Sponsored Educational Materials

SCHOLASTIC

The Anesthesia Issue

PATHWAYS

What is this?

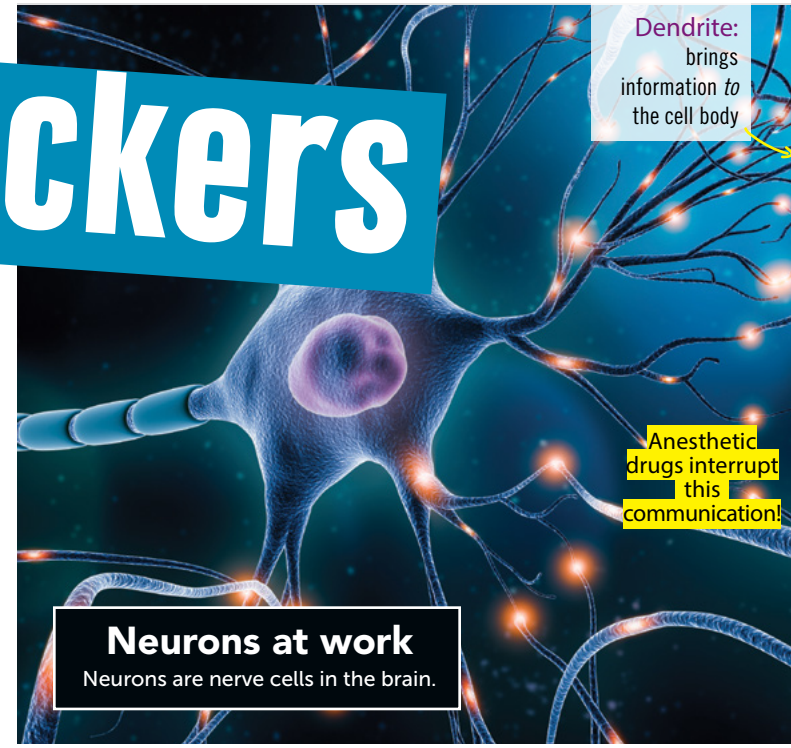
And what does it have to do with controlling how you feel **pain**?

(Find out inside!)

NIH National Institute of General Medical Sciences

Pain Blockers

Anesthesia has numbed the pain involved in dental work and enabled life-saving surgeries. Read on to learn how medical research is fueling innovation in pain prevention.



Neurons at work
Neurons are nerve cells in the brain.

It might surprise you to know that **anesthesia**, the medical treatment that prevents patients from feeling pain during surgery (and other medical procedures), is a relatively modern discovery.

"General anesthesia—it changed medicine practically overnight," says Dr. Emery Brown, professor of anesthesia at Massachusetts General Hospital/Harvard Medical School. "Life-saving procedures like open-heart surgery and organ transplantation would be impossible without it."

THREE TYPES OF ANESTHESIA

Patients remain **conscious** when receiving an injection of either **local anesthesia**, which numbs a small area (like near a tooth), or **regional anesthesia**, which numbs a larger area (such as around a knee). In contrast, **general anesthesia** puts patients into an **unconscious** state, enabling procedures like heart surgery. Plus, research has shown that managing pain during surgery—with a dose of anesthetic that thoroughly blocks pain signals during unconsciousness—may prevent or reduce pain *after* surgery.

ANESTHESIA AND CONSCIOUSNESS

"As recently as 175 years ago," says Dr. Margaret Sedensky, professor and researcher at the University of Washington and Seattle Children's Research Institute, "surgery was pretty rare, very dangerous, and a last resort." Those who did undergo surgery did so fully conscious. "Imagine a patient dying of appendicitis because surgery was basically impossible. The discovery of general anesthetics changed medicine in a way that is hard for us to imagine today."

