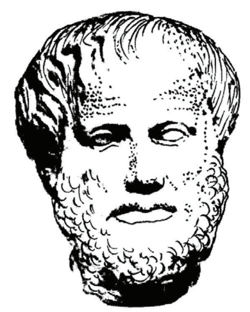
CHAPTER 1

A VERY BRIEF HISTORY OF BRAIN RESEARCH

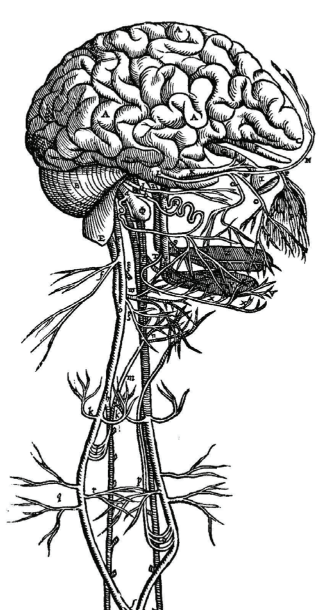
Even before reading this book, you already know more about the brain than the doctors and scientists of the ancient world up until about 300 B.C. If you've done even a little reading about the brain, you probably know more about it than any doctor before the 1800s. Brain research did not really begin until the late 1800s, and progressed slowly until the invention of scanning devices in the late 1900s. Even today, in the 21st century, with all our advanced medical technology, there is still a lot we don't know about the brain.

In about 300 B.C., the famous Greek thinker, Aristotle, proposed that the heart was the center of thought and emotion, and that the gray blob inside the head only served to cool the blood after it got all heated up by the heart. He was followed by a Greek doctor named Herophilus who actually cut bodies open to see how they worked. After studying the anatomy of the brain and making observations of what happened to people when they got hit on the head, he decided that the brain, not the heart, must be the control center of the body. Herophilus also noticed long, threadlike things running out from the brain to parts of the body. Today we call these things ***nerves***.



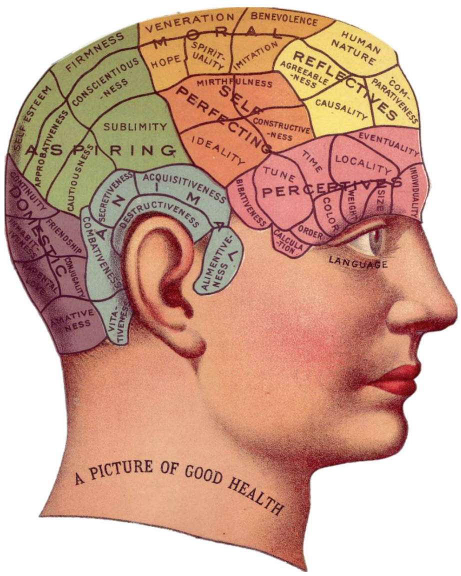
ARISTOTLE
384-322 BC

Another Greek doctor, Erasistratus, opened skulls to look at brains. He described all the wrinkles and folds that we now call ***convolutions***. He even noticed that human brains have more of these convolutions than the brains of animals do. He also saw that the brain has two main sections, and that it is covered by thin membranes. After Erasistratus, a doctor named Galen began poking around at the nerve stem that comes out of the bottom of the brain. He did experiments with animals where he cut this stem at various points and observed the results. Injuries high on the stem caused death. Injuries lower down on the stem caused only paralysis of body parts. From this he learned that the top part of what we now call the ***brain stem*** is in charge of basic functions like making the heart and lungs work.



After Galen, not much happened in the world of brain science for about a thousand years. Then a doctor named Andreas Vesalius came on the scene in the 1500s. His work was the beginning of modern medical science, as he dissected bodies more scientifically than anyone had ever done before. He figured out that the brain, the spinal cord, and all the nerves in the body make up a complete ***nervous system***. His anatomy books were used by medical schools for hundreds of years. The picture shown here is one of his drawings.

Even with all of Vesalius' wonderful drawings of the brain and spine, still no one knew exactly how the brain worked. Right into the mid 1800s, doctors were clueless as to how that gray blob actually worked. Did the whole brain function as a unit, or was it subdivided into specialized areas? How did it send messages to the muscles? No one knew. That didn't stop people from guessing, though. One theory was that the brain had many specialized areas for certain activities. Someone came up with a map of the brain and labeled each area. It was thought that the areas of your brain that were large (and therefore where your talents were located) would cause your skull to bulge just a little. Thus, you could tell someone's personality by feeling the bumps on their head!



This "science" was called phrenology. Believe it or not, diagrams like this were taken seriously until the mid-1800s. If you were unfortunate enough to have a large bump on your skull right above your ear, you would be classified as a "destructive" person. If you had a bump on the back of your head, it was good news—you'd be more likely to be successful at love and friendship. A bump in front of your ear would make you eat too much. (We must wonder how many people's heads did not match their personalities!) Many of these phrenology words are rarely used today, such as "sublimity" (excellence), "suavity" ("cool factor"), "amativeness" (loving), and "approbativeness" (desire for fame).

Not all scientists believed in phrenology, however, and there was an on-going debate among scientists about whether the brain functioned as a whole or was divided up into areas. Modern science has proven that both sides in the debate were right. The brain does indeed function as a whole, and the brain does indeed have specialized locations for certain activities.

In the late 1800s, brain researchers discovered that the best way to find out how the brain works is to study brains that have been injured. After an injured patient died, they would examine the brain to find out which area, or areas, had been damaged. They discovered that in patients who had lost the ability to speak, there were always damaged cells on the left side of the brain in the area behind the temple. In patients who had lost the ability to move their arms or legs, there was always damage on the top of the brain. The researchers kept track of their findings, and began a new map of the brain, based on observation, not on wild guesses.

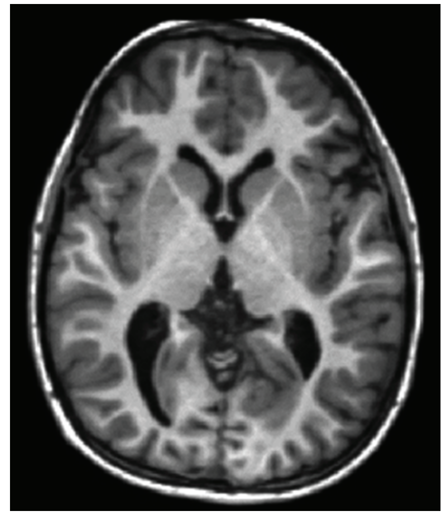
Photograph by Jack and Beverly Wilgus of daguerreotype originally from their collection, and now in the Warren Anatomical Museum, Center for the History of Medicine, Francis A. Countway Library of Medicine, Harvard Medical School. Enlarged using Waifu2x and retouched by Joe Haythornthwaite. Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=64865123

The most famous brain injury of all time happened to a man named Phineas Gage. He lived in the state of Vermont in the 1800s and worked for a railroad company as the foreman of a blasting crew. His job was to use dynamite to blast away rock that was in the path of the new railway. He would use a long metal tool called a tamping iron to carefully press gunpowder down into deep holes. One end of the rod was sharp so that it could be used to break apart stubborn clumps. On September 13, 1848, he accidentally dropped his metal rod into a gunpowder hole at the wrong time. The explosion sent the sharp end of the rod up through his head, entering under his jaw and coming right out the top. To everyone's surprise, he survived the accident and seemed to make a complete recovery. He traveled to South America and became a stagecoach driver. He became very attached to his tamping rod and took it everywhere he went. When he posed for this photograph he insisted on holding the rod.

Even though Phineas had appeared to make a good recovery, those who knew Phineas said that the accident had a profound effect on his personality. They said that "Gage was no longer Gage." He was restless, had trouble making decisions, and was often rude. Before the accident, he had been such a nice young man. The rod had damaged the left side of his brain—the area containing his social skills and his ability to make decisions. Eventually, the injury did begin to affect his health and he began having seizures (sudden bursts of intense electrical activity in the brain). He died of a seizure 11 years after his accident. Years later, his skull and his tamping rod were put into a museum.

Modern brain researchers have the benefit of high-tech scanning devices that allow them to look at the brains of living patients without causing them any harm. These scans are known by their initials, **CT** (computed tomography)**, MRI,** (magnetic resonance imaging), and **PET** (positron emission tomography). The CT scan uses X-rays, the MRI uses magnetism and radio waves, and the PET scan traces the path of radioactive sugar molecules. The CT and MRI produce black and white images, while the PET scans are in color. The PET scan is used to "watch" brain activity while patients are asked to perform certain tasks. A new type of scan called the functional MRI, or fMRI, can also be used to watch the brain in action.

Modern brain surgery has also added to our knowledge of the brain. Sometimes surgeons are even able to operate on the brain while the patient is awake, which allows them to ask the patient what they feel when different areas of the brain are touched. The brain itself has no pain sensors, so this is not as bad as it sounds!



MRI of brain. top view

https://commons.wikimedia.org/w/index.php?curid=3479321

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ACTIVITY 1.1 Use the Internet to compare types of scans

Use an Internet image search and these keys words: CT brain scan, MRI brain scan, PET brain scan. Notice the similarities and differences between these types of images.

1) Which type of scan is most similar to an x-ray and gives only black and white images? ____
2) Which type of scan seems to be used more often for side views? ______
3) Which type of scan seems the least helpful for mapping out small brain parts? _____
4) If you were a doctor, which type of scan would you NOT order if you knew your patient had metal implants in their body? _______ Why? ____
5) If you were a brain researcher and wanted to see what area of the brain was active when mathematical calculations were being done, which kind of scan would you use? _______
Why? ____

ACTIVITY 1.2 Videos about brain scans

A special playlist has been set up for this book. Go to **www.YouTube.com/TheBasementWorkshop**, click on "Playlists." then find "Brain curriculum." The videos are arranged by chapter, so the first few videos are about these types of brain scans. There are also some videos about Phineas Gage.

ACTIVITY 1.3 More about Phineas Gage

Phineas felt he was ready to go back to work only a few weeks after his accident. At first it looked like he would be able to pick up right where he left off, as the foreman of a blasting crew. His men soon discovered that he was hard to get along with and there were so many complaints about him that Phineas lost his job on the railway. While visiting his mother in New Hampshire, he was offered a job driving a stagecoach down in the country of Chile, in South America. He was promised he would not have to work with people, only horses. He got along just fine with animals, so he took the job and spent several years in Chile.

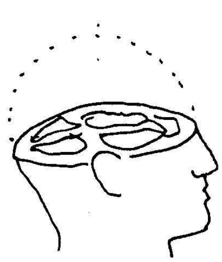
Meanwhile, Phineas' mother had moved to San Francisco. After Phineas lost his job in Chile, he went north to visit his mother. While in San Francisco, he began having seizures, which made him sick. His health started to deteriorate and eventually he had a seizure so severe that he died of it. He was buried in San Francisco, but several years later the doctor from Vermont asked to have Phineas' skull for medical research. Phineas' mother allowed the body to be dug up, and the head was removed by a surgeon. Along with the skull went the infamous tamping rod, which Phineas had taken with him everywhere he went since the accident. Both Phineas' skull and his tamping rod are now in the collection of the Harvard Medical School in Boston. (You can see these artifacts in one of the videos on the playlist.)

ACTIVITY 1.4 Color a PET scan

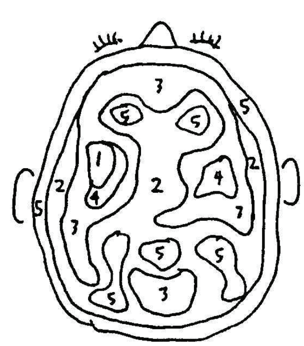
PET stands for Positron Emission Tomography. To prepare for a PET scan, the patient must drink a solution that has radioactive sugar molecules in it. Areas of the brain that are active use more sugar than areas that are inactive. The PET scanner can "see" the radioactive sugar as it is used by the brain and translates this into a color image. Areas of the brain that are highly active appear red. Areas that are less active are blue or purple.

