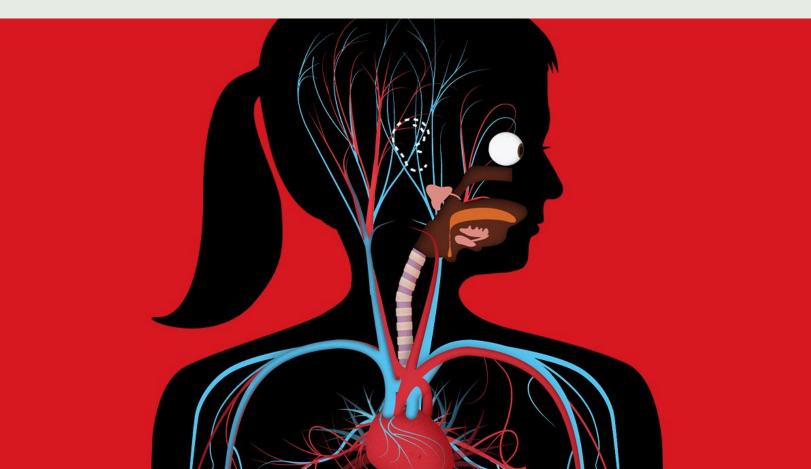


the HUMAN BODY handbook





THE HUMAN BODY is an introduction to the amazing and complicated machines we live in. This guide

offers facts, interaction tips, and prompts for conversation as you and your child explore eight of the body's systems:



Open up THE HUMAN BODY and see how we work.

Nervous system

GET STARTED

Laughing, tasting, seeing, hearing, smelling, daydreaming, and singing are just a few of the amazing things we can do because of the nervous system. The nervous system includes the spinal cord, nerves, neurons, and sensory organs: the ears, nose, eyes, tongue, and skin. At the center of it all is the brain. A brilliant scientist, James D. Watson (he co-discovered the structure of DNA), said the brain is "the most complex thing we have yet discovered in our universe."

The brain is constantly sending and receiving signals from tiny cells called neurons. Neurons pass messages to other neurons through synapses. These messages are transmitted along the spinal cord which, along with the skull and vertebrae, connects the brain to the rest of the body. Neurons send and receive signals to and from the brain (at speeds faster than 150 miles per hour!) to tell the body to do things like contract muscles, pump blood, breathe, blink, regulate its temperature, and stay balanced.

Through neurons, our brains process messages from the skin, eyes, ears, nose, and tongue about how things feel, look, sound, smell, and taste. This is how we know how sharp a pin is, how hot a cup of hot chocolate is, and how to respond. When the skin feels something sharp or hot, the brain sends a message for us to move away from it.



Tap the mosquito and send it flying. What happens when the mosquito bites the body?

Ouch! We feel mosquito bites because the skin reacts to touch. Skin is an organ that constantly sends messages about the stimuli it feels to the brain. Often, it's sending messages to keep us from doing things that might hurt, like touching a hot or sharp object. It might also tell you to slap that mosquito so the little bugger doesn't bite you again.



Drag the feather and tickle the body. What happens?

Skin feels the tickle of a feather the same way it feels the bite of a mosquito: by sending a message to the brain. But why we laugh when we're tickled is a bigger mystery, even scientists haven't quite figured it out. Many parts of the brain work together when we laugh. We do know that laughter is a way we communicate and that it can be triggered by thoughts and memories.



Smell starts inside the nose where special cells, called olfactory receptors, first detect a scent and send signals to the olfactory bulb in the brain. Located at the bottom of the brain, the olfactory bulb processes and identifies unique odors.

Swipe the legs. How does the nervous system respond to exercise?

The nervous system is super snappy during exercise: the brain is working with the muscular, circulatory, and respiratory systems. The cerebellum helps voluntary muscles with posture, balance, and equilibrium. The brainstem controls the involuntary muscles found in the circulatory and respiratory systems that are also working to keep you breathing and your blood moving.

Regular exercise benefits both the body and the mind. It helps keep bones, joints, and muscles healthy and strong. It's especially good for the heart and circulatory system, keeping blood vessels flexible and open and improving blood pressure. Exercise also releases chemicals, called endorphins, in the brain. Endorphins make you feel happy, alert, and help you concentrate.

Take a closer look: tap the nose. Drag different objects under it. How does the brain react to smell?