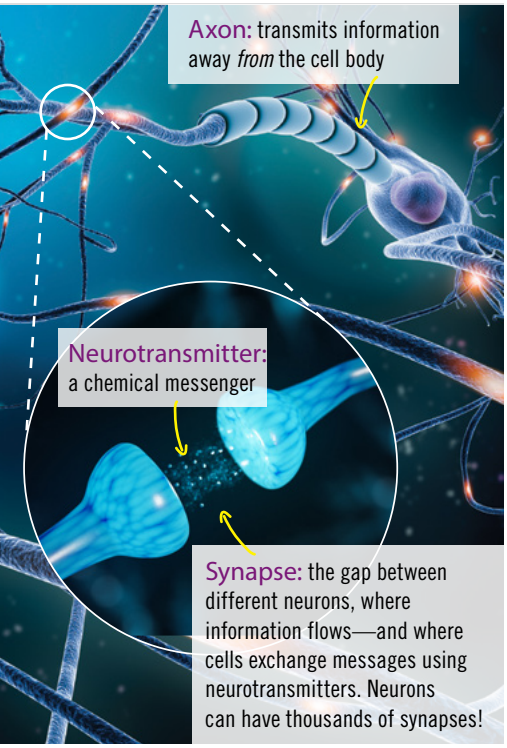
General anesthetics have been safely given to millions of Americans but until recently have been considered a medical mystery. "To me, it's still amazing! We have **receptors** somewhere inside of us that pick up anesthetizing compounds, allowing us to have surgery unconscious, completely still, with no pain. When surgery is over, voila! We're conscious again with no memory of the procedure. Very mysterious," says Dr. Sedensky.

THE FUTURE OF ANESTHESIOLOGY

Today, **anesthesiologists** and researchers are working to learn more. "There is so much that we don't know," says Dr. Jing Wang, an anesthesiologist and associate professor who conducts research at NYU. "What is consciousness? What neural activity defines the lack of consciousness? How do we experience pain via our neural pathways?"

Cover: Top image—a neuron's dendrites (in green). Main image—a synapse with neurotransmitters, sending messages between neurons. Scientists can influence neuronal networks to control how you feel pain.

Images: neurons, libre de droit/Getty Images; Dr. Brown and EEG graphic, Dr. Emery Brown, Massachusetts General Hospital and Massachusetts Institute of Technology



Anesthesia Research Currently Underway

HOW MUCH DO WE NEED?

Dr. Brown is on a quest to develop perfectly controllable anesthesia techniques so when patients undergo surgery, they receive only the amount of anesthesia they need. He wants patients to experience surgery without side effects like nausea or confusion afterward.

HUNTING FOR BINDING SITES

In order for general anesthetics to cause unconsciousness, molecules of the anesthetic drug must attach to molecules in the human body. But where in our cells are these **binding sites**? Dr. Sedensky wants to find out. Knowing the binding sites' structure and function could lead to the discovery of even safer anesthetics that have fewer side effects. Plus, her work could reveal a lot about how the **central nervous system** works. That could lead other researchers to better understand conditions like epilepsy.

DISCOVERING BIOMARKERS

Dr. Wang investigates how the brain perceives and regulates pain. Those experiencing chronic pain, for example, process certain signals in their brains differently. His lab is developing a **neuroengineering** tool that, with the help of **machine learning**, could lead to the discovery of a definitive biomarker [something measureable in the body] for pain. Finding this biomarker would help anesthesiologists identify and treat pain in real time, as well as screen for new pain relievers that could replace opioids, which can be addictive.

Q&A With a Science All-Star

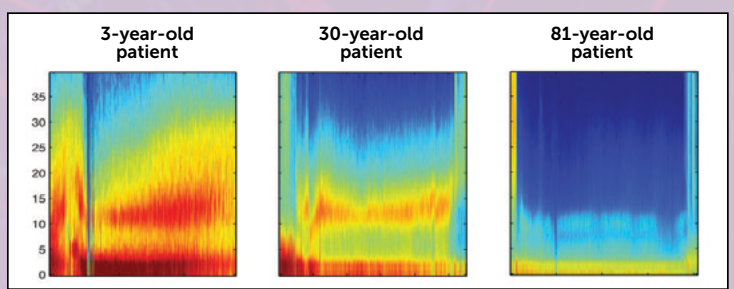
Dr. Emery Brown, M.D., Ph.D.

Professor of Anesthesia, Massachusetts General Hospital/ Harvard Medical School/MIT

What do we know so far about how anesthetic drugs work? The brain is a big collection of highly interconnected regions that communicate with each other—a lot like electrical circuits. The circuits produce rhythms, known as brain waves. General anesthesia interrupts and overpowers the natural waves that travel between the brain's **thalamus**, **cortex**, and **brainstem**, resulting in an unconscious patient who does not perceive pain.

What do brain waves under anesthesia show us? Different anesthetics affect the brain differently. Using the electroencephalogram (EEG), an instrument that measures brain waves (brain activity), it's possible to tell which anesthetic a patient is receiving, the dose, and how unconscious they are. Collecting and analyzing brain wave information allows anesthesiologists to create better outcomes for individual patients. The science we uncover may also help people sleep better and identify new ways to treat depression.

