

A woman's profile is shown in grayscale, looking to the left. Overlaid on her head is a glowing, translucent brain in shades of purple and blue. The background is dark blue with concentric, wavy lines in various colors (yellow, green, blue, purple) that create a sense of motion and energy. In the top left corner, there is a solid yellow square.

Know Your Brain



National Institute of
Neurological Disorders
and Stroke

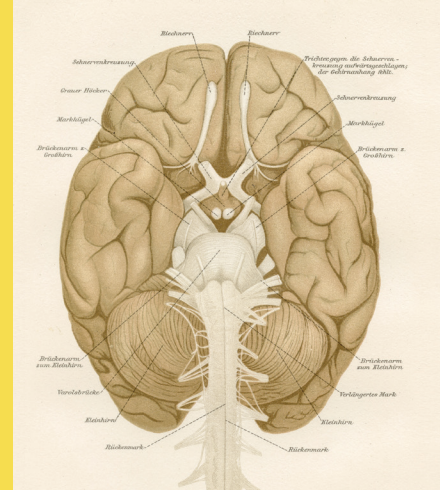
BRAIN BASICS

Introduction

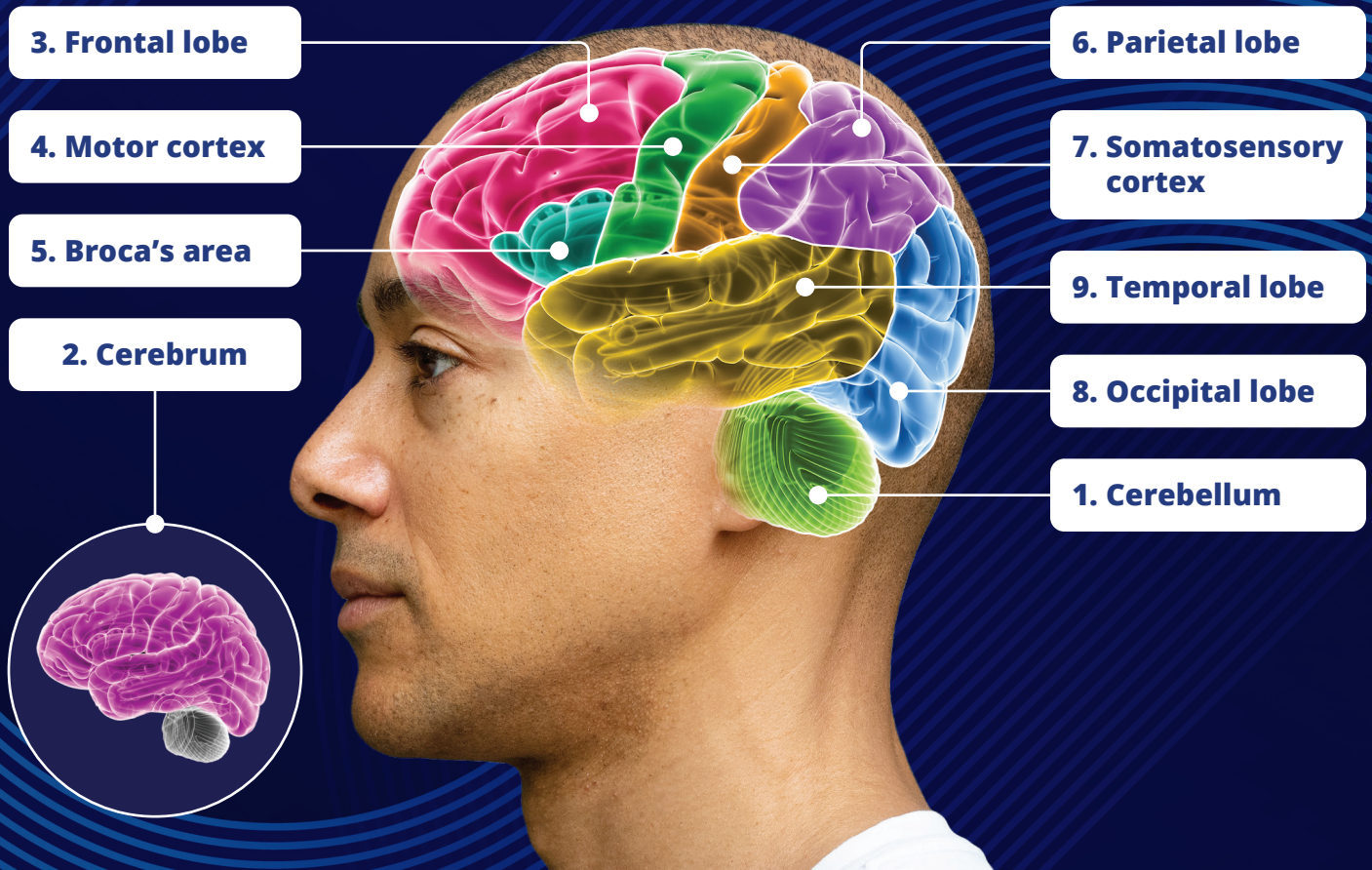
THE BRAIN is the most complex part of the human body. This three-pound organ is the seat of intelligence, interpreter of the senses, initiator of body movement, and controller of behavior. Lying in its bony shell and washed by protective fluid, the brain is the source of all the qualities that define our humanity. It is the crown jewel of the human body.

