NIH BRAIN FACT SHEET
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BRAIN BASICS
THE ARCHITECTURE OF THE BRAIN

The brain is like a committee of experts. All the parts of the brain work together, but each part has its own special properties. The brain can be divided into three basic units: the forebrain, the midbrain, and the hindbrain.

[**Note from webmaster** = Since most previous brain books have divided the brain into the following four parts — **cerebrum**, **cerebellum**, **brainstem,** and **limbic system**, this website will use these ***four classic distinctions*** with special notes to explain the interactive functions that involve the mutual connections of the three named physical structures discussed in the following sections of this **U. S. National Institute of Health** ***brain fact sheet.***]

HINDBRAIN - MIDBRAIN - FOREBRAIN

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*** coordinates movement and is involved in learned rote movements such as those needed for piano playing or playing tennis.

MIDBRAIN = 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.

FOREBRAIN = The forebrain is the largest and most highly developed part of the human brain. It consists primarily of the ***cerebrum*** and the structures hidden beneath it (see below "**The Inner Brain**").

CEREBRUM = 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 intellectual activities. It holds your memories, allows you to plan, enables you to imagine and think.It is split into two halves (hemispheres) by a deep fissure. Despite the split, your two cerebral hemispheres communicate with

each other through a thick tract of nerve fibers — **CORPUS COLLOSUM** — that lies at the base of this fissure. Although the two hemispheres seem to be mirror images of each other, they are different. For instance, the ability to form words...lies primarily in the left hemisphere, while the right hemisphere...controls many abstract reasoning skills. Your ***cerebrum*** allows you to recognize friends, read books, and play games.

For some as-yet-unknown reason, nearly all of the signals from your brain to your body and from your body to your brain ***cross over*** on their way to and from your 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 you can take a tour of the ***cerebral hemispheres,*** starting with the two **FRONTAL LOBES,** which lie directly behind your forehead.

When you plan a schedule, imagine the future, or use reasoned arguments, these two lobes are most active. 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 rearmost portion of each ***frontal lobe*** is a **MOTOR AREA,** which is involved in controlling voluntary movement. A nearby place on the ***left frontal lobe*** called **BROCA'S AREA** allows thoughts to be transformed into words.

When you enjoy a good meal — the taste, aroma, and texture of the food — two sections behind the frontal lobes called the **PARIETAL LOBES** are active. The forward parts of these lobes, just behind the motor areas, are the ***primary*** **SENSORY AREAS.** These areas receive information about temperature, taste, touch, and movement from the rest of the body. Reading and arithmetic are also functions made possible by ***both parietal lobes.***

As you look at the words on this page (or the online pictures), two

areas at the back of the brain are active. These lobes, called the **OCCIPITAL LOBES,** 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 your tour of the ***cerebral hemispheres*** are the **TEMPORAL LOBES,** 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

A vital layer of tissue — the thickness of a stack of two or three dimes — coats the surface of the **CEREBRUM** and the **CEREBELLUM**. It is called the "**cortex**" from the Latin word for bark or cover. Most of the actual information processing in the brain takes place in the ***cerebral cortex.*** The **"gray matter"** is a thin rind. 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 quantity of information that your brain can process.

THE INNER BRAIN

Deep within the brain, hidden from view, structures exist that are the ***gatekeepers*** between your **SPINAL CORD** and your **CEREBRAL HEMISPHERES.** These structures not only determine your emotional state, but they also modify your perceptions and responses depending on that emotional state. And they allow you to initiate movements that you make without thinking about them. Like the ***lobes*** in the **CEREBRAL HEMISPHERES**, the **LIMBIC STRUCTURES** described below come in pairs: ***each pair*** is duplicated in the ***opposite half*** of the brain.

The **HYPOTHALAMUS**, 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 molecules that make you feel exhilarated, angry, or unhappy. Near your ***hypothalamus*** lies the **THALAMUS**, 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**. This ***tiny nub*** acts as a **"memory indexer"**. It sends memories out to the appropriate part of the **CEREBRAL HEMISPHERE** for long-term storage and retrieval when necessary.