Use the numbers to color this PET image. Sharp colored pencils work best.

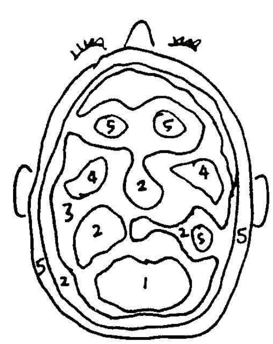
1 = red 2 = blue 3 = green 4 = yellow 5 = purple



This is the section of the brain that is being scanned.



This is how the section looks when the patient's eyes are closed.

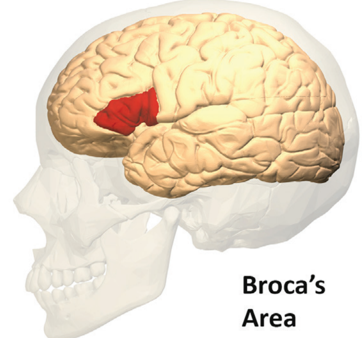


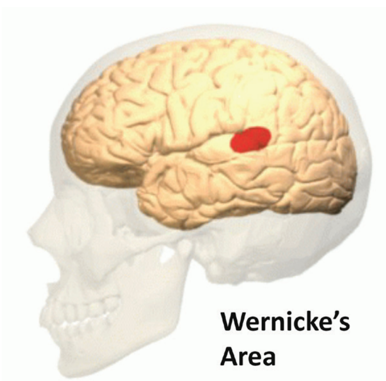
This is how the section looks when the patient's eyes are open.

CHAPTER 1.5

MORE ABOUT BRAIN RESEARCH

Starting in the late 1800s, doctors began to study patients with a type of brain injury called ***stroke***. In a stroke, one or more blood vessels in the brain become blocked and blood cannot be delivered to the cells that are supplied by that vessel. The affected brain cells die from lack of oxygen. Strokes are very specific, and affect only one portion of the brain; this characteristic makes them extremely useful for finding out what certain areas of the brain do. A French surgeon named Paul Broca began studying patients who could not speak after having a stroke. He asked their permission to examine their brains after they died. Enough of the patients agreed, that Broca was able to discover visible damage to cells on the left side of the brain in the area of the temple. He concluded that this area must be critical to speech. This part of the brain has become known as ***Broca's area***.





In Germany, a doctor named Karl Wernicke *(VER-nih-kuh)* was also studying stroke patients. He had a number of patients who could talk, but could not understand speech. Examining these patients' brains, he found that they all had a diseased area on the left side above the ear. He guessed that this area of the brain must be vital to our ability to process the sounds and words we hear. Not surprisingly, this area of the brain has become known as ***Wernicke's area***.

As sad as brain injuries and diseases are, without them scientists would not have been able to discover how a healthy brain works. The good news is that the brain has amazing abilities to fix itself. Even in elderly patients, the brain often recovers from a stroke. Every year there is more and more evidence that the brain has more recuperative powers than was previously believed.

A fascinating story of brain research involves the brain of the famous scientist, Albert Einstein. After Einstein's died, his body was sent to a special type of surgeon whose job was to examine bodies to determine why the person died. The surgeon the autopsy secretly removed Einstein's brain and kept it. No kidding—he really did! He kept it in a jar at his own personal lab, hoping that by examining it, he could find out what made Einstein so smart. Over the years, he sent small pieces of the brain to other researchers around the world. They all came up with different theories based on their research. Some said there was no difference. One researcher found that Einstein had more glial cells (you'll learn about them in a future chapter). Others said that the area on the right side of the brain used for higher math concepts (the parietal lobe) was larger than normal. Or perhaps it was a thicker corpus callosum? We have theories, but we still don't know for sure what made Einstein's brain able to think the way it did.

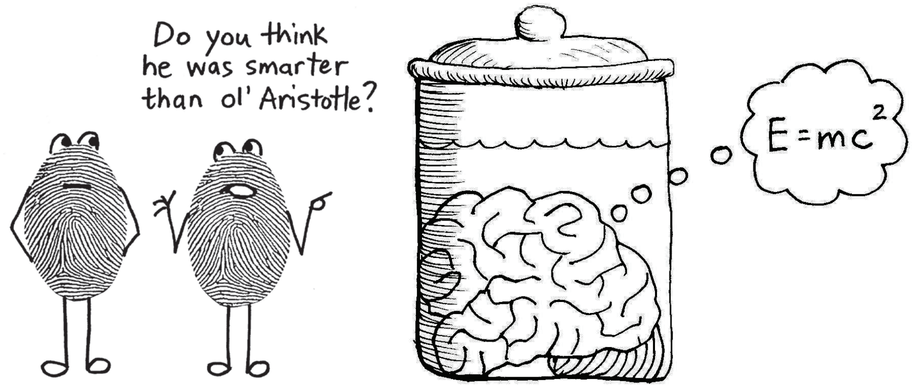
Illustration credits:

Broca's Area:

By Polygon data were generated by Database Center for Life Science(DBCLS)[2]. - Polygon data are from BodyParts3D[1], CC BY-SA 2.1 jp, https://commons.wikimedia.org/w/index.php?curid=32508617

Wernicke's Area:

By Polygon data were generated by Database Center for Life Science(DBCLS)[2]. - Polygon data are from BodyParts3D[1], CC BY-SA 2.1 jp, https://commons.wikimedia.org/w/index.php?curid=32533678



ACTIVITY 1.5 Find out more about MRI and PET

Use an Internet search engine to find more information on MRI and PET scans. YouTube or another video service could also be helpful. Answer the following questions about each.

MRI:

1) What does MRI stand for? ____
2) How big is an MRI machine? ____
3) Does it really have a big magnet in it? ________
4) Besides scanning the brain, what else is MRI good for? ____________________________________
____
5) Briefly describe how an MRI machine produces an image: ___________________________________
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6) What is the difference between regular MRI and functional MRI? __________________________
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PET:

1) What does PET stand for? ____
2) What must a person receive before getting a PET scan? ____________________________________
3) What does the PET scan "see"? ____
4) Why is the PET scan in color and what do the colors represent? __________________________
____
____
5) Besides brain imaging, what else is PET used for? _____________________________________
____

ACTIVITY 1.6 Find out more about Einstein's brain

If you find Einstein's brain a fascinating subject, there is more you can learn via the Internet. You can see actual pictures of his brain. (In fact, pieces of the brain were on public display in London in 2012.) Just use the key words "Einstein's brain" in any Internet search engine. Also, Wikipedia has article titled "Einstein's Brain."

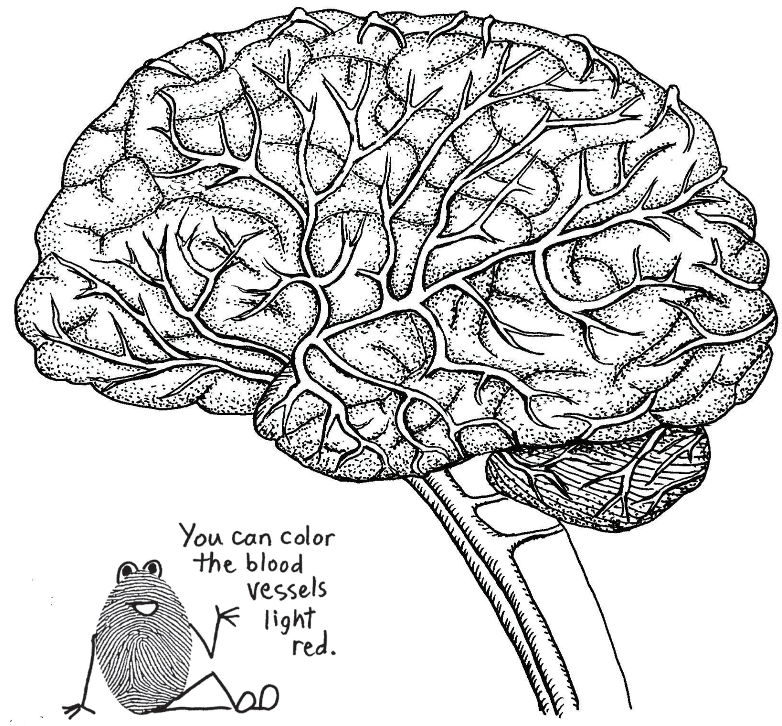
There is a short video documentary posted on the "Brain curriculum" playlist at **www.YouTube.com/TheBasementWorkshop**. Included in this video is an interview with Thomas Harvey, the doctor who removed and kept the brain. He kept parts of the brain in various jars that spent a good deal of time in the trunk of his car or in his basement. (Rumor has it that he also removed Einstein's eyes, and gave them to Einstein's eye doctor. The eyes are now reportedly in safe deposit box in New Jersey.)

ACTIVITY 1.7 Watch a few short videos on Broca's area and Wernicke's area

Go to the Brain curriculum playlist to see some video clips about these areas. (The exact videos available might change over time, as videos are added or removed from YouTube.)

CHAPTER 2

BASIC BRAIN ANATOMY



Your brain fills up most of your head and weighs about 1.5 kg (3 pounds). The brain needs a lot of blood, so it sits on top of some very large blood vessels, almost like a ball balanced on top of a water fountain. It receives 35 liters (about 8 gallons) of blood every hour. The blood brings oxygen and sugar to the brain and carries away waste products and carbon dioxide. The brain uses more energy than any other organ of the body, consuming 40% of the oxygen and sugar you take in. ("Sugar" includes digested carbohydrate foods such as bread, cereal, rice, potato and pasta.)

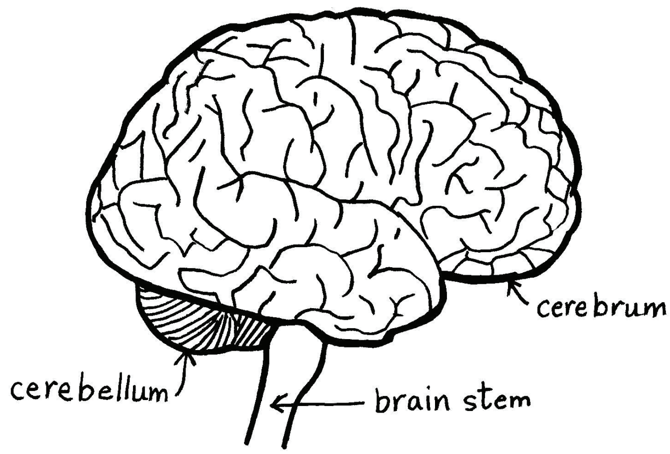
The large blood vessels at the bottom of your brain branch off into smaller and smaller vessels, down to microscopic vessels called ***capillaries***. The capillaries form a fine network all through the brain, making sure that every cell gets nourishment.

The brain looks wrinkled and folded, and there is a good reason for this. The surface layer, called the ***cortex***, is larger than it appears. If you peeled it off the brain and laid it out flat, it would cover an area about the size of a kitchen table. Imagine the cortex as a tablecloth that has been crumpled up to fit inside your head. The more wrinkles there are, the more brain cortex there is. In general, you can tell how intelligent an animal is by looking at how wrinkly its brain is. More wrinkles means more surface area, and more surface area means more space for learning and memory.

Inside the skull, the brain is surrounded by a layer of watery fluid called ***cerebrospinal fluid***, which cushions it and protects it from bumps and bangs. Although watery fluid isn't as exciting to learn about as the brain itself, it does deserve to be mentioned because without this fluid, you would be risking brain injury every time you went out to play. After the fluid bathes the brain, it flows down the middle of the spinal column, bathing all the spinal nerves. Eventually the fluid exits at the bottom of the spinal cord and is reabsorbed by other body tissues. The brain is constantly making new fluid at the rate of about a spoonful every hour.

There are three main sections of the brain. The largest section, the top part, is called the ***cerebrum***. (Most people pronounce it like "*sah-REE-brum*" but the dictionary says that "*SARE-eh-brum*" is also correct.) This is the part that you consider your "real" brain. This is where your thinking takes place. It is also the part that commands your muscles to move and processes information from your eyes and ears.

