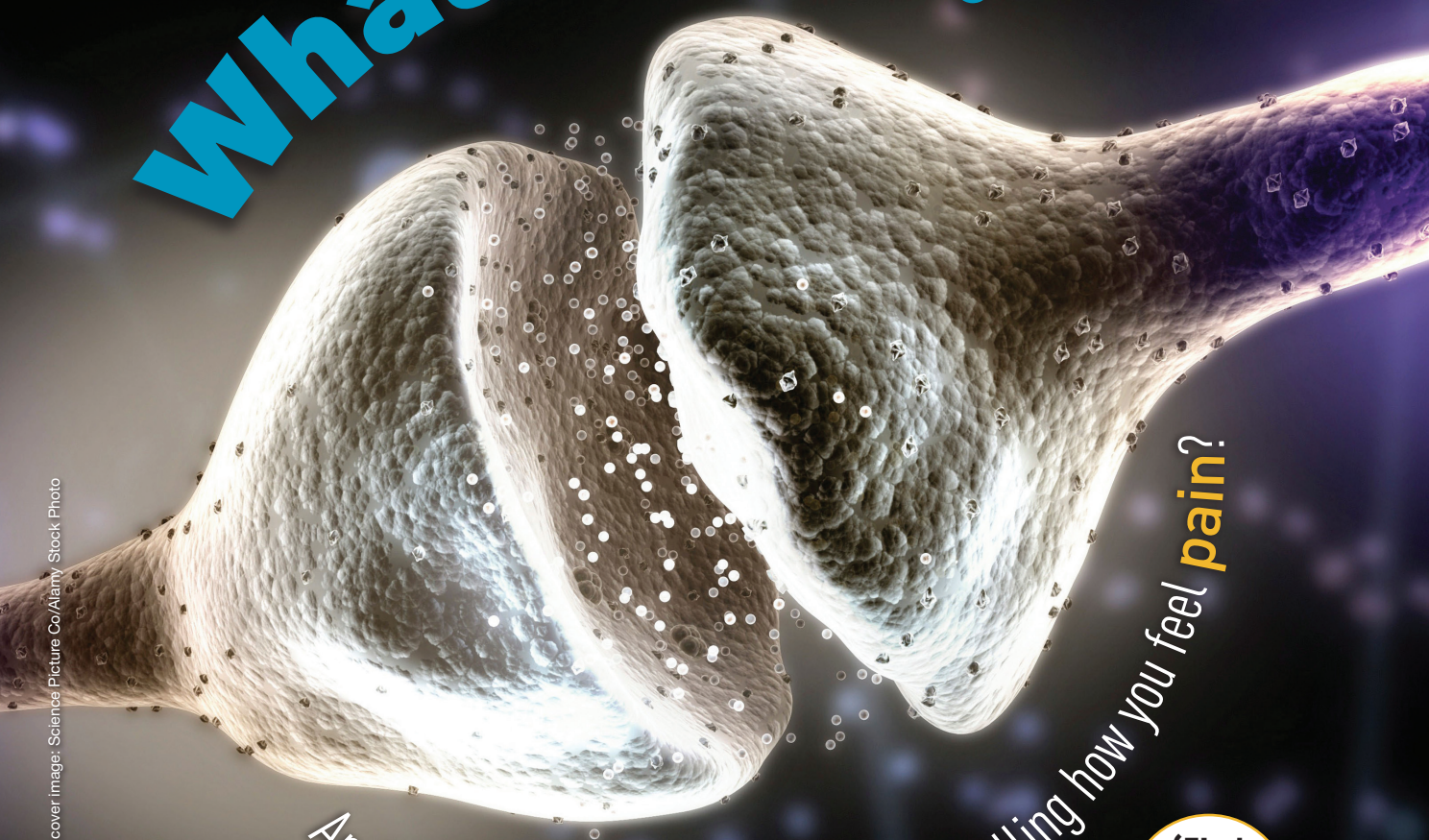
nigms.nih.gov/education/pathways

The Anesthesia Issue

PATHWAYS

What is this?



