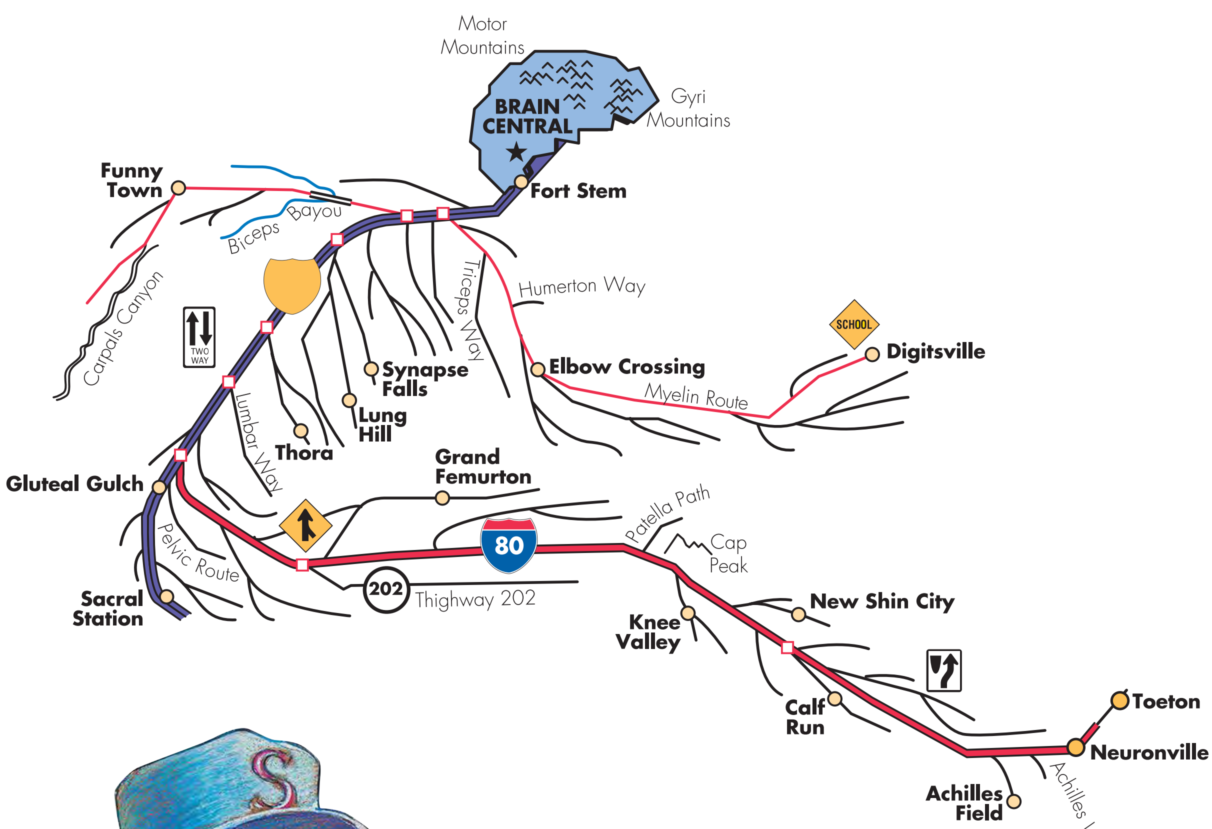
BrainLink®

THE MOTOR SYSTEM

EXPLORATIONS

The Road to Brain Central

How are the nerves and nervous system in your body like a network of roads and highways?



Find a direct path from Neuronville to Brain Central. Read “Matter of Fact!” on pages 2 and 3 to learn more!

Baylor College of Medicine

Matter of Fact!

A Network in the Body

Did you find a direct route from Neuronville to Brain Central? The route involved going up Interstate 101.

You have a similar network of highways in your body. The spiderlike tiny roads are the nerves that branch out all over your body. Your spinal cord is a bundle of nerve fibers which acts like the main interstate highway.

The spinal cord is the main link between your brain, the body's command center, and the rest of your body. Twelve pairs of nerves connect the brain with muscles and sensory organs in the head (cranial nerves). Thirty-one pairs of nerves connect the brain with muscles and sensory organs in the rest of your body (spinal nerves). Nerves are bundles of tiny **neurons** (NEW-rahns), or nerve cells. The entire network is called the **nervous system**.