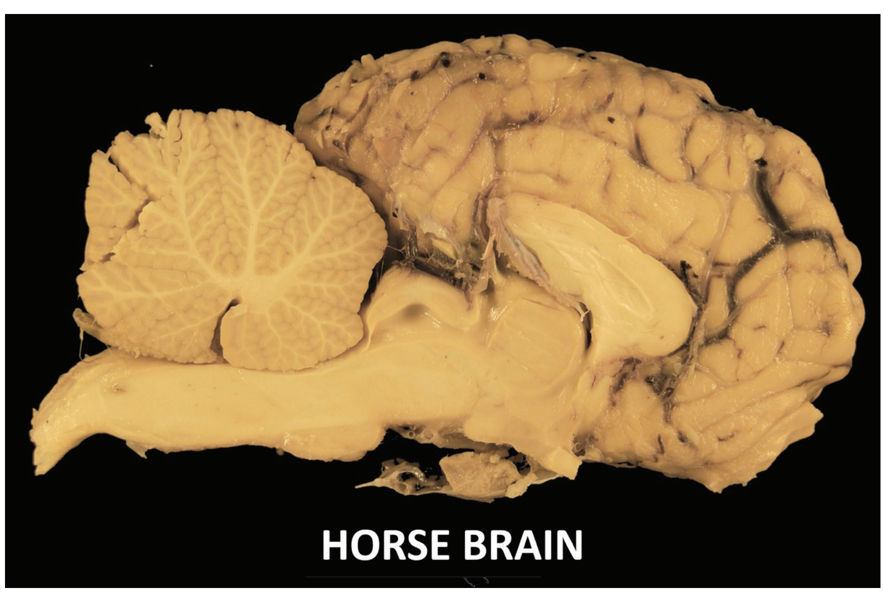
The word "cerebrum" is the Latin word for "brain." The word root "cere" comes from a very ancient word: "keres," meaning "horn or head." We find this root is a wide variety of words, such as hornet, unicorn, corn, corner, cornea, triceratops, rhinoceros, and carrot.



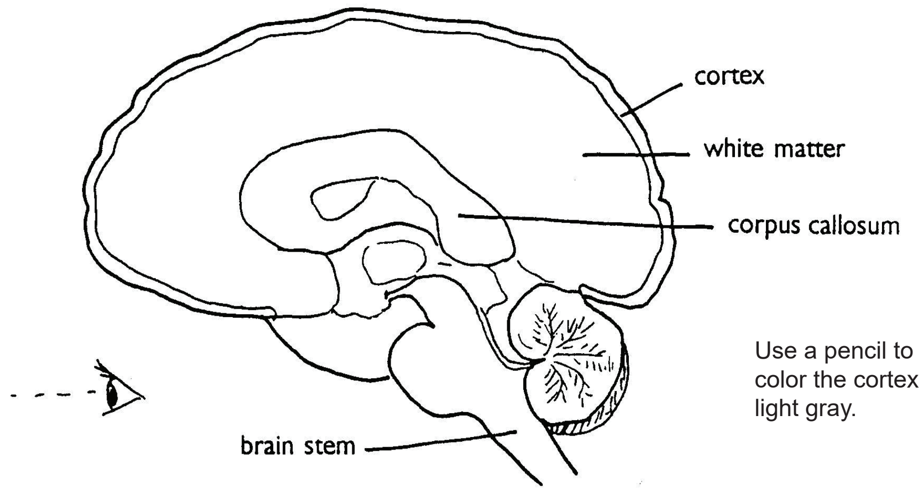
The little wrinkly blob under the cerebrum is called the ***cerebellum*** *(sare-eh-BELL-um)*. It's almost like a separate brain. Its name means "little brain." The cerebellum is in charge of coordinating balance and movement. Without your cerebellum you would fall over if you tried to walk. You need it to help you do things like throwing a ball into a hoop or shooting at a target. Also, some types of memory are stored here—your "muscle memories," such as how to ride a bike or tie your shoe. The cerebellum is the fastest growing part of the brain and reaches almost adult size by the time a child is two years old!

The stem-like thing sticking out the bottom is called the ***brain stem***. It performs the bodily functions you take for granted, such as your breathing and the beating of your heart. Some reflexes are also found here such as gagging, coughing or vomiting. Yes, these are yucky, but they keep you healthy.

Animals brains have basically the same structures as human brains. Can you identity the brain stem, the cerebellum and the cerebrum in this horse brain? Why do you think the brain stem is coming out the side instead of the bottom? (Think of what a horse's head and neck look like.) How big is the cerebellum compared to the cerebrum? Why might horses need their cerebellum to be larger than their cerebrum?

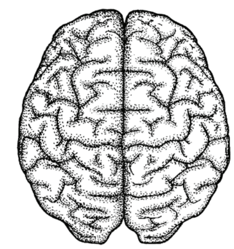


Now let's split the brain open and take a look at the inside.

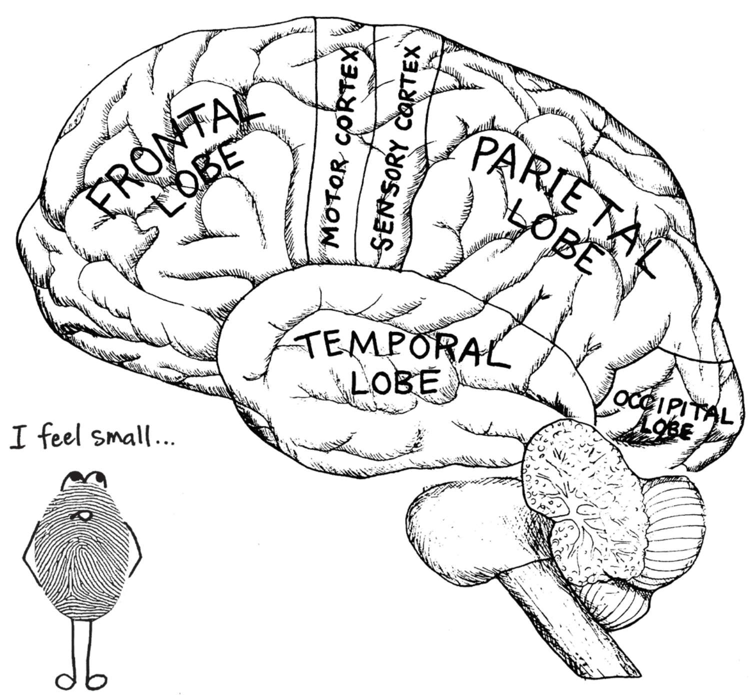


In this diagram, we've drawn and labeled the ***cortex***. In a real brain, there isn't a line between the cortex and the rest of the cerebrum (look at the horse brain). The cortex is about as thick as a piece of corrugated cardboard. This is where thinking takes place. The cortex is sometimes called our "gray matter" because it does look light gray in color. Underneath the gray matter is a thick section called "white matter." We'll learn more about the white matter when we learn about individual brain cells and what they do. The sideways C-shaped thing in the middle, the ***corpus callosum***, is a connecting bridge between the right and left sides of the brain. ("Corpus" is Latin for "body, and "callosum" is Latin for "thick.")

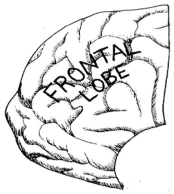
If you look straight down on the brain (top view), you can see that there is a split down the middle. The cerebrum has two almost identical halves which are connected to each other on the inside by the corpus callosum. It is believed that the thicker the corpus callosum is, the better the connection between the two hemispheres. Females tend to have thicker corpus callosums, on average, than males do. You would be able to see the corpus callosum on an MRI or CT scan.



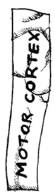
Now let's see how the cerebrum can be broken apart into six distinct areas. We know what and where these areas are because of the brain research techniques we read about in the first chapter. A real brain doesn't have any lines on it, of course. These are imaginary lines, similar to the lines between states or countries on a map. A brain surgeon must know where these areas are without any lines to help him!



What do these six parts do? The name of the sensory cortex might give you a hint about that one. But what about the parietal or the occipital? Anatomy words are often taken from Greek or Latin so they look strange to us. However, their meanings are usually very simple.

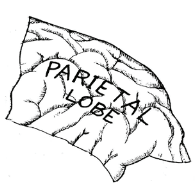


FRONTAL LOBE: Located in the front of your head, behind your forehead (thus its name), this is the area of your brain that you think of when you think of your “brain.” (Isn’t it funny that your brain can think about itself thinking?) The frontal lobe is where you make decisions and do mental calculations. When you play chess, you give your frontal lobe a real workout! The frontal lobe is responsible for monitoring your behavior and the learning social skills that you need in order to get along with other people. The famous example of Phineas Gage shows how damage to the frontal lobe can result in a change of personality. Before the accident Phineas was responsible, polite, and good with people. After the accident he was irresponsible, rude, and terrible with people. The frontal lobe has connections to other parts of the brain. For example, it gives directions to the motor cortex when you decide that you want to move your arms or legs. It also has connections to the parts that receive input from your eyes and ears.



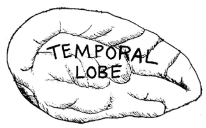
MOTOR CORTEX: Right next to the frontal lobe is the thin strip of cortex that sends signals to your muscles telling them to move (or to stop moving). Your frontal lobe thinks of your chess move, then sends a signal to the motor cortex, which in turn sends a signal to the muscles in your arm and hand, causing them to pick up your chess piece and move it to another square. The motor cortex also controls your legs and feet and any other muscle you can move voluntarily.

SENSORY CORTEX: This thin strip is connected to all parts of your body, but especially the skin. It receives messages about things you feel. Your skin has nerves that can sense hot, cold, pain, and pressure. These sensory feelings go into a middle part of your brain first, before they go to the sensory cortex. This middle part of your brain decides if the feelings are important enough to relay to your sensory cortex. This is why you don’t notice minor irritations if you are very busy doing something. The sensory cortex has two sides, each one matching up to one side of the body. You might guess that the left sensory cortex matches up with the left side of your body, but the reverse is true. The left sensory cortex goes to the right side of your body, and you right sensory cortex goes to the left side of your body. Some parts of the body, such as your fingertips and face, get a much larger section of the cortex devoted to them. These parts need more sensing nerves than parts such as the back or the legs.



PARIETAL *(par-EYE-it-al)* **LOBE**: This area of the brain is the most mysterious one. Scientists still don’t know everything the parietal lobe does. Its main job seems to be keeping track of where your body parts are. If you close your eyes, you still know what your arms are doing. You can bring your hands together without looking. This is your parietal lobe working. It also seems to keep track of all the objects in your environment, and knows “which end is up.” For example, you know which end of a pencil is used for writing, even if the pencil is upside down. This may seem a bit obvious, or even silly, but this function of the brain is very important; it allows you to see objects in your mind. The parietal lobe is very important in the study of geometry and other mathematical concepts. (Remember, Einstein had a large parietal lobe.) Last, but not least, the parietal lobe works with the cerebellum and the inner ear to give you your sense of balance.

OCCIPITAL (*ock-SIP-it-al)* **LOBE**: This area, located at the back of your head, is where the input from your eyes gets processed. It may seem strange, but the nerves from the eyes travel all the way to the back of the brain. Not only that, but the nerves from the eyes cross over in the middle so that the left eye connects to the right side of the brain and the right eye connects to the left side of the brain. To further complicate things, the images arrive at the occipital lobe upside down! The occipital lobe must turn everything right side up and figure out what you are looking at. Your eyes only do half the job of seeing. The occipital lobe has to finish the job.



TEMPORAL LOBE: This area is on the side of the head, above your ears and your temples. (The temples are the sides of your forehead.) The temporal lobe is in charge of quite a few things, including your ears and nose. Your ability to speak and to understand speech is located in the temporal lobe. (Do you remember from chapter one how we first learned what the temporal lobe does?) When you talk, you are using your temporal lobe to construct a sentence that makes sense. The temporal lobe has connections to the frontal lobe and the motor cortex. The frontal lobe decides what to say and sends signals to your temporal lobe and your motor cortex. Your sense of smell and your memory of smells are also located in the temporal lobe. Smell memories are often very strong memories because the temporal lobe is located very close to the inner part of your brain where memories are stored.