What advice do you have for students interested in biomedical research careers? Find a problem you are passionate about. Learn as much as you can or get involved in research. Do not be shy about writing directly to an expert to ask questions!

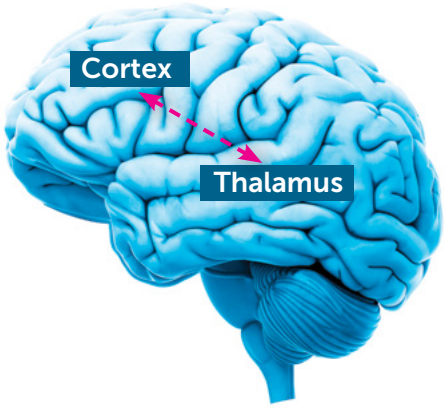


Captured by Dr. Brown, EEG information shows that the same general anesthetic drug affects patients' brain activity differently—depending on age.

BRAIN WAVES CHALLENGE!

Why might interrupting the normal communication between the brain's cortex and thalamus affect a person's alertness and consciousness?

Cortex In charge of processing or deciding what to do with the signals it receives. It's responsible for many things humans are able to do: think, move, remember, feel sensations, and remain alert.



Thalamus Responsible for receiving sensory and movement signals from the body and relaying them to different parts of the brain.

Answer: If a person's cortex doesn't receive sensory or movement signals from their thalamus, they won't be as alert or aware of sensations.

Scientists in the Spotlight

Still have questions for some of anesthesiology's top researchers? So do we!

Kristin Schreiber, M.D., Ph.D.

Associate Professor, Harvard Medical School; Associate Vice Chair of Anesthesiology Research, Brigham & Women's Hospital

Wants to find out: how people's nervous systems process pain differently

How do your roles as an ***anesthesiologist*** and ***anesthesiology researcher*** differ?

As an anesthesiologist, I do a pretty intense assessment of a patient's health from head to toe, and I help calm their fears about surgery. I feel a very close connection with my patients.

When they're unconscious, I'm with them the whole time, monitoring and stabilizing their vital signs and keeping them safe. As they're "waking up," I'm making sure the transition goes smoothly and making sure they don't have pain.

As a researcher, I help patients by exploring personalized medicine—learning more about how pain is processed differently by different people and finding out if they do better with different medications.

I would like to find out more about what's happening in the pain processing centers in the brain when people use active coping strategies like exercise, good nutrition, meditation, and mindfulness to help better control pain.

Jing Wang, M.D., Ph.D.

Associate Professor of Anesthesiology, Director of Pain Research, NYU Grossman School of Medicine

Wants to find out: how the brain perceives and regulates pain

What do you think might surprise students about anesthesiologists?

When people think of anesthesia, they tend to think of doctors who wear scrubs and work in the operating room. But anesthesiologists are also pain doctors who can help to treat patients outside of the operating room, like in clinics for chronic pain or in intensive care units for acute pain.

We work with medical and surgical problems and all organ systems, so there are so many questions we can ask and answer.

What advice do you have for students interested in biomedical research careers?

Always ask questions. Question why! Question how! Don't be satisfied with what we can do in medicine—think about what we cannot do yet and let that drive you to make real discoveries that will benefit people. All it takes is a curious mind!

Susana Vacas, M.D., Ph.D.

Assistant Professor, University of California Los Angeles

Wants to find out: how we can help a patient's brain and body recover after they have surgery

What do you think might surprise students about anesthesiologists?

During surgery, anesthesiologists take care of not only a patient's brain but also their entire body—their breathing, heart, liver, and kidneys.

What do you hope to discover?

I want to understand what happens during anesthesia—from the molecular level to the big picture, like how patients' brains look before and after surgery. Each discovery will lead to new questions about how things work and how we can improve upon the things we're already doing.

What advice do you have for students interested in biomedical research careers?

Start now! Look for volunteer opportunities at a hospital or in a lab. Be curious about the world and the people around you. If you have curiosity and empathy for others, there will always be ways to further science and improve people's health and lives.