Everything you smell, from fresh baked bread to a stinky trash can, puts molecules into the air. When we smell, the inside of the nose, the nasal cavity, detects these chemical molecules. The nasal cavity is lined with a wet, sticky liquid (mucus) and tiny hair cells (cilia, which you'll also find in the ear). The mucus helps capture dust and germs, preventing them from entering the body. The cilia detect microscopic molecules and tell the nerves to send a message to the brain. The brain responds and identifies what you're smelling.

You might sneeze to get rid of unwanted germs, or your mouth might water at the thought of... mmm...bacon. When the brain recognizes the smell of something tasty, it tells the mouth to create saliva in anticipation of eating and digesting food. Smell also helps the sense of taste tell the difference among foods that are sweet, salty, sour, bitter, and spicy.









Take a closer look: tap the brain. Move the slider. What do you see?

While the brain is so complicated that scientists are still figuring out exactly how everything works, there are some things we do know about it, starting with what we can easily see: all those wrinkles. The outer surface of the brain, the cerebral cortex, has crevices, called sulci, and ridges, called gyri, to increase the surface area of the brain without making it too big for the skull. The larger surface area allows for more neurons. We need all of the room for neurons we can get: adults have about 90,000 miles of neural pathways in their brains.



Tap different parts of the brain. What processes happen in each part?

Most thoughts, language, movement, and memories are processed in the part of the brain called the cerebrum. Four different parts of the cerebrum, called lobes, manage different tasks. The frontal lobe processes speech, thought, learning, emotions, and movement. The occipital lobes process visual images. The parietal lobes process touch, temperature, and pain. And the temporal lobes process sounds, along with some memories and vision.

MEMORY

Memory allows us to retain what we've learned over time. As we learn, neurons connect to one another; these connections are called synapses. As we learn more and more, the number of synapses between neurons increases, creating pathways in our brains. When we remember something, the brain reconstructs those pathways to recall the information.

This sounds simple enough, but our thoughts and knowledge aren't neatly filed away in one place like books on a shelf: those neural pathways wind all over. As the brain (constantly!) processes new information, neural pathways change and connect in different ways. We tend to remember things better if we link them to other things we already know and understand, so to retrieve memories, the brain traces back through all of those paths. This is why memories seem to change sometimes. The way that you think of something now may not be the way you think of it, or remember it, in the future.

MUSIC

Sound is processed in the brain's temporal lobes, which also help process memory and vision. We know that listening to and enjoying music involves memory, learning, and emotions. But just how and why this happens remains a mystery.

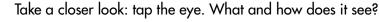
VISION

Images are processed in the brain's occipital lobes with a little help from the temporal lobes. Signals from the eyes are translated by the visual cortex in the occipital lobe, which processes information about shape, color, texture, size, distance, depth, movement, and location. It also turns what you see right side up (learn more about that in the eye).



Take a closer look: tap the ear. Speak or drag an instrument to the ear. How does sound travel?

When something—your voice or a violin—makes a noise, it sends out vibrations, also called sound waves. Hearing is the ability to detect those vibrations in the air. Sound waves travel from the air into your ear and through the auditory canal. When they reach the eardrum, the waves turn into vibrations that travel into the inner ear, then to the cochlea which is filled with fluid and lined with tiny hairs called cilia (just like in the nose). Neurons attached to the cilia detect the sound waves and send a signal to the brain. Your brain tells you what you hear.



Yep, what you see is actually upside down in your brain. The camera on your device is acting in the same way your eye reads light. In the eye, light travels through the lens and onto the retina, which first displays what you see upside down. Cells called photoreceptors—each eye has almost 125 million of them!—on your retina detect the light in this upside down image and send signals to the brain along the optic nerve. The occipital lobes receive the signals and process what you're seeing, right side up.

Experiment with the eye. Cover the camera and tap the eye. What happens?

When you block or let light into the eye, the size of the pupil changes. It gets bigger to allow more light to pass through to the retina when it's dark, and shrinks to let less light in when it's bright. Your eyes adjust according to the amount of light so you can see regardless of whether it's day or night. The magic part: your eyes do all of this automatically.

When you blink, the eyelid and its eyelashes help protect the eye by keeping tiny particles of dust and dirt from entering it. The eyelid also helps to keep the eye moist, spreading a layer of tears, oil, and mucus over the cornea every time we blink. An average person blinks 15 to 20 times per minute!

Eyes can be many different colors, from brown, blue or green, to hazel or gray. Our genes determine eye color. But, that doesn't mean you have the same color eyes as your parents, it can still be a surprise. Eye color is one of those things that's so complicated scientists are still trying to figure it out.