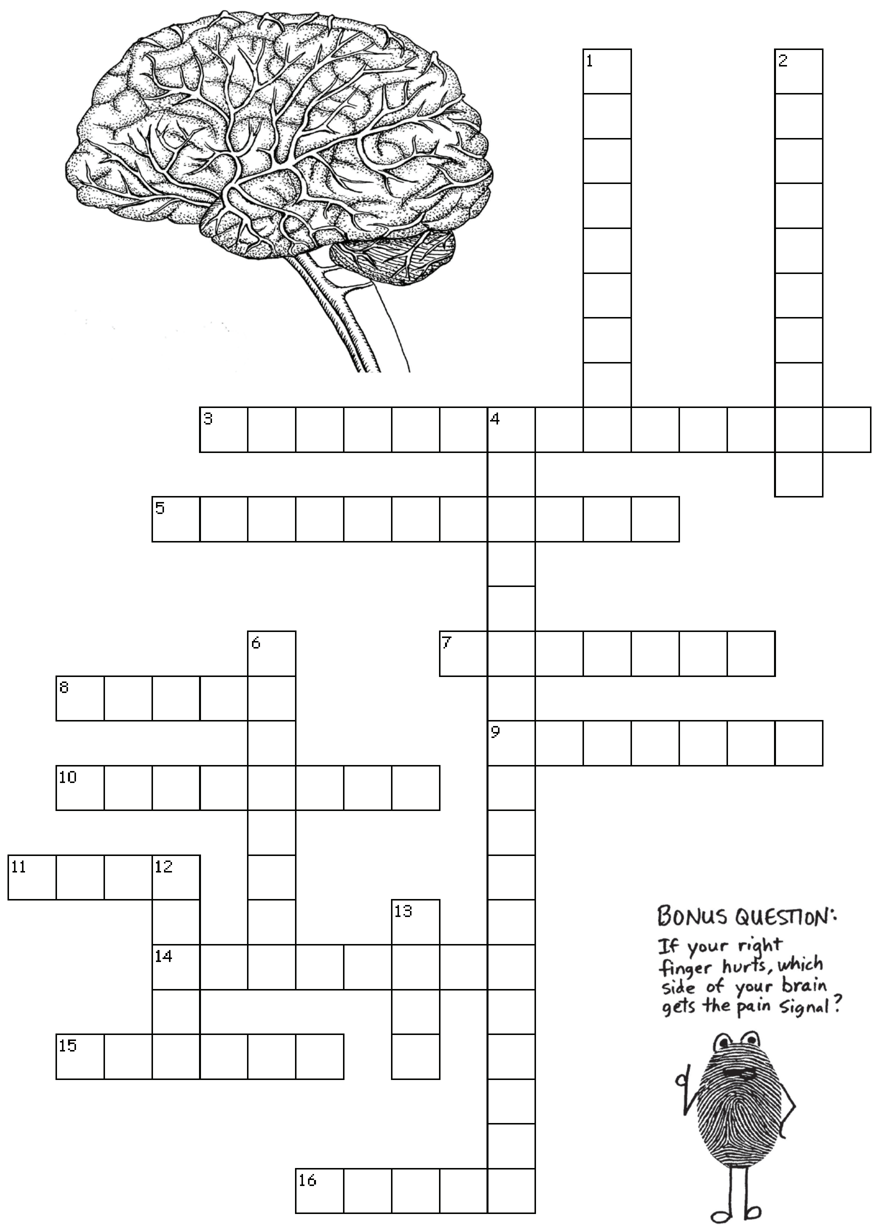
****

ACTIVITY 2.1 A crossword puzzle about the brain words you've learned

Clues are from chapters 1 and 2.

ACROSS:
3) This "firm body" is the bridge between the two hemispheres.
5) Tiny blood vessels
7) This lobe is the one you use to make decisions.
8) The ____ matter is the interior of the cerebrum. It is much thicker than the gray matter.
9) The _____ cortex receives incoming signlas from the nerves in the skin.
10) The ___ lobe keeps track of where your arms and legs are.
11) The brain ____ contains many reflexes and automatic functions like breathing.
14) The ___ lobe has many functions including smelling, hearing, speaking and listening.
15) The outer layer of the cerebrum is often called the ______.
16) This fluid brings oxygen to the brain.

DOWN:
1) This lobe is connected to your eyes and is responsible for interpreting visual signals.
2) This means "little brain." It coordinates movement and balance.
4) This fluid is in the "empty spaces" in the brain and helps to cushion and protect it.
6) This is the large top part of the brain. It is divided into both hemispheres and lobes.
12) The ___ cortex sends out signals to the muscles.
13) The ___ matter is the outer layer (the cortex) of the cerebrum.



ACTIVITY 2.2 What brain parts are used for these activities?

For each of the activities described below, list the lobes of the brain that you would use and what each one would be used for. The first one is done for you as an example.

1) Brushing your teeth:
FRONTAL LOBE: decides to brush teeth and sends signals to motor cortex
MOTOR CORTEX: tells muscles to move toothbrush around in the mouth
SENSORY CORTEX: Feels the brush in your hand, feels the scrubbing on your gums and teeth
PARIETAL LOBE: Senses that the hands are raised to the mouth, also keeps you balanced
OCCIPITAL LOBE: Makes sense of what your eyes are seeing in the mirror
TEMPORAL LOBE: Smells the toothpaste

2) Playing the piano
FRONTAL LOBE: ______________________________
MOTOR CORTEX: ______________________________
SENSORY CORTEX: ______________________________
PARIETAL LOBE: ______________________________
OCCIPITAL LOBE: ______________________________
TEMPORAL LOBE: ______________________________

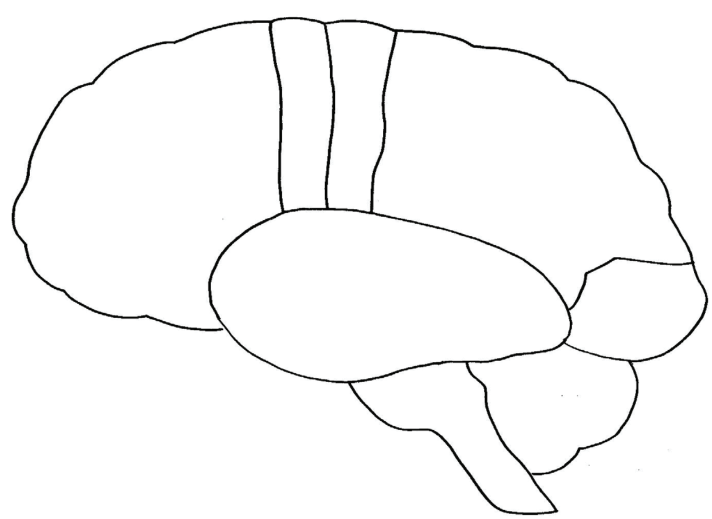
3) Riding a bicycle
FRONTAL LOBE: ______________________________
MOTOR CORTEX: ______________________________
SENSORY CORTEX: ______________________________
PARIETAL LOBE: ______________________________
OCCIPITAL LOBE: ______________________________
TEMPORAL LOBE: ______________________________

4) Talking on the telephone
FRONTAL LOBE: ______________________________
MOTOR CORTEX: ______________________________
SENSORY CORTEX: ______________________________
PARIETAL LOBE: ______________________________
OCCIPITAL LOBE: ______________________________
TEMPORAL LOBE: ______________________________

ACTIVITY 2.3 Color a "map" of the brain

Fill in a color for each square of the key, then color the corresponding brain part.

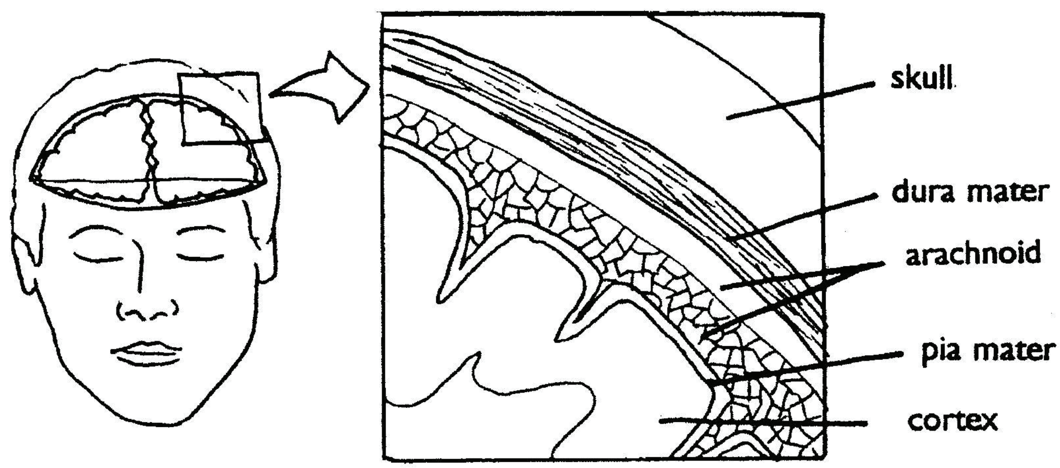
- ☐ FRONTAL LOBE
- ☐ CEREBELLUM
- ☐ MOTOR CORTEX
- ☐ TEMPORAL LOBE
- ☐ SENSORY CORTEX
- ☐ BRAIN STEM
- ☐ PARIETAL LOBE
- ☐ OCCIPITAL LOBE



CHAPTER 2.5

MORE ABOUT BASIC BRAIN ANATOMY

Let's take a closer look at the tissues and fluid that surround and protect the brain. These tissues are called the ***meninges*** *(men-IN-juz)* and are made of three distinct layers. The first layer, right under the skull, is called the ***dura mater***. ("Dura" means "hard or tough," and "mater" means "mother.") The texture of this layer is leathery and tough and is attached to the skull. (Mothers have to be tough sometimes!)

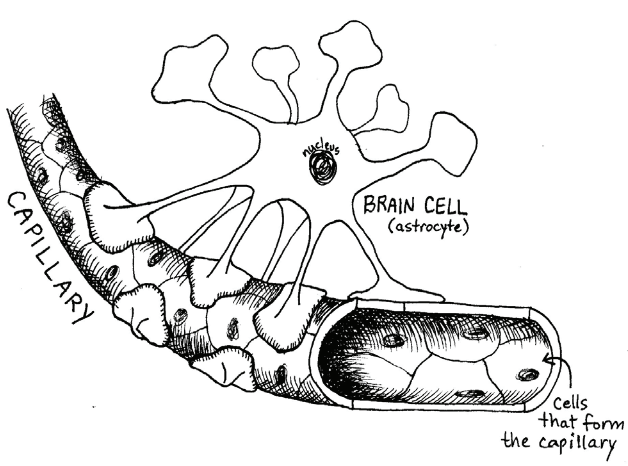


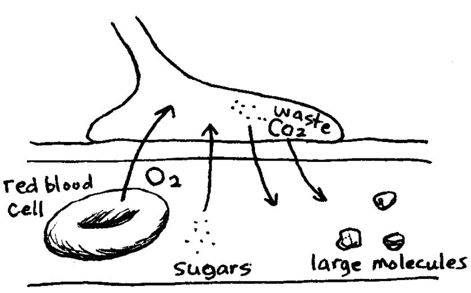
The second layer is called the ***arachnoid*** layer. This word might remind of the scientific name for spiders: the arachnids. The arachnoid layer of the brain was given this name because under the microscope it looks a bit like a spider web. It is inside the arachnoid layer that the protective ***cerebrospinal fluid*** flows.

The third layer, called the ***pia mater,*** is delicate and soft ("pia" means soft) and it attaches to the surface of the brain, following every wrinkle and bump. These three layers work together to cushion the brain and protect if from all the bangs and bumps that life inevitably brings.