Ready for Action

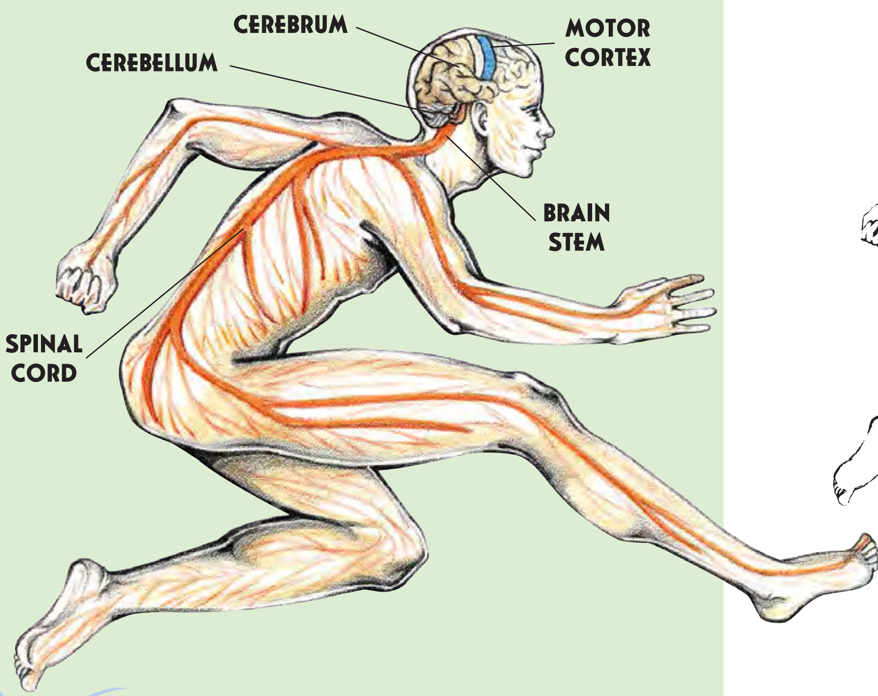
Just imagine that you are walking across the playground at school and a big orange basketball suddenly flies toward you. Your friend shouts at you to duck. Your eyes widen. Your heart beats faster. Your muscles go into action as you dodge the oncoming ball. All this happens in a split second. What made this fast reaction possible? The amazing nervous system did!

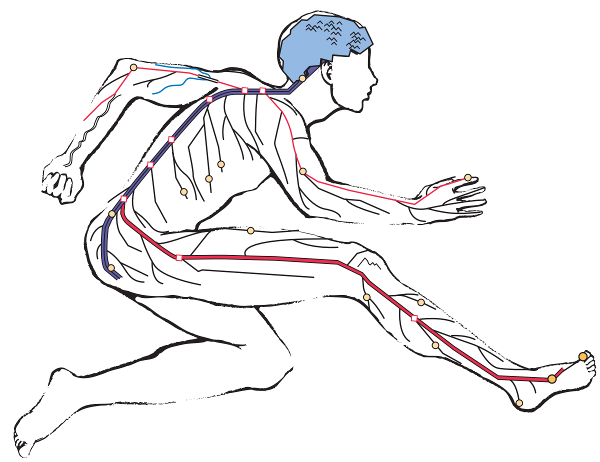
BRAIN FLASH

Did you know that a cough or a sneeze is a reflex action? They are ways your body uses to clear things out of your system.

Lines of Communication

The body's nerve highways are its lines of communication. Our senses gather information about what is going on around us and send messages to the brain about what we see, hear, smell, taste and touch. **Sensory neurons** carry messages from sense organs to the brain. The brain sends messages to the muscles





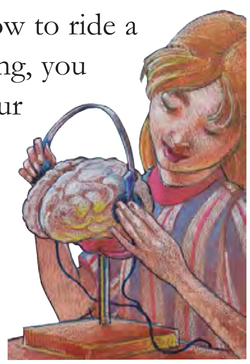
Signals for movement start in the brain or spinal cord. The messages are carried along special cells, called neurons, to muscles in the body.

along **motor neurons**. In our example of dodging the basketball, your eyes saw the ball. Then, your sensory neurons told your brain, "There is a basketball coming toward me." The brain decided, "I am in danger of getting hit." Your brain sent a message through the motor neurons that told your muscles, "Duck, and get out of the way." And then, a completely different part of your brain started thinking, "Who threw that ball at me?"