For centuries, scientists and philosophers have been fascinated by the brain, but until recently they viewed it as nearly incomprehensible. Now, however, the brain is beginning to relinquish its secrets. Scientists have learned more about the brain in the last several decades than in all previous centuries because of the accelerating pace of research in neurological and behavioral science and the development of new research techniques. At the forefront of research on the brain and other elements of the nervous system is the National Institute of Neurological Disorders and Stroke (NINDS), which conducts and supports scientific research in the United States and around the world.

This brochure is a basic introduction to the human brain. It can help you understand how the healthy brain works, how to keep your brain healthy, and what happens when the brain doesn't work like it should.



The **Architecture** of the **Brain**



The brain is like a group of experts. All the parts of the brain work together, but each part has its own special responsibilities.

The brain can be divided into three basic units: the forebrain, the midbrain, and the hindbrain.

The hindbrain includes the upper part of the spinal cord, the brain stem, and a wrinkled ball of tissue called the cerebellum. The hindbrain controls the body's vital functions such as respiration and heart rate.

The **cerebellum** **1** coordinates movement and is involved in learned movements. When you play the piano or hit a tennis ball, you are activating the cerebellum.

The uppermost part of the brainstem is the midbrain, which controls some reflex actions and is part of the circuit involved in the control of eye movements and other voluntary movements.

The forebrain is the largest and most highly developed part of the human brain: it consists primarily of the **cerebrum** **2** and the structures hidden beneath it (see “*The Inner Brain*”).

When people see pictures of the brain it is usually the cerebrum that they notice. The cerebrum sits at the topmost part of the brain and is the source of conscious thoughts and actions. It holds your memories and allows you to plan, imagine, and think. Your cerebrum helps you recognize friends, read, and play games.

The cerebrum is split into two halves (hemispheres) by a deep fissure. The two cerebral hemispheres

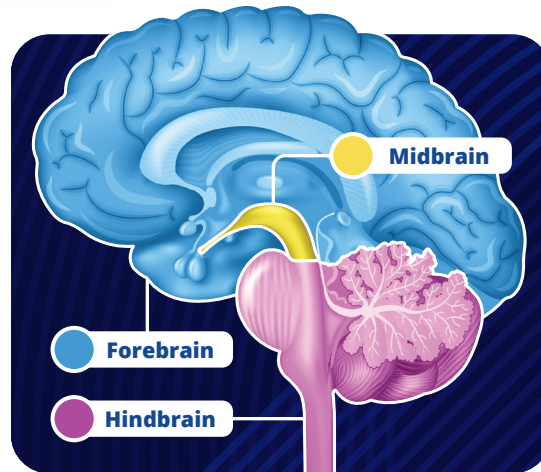
communicate with each other through a thick tract of nerve fibers that lies at the base of this fissure called the corpus callosum. Although the two hemispheres seem to be mirror images of each other, they are different. For instance, the ability to form words seems to lie primarily in the left hemisphere, while the right hemisphere seems to control many abstract reasoning skills.