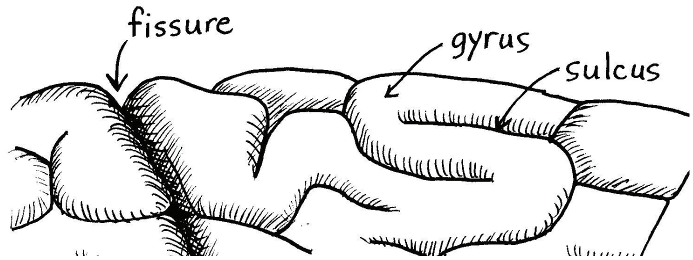
Another important safety feature of the brain is called the ***blood-brain barrier (BBB)***. The tiny blood vessels in the brain (the capillaries) are close enough to the brain cells that oxygen and sugar can pass from the blood into the cells, and carbon dioxide and waste molecules can pass out of the cells and be carried away by the blood. (The brain cell in the picture is really weird-looking, isn't it? More about brain cells in chapter 5!)

The cells that make up the capillaries in the brain are joined together very tightly so that only very small molecules can get in or out. This protects the brain from potentially harmful substances. Bacteria are huge compared to nutrient molecules, so they hardly ever get into the brain. If bacteria do get in, this poses a problem for doctors because the barrier keeps most antibiotic medicines out. A sugar called mannitol is often used to temporarily loosen up the junctions between the cells and allow larger molecules, such as antibiotics, to get in.)

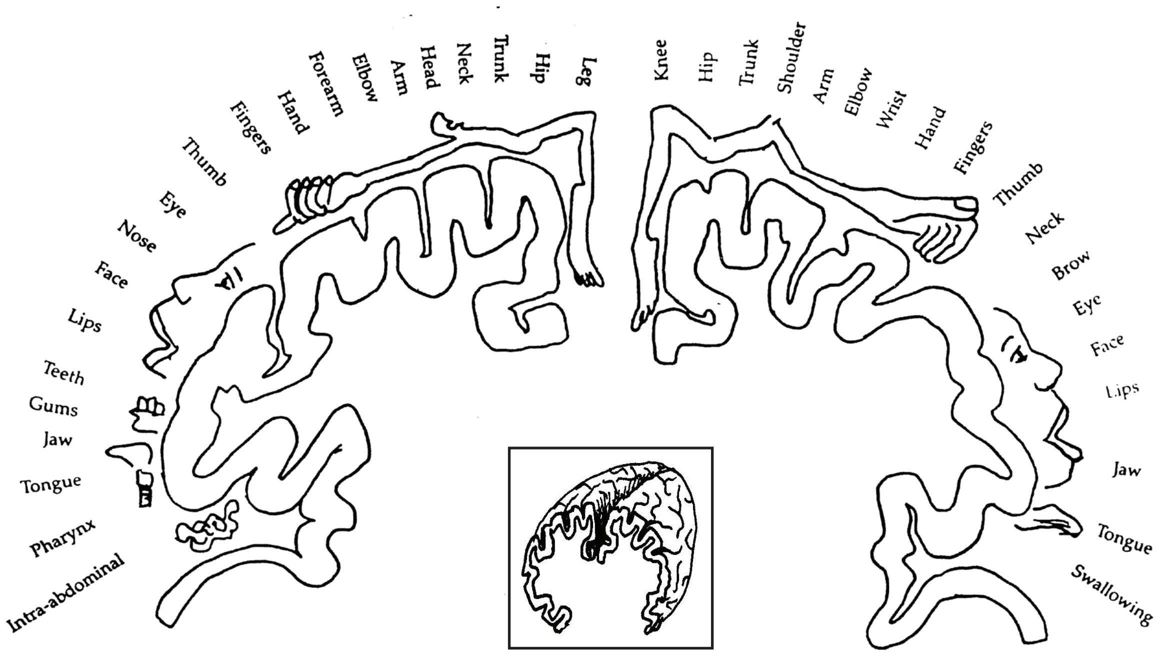




Here are a few more correct technical words for brain parts: The correct name for a wrinkly bump is a ***gyrus*** *(JIE-rus).* The valley in between is called the ***sulcus***. A split between lobes of the brain is called a ***fissure***, which is just a fancy name for "crack."



Now let's take a closer look at the sensory cortex. If you laid it out in a semi-circle and wrote down what each part of it did, you would get a "map" that looks something like this:



Scientists call this diagram the ***homunculus***, meaning "little man." It shows how much of the cortex (and which parts) are devoted to certain parts of the body. Your back doesn't need to be as sensitive as your finger-tips, so less of the cortex is devoted to the back. You can see that the face takes up almost as much space as the rest of the body does. The lips and mouth get a sizeable portion of the cortex. If you drew a person with these proportions, it would look very strange indeed!

****

ACTIVITY 2.4 Measure the length of the sensory cortex

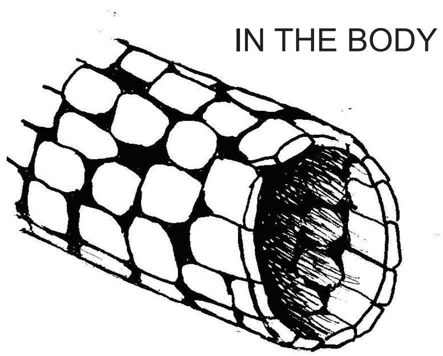
The sensory cortex is very wrinkled. You'll remember that the cortex is wrinkled so that a large surface area can be scrunched into a small space. Use a piece of string to measure the cortex in this diagram. Lay the string along the cortex, following all the twists and turns. Put a mark on the string where it reaches the end of the cortex.Then pull the string out to its full length and measure it. If you don't have a ruler with centimeters you can use inches instead. Scientists prefer measuring with metric units, as they are based on the number 10 and are therefore easier to use in calculations.

The cortex on the left is _____ centimeters long. The cortex on the right is _____ centimeters long.

ACTIVITY 2.5   Read more about the blood-brain barrier

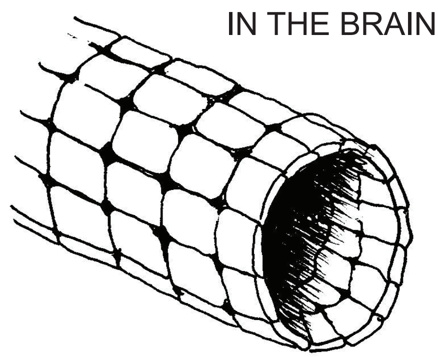
The discovery of the blood-brain barrier (abbreviated as BBB) goes back to the late 1800s when Paul Ehrlich, (famous for inventing many of the stains that are used in preparation of microscope slides), discovered that when blue dye was injected into a lab animal's body, it stained all the tissues in the body except for the brain. This suggested that something was not allowing the dye to enter the brain. Then it was found that if the dye was injected into the cerebrospinal fluid, the brain would be dyed, but nothing else in the body would be. This suggested that something was not allowing the dye to exit the brain. There seemed to be a barrier that would not allow chemicals to pass either into or out of the brain.

With the invention of the electron microscope in the 1960's, researchers could take a close-up look at the cellular structure of the capillaries in the brain. The capillaries are made up of individual cells, just like any other organ of the body. In the rest of the body, the cells that make up the capillary walls seem to be spaced far enough apart that almost any size or type of molecule can get in or out.



This drawing represents capillaries in regular body tissue. The cells have large gaps between them that allow molecules to go in and out easily.

NOTE: This drawing is not to scale. The cells have been simplified to make it easier to see the gaps. Real capillary cells are not square.



This drawing represents capillaries in the brain. The cells are squeezed tightly together so that the spaces in between are very small.

NOTE: As with the other drawing, the cells are not to scale, and have been simplified.

In brain capillaries, however, the cells are more tightly packed together. Most molecules are too big to squeeze through the gaps. The BBB blocks most molecules from crossing, except those that the brain needs (or needs to get rid of): oxygen, carbon dioxide, hormones, sugars and amino acids (the units that proteins are made of). Small molecules such as alcohol (ethanol) can also pass through the BBB. The brain does not need alcohol and yet it can get into the brain. When too much alcohol passes into the central nervous system it causes a mild case of poisoning called "intoxication." In common speech, when someone is intoxicated we call this "being drunk."

About 98 percent of all medical drugs cannot get past the BBB. This makes it very difficult for doctors to treat brain problems, especially infections. To treat brain infections, doctors must first give the patient a medicine that causes the capillary cells to loosen up. Fortunately, the BBB does an excellent job of preventing bacteria and viruses from entering the brain in the first place, so brain infections are extremely rare.

Certain diseases and conditions can weaken the BBB and increase the gaps so that larger molecules can squeeze through. The meninges are on the outside of the BBB so they are susceptible to infection. If the meninges are inflamed, the BBB is disrupted. High blood pressure can also weaken the barrier. Imagine the blood flowing through the tiny capillaries, putting so much pressure on the capillary walls that little gaps are opened up, allowing larger molecules to leak through. Diseases such as Alzheimer's and multiple sclerosis (MS) can also disrupt the BBB.

There are a few places in the brain where the blood is sampled to see how much of a certain substance is in it. The brain is the master controller of bodily secretions such as hormones, and must maintain the right balance of these chemicals in the blood. As you might guess, the blood sampling areas in the brain have a weak barrier and allow everything to pass through.

ACTIVITY 2.6 Look at animal brains and compare them to the human brain

Check out **brainmuseum.org**. Click on “brain sections” in the menu bar on the left. Then scroll down and click on the name of any animal to see a photographs of its brain. The charts will show you different views of the brain: left, right, bottom, top.

How do the sizes of the cerebrums compare to the total brain size? Remember that the cerebrum is where thinking takes place and wrinkles indicate a large surface area crunched into a small space. No wrinkles means less surface area, and, therefore, less thinking power. How does a rabbit brain compare to a pig? Which one would be capable of learning more tricks? Compare the manatee brain with the dolphin brain. Both are sea mammals, but which one is probably smarter? Can you spot any differences between a human brain and a chimp brain? Notice in many of the animal brains that there is a large bulbous part coming out in front of the frontal lobe. These are sensory areas, likely connected to the nose. How much of the lion’s brain is devoted to the sense of smell?

ACTIVITY 2.7 Watch some brain anatomy videos

Use the playlist for this curriculum (**www.YouTube.com/TheBasementWorkshop**, click on “Playlists” then on “Brain Curriculum”) to watch a few videos. The videos might contain some brain parts we won’t cover until future chapters, but they will also review much of what you’ve just read.)

PANIC PREVENTION: You might hear some new vocabulary words in these videos. Don’t panic! Just focus on listening for the words you’ve learned so far. Then, watch the video again, this time listening for new words and trying to figure out what they mean. (TIPS: “Saggital view” means splitting something into left and right sides, “posterior” means “back,” and “anterior” means “front.”)

ACTIVITY 2.8 Cerebrospinal Greek and Latin

You have noticed that most medical words are taken from either Latin or Greek. It seems like scientists are always trying to make things harder for students! Why can’t they just say “membrane” and not “meninges”? Why does “little brain” have to be “cerebellum”? The reason for this is that scientists have tried to choose names that are as “neutral” as possible and don’t favor any one modern European language, such as English, French, German or Spanish. Basing science words on an extinct language also guarantees that the words won’t change their meaning over time. Modern Greek isn’t the same as ancient Greek. The more a language is spoken, the more it changes.

This word puzzle doesn’t need much explanation. Just figure out which of the Latin or Greek words on the right matches each definition on the left. For this exercise, we won’t bother sorting out which are Latin and which are Greek. If you want to do that, just look the words up in a dictionary.

