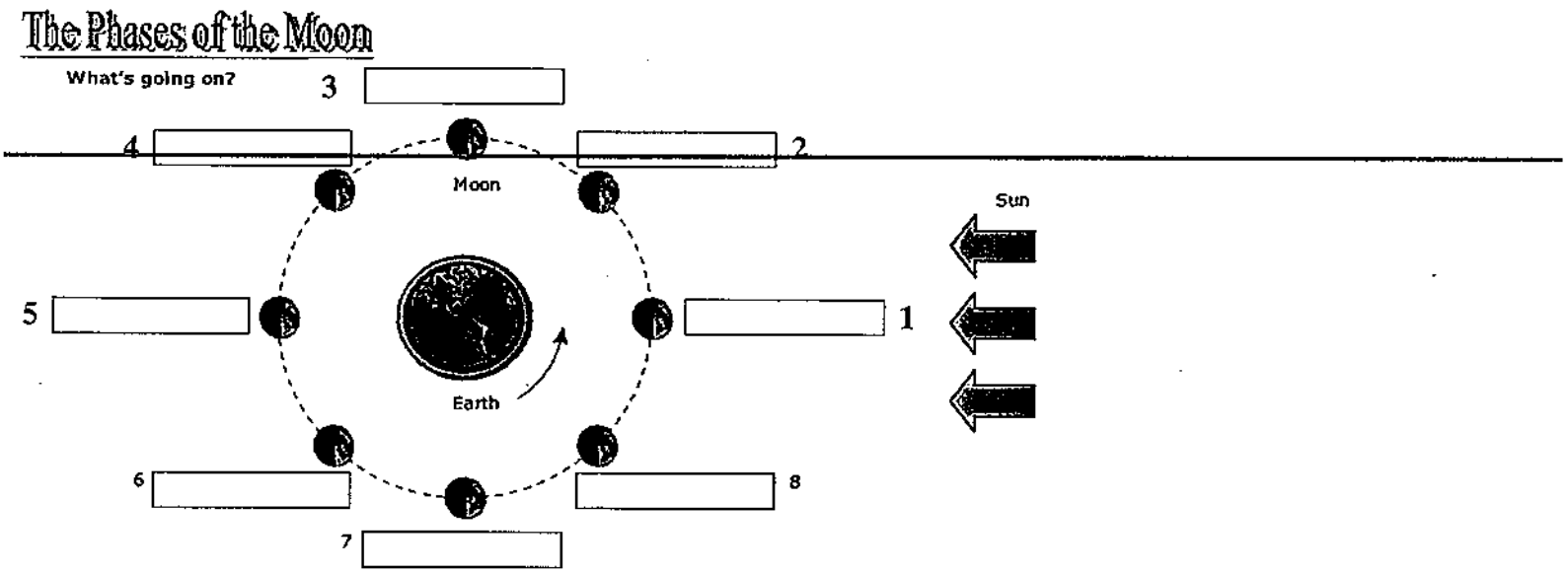
Drawing Moon Phases

Using the description and matching words, complete worksheet by adding the drawing of that phase of the moon.

1. **New Moon** Moon is almost directly between the sun and Earth (start of cycle).	
2. **Waxing Crescent Moon** A bit of the sunlit side of the moon shows on the right side.	
3. **First Quarter Moon** The moon is a quarter of its way around Earth. It is in its first quarter phase.	
4. **Waxing Gibbous Moon** The moon is increasing in light between a first quarter moon and a full moon.	
5. **Full Moon** Two weeks have passed since the new moon. We see the entire face of the moon shining.	
6. **Waning Gibbous Moon** The moon is decreasing in light between a full moon and a last quarter moon.	
7. **Last Quarter Moon** The moon is three-quarters of its way around Earth. It is in its last quarter phase.	
8. **Waning Crescent Moon** A bit of the waning sunlit side of the moon shows on the left side.	

8 Identifying Moon Phases

Complete the diagram below.