For some as-yet-unknown reason, nearly all of the signals from the brain to the body and vice-versa cross over on their way to and from the brain. This means that the right cerebral hemisphere primarily controls the left

side of the body, and the left hemisphere primarily controls the right side. When one side of the brain is damaged, the opposite side of the body is affected. For example, a stroke in the right hemisphere of the brain can leave the left arm and leg paralyzed.

The Geography of Thought

Each cerebral hemisphere can be divided into sections, or lobes, each of which specializes in different functions. To understand each lobe and its specialty,



we will take a tour of the cerebral hemispheres, starting with the two **frontal lobes** ③, which lie directly behind the forehead. When you plan a schedule, imagine the future, or use reasoned arguments, these two lobes do much of the work. One of the ways the frontal lobes seem to do these things is by acting as short-term storage sites, allowing one idea to be kept in mind while other ideas are considered. In the back portion of each frontal lobe is a **motor cortex** ④, which helps plan, control, and execute voluntary movement like moving your arm or kicking a ball. **Broca's area** ⑤, on the left frontal lobe, allows thoughts to be transformed into words.

When you enjoy a good meal—the taste, smell, and texture of the food—two sections behind the frontal lobes called the **parietal lobes** ⑥ are at work. The parietal lobes also support reading and arithmetic. The forward parts of these lobes, just behind the motor areas, is the **somatosensory cortex** ⑦. These areas receive information about temperature, taste, touch, and movement from the rest of the body. As you look at the words and pictures on this page, two areas at the back of the brain are at work. These lobes, called the **occipital lobes** ⑧, process images from the eyes and link that information with images stored in memory. Damage to the occipital lobes can cause blindness.

The last lobes on our tour of the cerebral hemispheres are the **temporal lobes** ⑨, which lie in front of the visual areas and nest under the parietal and frontal lobes. Whether you appreciate symphonies or rock music, your brain responds through the activity of these lobes. At the top of each temporal lobe is an area responsible for receiving information from the ears.

The underside of each temporal lobe plays a crucial role in forming and retrieving memories, including those associated with music. Other parts of this lobe integrate memories and sensations of taste, sound, sight, and touch.