DISCUSS

Why do you have a brain? What is your brain made of? Why does your brain have wrinkles? How is the brain connected to your body? How does your brain learn new things? How do you feel something hot, cold, painful, or ticklish? How do you see? How do you hear?

Skeletal system

GET STARTED

The skeleton gets a bum rap as a creepy creature that lurks in graveyards (and closets); but the truth is, we wouldn't be able to stand upright, sit, or move, without our bones. A total of 206 bones provide a framework for our bodies, protect important organs, and support movements big and small—from running to tying our shoes. Teeny-tiny bones in our hands enable precise movements making them the most useful tools in the world.

While bones are strong—pound for pound, stronger than concrete they're not totally solid. Our bones have tiny holes, like a sponge. And, they've got a lot going on inside: new blood cells are being made. The role that the skeletal system plays in our health and growth is anything but bare.



Drag the bones apart and reassemble them. How do bones fit together?

Like a puzzle, bones fit together to do specific jobs in the body. They work so well together that you might not even realize you have 206 of them. For example, your skull: that hollow ball comprises eight bones that create a case to protect the brain. Twenty-four ribs—poke your side (you can feel them)—form a cage to protect the lungs, heart, and other internal organs.

Twenty-four small bones, called vertebrae, stack on top of each other to create the spinal column, for short, the spine. It helps us sit up straight, twist, or bend up and down. Vertebrae also protect the spinal cord, the main passageway for messages going to the brain.



Take a closer look: tap the hand or pelvis. Swipe to move the bones. How do joints help them move?

Bones swing and slide, bend and straighten from the places they're connected by joints. Different types of joints allow for different movements; here are a few examples:

In the elbow and knee, HINGE JOINTS allow the arms and legs to bend and straighten. They're used every time you take a step.

In the shoulder and hip, BALL-AND-SOCKET JOINTS allow for even greater movement rotation—of arms and legs. Ball-and-socket joints are used when you throw a ball.

In the thumb, the SADDLE JOINT enables side-to-side and backwards-and-forwards movement. You use the saddle joint to hold a pencil.

In ankles and wrists, GLIDING JOINTS connect flat or slightly curved bones, letting them slide back and forth. You use gliding joints when you shake a new friend's hand.

Also found in wrists, CONDYLOID JOINTS permit all movement except rotation. You use condyloid joints when you make your hand into a fist and curl it in.

You can't see it in the app (it can't be shown in two dimensions!) but the PIVOT JOINT in the neck enables the head to turn. Look to the left or right and you're using the pivot joint.



Take a closer look: tap the magnifying glass or a bone. What are bones made of, and what do they make?

Ranging from solid to spongy, the composition of bone varies as you move from the outside in. The strong, outermost part of the bone is called the compact bone. Inside the compact bone is the cancellous, or spongy, bone; it's softer and has tiny holes for blood vessels and nerves to weave through. In the core of the bone, you'll find marrow. Bone marrow is made up of tissue, fat, veins, and arteries: this is where all those new red blood cells are produced. About 500 billion blood cells are made inside your bones every day. (Learn more about blood in the circulatory system.) Bones also add new cells and get bigger and stronger as we grow.



DISCUSS

Why do you have bones?

How are your bones connected?

Why do your bones have different shapes?

What are your bones made of?

What's inside of a bone?

What do your bones do?

How do your bones change as you grow?

What allows the spine to move?

Respiratory system

GET STARTED

Breathing is essential to our survival. Thankfully, it happens automatically so we don't have to think twice about it. With the help of an involuntary muscle, the diaphragm, air enters through the nose or mouth, travels down the windpipe, through the bronchi and an intricate network of airways, and finally, into the lungs. We take in the oxygen needed for energy and growth and exhale to expel carbon dioxide. This process continues as we breathe in and out, and in and out, about 20,000 times a day.



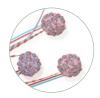
Swipe the legs. What happens in the respiratory system during exercise?

To get energy to run, jump, or dance, cells in the body use oxygen to burn sugars and starches from food. Carbon dioxide is created as a waste product of this process. When the brain recognizes the increase in CO2, it makes you breathe faster to exhale and get rid of it. The respiratory system picks up the slack to support this exchange of oxygen and CO2.



Take a closer look: tap the lungs. Move the slider. What do you see?

The lungs expand to fill with air and contract to empty with help from the diaphragm, the bulging muscle beneath the lungs. An involuntary muscle, the diaphragm moves up and down as air enters and exits the lungs, and we breathe in and out.