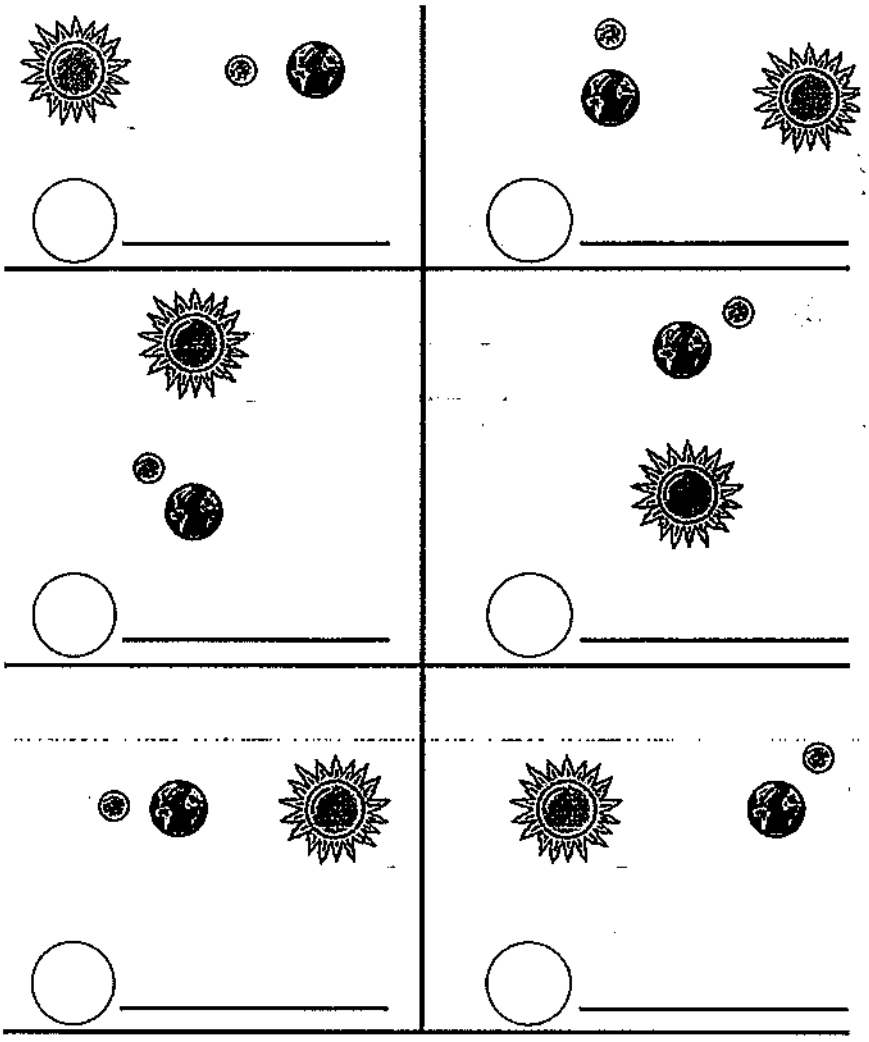


Moon Phases

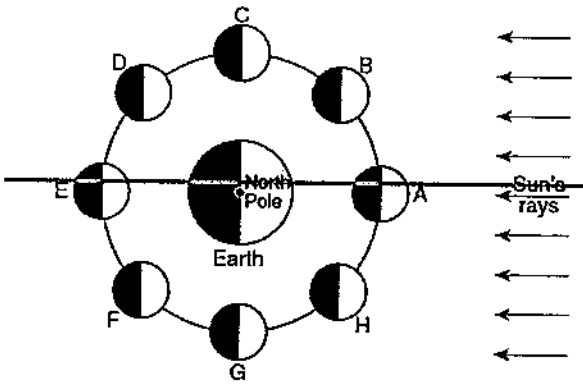
First Quarter
Full Moon
Waning Gibbous
Waxing Gibbous
Last Quarter
New Moon
Waxing Crescent
Waning Crescent

Moon Phases

In the blank circle, draw the Moon phase we would see if we were on Earth in the diagram and write the name of that Moon phase on the blank line.



