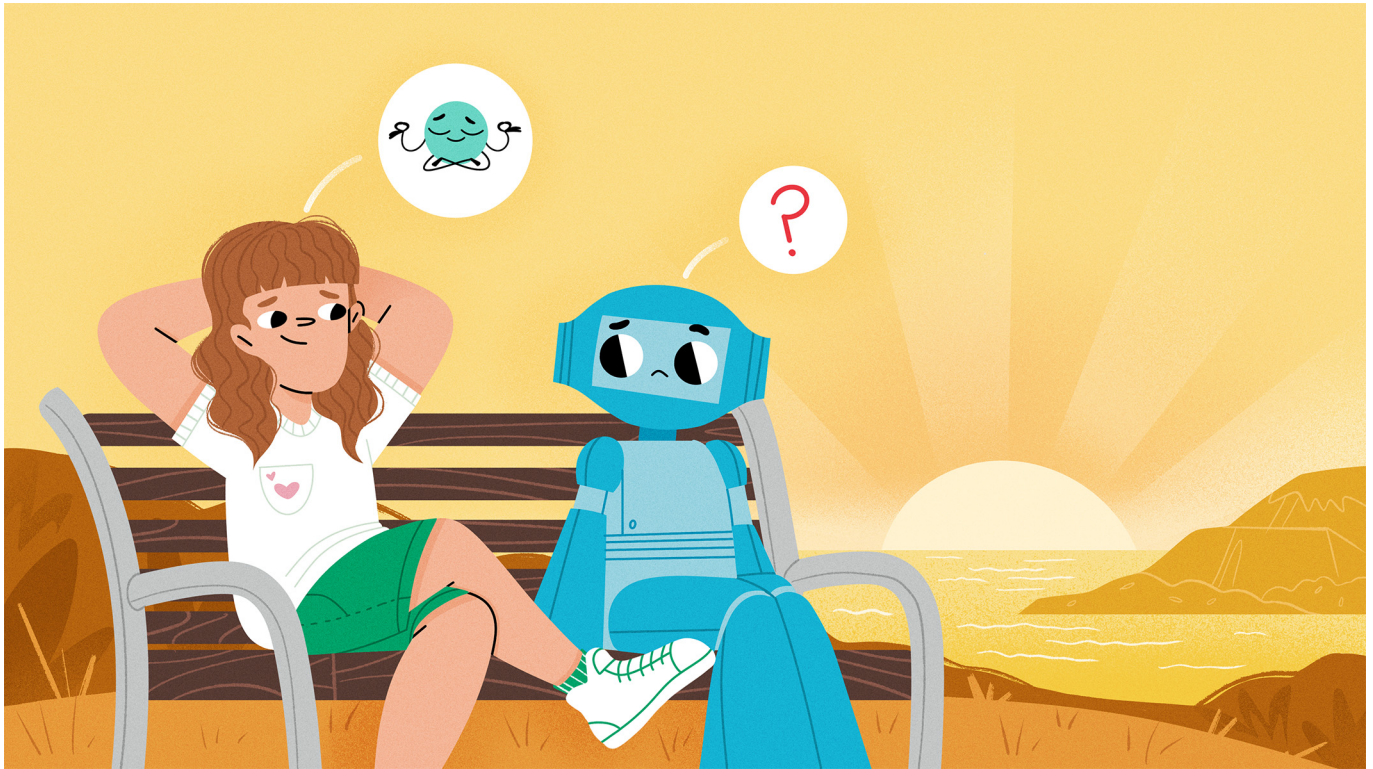




THE SEARCH FOR CONSCIOUSNESS—FROM HUMANS TO MACHINES

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What is consciousness, and how can we tell who—or what—has it? Consciousness is the ability to have experiences, such as seeing, feeling, thinking, or knowing that you exist. Scientists believe it depends on the brain, but they still do not fully understand how it works. Studying consciousness is difficult because it is personal and cannot be directly measured. Researchers use tools like brain imaging, virtual reality, and computer models, as well as philosophy, to explore when and how consciousness appears in humans and animals—and whether machines could ever have it, too. Understanding consciousness could help doctors treat brain injuries and mental illnesses, improve how we care for animals, and prepare

us for future technologies. It also raises big questions about fairness, free will, and the nature of life and mind. As science gets closer to solving this mystery, the answers could change the way we see ourselves and our place in the world.

BRAINS, BOTS, AND BIG QUESTIONS

Have you ever wondered if your tablet or AI chatbot feels good when it helps you with your homework? Or whether it can experience what it is like to see the color blue when you upload a photo of the sea? Machines are getting smarter all the time—they can write essays, hold conversations, and even win chess tournaments. But does that mean they *experience* doing these things? Can they feel excited before a game of chess, happy when they win, or sad when they lose? No, they cannot, at least as far as we know—because they lack a special quality called **consciousness**.