The Cerebral Cortex

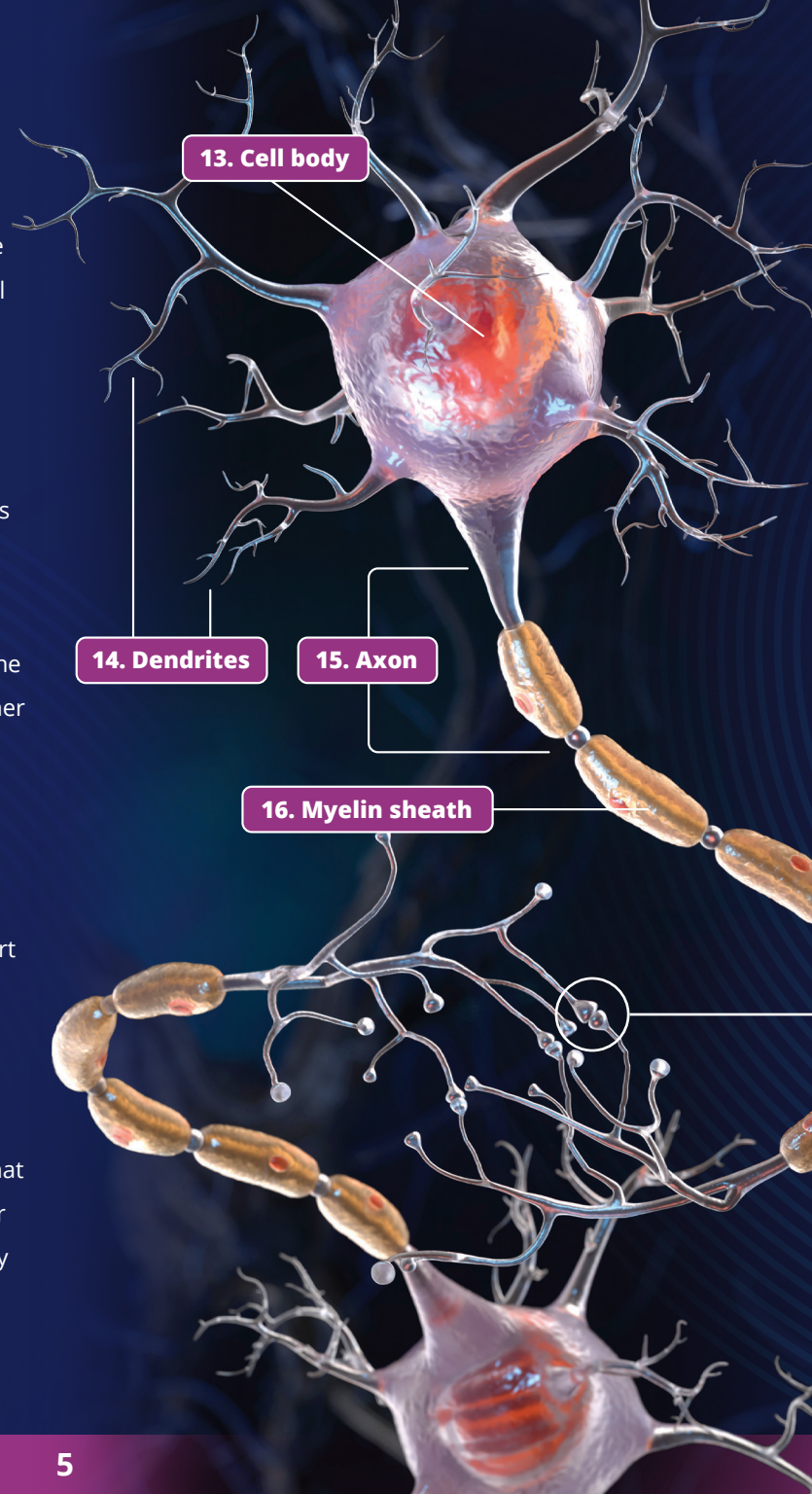
Coating the surface of the cerebrum and the cerebellum is a vital layer of tissue the thickness of a stack of two or three dimes. It is called the cortex, from the Latin word for bark. Most of the actual information processing in the brain takes place in the cerebral cortex. When people talk about “gray matter” in the brain, they are talking about the cortex. The cortex is gray because nerves in this area lack the insulation that makes most other parts of the brain appear to be white. The folds in the brain add to its surface area and therefore increase the amount of gray matter and the volume of information that can be processed.

The Neuron

The brain and the rest of the nervous system are composed of many different types of cells, but the primary functional unit is a cell called a neuron. All sensations, movements, thoughts, memories, and feelings are the result of signals that pass through neurons. Neurons consist of three parts: the cell body, dendrites, and the axon. The **cell body** **13** contains the nucleus, where most of the molecules that the neuron needs to survive and function are manufactured.

Dendrites **14** extend out from the cell body like the branches of a tree and receive messages from other nerve cells. Signals then pass from the dendrites through the cell body and travel away from the cell body down an **axon** **15** to another neuron, a muscle cell, or cells in some other organ.