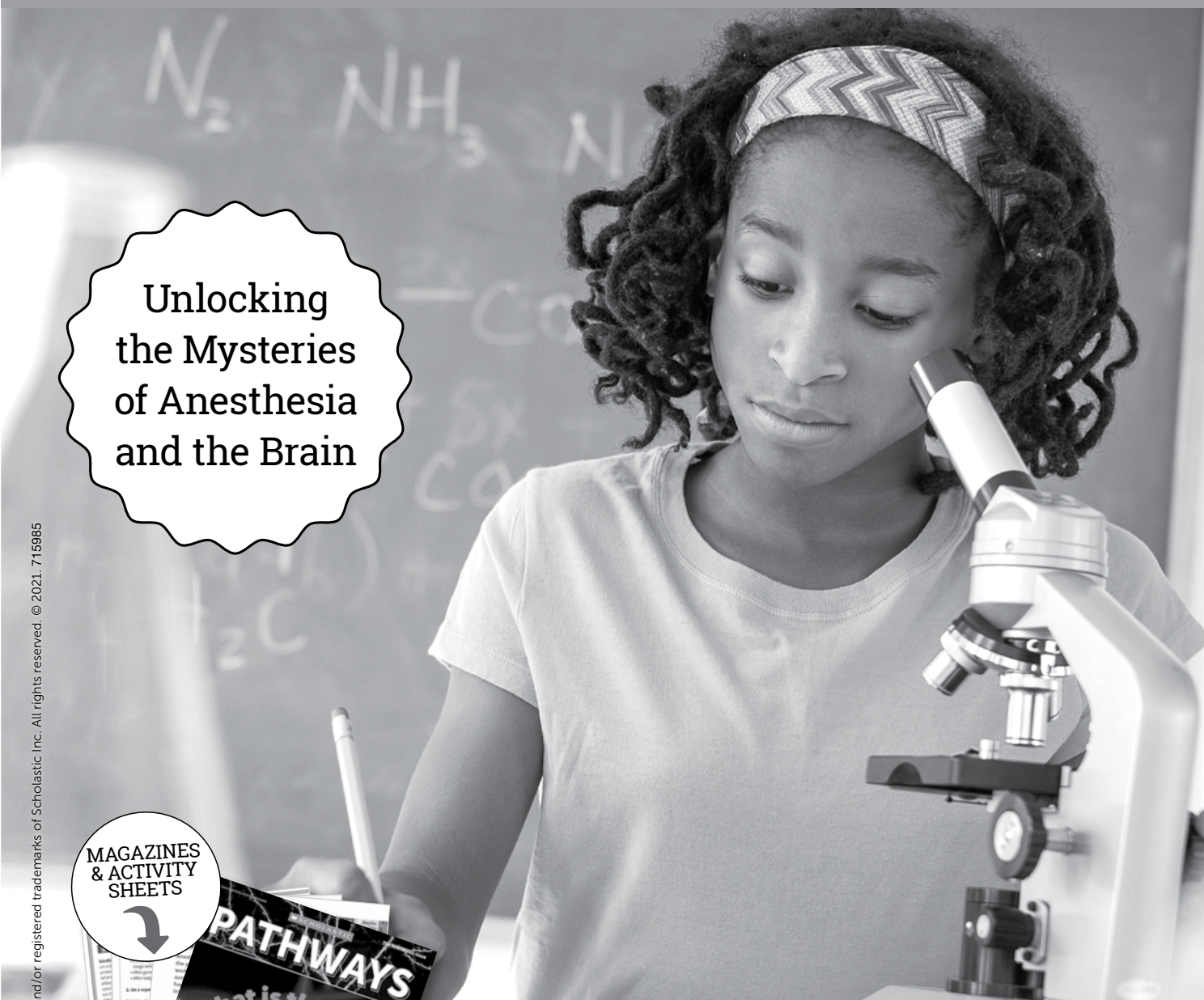
Illustration: Sebastian Kaulitzki/Science Photo Library/Getty Images; Scientists in the Spotlight photos: courtesy of interviewees

Sponsored Educational Materials

SCHOLASTIC

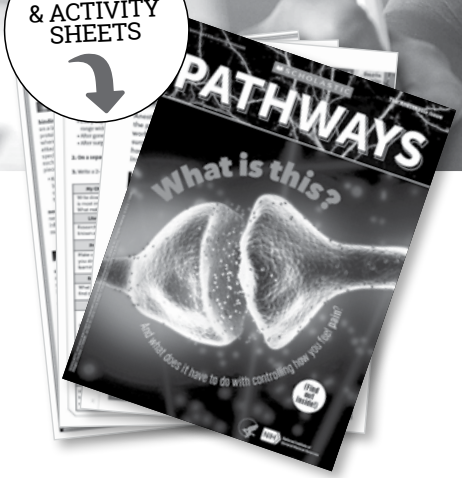
GRADES 6–12

PATHWAYS



Unlocking the Mysteries of Anesthesia and the Brain

MAGAZINES & ACTIVITY SHEETS



TEACHING GUIDE

Science and ELA Activities
Investigating Anesthesia and Research Careers

Visit **scholastic.com/pathways** for additional lessons, videos, and more.