Consciousness is one of the biggest mysteries in science (To learn more about consciousness and why it is important, see [this Frontiers for Young Minds article](#)). You know you are conscious because you can feel things and experience what is happening around you: “being you” feels like something! But what exactly *is* consciousness, and how do we know if another creature—or a computer—has it too? Scientists and philosophers have been asking these questions for centuries and today, new tools and technologies are helping researchers to explore consciousness in new ways.

WHAT IS CONSCIOUS... AND WHAT IS NOT!

Have you ever watched a beautiful sunset? Maybe you saw its orange and pink colors, felt the breeze on your skin, and heard the chirping of birds as they settled down for the night. These sights, sounds, and feelings—the ability to experience things happening through your senses—is one part of consciousness, which scientists call **perceptual awareness**.

Not everything that responds to light, sound, or touch is conscious. Some machines, like security cameras or voice assistants, can recognize faces or respond to voices, and simple organisms, like bacteria, can react to light or movement. These reactions show sensitivity to the world, but perceptual awareness is more than the ability to respond to things. It is fundamentally about *experiencing*: feeling what it is like to see the sunset and to sense the breeze.

Sometimes, consciousness also involves **self-awareness**, which is knowing that you exist and being able to think about your

CONSCIOUSNESS

The capacity to have experiences: of the world around you. Many people use the words “consciousness” and “awareness” to mean the same thing.

PERCEPTUAL AWARENESS

Conscious experiences of sights, sounds, smells, and other sensations. These experiences can happen even if you are not thinking about them.

SELF-AWARENESS

Knowing that you exist and being able to think about your own thoughts, feelings, and actions.

thoughts and feelings. This is an important part of being human, but not everyone agrees that self-awareness is needed to have consciousness. Many researchers think that as long as you can experience anything, you are conscious. Machines and simple organisms can process information, but they probably do not have experiences the way we do, or have self-awareness the way we do. In short, consciousness is the ability to experience what is going on around you and inside you—it is what makes you *you* (Figure 1).

Figure 1

This figure demonstrates how different living and non-living things might show sensitivity to the environment, as well as features of consciousness, and why it is so hard to draw clear lines between who (or what) is conscious and who is not. Humans, animals, bacteria, and machines can all respond to their surroundings (sensitivity). But humans and many animals are believed to have perceptual awareness—the ability to *experience* those sensations. Self-awareness—knowing you exist and reflecting on your own thoughts—is found in humans, though some animals may have it too.

	 Humans	 Animals	 Bacteria	 Machines
Sensitivity	✓	✓	✓	✓
Perceptual Awareness	✓	✓	?	✗/?
Self-Awareness	✓	?	✗	✗/?

Figure 1

WHO IS CONSCIOUS?

Sometimes it is pretty easy to tell if another person is conscious. If someone gets hit hard on the head with a baseball or falls off a bike and does not get up right away, we might say they were “knocked unconscious”, which means they were still alive, but for a little while they were not experiencing anything—not the world around them, and not even themselves. But in other cases, knowing whether someone is conscious is much harder, especially if the person cannot speak or act in typical ways. What about a newborn baby, or a person in a coma? Are they aware in ways we do not fully understand or cannot easily measure? What about a sleeping person? During sleep, people are generally not conscious of what is happening around them, but when they dream, vivid experiences flood their minds. Dreaming is different from being fully awake, but it shows that consciousness can exist even when we are not responding to the external world—it can be fully created by our own brains.

BRAIN IMAGING

Tools that let scientists see what is happening inside a brain, by measuring things like blood flow or electrical signals.

CONSCIOUSNESS IS CHALLENGING TO STUDY

Studying consciousness is one of the toughest challenges in science because it is invisible and personal [1]. You might see a red apple and feel hungry, but no one else can directly know what that feels like *for you*. This makes it very/extremely hard for researchers to design tests that prove whether someone is conscious or exactly what a person is conscious of. So far, there is no laboratory test that can reliably tell them whether someone (or something) is conscious or not. At least, not yet!

Researchers know that the biological activity of the brain causes consciousness, but they do not know exactly which parts of the brain create consciousness, or how those brain areas do so [2]. There does not seem to be a single place in the brain that scientists can point to and say, “There it is—that is consciousness”. Scientists can measure brain activity using **brain imaging** techniques, including EEG scans that record electrical signals arising from the brain, or fMRI, which tracks blood flow to different brain regions while people are doing various tasks. Brain imaging can tell scientists which brain areas are active when someone is awake, asleep, or experiencing different kinds of things, like performing simple tasks. But it is extremely difficult to figure out how these measurable brain signals relate to conscious experiences like thoughts, feelings, and sensations. It might be that scientists are not even asking the right questions yet.

HOW DO RESEARCHERS STUDY CONSCIOUSNESS?