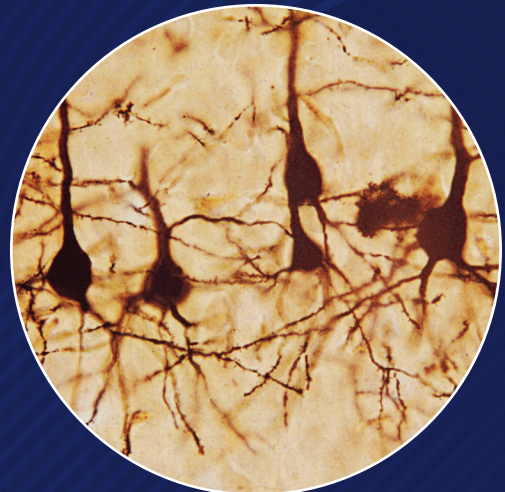
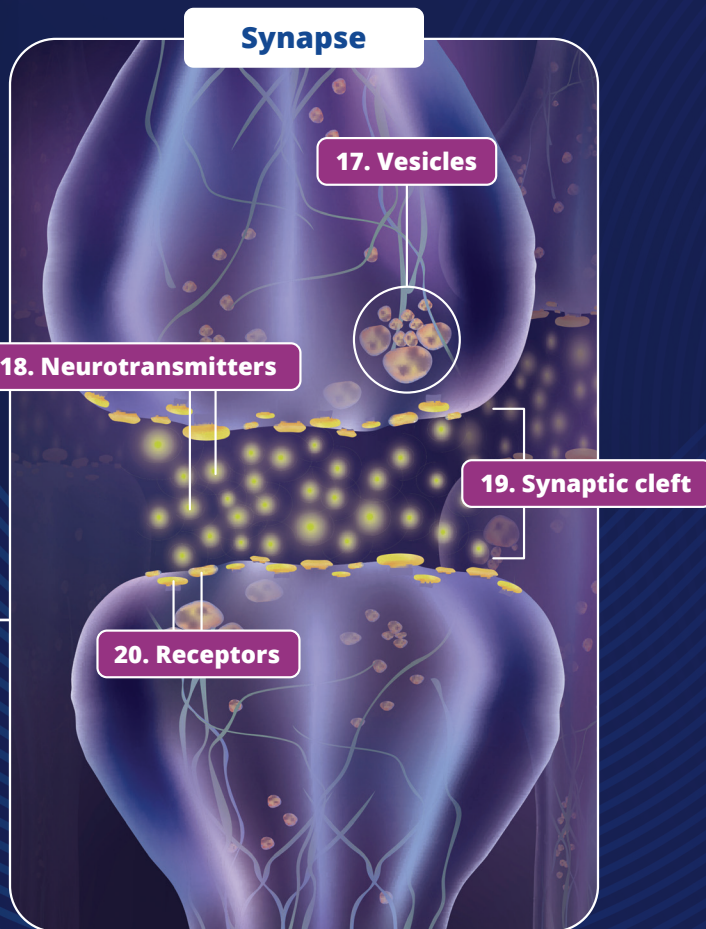
The neuron is usually surrounded by many support cells. Some types of cells wrap around the axon to form an insulating **myelin sheath** **16**. Myelin is a fatty molecule which provides insulation for the axon and helps nerve signals travel faster and farther. Axons may be very short, such as those that carry signals from one cell in the cortex to another cell less than a hair's width away. Other axons may be very long, such as those that carry messages from the brain all the way down the spinal cord.



Scientists have learned a great deal about neurons by studying the synapse—the place where a signal passes from the neuron to another cell. When the signal reaches the end of the axon it stimulates the release of tiny sacs called **vesicles** 17 . These vesicles release chemicals known as

neurotransmitters 18 into the **synaptic cleft** 19 .

The neurotransmitters cross the synapse and attach to **receptors** 20 on the neighboring cell. These receptors can change the properties of the receiving cell. If the receiving cell is also a neuron, the signal can continue the transmission to the next cell.



Microscopic view of neuron cells of the cerebral cortex.