The **BASAL GANGLIA** are ***clusters of nerve cells*** surrounding your **THALAMU**S. They are responsible for initiating and integrating movements. Parkinson's disease, which results in tremors, rigidity, and a stiff, shuffling walk, is a disease of nerve cells that lead into the ***basal ganglia.***

MAKING CONNECTIONS

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 the **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** contains the **NUCLEUS OF A NEURON**, where most of the molecules that the **NEURON** needs to survive and function are manufactured.

DENDRITES 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 may travel away from the ***cell body*** down an **AXON** to another neuron, a muscle cell, or cells in some other organ.

The **NEURON** is usually surrounded by many support cells. **GLIAL CELLS** wrap around the **AXON** filament to insulate it with a **MYELIN SHEATH**. This ***sheath*** includes fatty molecules called **MYELIN**, 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. Or **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 their **SYNAPSES** — the place where signals pass from the ***neurons*** to other ***neuron cells.*** When the signals reach the end of the **AXONS**, they stimulate the release of ***tiny sacs*** or ***receptors*** connected to **SYNAPSES**.

These ***receptors*** release chemicals known as **NEURO-TRANSMITTERS** into your **SYNAPSES.** The ***neurotransmitters*** cross the ***synapses*** and attach to ***receptors*** on neighboring cells. These ***receptors*** can change the properties of the receiving cells. If the ***receiving cells*** are also **NEURONS**, the signals can continue the transmission to the next cells.

HOW KEY NEUROTRANSMITTERS IN A CELL BODY ACTIVATE YOUR BRAIN

ACETYLCHOLINE is called an ***excitatory neurotransmitter*** because it generally makes cells more excitable. 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.***

GABA or ***amma-aminobutyric acid*** is called an **INHIBITORY NEUROTRANSMITTER** because it tends to ***make cells less excitable.*** It 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,*** brings on sleep, and is involved in temperature regulation.

DOPAMINE functions as both an ***inhibitory neurotransmitter*** and ***excitatory neurotransmitter*** depending upon where in the brain and at which particular receptor site it binds to. It is involved in the ***regulation of moods*** 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 behavioral disorders work by modifying the action of ***dopamine*** in the brain.

NEUROLOGICAL DISORDERS

When the brain is healthy it functions quickly and automatically. But when problems occur, the results can be devastating. Some 50 million people in this country — ***one in five*** — suffer from damage to the nervous system. The **NINDS** supports research on more than 600 neurological diseases. Some of the major types of disorders include: ***neurogenetic diseases*** (such as ***Huntington's disease*** and ***muscular dystrophy***), developmental disorders (such as ***cerebral palsy***), degenerative diseases of adult life (such as ***Parkinson's disease*** and ***Alzheimer's disease***), metabolic diseases (such as ***Gaucher's disease***), cerebrovascular diseases (such as ***stroke*** and ***vascular dementia***), trauma (such as ***spinal cord*** and ***head injury***), convulsive disorders (such as ***epilepsy***), infectious diseases (such as ***AIDS dementia***), and ***brain tumors.***

THE NATIONAL INSTITUTE OF NEUROLOGICAL DISORDERS AND STROKE

Since its creation by Congress in 1950, the **NINDS** has grown to become the leading supporter of neurological research in the United States. Most research funded by the **NINDS** is conducted by scientists in public and private institutions such as universities, medical schools, and hospitals. Government scientists also conduct a wide array of neurological research in the more than 20 laboratories and branches of the **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 those with neurological disorders.

For information on other neurological disorders or research programs funded by the National Institute of Neurological Disorders and Stroke, contact the **Institute's Brain Resources and Information Network** (BRAIN) at: BRAIN - P.O. Box 5801 - Bethesda, MD 20824 - (800) 352-9424 = **www.ninds.nih.gov/**

Prepared by: Office of Communications and Public Liaison - National Institute of Neurological Disorders and Stroke - National Institutes of Health - Bethesda, MD 20892.

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