Since they cannot directly see or measure consciousness, researchers must look for clues and design clever experiments that look at both the brain and behavior. While brain imaging techniques do not show consciousness directly, they *can* help scientists see what the brain is doing. So, scientists can compare brain activity across different states, like when a person is awake, asleep, or performing mental tasks, to start to identify patterns linked to consciousness.

For example, researchers may ask participants to imagine doing something while their brains are being scanned. In one well-known study, scientists asked patients who could no longer communicate because of brain damage to imagine playing tennis or to imagine walking around their house [3]. Their brain activity showed they were following these instructions, even though they could neither speak nor move. This suggests that these patients were still conscious.

Other experiments test how people experience the world around them. Researchers might flash an image on a screen for just a tiny fraction of a second—too fast for the person to consciously experience it [4]. Then they check whether the person’s brain still responds to the image, or if the image still affects the person’s behavior. These tests

BISTABLE PERCEPTION

When your brain flips back and forth between two ways of interpreting an image, like when a picture looks like a duck and then a rabbit.

Figure 2

Visual illusions can reveal how conscious experiences relate to what the eyes see. Both images shown here can be seen in more than one way—your conscious experience can flip back and forth, even though the image stays the same. **(A)** Do you see a rabbit or a duck? **(B)** Do you see a vase or two faces looking at each other? These illusions show that conscious perception is not *just* about what hits your eyes. Your brain actively interprets what you see, and that interpretation—what you become perceptually aware of—can shift in an instant (Image credits: Wikimedia Commons).

COMPUTER MODELS

Programs that use math and rules to simulate or mimic how something works, like a brain process or behavior, so that scientists can test ideas and make predictions.

help scientists understand what the brain can do *without* perceptual awareness, and what it takes for someone to become truly conscious of something.

Some further experiments use a specific type of optical illusion called **bistable perception** to show how the brain can switch between different interpretations of the same picture—demonstrating that perceptual awareness is not just about what information is available to your eyes, but how your brain *interprets* that information. This approach can help researchers identify the brain processes involved when what we see changes even though the image itself does not change (Figure 2).

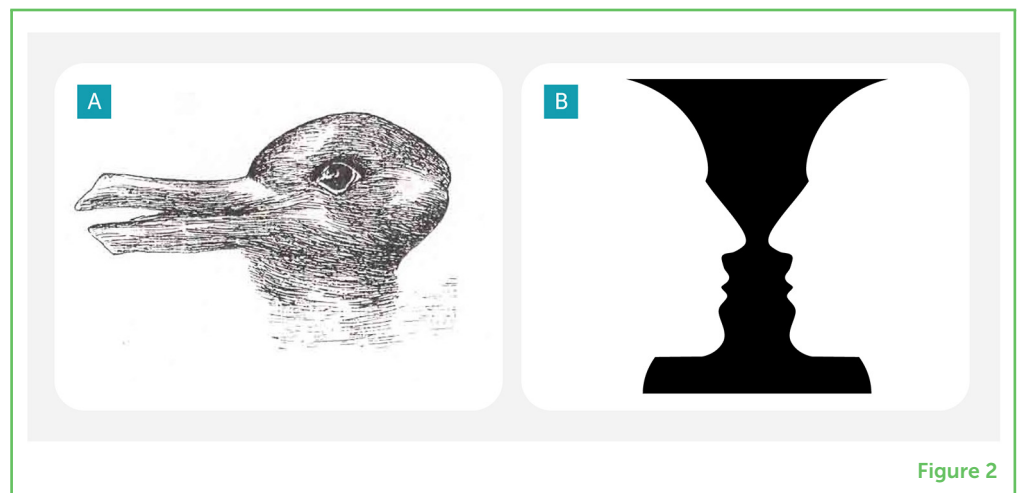


Figure 2

Researchers can also use newer tools like virtual or augmented reality to create new kinds of experiences and check how the brain responds. They can build **computer models** of the brain or use **artificial intelligence** to mimic brain processes that are related to consciousness. Virtual tools can help test theories about how consciousness might arise in the brain. These methods are all very powerful, but no single method can solve the mystery of consciousness. Together, however, they are helping researchers get closer to understanding how consciousness works.

ARE OTHER ORGANISMS CONSCIOUS?

Besides humans, what other organisms might be conscious? Many animals very likely have perceptual awareness—they can experience seeing, hearing, smelling, feeling, and reacting to the world around them. Dogs' brains are in some ways quite similar to human brains, and a dog might wag its tail when it sees you or whimper when it is scared, so it definitely seems like certain animals have conscious experiences and feelings. But just because something *acts* conscious does not prove that it feels conscious on the inside—and consciousness gets much harder to study as we look at animals that are less like us.

ARTIFICIAL INTELLIGENCE

Computer systems that can do tasks that usually require human intelligence, like recognizing faces, playing chess, or writing stories.