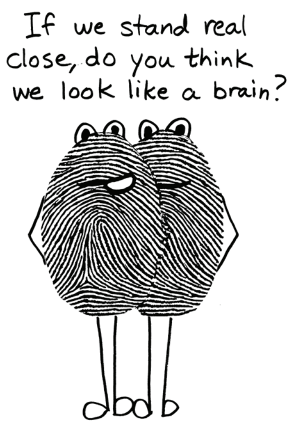
1) Hard: __ __ __ __
2) Soft: __ __ __
3) Spider-like: __ __ __ __ __ __ __ __ __
4) Crack: __ __ __ __ __ __ __
5) Body: __ __ __ __ __ __
6) Firm: __ __ __ __ __ __ __ __
7) Against: __ __ __ __
8) Brain: __ __ __ __ __ __ __ __
9) Little brain: __ __ __ __ __ __ __ __ __ __
10) Ring or circle: __ __ __ __ __
11) Furrow, valley or groove: __ __ __ __ __ __
12) Pertaining to the eye: __ __ __ __ __ __ __ __ __
13) Bark, covering, or shell: __ __ __ __ __ __
14) Membranes: __ __ __ __ __ __ __ __
15) Pertaining to walls: __ __ __ __ __ __ __ __

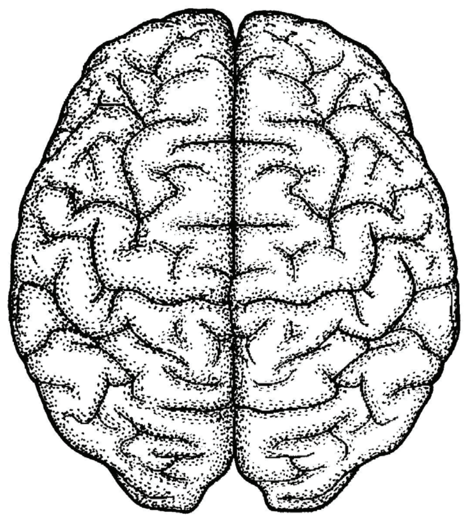
ANTI
ARACHNOID
CALLOSUM
CEREBELLUM
CEREBRUM
CORPUS
CORTEX
DURA
FISSURE
GYRUS
MENINGES
OCCIPITAL
PARIETAL
PIA
SULCUS

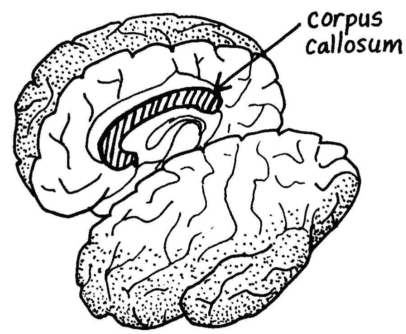
CHAPTER 3

LEFT BRAIN//RIGHT BRAIN

Have you ever heard someone say that they are "left-brained"? What are they talking about? Does that mean half their brain is missing? In the last chapter we always looked at the brain from the side. Now we are going to look straight down on the brain.

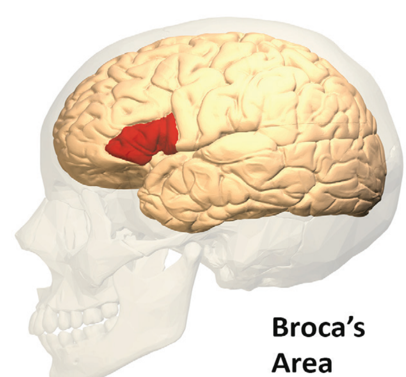




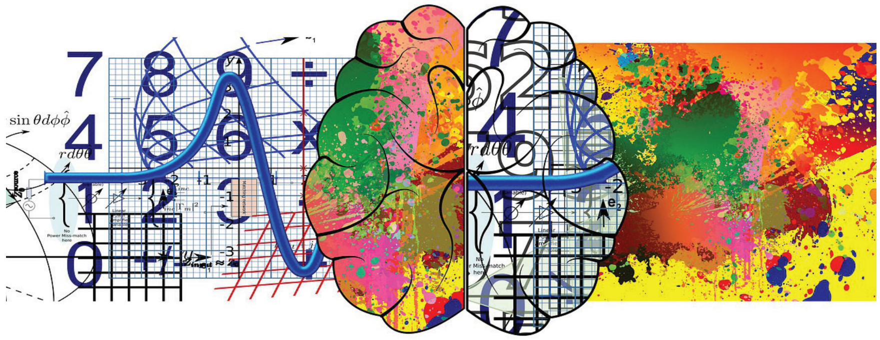


From this top view, the cerebrum looks a bit like a perfectly cracked walnut. It's wrinkly and it's got that crack, or fissure, down the center. The two halves of the brain are firmly connected in the middle by the corpus callosum (which means "firm body"). The two halves, or ***hemispheres***, look identical. They have the same lobe sections: frontal, motor, sensory, parietal, occipital and temporal. Oddly enough, however, the left hemisphere controls the right side of the body and the right hemisphere controls the left side of the body. We've already seen that the nerves from the eyes cross over and connect to the opposite sides in the back of the brain. This pattern holds true for the rest of the brain. No one is sure why this should be the case. Does it confer some kind of advantage? We don't know.

Recent brain research has turned up marked differences between the left and right hemispheres of the cerebrum, especially in the frontal and temporal lobes. We've already learned that the left temporal lobe contains important speech and language centers, Broca's area and Wernicke's area. Very rarely, someone will have their language center on the right side, instead of the left. If a brain surgeon must operate on a temporal lobe and is concerned about not harming the speech center, he can do a pre-operative experiment to find out for sure where the patient's speech center is located. The patient's right hemisphere is put to sleep for a few minutes with a mild anesthetic, then the patient is asked to answer some simple questions. If the patient can talk and answer the questions, this means that their speech center is on the left side. If they can't produce any words, then their speech must be asleep, along with the rest of the right hemisphere.



In the frontal lobe, the left side is particularly good at logic, mathematical calculations, sequencing, spelling, and vocabulary, while the right side excels in art, music, and creativity.

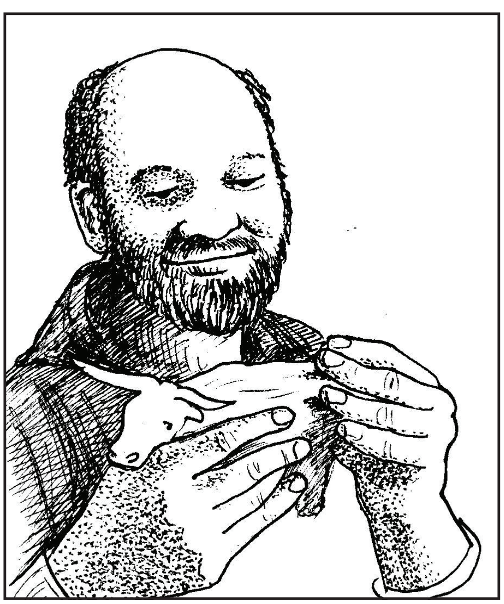


By studying people who have had brain damage on either the left or right side (and recently aided by the use of PET scans) researchers have been able to come up with a list of what the left and right sides of the cerebrum do:

LEFT
Uses words to name things
Uses symbols to stand for things
Keeps track of time
Understands sequences
Organizes
Counts and calculates
Uses logic and reasoning
Reads music (sheet music)

RIGHT
Puts pieces of information together
Sees similarities between things
Sees patterns
Sees the "big picture," not details
Appreciates and creates music
Good at drawing, painting and sculpting
Recognizes faces
Uses intuition and has "hunches"

You can see that both sides are important. The brain was designed so that the two sides would work together and complement each other. Most people use both sides of their brain about equally, though they may tend to use one side a little more than the other. When someone says that they are "left-brained," they usually mean that they are better at math and logic than they are at music and art. It might also mean that they get caught up in the details of a project and lose sight of the overall plan. People who are disorganized or have trouble keeping track of time sometimes explain it as being too "right-brained." There isn't always a correlation between hemisphere dominance and handedness. Left-handed people are not always "right-brained." Plenty of artists are right-handed.



People who use one hemisphere almost exclusively are called ***savants***. They are extremely rare, and are of great interest to researchers. Savant syndrome can be caused by injury, but sometimes people are just born that way. The side they use gets extremely good at what it naturally does well. The side they don't use gets behind in its development, leaving the person with disabilities. There is a famous case of a man from Colorado, USA, whose left hemisphere was damaged by an accident in childhood. As he grew up, the right side overcompensated for the loss of the left side and he developed into a sculpting genius. He is so talented that he can sculpt any animal perfectly after seeing it only once. If you look at the "left side" list above, you will be able to guess what he can't do. He can barely talk, and he can't read, write or count. He must rely on other people to help him with basic life skills like cooking, cleaning and making appointments.

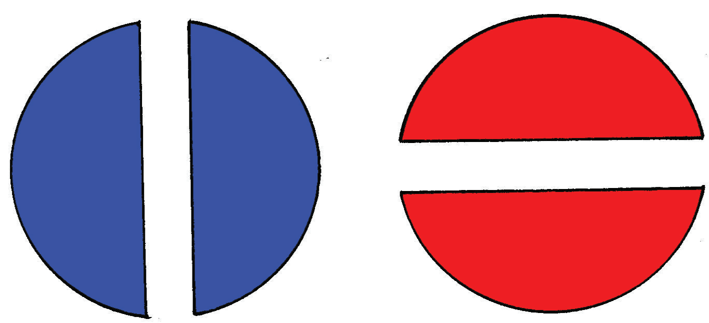
ACTIVITY 3.1 Meet Alonzo Clemens and other savants

If you go to **www.YouTube.com/The BasementWorkshop**, you can watch a short video about Alonzo Clemons, the sculpting savant from Colorado. There are also videos about other people with savant syndrome. Remember, “savants” are not just people who are good at what they do. They have genius qualities in one area, but they also have serious deficits. Kim Peek, for example, has almost perfect recall of everything he reads (and he reads a lot!) but is mentally disabled in other ways and will always need someone to take care of him. The most fortunate savanat is Daniel Tammet, who suffered seizures during his early childhood. The seizures left him with autism, but also with amazing abilities to recognize patterns in math and in language. As a young adult, Daniel was able to learn social skills and oversome much of his autism. He can now talk about what it is like inside his head, how he literally sees numbers and simply “reads landscapes” in order to do a calculation.

ACTIVITY 3.2 Fighting for dominance: witness a struggle between the hemispheres!

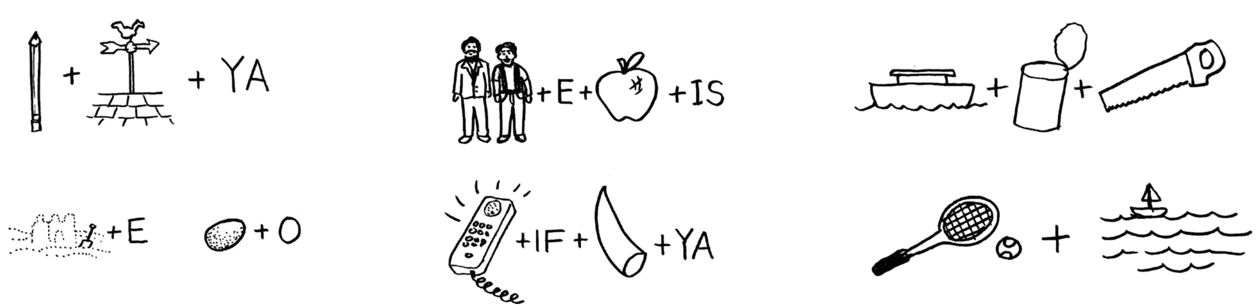
The two hemispheres usually cooperate by taking turns being in charge. These turns can last a split second, a few minutes, or several hours, depending on what we are doing. Both hemispheres are still active, but one is the boss. In this activity you will actually watch the hemispheres taking turns every few seconds.

Put this page about 2-3 feet (50-80 centimeters) in front of you. Relax your eyes and cross them until you see a third (somewhat blurry) circle in the middle with the blue and red circles right on top of each other. If you stare at this overlapped image, you will see it alternate back and forth from red to blue to red to blue. The white line in the middle will go back and forth from horizontal to vertical, along with the color change. This switching back and forth is your left and right hemispheres taking turns being dominant. When blue is on top, your right side is dominant. When red is on top, the left side is dominant. Remember, the eyes are attached to the opposite sides of the brain.