The Inner Brain

Deep within the brain, hidden from view, lie structures that are the gatekeepers between the spinal cord and the cerebral hemispheres. These structures not only determine our emotional state, but they also modify our perceptions and responses and allow us to initiate movements without thinking about them. Like the lobes in the cerebral hemispheres, the structures described below come in pairs: each is duplicated in the opposite half of the brain.

The **hypothalamus** **10**, about the size of a pearl, directs a multitude of important functions. It wakes you up in the morning and gets the adrenaline flowing during a test or job interview. The hypothalamus is also an important emotional center, controlling the chemicals that make you feel exhilarated, angry, or unhappy. Near the hypothalamus lies the **thalamus** **11**, a major clearinghouse for information going to and from the spinal cord and the cerebrum.

An arching tract of nerve cells leads from the hypothalamus and the thalamus to the **hippocampus** **12**. This tiny nub acts as a memory indexer—sending memories out to the appropriate part of the cerebral hemisphere for long-term storage and retrieving them when

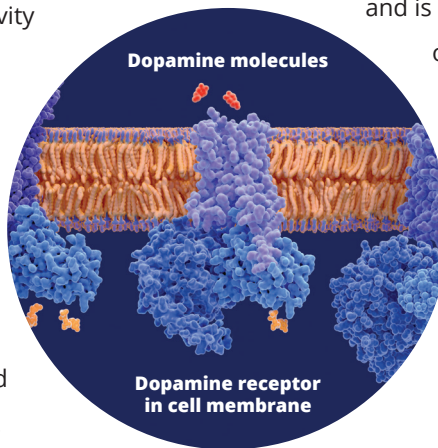
necessary. The **basal ganglia** (not shown) are clusters of nerve cells surrounding the thalamus. They are responsible for initiating and integrating movements. Parkinson's disease, which results in tremors, rigidity, and a stiff, shuffling walk, affects the nerve cells in the basal ganglia.



Some Key Neurotransmitters at Work

Neurotransmitters are chemicals that brain cells use to talk with each other. Some neurotransmitters make cells more active (called excitatory) while others block or dampen a cell's activity (called inhibitory).

- **Acetylcholine** is an excitatory neurotransmitter. It governs muscle contractions and causes glands to secrete hormones. Alzheimer's disease, which initially affects memory formation, is associated with a shortage of acetylcholine.
- **Glutamate** is a major excitatory neurotransmitter. Too much glutamate can kill or damage neurons and has been linked to disorders including Parkinson's disease, stroke, seizures, and increased sensitivity to pain.
- **GABA** (gamma-aminobutyric acid) is an inhibitory neurotransmitter that helps control muscle activity and is an important part of the visual system. Drugs that increase GABA levels in the brain are used to treat epileptic seizures and tremors in patients with Huntington's disease.



- **Serotonin** is a neurotransmitter that constricts blood vessels and brings on sleep. It is also involved in temperature regulation. Low levels of serotonin may cause sleep problems and depression, while too much serotonin can lead to seizures.
- **Dopamine** can be excitatory or inhibitory and is involved in mood and the control of complex movements. The loss of dopamine activity in some portions of the brain leads to the muscular rigidity of Parkinson's disease. Many medications used to treat mental disorders and conditions work by modifying the action of dopamine in the brain.

Neurological Disorders

The brain is one of the hardest working organs in the body. When the brain is healthy it functions quickly and automatically. But when problems occur, the results can be devastating. NINDS supports research on hundreds of neurological diseases. Knowing more about the brain can lead to the development of new treatments for diseases and disorders of the nervous system and improve many areas of human health.

The National Institute of Neurological Disorders and Stroke

Since its creation by Congress in 1950, NINDS has grown to become the leading supporter of neurological research in the United States. Most research funded by NINDS is conducted by scientists in public and private institutions such as universities, medical schools, and hospitals. Government scientists also conduct neurological research in the more than 20 laboratories and branches of NINDS itself. This research ranges from studies on the structure and function of single brain cells to tests of new diagnostic tools and treatments for people living with neurological disorders. For more information, visit the resources below:

National Institute of Neurological Disorders and Stroke Information Resource Center

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