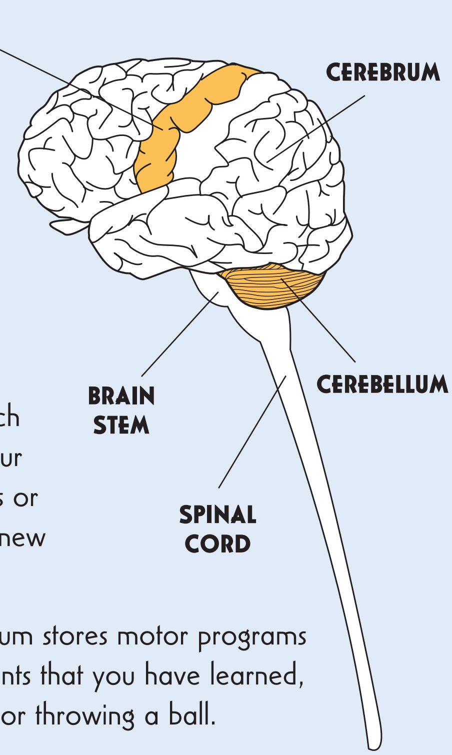
Learning How to Move

Motor control, or movement, is one of the most important things our bodies can do. Think of how many things you do each day that require your body to move. There are many parts of the brain involved in this process.

Remember when you learned how to ride a bicycle or to skate? In the beginning, you fell down a lot. This is because your brain first had to learn these new tasks. Next, your brain taught your muscles how to make the correct movements. The part of the brain that "issues orders" to move the muscles is the **motor cortex**. It is located in the cerebrum, just about where you might wear head phones across the top of your head.



When you are first learning a new set of motor skills, you have to concentrate. The motor cortex directs all muscle movements with instructions from all over the **cerebrum**, the "thinking" part of your brain. At the same time, a different part of the brain, the **cerebellum**, is "learning" how the movements are made. After you have learned to ride a bike or to roller skate well, the motor cortex receives instructions directly from the cerebellum. This small, cauliflower-shaped part of the brain sits near the back of the head. It "knows" how to bike or skate because you have already learned those skills. In fact, the cerebellum knows the "motor programs" for all your familiar actions, so you don't have to think about them.



The motor cortex is a special part of the brain that directs movements you choose to make, such as raising your hand in class or trying out a new dance step.

The cerebellum stores motor programs for movements that you have learned, like walking or throwing a ball.

If you have a baby in your family who is just starting to walk, you can see the marvelous way in which the brain learns about movement. Have you noticed that if you distract a baby who is just beginning to toddle, he or she probably will fall down? That's because the cerebellum hasn't taken over walking skills yet. The motor cortex of the cerebrum is coordinating the movement and the baby really has to "think" about it. As the baby gets more practice, the "walking program" is transferred to the cerebellum. That's why you can walk and talk at the same time, or sing while you are skating. You don't have to concentrate hard on telling your muscles what to do. Your cerebellum is doing the work for you.

BRAIN FLASH

Amazingly, near the end of your brainstem the neuron highways that lead to muscles from the left side of your brain cross over to the right side of your body and the neuron highways from the right side of your brain cross over to the left side of your body! You could say that you are cross-wired!

Have you ever heard of the **cauda equina** (KAW-da ee-KWY-na)? These words are Latin for "tail of the horse." Everyone knows what the tail of a horse looks like, but did you know that you have one, and that it is related to your brain?

Hey, we're not just horsing around! Your brain connects to nerves in your body by way of the spinal cord. This cord is a long "bundle" of nerves that runs along the inside of your backbone, or spine.

cauda equina

Thirty-one pairs of spinal nerves branch off from the cord at different points along the spine and pass through the narrow spaces between the bones, called **vertebrae** (VER-tuh-bray). From there, the nerves run throughout your body, to the tips of your fingers and to the tips of your toes. They even reach places like your stomach and your kidneys!

At the very end of your spinal cord, nerves split out so that they look like the tail of a horse. Can you find the area of your cauda equina? It starts about where the top of your jeans crosses your back.