ACTIVITY 3.3 Use the left side of your brain

Can your left hemisphere figure out what these place names are? (places in the USA)



ACTIVITY 3.4 Use the left side of your brain again

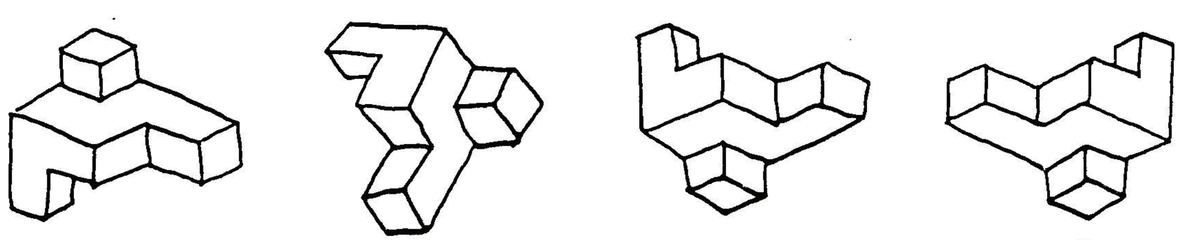
Make an interesting-looking squiggle in each of these boxes:

ACTIVITY 3.5 Use the right side of your brain

Now make an exact copy of each squiggle in each of these boxes. You will be drawing using the right side of your brain. You'll have to look carefully at the originals, above.

ACTIVITY 3.6 Use the right side of your brain again

Three of these figures are identical, even though they are pointing different ways. One of them is reversed left to right, making it different. Which one is different? You will have to use the right side of your brain to rotate them in your mind.



A B C D

ANSWER KEY

<u>CHAPTER 1</u>

ACTIVITY 1.1

1) CT 2) MRI 3) PET 4) MRI is dangerous for anyone with metal implants (because of the strong magnetism used) 5) PET, because it is the only one that can show activity level in real time.

<u>CHAPTER 1.5</u>

ACTIVITY 1.5

MRI:
1) Magnetic Resonance Imaging
2) Very large! The interior hole of an MRI is large enough for a person's entire body to go into it.
3) Yes, it has an incredibly powerful magnet inside.
4) Answers will vary. MRI is used to diagnose any problem that involves healthy versus unhealthy body tissue, such as tumors, joint deterioration, blockages, torn ligaments, heart disease, multiple sclerosis, and others. MRI can also be used in non-medical application such as determining the physical properties of rocks and other non-living materials.
5) Answers will vary. The strong magnet is used to line up protons in hydrogen atoms. Then, a radio frequency is pulsated in the area that is to be examined. The radio waves will cause some of the hydrogen atoms to absorb energy (causing "resonance"). When the radio waves are stopped, this extra energy is released, and is detected by the imaging system, which displays it on a screen.
6) fMRI can give 3D images and is used to detect changes in oxygen level in the tissues. fMRI studies metabolism and is more like PET in this regard. MRI only shows you structure, not functioning.

PET:
1) Positron Emission Tomography
2) Patients must receive an injection of radioactive glucose (sugar).
3) The PET scan is used to show the <u>level of activity</u> in bodily tissues (as opposed to MRI which shows structure, not activity). In other words, PET scans show how quickly cells are using glucose. Normal tissue and diseased tissue use glucose at different rates and this shows up on PET scans as different colors.
4) The PET scan detects radiation given off by the radioactive glucose. The more radiation, the brighter the color. Cells that are more active will have more of the radioactive glucose in them, therefore they will appear as reds and yellows. Less active areas will be blues and greens.
5) PET is used to diagnose many heart conditions and blood flow problems. It can also be used to search for tumors, since they take up glucose at a faster rate than normal tissue.

<u>CHAPTER 2</u>

ACTIVITY 2.1

ACROSS: 3) corpus callosum, 5) capillaries, 7) frontal, 8) white, 9) sensory, 10) parietal, 11) stem, 14) temporal, 15) cortex, 16) blood
DOWN: 1) occipital, 2) cerebellum. 4) cerebrospinal fluid, 6) cerebrum, 12) motor, 13) gray
BONUS QUESTION: left

ACTIVITY 2.4

2) Playing the piano
FRONTAL LOBE: Decides to play, understands what you are playing, send signals to motor cortex to move fingers, interprets what the musical notation means ("reads" the music)
MOTOR CORTEX: Sends signals to fingers (and to feet if you are using pedals)
SENSORY CORTEX: Feels the keys under your fingers
PARIETAL LOBE: Senses where your hands are arms are in relationship to the piano, senses that you are sitting in front of the piano, helps keep you balanced on your piano bench
OCCIPITAL LOBE: Sees the notes on the sheet music
TEMPORAL LOBE: Hears the notes as they are being played

3) Riding a bicycle
FRONTAL LOBE: Decides to ride, knows where you are going and makes decisions about whether to turn left or right, sends signals to motor cortex,
MOTOR CORTEX: Sends signals to muscles in arms and legs
SENSORY CORTEX: Feels the wind on your skin, feels the pedals under your feet, feels the hand grips in your hands
PARIETAL LOBE: Helps you keep your balance on the bike
OCCIPITAL LOBE: Sees the landscape around you
TEMPORAL LOBE: Hears things like birds singing, traffic sounds, the wind in your ears

4) Talking on the phone
FRONTAL LOBE: Decides what to say and when to say it, sends signals to the motor cortex
MOTOR CORTEX: Sends signals to the muscles in the mouth and vocal chords (and your hand that is holding the phone)
SENSORY CORTEX: Feels the phone in your hand
PARIETAL LOBE: Isn't essential for talking on the phone, but it is doing its basic job of sensing where your body is in relationship to the objects around you
OCCIPITAL LOBE: Isn't essential for talking on the phone, but if your eyes are open, it is taking in the sights around you
TEMPORAL LOBE: Hears the words that are being said to you by the other person, makes sense of the words and sentences you are hearing.

CHAPTER 2.5

ACTIVITY 2.4

We measured the cortex on the left to be about 26 centimeters and the one on the right to be about 22 centimeters, but your measurements might be a little more or less. The main point is to notice how folding and creasing allows something to occupy a smaller area. If you straightened out those cortexes, they would extend well beyond the edges of the page!

ACTIVITY 2.8

1) DURA 2) PIA 3) ARACHNOID 4) FISSURE 5) CORPUS 6) CALLOSUM
7) ANTI 8) CEREBRUM 9) CEREBELLUM 10) GYRUS 11) SULCUS
12) OCCIPITAL 13) CORTEX 14) MENINGES 15) PARIETAL

CHAPTER 3

ACTIVITY 3.3

Pennsylvania, Minneapolis, Arkansas
San Diego, California, Tennessee

ACTIVITY 3.6

The one turned the wrong way is C.

CHAPTER 4

ACTIVITY 4.2

ACROSS: 3) motor cortex 7) fornix 8) parietal 11) occipital 13) hypothalamus 14) pituitary 16) midbrain 17) temporal 18) sensory cortex
DOWN: 1) cingulate gyrus 2) amygdala 4) cerebellum 5) medulla oblongata 6) olfactory bulb 7) frontal 9) hippocampus 10) pons 12) ventricles 15) thalamus

CHAPTER 5.5

ACTIVITY 5.6

1) fissure 2) gyrus 3) sulcus 4) ventricles 5) homunculus 6) dendrites 7) Schwann cell 8) node of Ranvier 9) nucleus 10) glial cell 11) pons 12) medulla oblongata 13) cerebellum 14) occipital lobe 15) parietal lobe 16) sensory cortex 17) motor cortex 18) frontal lobe 19) olfactory bulb 20) cingulate gyrus 21) corpus callosum 22) midbrain 23) thalamus 24) skull 25) dura mater 26) arachnoid layer 27) pia mater 28) cortex (gray matter) 29) PET scan 30) MRI scan 31) synapse 32) neurotransmitters 33) receptor site 34) vesicles 35) axon knob

ADDITIONAL ACTIVITY IDEAS

CHAPTER 1

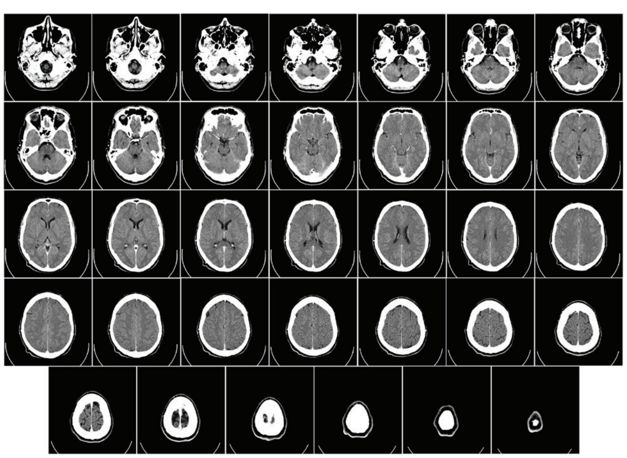
Activity idea 1A: Do an "MRI" of an orange

You will need:
- several oranges (the big, not-too-juicy kind is best)
- a sharp paring knife
- a cutting board
- something square on which to lay out all the slices (paper towels are fine)
- a pointed wooden skewer or a large nail
- a small syringe or eye dropper
- food coloring
- optional: raisin or something else firm and soft, to implant inside the orange

You will need to prepare the orange ahead of time by either inserting a few drops of food coloring with an eye dropper or small syringe, or else poking a hole and inserting a raisin or piece of cheese or other soft item that will slice easily when you are slicing the orange. (You can pre-poke a hole with a skewer or nail before inserting the dropper or syringe.)

First, show the students an MRI or CT image so that they can see that these scans are often not just one image, but a whole series of images. Explain that each image represents a very thin "slice" of the head. The first image is the top layer, and the last image is the bottom one, with the rest of the images exactly in order from top to bottom.

Explain that you will simulate an MRI by using an orange for a head and actual slices instead of scanner images. (Make sure the students understand that real MRI's don't really slice your head!) Before you begin slicing, you may want to draw a line down one side with a permanent marker. If the orange was a real head, this line would go between the eyes and through the middle of the nose and mouth. This line will help you keep the slices oriented correctly when you lay them down. Then begin slicing the orange and lay out the slices in order as they are cut. Make the slices as thin as possible. You'll end up with about 12-15 slices.



MRI and CT scans look like a series of slices.

Slices of an orange that had some blue food coloring injected with an eyedropper. It leaked to the side more than planned, but even so, the color was not very visible from the outside. (This orange doesn't have a raisin implanted.)

CHAPTER 2

Activity idea 2A: Take a "hands-on" tour of the cerebrum (especially helpful for younger students)

The teacher or parent leads this activity, demonstrating where the students are to put their hands while they listen to the teacher/parent tell them the information about each lobe.

FRONTAL LOBE: *Make one hand cover the whole forehead*. Underneath your hand is your frontal lobe. If you see someone in this position it looks like they are thinking, or like they forgot something. This is how you can remember that the frontal lobe is where your thinking and deciding takes place. This is the lobe that is in charge. It's got a lot of responsibility! Isn't it funny that when this lobe gets stressed, we put our hand on it?

MOTOR CORTEX: *Put each hand into a fist except for the first (pointer) finger sticking up. Then touch the tips of the fingers together, like they are pointing at each other. Keeping them together, put them on top of your head so they form a band right over the top (a little like a hair band).* The strip of brain underneath your fingers is called the motor cortex. The word "motor" makes you think of movement. The motor cortex is the place in the brain that sends the signals to your muscles telling them to move. Notice that it is right next to the frontal lobe. This is handy, because the frontal lobe is what tells the motor cortex to send out its signals. Your frontal lobe decides the body needs to move, then the motor cortex actually sends out the signals.