Use the diagram below to fill in the name of the moon phases for the position indicated by the letter



(Not drawn to scale)

A: _____

C: _____

D: _____

E: _____

G: _____

H: _____

In the space below, draw a diagram with the Sun on the right, so that if we were on Earth we would see a waning crescent moon.

In the space below, draw a diagram with the sun on the left, so that if we were on Earth we would see a waxing quarter moon.

Lunacy

By Ken Kaye, Staff Writer
Sun-Sentinel
(Ft. Lauderdale, FL)
Aug. 11, 2003, pp. D1

The worst things in the world happen during a full Moon, right? Wrong.

For those given to lore, it might seem likely that a full Moon shone on the sinking of the Titanic in 1912, the bombing of Pearl Harbor in 1941 or the Sept. 11, 2001, terrorist attacks.

The full Moon, after all, is frequently associated with dark calamities, if not werewolves and haunted houses.

But that wasn't the case.

Surely, then, the Moon turned full on the day the stock market crashed in 1929, or that Amelia Earhart vanished in 1937 or President John F. Kennedy was assassinated in 1963, right?

Nope.

The fact is a full Moon ... has been in the sky during very few major world events in the past century, which would seem to debunk the myth that lunar forces inspire aberrant behavior or influence the course of history on Earth.

"There are always lots of reports of strange things during a full Moon. But I think if you look at overall statistics, there's no [link]," says Geoff Chester of the U.S. Naval Observatory in Washington, D.C., which has kept a careful record of full Moons dating to 1700.

A review of full Moon dates, compiled by the Naval Observatory, shows that most of the major events of our time took place during some other lunar phase.

For instance, when the atomic bomb was dropped on Hiroshima, Japan, on Aug. 6, 1945, the Moon was in its last-quarter phase. When civil rights leader Martin Luther King Jr. was assassinated in April 1968, the Moon was new. President Richard Nixon's resignation in August 1974 came six days after the full Moon.

Even for humankind's major forays into space, when you might think a full Moon would be appropriate, it was a no-show.

When Soviet cosmonaut Yuri Gagarin became the first man in space in April 1961, the Moon was in its last-quarter phase. When Neil Armstrong took the first step on the lunar surface in July 1969, it was during the gibbous waxing Moon.

Some major developments did happen close to a full Moon:

~~One day after a full Moon, on Feb. 20, 1962, John Glenn became the first American to orbit the~~ Earth.

Two days after a full Moon, on Jan. 28, 1986, the space shuttle Challenger exploded, killing seven astronauts, including schoolteacher Christa McAuliffe.

But of the major historic milestones in the past 100 years, only D-Day, June 6, 1944, when Allied Forces stormed the beaches of northern France to begin the conquest of Germany in Europe, took place during a full Moon.

And that was deliberate: Military commanders wanted lots of Moonlight so airborne troops could land near enemy lines and Navy ships could fire on German targets with precision before dawn...

Strange Things Happen

From a global standpoint, full Moons have seen their share of mayhem:

- On Jan. 16, 1995, a Japan earthquake killed more than 400 people.
- On Nov. 11, 2000, 170 skiers and snowboarders were trapped and killed when their cable car caught fire while being pulled through an Alpine tunnel.
- On Jan. 28, 2002, more than 600 were killed in Nigeria, trying to flee explosions at an army weapons depot, only to drown.

Did the Moon actually provoke any of these episodes?

No way, astronomers and historians say.

"It's pure coincidence," says Travis Wright, an employee at Buehler Planetarium in Davie. "I doubt that it has anything to do with the voice of the universe telling people what to do."

On the other hand, astrologers, or those who think celestial bodies affect the course of human events, say a full Moon makes people more amorous.

"The Moon affects tides, and since our bodies are mostly water, there probably is a physical reaction," says Linea Van Horn, an accredited astrologer who works for Astrology.com, the largest astrological site on the Internet, based in San Francisco. "When it's big and beautiful in the sky, it does awaken something in us humans."