BRAIN FLASH

Have you noticed that your spine is flexible? There are 33 bones in your spine. If there were only one solid bone, what would happen to you? For one thing, you couldn't bend.

Try This!

Follow the instructions below to make your own critter, with spinal cord and cauda equina.

plastic drinking straw
small paper clip
small paper cup
one yard (about a meter) of yarn
scissors
ruler
tape

1. Cut four pieces of yarn, so that each is about 9 inches (23 cm) long.
2. Tie one end of each piece of yarn to the smaller end of the paper clip. Unravel the pieces of yarn.
3. Cut the straw into five pieces, so that each is about 1 inch (2.5 cm) long. These five pieces will represent groups of vertebrae, or bones, in your spine.
4. Use the paper clip to thread the yarn through the five pieces of straw.
5. Poke a hole in the bottom of the paper cup. The cup represents the head of your critter.
6. Push the end of the paper clip with no yarn tied to it through the hole of the cup. Tape the paper clip to the bottom of the cup. Be careful to keep the yarn inside of the straw pieces.
7. Gently pull two strands of yarn through the spaces between each of the straw pieces. You will need to hold the strings of yarn at the bottom of your critter so you don't pull all the yarn through at once. The bunch of strands that hang from the bottom represent the cauda equina.
8. Tape or tie the cauda equina end of your critter to keep the straw pieces from falling off.

Notice the flexibility of your critter. He has rigid bones (straw pieces) that make up a structure that can bend and move in many directions. Tape your critter onto a piece of paper. Notice how the nerves (yarn) sneak out of the spinal column between vertebrae (straw pieces).

Note. You can make a larger or smaller critter by changing the sizes of the pieces of yarn and straw. Be certain that the paper clip can be threaded through the pieces of straw!

Double  Trouble!

Did you realize that more than one collision occurs in any car (or other vehicle) accident? Consider this. If two people are traveling in a car that is moving at 30 miles per hour (mph), they each also are moving 30 mph. If the car hits an object and stops, the people in the car keep moving forward at 30 mph (the same speed the car was traveling) until they collide with something. That "something" is usually the steering wheel, windshield or dashboard. It is this "second" collision that often results in injury or death.

Vehicle collisions injure and kill more kids than any disease. Vehicle collisions also are the leading cause of spinal cord injury. Worn correctly, seatbelts with shoulder harnesses can save your spinal cord or your life.

To see what can happen in a collision, try the experiment below. It's a bit messy, so conduct the experiment outdoors. You also will need a partner.

You will need:

- toy car, large enough to fit both eggs on the seat
- flat board, about 3 feet long, and wide enough for it to be a "road" for the car
- 2 raw eggs
- masking tape
- several sheets of newspaper

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1. Cover the area you will use with several sheets of newspaper.
2. Place the two raw eggs in the toy car.
3. Use masking tape to make a "safety belt" and tape one egg securely to the car.
4. Wedge one end of the board against the base of a wall.
5. Have your partner hold up the other end of the board, about 18 inches above the ground, to form a "down-hill" ramp.
6. Roll the car down the ramp toward the wall.

What happens to the eggs?

BRAIN FLASH

Isaac Newton, an English mathematician born in 1642, figured how moving objects behave. His first law of motion states that a moving object will keep the same speed and direction as long as nothing interferes with it.

Once something is standing still, it will remain still unless something pushes or pulls it.

In other words, all objects tend to keep on doing what they're doing.

Did You Know?

Your spinal cord is made up of millions of neurons (tiny cells of the nervous system) that allow your brain to communicate with the rest of your body. Each year, about 12,000 Americans suffer spinal cord injuries, usually from auto and sports accidents and falls. Often the result is paralysis — not being able to move parts of the body, because the brain's messages no longer can reach the muscles.

Much of the damage to the spinal cord often doesn't happen at the time of an accident, but sometime later. The tissue around the spinal cord begins to bleed and swell. Since this can cause a lot of harm to the neurons in the spinal cord, doctors use special drugs to reduce the bleeding and swelling as much as possible.

If the neurons in the spinal cord are hurt in an accident, they do not grow back along their original pathways as do neurons in the arms and legs. Scientists are trying to find treatments that get these spinal neurons to grow in the proper direction, and reconnect to restore movement and feeling in the rest of the body.