Take a closer look: tap the magnifying glass. How do blood and oxygen travel in and out of the lungs?

Tiny alveoli, or little air sacs, transfer oxygen from the lungs into the blood and get rid of carbon dioxide. The walls of the alveoli are super thin, like a screen door, so oxygen (little blue dots) can easily pass into the blood as you inhale, while carbon dioxide (little yellow dots) departs as you breathe out. In an adult's lungs, there are about 600 million alveoli—enough to cover the surface of a tennis court.



DISCUSS

Why do we breathe?

Where does air go when you take a breath?

What do you think happens if you hold your breath?

Why do your lungs work harder when you exercise?

What are alveoli? What do they do?

What waste product do you get rid of every time you exhale?

Circulatory system

GET STARTED

The heart is at the center of the circulatory system. About the size of your fist, the heart pumps blood through a network of blood vessels throughout the body to deliver oxygen and nutrients and remove the waste product, carbon dioxide. In an adult, the heart beats 60 to 100 times per minute, about 100,000 times a day, 35 million times per year, and about 2.5 billion times in a lifetime. It's working nonstop to keep you alive.

In the app, you'll see red and blue blood vessels. The red ones are arteries carrying oxygen-rich blood away from the heart; the blue ones are veins carrying oxygen-depleted blood back to the heart. There are three different types of blood vessels: capillaries, arteries, and veins. Capillaries are the smallest vessels. They allow for the exchange of water, oxygen, carbon dioxide, and other nutrients and waste between blood and surrounding tissues. Arteries are thicker and more rigid; they carry blood pumped straight from the heart under high pressure. Veins are smaller with thinner walls; they carry more blood that's traveling farther away from the heart. The whole network of blood vessels in your body can stretch close to 60,000 miles (that's like circling the world, twice!). Blood goes the distance to keep us healthy.



Swipe the legs. What happens in the circulatory system during exercise?

The heart beats faster when we run because muscles are using more energy and producing more waste (CO2). So, the brain tells the heart to increase the flow of blood to deliver more nutrients and pump the waste away. If you run or jump and then stop and touch your fingers to a pulse point—located on your wrist, neck, and upper arms—you can feel your heart working. Your pulse is the number of times your heart beats in a minute. This determines how quickly or slowly blood is traveling through your body.

Take a closer look: tap the heart. Move the slider. How does blood travel in and out of the heart?

Blood takes a winding route throughout the body, but as it leaves and returns to the heart, it basically goes in from the right and out to the left. Deoxygenated blood travels to the heart via the right atrium, then moves through the right ventricle into the lungs where it absorbs oxygen. Next, it moves into the left atrium and exits the heart through the aorta in the left ventricle and starts another journey throughout the body as oxygenated blood.

As blood travels through the heart, a valve in each of the heart's four chambers makes sure it travels in one direction. Just like you don't have to think about making your heart beat because it's an involuntary muscle, you don't have to think about which direction your blood travels. Valves in each chamber close, like doors, behind the blood as it flows so it can't go in the wrong direction.



Blood is made up of three kinds of cells: red blood cells, white blood cells, and platelets. They are suspended in plasma, a yellowish fluid that's mostly (90%) water, but also contains and delivers nutrients, proteins, and hormones to the body. Plasma also picks up waste products and carries them away as blood circulates through the blood vessels.

Blood cells are tiny-but-mighty fighters for your health. Every single drop of blood holds 250 million red blood cells which carry vital oxygen to every cell in your body. Platelets help heal wounds on the skin and in blood vessels, gathering to stop the leak of blood by clotting. On the skin, they form a scab. White blood cells attack unwanted bacteria and viruses.



Take a closer look: tap the blood vessel. Drag white blood cells over bacteria. What happens?

Ack! It's an attack! White blood cells fight off infection and disease to help keep you healthy. When foreign microbes, like bacteria, germs, and viruses, enter the body, white blood cells produce antibodies that help destroy them. When you're sick, white blood cells increase in number, surround the invaders, and overtake them. They also remember their battles and can quickly make antibodies, so they're ready if the same germ returns again.





DISCUSS

What does your heart do? Why do you have blood in your body? How does blood move through your body? Where is your blood made? What is blood made of? What do arteries and veins do? How does your blood help keep you healthy?

B Digestive System

GET STARTED

From chicken sandwiches to ice cream, everything you eat and drink takes the same trip through the digestive system—basically a long, hollow tube from the mouth to the anus. The digestive system starts in the mouth: muscles and spit begin to break down food we chew. As it travels through the esophagus, stomach, and intestines, it's further broken down into nutrients that our bodies can absorb. The digestion process takes four to five hours from end to end. The nutrients that aren't absorbed by our body are turned into waste and discarded as—you know it—poop.