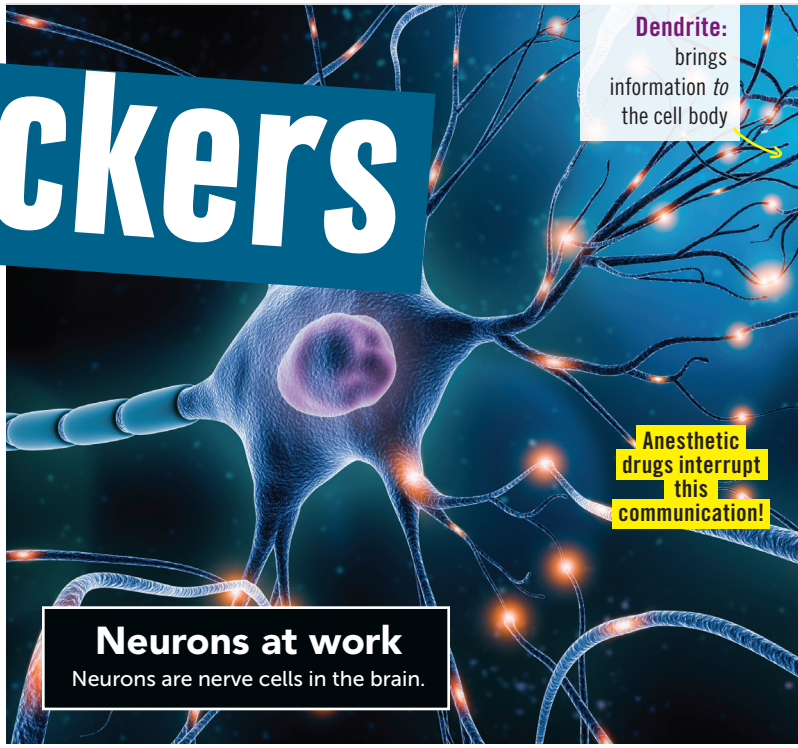
And what does it have to do with controlling how you feel pain?

(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."

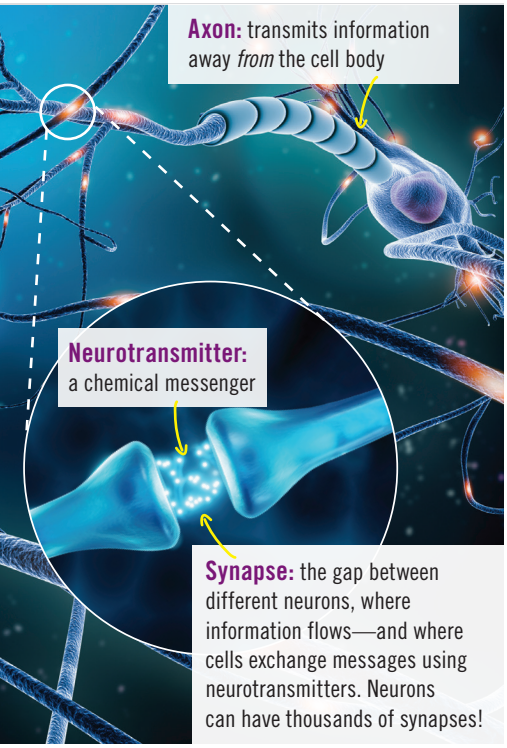
General anesthetics have been safely given to millions of Americans but until recently have been considered a medical mystery. "To me, it's still amazing! We have **receptors** somewhere inside of us that pick up anesthetizing compounds, allowing us to have surgery unconscious, completely still, with 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/Adobe Stock; 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

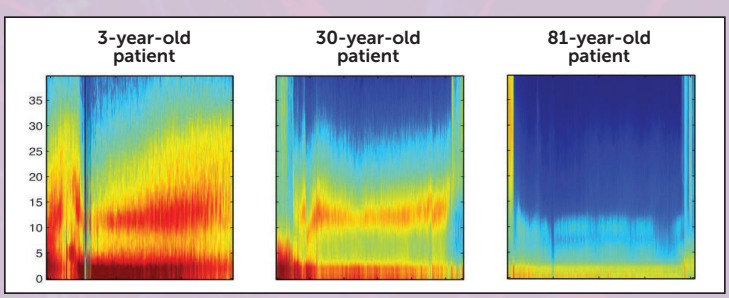
Dr. Wang investigates how the brain perceives and regulates pain. Those experiencing chronic pain, for example, process certain signals in their brains differently. His lab is developing a **neuroengineering** tool that, with the help of **machine learning**, could lead to the discovery of a definitive 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.



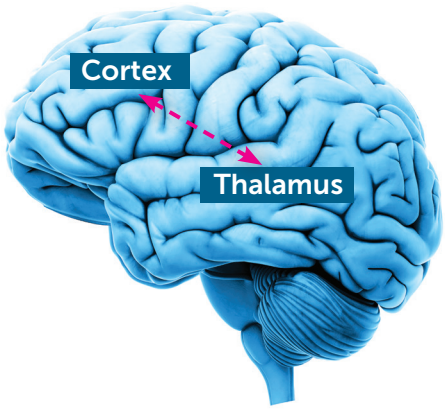
Captured by Dr. Brown, EEG information shows that the same general anesthetic drug affects patients' brain activity differently—depending on age.

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!

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/Adobe Stock; Scientists in the Spotlight photos: courtesy of interviewees

NIH Publication number: 21-GM-8161