Now Switching to Auto Pilot...

Which hand do you use to write or draw? The hand that you use for doing most tasks is called the dominant hand. By the time you are ten years old, one side of your brain has become dominant for motor skills. Hand movements of right-handed people are dominated by the left side of the brain. Which side of the brain is dominant for lefties? Right is right! This cross-wiring occurs because the neuron highways switch sides in your brain.

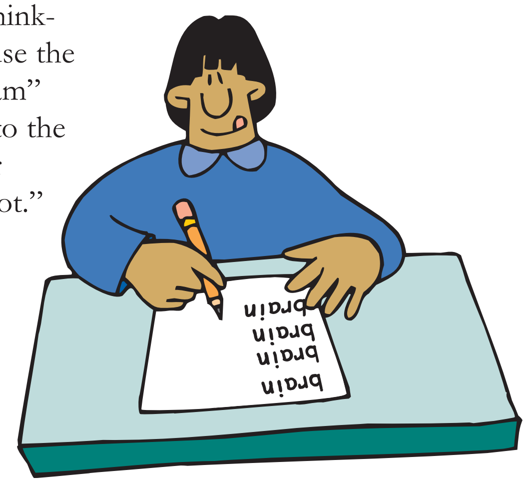
BRAIN FLASH

You also have a dominant eye, foot and ear. How would you go about checking this out?

When you write with your dominant hand, you are doing a task that is very well-learned, a skilled movement. Do you remember which part of the brain guides these activities? The **cerebellum** does most of the brain work needed to guide the hand that is writing, so the **cerebrum** is free to do other things— like pay attention to what your teacher is saying in class. When you try to write with your non-dominant hand, you don't have a "motor program" to follow in the cerebellum. Instead, you have to use the cerebrum to think about what you are doing. This is why you have to pay close attention as you learn a new task.

Do other animals also favor one side over the other? Watch your pet to see whether it favors one paw or foot over the other.

Practicing a task, performing it over and over again, can turn that task into a skilled movement. This can save a lot of thinking time because the "motor program" is transferred to the cerebellum for "automatic pilot."



Now comes the fun part! Here is an experiment you can try with a friend or family member. It will give you an idea how much effort it takes to get a task transferred from the cerebrum to the cerebellum.

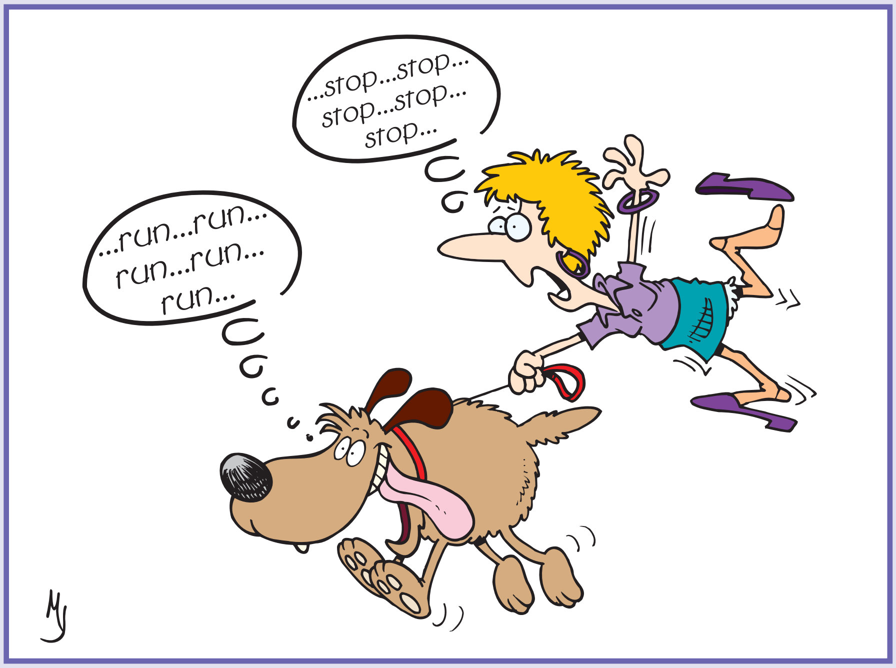
1. Pick a word (like "brain") to practice. Write the word 10 times with your non-dominant hand. How legible was the word in your first try, compared to your last try?
2. Let your partner do the same thing. Do you both improve?