According to folklore, the full Moon usually has negative connotations, says Christine Jackson, a professor of humanities at Nova Southeastern University in Davie.

For instance, she says it is believed the full Moon triggers more suicides than usual and sends more people to mental institutions.

In fiction and film, the Werewolf needed the light of the full Moon to come to life, and Dracula had to avoid Moonlight to suck blood from his victims.

In the recent movie, *Pirates of the Caribbean, moonlight* revealed the pirates were half-dead, nothing but skeletons.

"So the light of a full Moon can sometimes show death," she says

Only a Minute

Astronomically speaking, a full Moon occurs for about one minute, when the Moon and the Sun are on opposite sides of the Earth. The reason this instant is so short is that all three bodies are in constant motion.

However, planetarium officials consider the full Moon to occur over a full day and even more loosely, over three days, says Jack Horkheimer, director of Miami Planetarium.

"The night before a full Moon and night after full Moon look that same to the untrained eye," he says.

The Moon has four major phases in a month, or more precisely, 29.5 days: New Moon, first quarter, full Moon, and last quarter.

Those phases are further broken down into waxing crescent, waxing gibbous, waning crescent and waning gibbous, based on how much of the lighted surface is visible...

Horkheimer says the myth that the Moon creates strange events arises from ancient times, when there were few cities and the countryside was extremely dark on Moonless nights.

The full Moon provided enough light for people to attend festivals and other gatherings at night. This was when they were most susceptible to thieves, pickpockets and robbers, he says.

That led to the fear that the full Moon created havoc in people's lives, he says.

Today, police can't say for sure whether crime increases during a full Moon, other than to say the "freaks" tend to come out. But then, they note such people come out the rest of [the] time as well.

"In general, in South Florida, it's irrelevant whether the Moon's in or out," says Hollywood Police Lt. Tony Rode. "We have our fair share of crime either way."

As for that term "lunatics," derived from "Luna," the Roman Moon goddess: Horkheimer says the light of a full Moon might keep people up at night, and a lack of sleep might make them cranky, if not crazy.

But does the full Moon inspire werewolves to howl or monsters to come out?

Only in people's imaginations, Horkheimer says.

"People want to believe in the mysterious, in magic and in things beyond their control," he said. "So if something happens they can say it must have been the full Moon."

Moon Facts

- The Moon is believed to be 4.6 billion years old, the same age as the Earth.
- It has no atmosphere or water.
- It is comprised of a rocky material that is heavily scarred with craters from meteorite impacts.
- The same side is permanently turned toward Earth.
- The gravitational forces between the Earth and the Moon generate two ocean high tides per day.
- The word "lunatic" comes from the notion that the Moon's forces could make a person go crazy.
- The Moon is moving away from the Earth at a rate of 3.8 centimeters each year. When it formed, the Moon was about 14,000 miles from Earth; now it's about 240,000 miles away.

Moon Nicknames

- January: Wolf Moon
- February: Ice or Snow Moon
- March: Storm or Worm Moon
- April: Growing or Pink Moon
- May: Hare or Flower Moon
- June: Mead or Strawberry Moon
- July: Hay or Buck Moon
- August: Corn or Sturgeon Moon
- September: Harvest Moon
- October: Blood or Hunter's Moon
- November: Snow or Beaver Moon
- December: Cold Moon

Historic Moon Events

- Dec. 16, 1773: Boston Tea Party; new Moon
- July 4, 1776: Declaration of Independence; waning gibbous.
- April 12, 1865: Surrender of the Confederate Army after the battle of Appomattox, signaling the end of the Civil War; waning gibbous
- April 14, 1865: President Abraham Lincoln assassinated; waning gibbous

Lunacy Worksheet

1. Lunar forces inspire unusual behavior or influence the course of history on Earth.

   a. True b. False

2. Most of the major events of our time did not happen during a Full Moon.

   a. True b. False

3. According to astronomers and historians, a full Moon causing bad things to happen is pure _____.

4. A full Moon occurs _____.