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NIH National Institute of General Medical Sciences

Photo: Tom Grill/JGI/Getty Images

The Science of Anesthesia: How Scientists Research Mysteries of Pain and Consciousness

Anesthesiology researchers are on the case, working to find answers to questions that have stumped modern medicine for decades! Have your students join in the search for answers.

Objective

Students will develop their literacy in science skills and practice writing for a domain-specific purpose.

NGSS

- **LS1.D** Signal processing in the brain
- **MS-LS1-3** Body subsystems (nervous system)
- **CCC** Science is a Human Endeavor

CCSS Literacy in Science

- **RST.2** Summarize conclusions and central ideas of a text
- **W.4** Produce writing appropriate to task, purpose, and audience

Time

1–2 periods, depending on time allotted to work and peer review

Materials

- *Pathways* classroom magazine
- Respond to Anesthesia Research activity sheet
- Write Like a Medical Detective activity sheet

1 **Ask:** *If a person were lying here on the floor with their eyes closed (and you could see that they were breathing), what are some of the ways you could test to see whether they were asleep or unconscious?* Prompt for answers like: I could try to wake them (gently shaking or pinching their arm; making a loud noise). I could use observation (are they moving or perfectly still?).

2 **Tell** students they will be learning more about general anesthesia and how it creates a state of unconsciousness and painlessness in patients who need surgery and other major medical procedures. Contrary to what people may believe, patients who are under anesthesia are not "asleep" and can't be woken in the conventional way. Although anesthesia is commonly used, there's a lot we still have to learn about *how* anesthetics produce their effects in the brain. Researchers are at work right now on solving that mystery, so we can use anesthetics in even more effective ways.

3 **Explain** that anesthesiology researchers are interested in finding out more about the state of unconsciousness, the ways people perceive pain, and the mechanisms in the human body that respond to anesthetics.

4 **Distribute** the **classroom magazine** and the **Respond to Anesthesia Research activity sheet**. Have students read the magazine and respond to the questions. Refer to the vocabulary sheet (**scholastic.com/pathways)** as needed.

5 **As a class,** conduct a brainstorming discussion. If students were researchers in a lab, how might they conduct research to answer questions such as: What is pain? What is unconsciousness? How can pain be measured? Consider possible experiment designs, real and hypothetical tools (e.g., a tool that tracks neurotransmitter activity throughout the brain), and vital signs to measure (e.g., heart rate).

6 **Distribute** the **Write Like a Medical Detective activity sheet**. Taking on the role of anesthesiology researcher, students will design a research question and a simple study. Encourage them to draw connections to their classroom learning (life sciences, engineering, technology, and applications of science) where possible.

7 **Once complete,** have students trade proposals and play the role of reviewer. Reviewers should comment on the design of the study and the wider implications of the research. Which questions would they like answered before they grant funding for the project?

Answer Key: Respond to Anesthesia Research activity sheet

1. Surgery was too painful and/or dangerous. General anesthesia makes life-saving procedures possible and contributes to longer, healthier lives.
2. Anesthesiology researchers are seeking to understand pain, consciousness, and unconsciousness. They want to make anesthesia safer, with fewer side effects, and tailor treatment to individual patients. Implications for other research: better understanding of central nervous system, treatment of neurological conditions like epilepsy, alternatives to opioids.
3. EEG, machine learning, neuroengineering [can vary]
4. Varied student responses

Name _____

Respond to Anesthesia Research

Read the *Pathways* classroom magazine, then answer the questions below.

1. Why was surgery considered a "last resort" before the discovery of general anesthesia? Why is the discovery of anesthesia significant?

2. What sorts of things are anesthesiology researchers trying to find out? How might their research have wider implications for other research and health care in general?

3. What kinds of interesting technology, tools, and methods are anesthesiology researchers currently using in their work? List three examples.

4. Choose one of the anesthesiology researchers featured in the magazine. Summarize their research. What are they studying? What are they hoping to achieve? How will their research help people? If you had the chance to interview them about their research to find out more, what questions would you ask?

Write Like a Medical Detective

A *grant*—money given for a particular purpose—often provides the funding needed for scientists to investigate medical mysteries and make discoveries by conducting research. Use the steps below to design and seek funding for your own anesthesiology research project!