BRAIN FLASH

About 89% of persons are right-handed. About 11% are left-handed or ambidextrous (use both hands equally).

If you continue to practice, you could learn to write well with both hands. Can you think of other motor activities that were hard at first but that you can do well now?

Brain Busters!



Thank goodness for our hard-working cerebellums! If we had to "think" about how to do **every** single movement we make each day, such as running or keeping our balance, we wouldn't get very much accomplished. But with such tasks controlled by the cerebellum, our cerebrums are free to think about more complex things, like how to solve math problems or how to train a pet!

Careers for NeuroExplorers:

Pediatric Physiatrist

When the brain or spinal cord is injured, a person may be left with a disability, like not being able to walk, speak or read. Some neuro-explorers in the field of Physical Medicine and Rehabilitation help people with diseases and injuries of the nerves, muscles and joints.

Neuro-Explorer:
Charlotte Stelly-Seitz, M.D.
Pediatric Physiatrist (pee-dee-A-trik fiz-ee-A-trist)
The Institute for Rehabilitation and Research
Houston, Texas

Dr. Stelly-Seitz, what do you do?

I am the team leader for a group of people who take care of children who are having trouble using or controlling parts of their bodies. With special therapy and equipment, we can help them overcome many of the problems caused by damage to their brains or spinal cords. I work with other specialists, schools and families to take whatever disabilities a child has and find another way for him or her to do everyday things.

What do you find the most fun or most interesting about your work?

I love the kids' willingness to try something new. They have a spirit to beat the odds — they believe they can do it, even if other people say they can't. And I really enjoy the creativity allowed in my work. The team must find imaginative ways to help each child overcome his or her disability.

What advice do you have for future physiatrists?

Explore a lot of different things. Ask questions and look for ways to get the answers. Find people who have enthusiasm to teach you and use them to help you learn. Learn to be a good reader, because then you can always teach yourself.

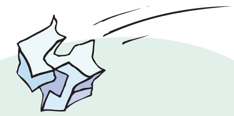
Faster than Fast!

Have you ever touched something hot? If you have, you know you jerk your hand away extremely fast. (If you had to stop and think about how to move your hand, you would already be burned.) This type of quick movement is called a **reflex action**. Your reflexes are automatic and **involuntary**, which means that they happen without your having to think about them. Most reflexes protect the body from harm.

Reflexes follow simple pathways. For example, if you step on a piece of glass, a reflex response is triggered in your leg. Immediately, sensory neurons in your foot send a signal to motor neurons in your spinal cord. In a flash, (less than one-tenth of a second), motor neurons carry messages to muscles, so that your foot lifts itself out of danger and you keep your balance. Only later does your brain receive a message through the spinal cord, so the brain knows what happened and can figure out whether more actions are needed. That's why you feel the pain after you have jumped away, and then say "Ouch!"

Try these experiments to test your reflexes.

You will need several balloons and a partner. Blow up the balloons. Stand close behind your partner and pop a balloon when he or she is not expecting it. He or she will jump. This is called a **startle reflex**. What happens if you repeat the test? Will your partner continue to react the same way or get used to the noise? Switch places. Have your partner move further away behind you before beginning the test. Is your reaction as strong as your partner's was?



You will need a sheet of notebook paper, a piece of clear plastic wrap and a partner. Hold the plastic wrap about 2 inches (5 cm) in front of your face. Have your partner ball-up the sheet of paper and throw it gently towards your face. Did you blink? Try it again. With lots of practice, some reflexes, like blinking, be controlled. How much practice did it take until you could keep yourself from blinking?

BRAIN FLASH

Another common reflex is putting your arms out to break a fall. You may end up with a broken wrist, but it's better than hitting your head. Have you noticed how cats land on their feet when they fall? Animals also have reflex actions.

You will need a flashlight and a mirror to test your **light reflex**. Look in the mirror at your pupil, the round black center of your eye. Next shine the flashlight near the pupil and see if you notice any change. Your eye should automatically adjust to let the needed amount of light into your eye. What does your pupil do to adjust to very limited light in a dark room?

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