SENSORY CORTEX: *Move your finger "hair band" back about one centimeter (half an inch)*. The thin strip of brain running underneath the place where your fingers are is called the sensory cortex. *Make those two fingers rub or scratch your head.* This is a clue as to what the sensory cortex does. The sensory cortex is where your brain processes the "touch" sensations coming in from all parts of your body. When something scratches or touches your skin, the signals are sent to the sensory cortex.

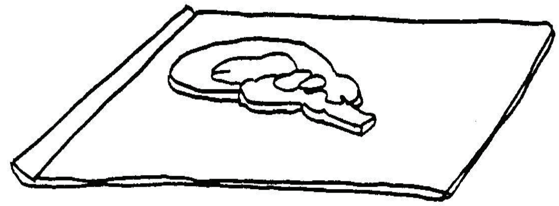
PARIETAL LOBE: *Take one hand and put it over the crown of your head, right over the place where your hair sprouts out.* Underneath your hand is your parietal lobe. The name of this lobe comes from the Latin word for wall. That doesn't make much sense, does it? Actually, the lobe is named after the part of the skull that covers it, the parietal bone. The parietal lobe is not very well understood, and remains somewhat of a mystery, but we do know the parietal lobe helps you to know where your body parts are, even if you can't see them. Try this: Put your arms out to the sides, close your eyes, and stick out your index (pointer) fingers. Can you bring your index fingers together without opening your eyes? You probably can, or very nearly so. How can you know where those fingers are without looking at them? It is your parietal lobe that keeps track of where they are. The parietal lobe also works with your cerebellum and inner ear to give you your sense of balance. It also play a role in understanding shapes in geometry and abstract ideas of mathematics (what Einstein was good at!).

OCCIPITAL LOBE: *Put your hands behind your head, with fingers "knitted" together, as though you are lying in a grassy field watching the clouds roll by*. Behind your hands is your occipital *(ok-SIP-it-al)* lobe. This is the lobe where your vision is located. It's what actually "sees" those clouds floating by. The images from your eyes are sent to the occipital lobe for processing. When the images come in, they are upside down and your brain must learn to turn them right-side up. A brain researcher once tried an experiment where he asked someone to wear special glasses that made everything look upside down. The result was that the occipital lobe compensated for what the glasses were doing and reversed the image a second time, making everything appear right-side up again!

TEMPORAL LOBE: *Put your fingers on your temples.* Behind your fingers and over your ears is the temporal lobe. This part of the brain is connected to your ears, which is not surprising, but is also where your sense of smell is. In addition to these functions, the temporal lobe is where your speech center is located. Right behind your temple is the area that forms words and sentences (then relays this to the motor cortex, which makes your lips and tongue move). Right above your ear is the area that understands words and sentences.

Activity idea 2B: Brain cookies

You will need a batch of standard sugar cookie dough and some food coloring. (You are welcome to adapt as needed: sugar-free, gluten-free, natural dyes, etc.) Divide the dough into at least four parts. Use food coloring to color each a different color. (The more colors the better.) Use the outline drawing shown in activity #2.3 in chapter 2 as your guide to make a flat cookie where each lobe is a different color.



Activity idea 2C: Draw brain parts on a real head

You will need a tight-fitting swim cap and a marker. Put the cap on a volunteer, then draw in the lobes on the cap. (This activity is guaranteed to produce smiles and laughs.)

Activity 2D: Cerebrospinal fluid experiment

<u>You will need</u>:

- at least two raw eggs
- at least one small plastic container just slightly larger than the egg (Two identical containers is best, as it will save you clean up time in the middle of the experiment and let you do it at the end.)
  NOTE: Small clear plastic jars with screw lids (used for peanut butter in America) are ideal
- water
- rubber bands or duct tape (or both) to keep the lid on the container if not using screw lids
- a large pot into which you can drop the container (to avoid getting raw egg on floor)
- on hand: paper towels for clean up

Put a raw egg inside the container. The egg will represent the brain and the container will represent the skull. This part of the experiment simulates what would happen if your brain had no fluid around it. Secure the lid by either screwing it on tightly, or using rubber bands or duct tape. Shake the container. If the egg survives the shaking, drop the container into the large pot. If it survives, drop it again from a greater height. At some point, the egg will crack.

Empty the container (or use the other one). Put in a fresh egg and then fill the container with water and secure the lid.tightly. Shake and drop the container again, and see what happens. Does the water around the egg protect it from breaking?

NOTE: Some plastic containers will be more brittle than they appear and will crack when dropped. Use either soft plastic containers, such as a yogurt containers. or an extremely heavy-duty container such as the indestructible "Tupperware" type.

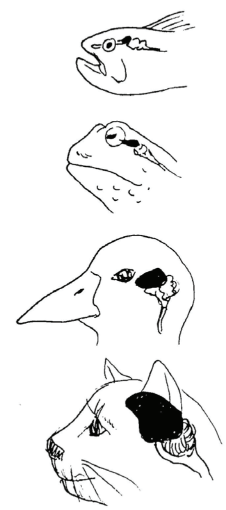
Activity idea 2E: Observe a thin membrane similar to the meninges in the brain

You will need:

- a raw egg
- something to crack it into
- paper towels

Crack the egg and dump out the contents. Carefully crush the side of one of the empty egg shells, so that you have some pieces that are being held together by a thin membrane. Notice that the membrane is attached to the inside of the egg shell. In the brain, the outer layer of the meninges (the dura mater) is attached to the skull. Now gently pull the cracked pieces away from the rest of the shell so that the membrane slowly peels off the inside of the shell. It's not too hard to do. You should be able to get a piece of membrane at least a centimeter wide and two centimeters long, possibly larger. (If it doesn't seem to be working, try a different egg.) Gently pull and stretch the membrane to test its strength. It's surprisingly tough. You might want to see what happens if you leave the membrane out to dry. How does lack of water affect its strength?

OPTION: Use a hard boiled egg to make the experiment less messy.



Activity 2F: Compare the human brain to animal brains

If you log on to the website **www.brainmuseum.org**, you will find a library of images of animal brains. On the menu bar on the left, click on LIST OF SPECIMENS. Then click the names of animals to see their brains. Notice differences in the sizes of the cerebrums, and in the amount of wrinkles. Remember that the reason a brain has wrinkles is to get a large surface area into a small space. If a brain does not have wrinkles, this indicates that it has a smaller surface area. Less surface area means less mental capability. Compare the rabbit brain with the bat brain. Which animal is probably more intelligent? Compare the manatee with the dolphin. Can you find any differences between a chimpanzee brain and a human brain?

CHAPTER 3

Activity idea 3A: Play "charades"

A great left brain/right brain game is "charades." The players giving the clues are using the right side of the brain. The players trying to guess the correct word are using language skills on the left side of the brain. You can play the standard way with hand gestures and motions used as clues, or you can get even more right-brained and make the clue givers sculpt their clues out of modeling dough or draw the clues on a paper or white board.

Activity idea 3B: Do more drawing using the right hemisphere

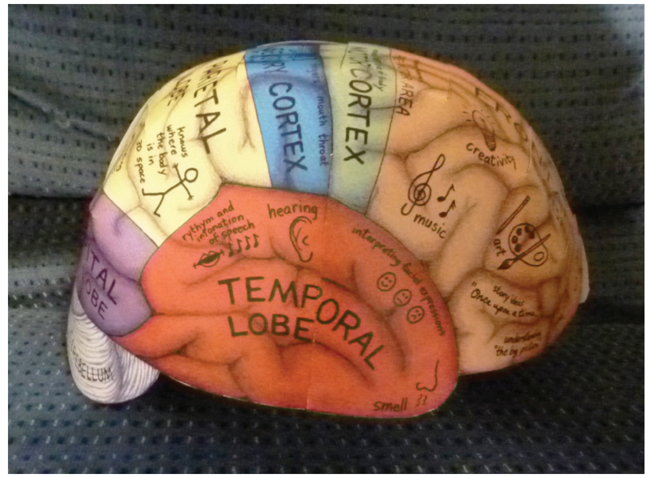
For more activities and information about drawing with the right side of the brain, use the first four chapters of the book Drawing on the Right Side of the Brain by Betty Edwards. You will find many easy and interesting drawing activities that require little or no preparation on the part of the teacher. Everything you need or need to know is in the text. The book works best with middle or high school students.

Activity idea 3C: Make up your own rebus puzzles

You might want to start by searching the Internet for "rebus puzzle" so the students can get a better feel for what they are. Then ask them to make up a few of their own. Making rebus puzzles uses different brain parts than solving them.

Activity 3D: Make a "hemisphere hat"

NOTE: If you working from a paperback version of this book instead of a digital copy, you can get digital patterns by going to to www.ellenjmchenry.com/Brain. Or, go to my website and click on FREE DOWNLOADS then on HUMAN BODY, then on the "brain hemisphere hat." (The hat even comes in other languages!)



<u>You will need</u>:

- copies of the patterns printed onto white card stock
  NOTE: Most home printers can print on regular weight card stock. Don't use super heavy "cover stock." Print shops can print on heavy cover stock.
- scissors and clear tape
- optional: good white glue (see note below)

NOTE: If you use white glue, I recommend using clothespins or paper clips to hold the joints while they dry. Also, for those of you living in North America, please note that for us, white glue (such as Elmer's) isn't what it used to be. "School glue" is just about useless for paper crafts. In the UK, "PVC glue" is still good. (I order them from amazon.co.uk.) A good white glue will hold if you apply just a tiny dab, then press the joint and count to ten. If you don't want to special order PVC glue, try Aleen's Tacky glue, or a high quality craft glue intended for adult use. If you want to try a glue stick, make sure to buy the "extra strong" kind intended for adults.

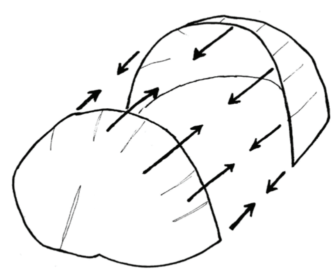
You can tape all the joints with clear tape if you don't mind seeing the tape on your final product. Kids don't seem to care about it and are usually fine with tape. Even if you use glue for the V-shaped seams, use tape on the inside of the hat when you do the seam down the middle, joining the two halves.

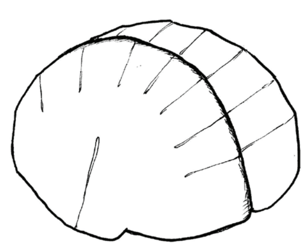
ABOUT THE PATTERNS:

There are both color and black and white, and labeled and unlabeled patterns to give you maximum flexibility. You can add color to the gray hats. Color lightly, though, so you don't obscure the words. Do all coloring before you assemble them.

The hat is designed to be as "one-size-fits-all" as possible, although the color pattern does come in LARGE and SMALL. The smaller size is for use with children under the age of 10, though head sizes can vary more with body type than with age. With either pattern, the size of the hat can be made a little smaller by overlapping the two hemispheres a little more before taping them together. If necessary, the folds can also be overlapped a bit, as well.

If you are doing this project with a class, you might want to have pre-assembled hats in both sizes for the students to try on before assembling their own.





Cut out both hemispheres, cutting around the outside edge. Then snip in on the solid V line. Don't snip on the dashed lines! Then pull the "flap" you have created over to the dashed line and secure with glue or tape. After you have pulled all the flaps over to their dashed lines, it should then take on a half-round shape.

To put these two halves together, simply choose one side to overlap just slightly onto the other (but overlap more if you are trying to shrink the size of the hat) and secure with tape. Use the same approach that you would for sewing a curved seam. Working on the inside of the hat, start on one end and secure just that end with tape. Don't worry if the rest of the seam is wide open. Then pull the hat together correctly just at the end inch or so. Tape that in place. Then do the next little bit, not worrying that the rest of the seam is still gaping open. Just work you way down the seam little by little. When you read the end, the hat should have a nice shape.

Optional cerebellum: If you want to add the cerebellum just fasten it to the inside of the back of the hat as shown in photo. Glue or tape in place.

If you need more thorough instructions, there are assembly photos included with the pattern download on the website.