1. Choose ONE prompt that interests you most:

- Every day about 60,000 people nationwide have surgery under general anesthesia. Surgery patients range widely in age, genetics, and health, and do not all respond exactly the same to anesthesia.
- After general anesthesia, some patients experience side effects like nausea and confusion.
- After surgery, when anesthesia wears off, some patients feel pain and discomfort.

2. On a separate page, create and fill a planner like the example below about your own research idea.

3. Write a 2–3 paragraph grant proposal, persuading reviewers to fund your research.

My Chosen Prompt Write down the prompt that is most interesting to you. What makes you curious?	Prompt: "After general anesthesia, some patients experience side effects like nausea and confusion." I'm curious about: why some patients experience nausea and others do not.
Literature Review Research what is already known about your topic.	My research reveals that nausea could be related to dehydration since patients often aren't able to eat and drink in the hours leading up to surgery.
Prior Knowledge Make connections to things you already know or are learning about.	I know that leading up to a big race, long distance runners take care to hydrate their bodies well because they can't drink a lot of fluid while running. I know that ***homeostasis*** helps to keep fluid levels steady in the human body. I know that thirst and dehydration are related to homeostasis.
Research Question What would you like to find out?	Do patients who hydrate well in the days leading up to surgery experience nausea after surgery less frequently than patients who do not?
Study Design Explain in simple terms how you plan to test your research question.	My study will compare two groups. Group A will be advised to drink the recommended number of ounces of water per their body weight in the four days leading up to surgery. Group B is the control and will not receive any special instructions. My study will track body fluid homeostasis once a day leading up to surgery, right before surgery, and during emergence from surgery with the help of blood tests. My study will compare reported instances of nausea with body fluid homeostasis data to see if there is a connection.
Tools & Methods What will you use?	My study will use a *serum osmolality test*—which checks levels of sodium and other essential minerals in the blood—as a measure of homeostasis.
Implications How could your research help patients or other researchers?	The findings of my research could: • provide a simple preventive intervention for postoperative nausea • inspire future researchers to develop easier ways to monitor body fluid homeostasis • help inform research on other patients who experience nausea, such as migraine sufferers and those undergoing cancer treatment

VOCABULARY LIST

BRAIN & BODY

binding site *(noun):* a region on a large molecule, such as a protein within a living organism, where another molecule can attach (called binding). Only specific molecules can attach to each binding site (think of puzzle pieces fitting together).

- Knowing the shape of a binding site helps scientists create targeted drug treatments.

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

BRAIN STATES

conscious *(adjective):* awake and aware of one's thoughts and surroundings; alert to sensations in the body and able to respond.

unconscious *(adjective):* not awake or aware, due to an interruption in communication between different parts of the brain.

- Unconsciousness is a different state than sleep. For example, a sleeping person can be woken by a loud noise, but an unconscious person cannot. While a person can fall asleep naturally, they can't become unconscious unless they receive anesthesia or experience a head injury, such as a concussion.

PAIN

acute pain *(noun):* pain that lets you know you may be hurt or have a problem you need to do something about.

- The nerves in the injured part of your body send messages to the brain about the situation. Your brain then makes you feel pain.

chronic pain *(noun):* pain that may last for weeks, months, or even years. There are many causes of chronic pain.

ANESTHESIA & RESEARCH

anesthesia *(noun):* a loss of sensation; a medical treatment that prevents patients from feeling pain during surgery and other medical procedures.

- Some *anesthetics* (drugs doctors use to produce anesthesia) cause numbness in a specific area, while others cause unconsciousness as well.

anesthesia researcher *(noun):* a scientist who studies anesthesia and its effects on the brain and body in order to investigate questions about the nature of pain, consciousness, and unconsciousness, and how to develop even more effective anesthetics.

anesthesiologist *(noun):* a doctor who administers anesthesia and treats pain.

- Anesthesiologists carefully monitor patients throughout a medical procedure using a variety of devices that display blood pressure, blood oxygen levels, heart function, and respiration. They adjust medications as needed to make sure each patient remains safe.
- Anesthesiologists can also help treat chronic or acute pain outside the operating room, and may conduct research as well.

machine learning *(noun):* a type of artificial intelligence in which computer algorithms (sets of rules and procedures) are developed to analyze and make predictions from data that's fed into the system.

neuroengineering *(noun):* the field combining engineering techniques and technology with neuroscience (the study of the nervous system).

TAKE IT FURTHER

Choose five vocabulary words that you think will be the hardest to remember, then write a paragraph with them (nonfiction or fiction).