

Caltech science exchange on **NEUROSCIENCE**



How Do Scientists Study the Brain?



The Brain and Neuroscience

The brain is the control center of the body. It helps us plan, think, feel emotions, remember things, and move around.

The nervous system is a complex network that carries messages throughout the body. It consists of the **central nervous system**, which includes the brain and spinal cord, and the **peripheral nervous system**, which is made up of nerves that connect the spinal cord to the rest of the body. Together, these systems coordinate movement, feeling, and function.

Scientists who study the brain and nervous system are called **neuroscientists**. Neuroscience has many branches that focus on specific areas. For example, behavioral neuroscience focuses on how brain activity affects actions, and molecular neuroscience examines the chemical processes that keep the brain working.



Model Organisms: How Other Animals Help Scientists Understand the Brain

Studying the brain in humans can be challenging. Often, neuroscientists instead use what are called **model organisms**—animals like worms, flies, and fish—that have simpler nervous systems. Even though these animals are different from humans, they share important traits such as **basic instincts** (like finding food and avoiding danger) and **neurons as the building blocks of their brains**. These similarities help scientists understand how the human brain works.

Here are some **common model organisms**:



NEMATODES (TINY WORMS):

These worms do not have a centralized brain. Instead, they have **302 neurons** spread throughout their tiny 1-millimeter-long bodies. Their small number of neurons makes it easier for scientists to study each one in detail.



FRUIT FLIES:

Scientists have mapped out the **entire wiring of a fruit fly's brain**. They can also turn specific genes **on and off** to study how their brains—and behavior—respond.



ZEBRAFISH:

These fish are **transparent**, which means scientists can watch their brain activity in real time under a microscope. Scientists can also **use light** to control zebrafish brain activity through a technique called **optogenetics**.



MICE:

Since mice are mammals, their brains are **more complex and similar to human brains**. Mice also show signs of having states like aggression and anxiety, making them useful for studying emotions.



Reading Minds: Tools to Study Brain Activity

How do scientists figure out what's happening inside the brain? They use **special tools** to observe brain activity. Some methods are **noninvasive**, meaning they don't require surgery. Here are some tools they use:



CALCIUM IMAGING

Brain cells release **calcium** when they send signals. Scientists use special proteins that **glow when calcium levels rise**, allowing them to watch neuron activity under an advanced microscope.



FUNCTIONAL MAGNETIC RESONANCE IMAGING (fMRI)

This is one of the least invasive ways to look at what the brain is doing. It works by measuring **blood flow** in the brain. fMRI can't show scientists what is happening with individual neurons, but it can show which areas of the brain are working as a human performs certain tasks, such as solving a puzzle.



ELECTROPHYSIOLOGY:

This method involves placing tiny **electrodes** in specific brain regions to measure **electrical signals**. It requires surgery to insert the electrodes, so it involves more risk than noninvasive methods.

What Are Neurons and How Do They Work?

Neurons are the brain's messengers. These special cells send and receive signals throughout the brain and nervous system, helping us think, feel, move, and remember things.

The human brain has about **86 billion neurons**, with trillions of connections between them! Think of neurons like people in a crowded room—each one can interact with others nearby and then those messages can be passed through the entire room.



Parts of a Neuron

A neuron has three main parts:

- **CELL BODY:** the main part of the cell that contains all the tools it needs to stay alive.
- **DENDRITES:** branch-like structures that receive signals from other neurons.
- **AXON:** a long wire-like part that sends signals to other neurons.

Neurons **don't touch each other**—instead, they pass signals across tiny gaps called **synapses**.



How Neurons Send Signals

Neurons communicate by passing along **chemical molecules** and **electric signals**.

A group of neurons working together to send signals is called a **neural circuit** or **neural pathway**.



What Is Neuroplasticity?

Neuroplasticity is our brain's ability to change. It helps us **learn new skills, build memories, and even recover from brain injuries**.

One way this happens is through **neurogenesis**, where the brain creates new neurons, mostly when we're young but sometimes in adulthood too.

Another key process is **synaptogenesis**, which forms new connections between neurons, allowing us to learn and build skills.

Did You Know?

Forgetting can be just as important as remembering! The brain **weakens some connections** to clear out unimportant information and stay efficient.

Quick Quiz

1. Which animal has a see-through brain that scientists can observe in real time?

- A) Mouse
- B) Zebrafish
- C) Fruit Fly
- D) Nematode

2. How many neurons does the human brain have?

- A) 1,000
- B) 302
- C) 86 billion
- D) 50 million

3. Which model organism is often used to study things like anxiety and aggression because their brains are similar to humans?

- A) Fruit Flies
- B) Zebrafish
- C) Mice
- D) Nematodes

4. Which tool lets scientists see glowing neurons in real time using special microscopes?

- A) Photoacoustic Tomography
- B) fMRI
- C) Calcium Imaging
- D) Electrophysiology

5. What is the gap called where neurons pass signals to each other?

- A) Myelin
- B) Synapse
- C) Circuit
- D) Pathway

MYTH BUSTING

X Myth: We only use 10 percent of our brains.

✓ Truth: You use all the parts of your brain at different times!

X Myth: When brain cells die, they can't be replaced.

✓ Truth: Your brain can create new neurons even in adulthood!

X Myth: Some people are left-brained and some are right-brained.

✓ Truth: Both sides of your brain work together for almost everything you do!

FILL IN THE BLANK

6. A neuron has three main parts:

_____, _____,
and _____.

7. Neuroplasticity is the brain's ability to _____ over time.

- 7. change/adapt
- 6. cell body, dendrites, axon
- 5. B) Synapse
- 4. C) Calcium Imaging
- 3. C) Mice
- 2. C) 86 billion
- 1. B) Zebrafish

Answers:

ABOUT THE CALTECH SCIENCE EXCHANGE:

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