PHILOSOPHICAL

Related to deep questions about life, knowledge, or right and wrong—often with no easy or final answers.

What about self-awareness? Elephants, dolphins, apes, and potentially some other animals have passed the “mirror test”—they seem to recognize their own reflections, which could be a sign of self-awareness (though not everyone agrees that this test is very useful) [5]. But do animals really have something like the self-awareness that humans have?

The answer to this question is still unknown. Some scientists believe that consciousness might come in levels or kinds, depending on the brain, the situation, or the type of creature [6]. So maybe other animals experience simpler or different forms of consciousness—not less *important*, just not exactly the same as ours.

WHY DOES UNDERSTANDING CONSCIOUSNESS MATTER?

You might wonder—if it is so hard to study and measure consciousness, why bother trying at all? Learning more about consciousness is not just solving a scientific or **philosophical** puzzle. It could change the way we treat people, animals, and even machines (Figure 3).

People

Knowing more about consciousness could help doctors and caregivers better understand people who cannot communicate—like newborn babies or patients with serious brain injuries. New discoveries about consciousness could improve how we care for these patients and even how we communicate with them, and could help families make difficult decisions—like whether to continue life support, try new treatments, or consider end-of-life care. Knowing more about consciousness could also help doctors understand and treat mental illnesses, since some mental illnesses involve people experiencing the world—and their own selves—in unusual ways. A deeper understanding of consciousness might even help us figure out what we mean by tricky concepts like “free will”—the idea that we can control what we do and that we are responsible for our actions.

Animals

Learning more about the conscious experiences of animals might lead us to treat them with greater care and respect. We might rethink whether animals should be used in experiments, or how they are raised on farms. And if science confirms that animals like fish or insects have conscious experiences, there would be stronger arguments for protecting their welfare. The more we understand how animal experiences differ from our own, the more we might recognize that being a human is just one little region in a vast space of “possible minds”.

Figure 3

Understanding consciousness could change how we treat people, animals, and machines. **(A)** Studying consciousness might help doctors understand whether unresponsive patients—such as those in comas—are still conscious, and improve how they are treated. **(B)** Understanding animal consciousness will help us rethink how we treat them in labs, on farms, and in the wild. **(C)** If machines ever become conscious, we would face new ethical questions about their treatment and rights. Studying consciousness is not just about science—it helps us think more deeply about fairness, kindness, and what it means to be alive.



Figure 3

Machines

Finally, as AI systems get more complex, some people wonder whether a machine might one day become conscious. If that ever happens, might machines want things or suffer if they are not treated well? Would they have rights, like the right not to be shut down or the right to be treated fairly? Should we treat an AI like a person with thoughts and feelings, or like a tool we can use however we want? Questions like these used to belong only in science fiction, but they are beginning to feel a little more real. Some AI systems today can hold conversations, write stories, create pictures, or even play music. These systems are good at imitating human behavior, but most scientists do not think they have consciousness—at least not yet. It is also important

to remember that intelligence is not the same as consciousness. Just because intelligence and consciousness go together in humans, this does not mean they *always* have to go together. There may be many conscious animals that are not intelligent by human standards, and advanced AI could demonstrate intelligence without any flicker of consciousness at all.

SO MUCH TO LEARN—AND WHAT IF WE SUCCEED?

Understanding consciousness is one of the most exciting—and challenging—areas of science. As researchers and philosophers continue to explore these huge questions, their findings could change how we think about ourselves, others, and the future [4]. If we *do* succeed in understanding consciousness, the answers might do more than help us treat others more fairly. They could also change how we see ourselves—what it means to be human, and how we fit into the larger picture of the world around us. Maybe someday there will be a simple test that can determine which organisms or systems are conscious—but we are not there yet. In the meantime, the more we use new technologies and methods to learn about consciousness, the better equipped we will be to think about questions of fairness, kindness, and responsibility—not just toward people, but toward all conscious beings, whatever form they might take.

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YOUNG REVIEWERS

NICANOR, AGE: 8

Nicanor is an 8-year-old third grader at a public school in the United States. He enjoys thinking about how the brain works and what lies beyond our solar system. Nicanor also loves playing soccer and videogames with friends and performing classical piano pieces—his favorites are by Russian composers like Kabalevsky. He is excited to be part of Frontiers for Young Minds because he enjoys asking questions, learning new things, and helping scientists explain their work to other kids.



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Anil Seth is a neuroscientist at the University of Sussex. He was born in Oxford and worked for some time in California, where he enjoyed surfing as well as science. His research is all about the nature of consciousness, how perception works, and the differences between brains and computers. A keen enthusiast for scientific communication, he has written several books, and he recently won the Royal Society Michael Faraday prize. He enjoys hiking, swimming, traveling, and playing the piano.