Drag different foods and feed the body. How does the body respond?

Different foods affect the body, well—differently. Eating a balanced diet with a range of foods supports the body's functions and likewise supports good health. Fruits and vegetables are great sources of vitamins and minerals that help the body grow, develop, and boost the immune system to fight off illness and infection. Dairy products, like milk and cheese, contain calcium to help grow and maintain strong bones. Meats can be a good source of protein and help to build muscle. Grains, like bread and rice, contain fiber, which helps keep the intestines healthy by moving food through the digestive system and causing regular bowel movements, aka good poops.

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As you feed the body, what happens to the food?

Food breaks down as it travels through the digestive system, thanks to digestive juices that also help transform it into nutrients. Glands on the tongue make spit to ease food down the esophagus. The stomach releases strong gastric acids that mix and mash food even more (these acids are so powerful the stomach has a lining to protect itself!). When food molecules reach the small intestine, bile from the liver and enzymes from the pancreas break down proteins, fats, and carbohydrates into nutrients that the body can absorb. Bile also helps carry away waste into the large intestine.



Take a closer look: tap the mouth. Drag food to the tooth. Drag the toothbrush over the tooth. What happens?

Healthy teeth help the digestive system by breaking down food into smaller, swallowable pieces. But not everything goes down the pipe: as you chew, food can get stuck in and between the teeth. Brushing and flossing your teeth regularly help keep them clean.

Brushing your teeth helps prevent cavities and other kinds of tooth decay. When sugars and starches from food and drinks mix with a sticky bacteria (plaque) found on your teeth and gums, they produce acids that can decay the outside of the tooth. If the acids eat all the way through the enamel into the tooth, they create a cavity—a hole—that you'd need a dentist to fix.

Swipe the legs. What happens in the digestive system during exercise?

How much food you have in your digestive system affects how you feel when you exercise. Too little food, and you might feel dizzy. When you exercise, the body burns fuel from food (glucose) for energy. If your stomach is empty, you might not have enough fuel to burn, so your head might start to feel woozy.

Too much food, though, and you might feel sick. Both digestion and exercise require blood. When you run, swim, or jump, blood leaves the digestive tract and travels to your muscles to deliver much needed oxygen. This slows down digestion, which might cause nausea or worse—vomiting!





Take a closer look: tap the stomach. Move the slider. Pop a bubble. What do you see and hear?

Your stomach is always ready to welcome food. It's only about the size of your fist but it will expand up to 10 times its size when you eat. To prepare for food, the stomach produces gastric juices that help mix, mash, and break down food. When you eat, the stomach fills with food and these juices, causing an increase in pressure. Receptors and hormones sense this pressure and send signals to your brain to let you know when you're full.

If you eat quickly and accidentally inhale too much air, or drink something with a lot of gas (like a fizzy soda), you'll end up with too much air in your system. That air needs to escape, and it does—as a big burp. If the gas doesn't escape then, it continues through your digestive system, creating new gases along the way that eventually come out as—you guessed it—farts.

Take a closer look: tap the small intestine. Drag food molecules around. What happens to them?

As food travels through the small intestine (which is actually about 20 feet long), it's mixed with enzymes from the pancreas and bile from the gallbladder, which help break it down even more. The food turns into tiny molecules, which are absorbed into the bloodstream through a network of tiny capillaries. The remaining bits of undigested food continue into the liver or the large intestine.

Take a closer look: tap the large intestine. Drag food molecules around. What happens when they exit the large intestine?

As food rolls through this final five feet of tube (yep, it's much shorter than the small intestine), hundreds of types of bacteria pitch in to help complete digestion by extracting additional vitamins. The large intestine is the last place nutrients from food can be absorbed into your body. Any food that remains after this point is considered waste. Water is squeezed out and the waste is compacted before it is—to put it politely—discharged as poop.



DISCUSS

Why do you need to eat?

Which parts of the body make up the digestive system?

What happens to food in the stomach?

Where does food go in the intestines?

What foods do you eat to stay healthy?

Why do you burp and fart?

How are nutrients absorbed into your body?

What is poop?

Muscular system

GET STARTED

We tend to think of muscles as signs of strength. While they definitely help us pick up something heavy, they also help with small movements, including ones you might not think about. When you smile or frown, breathe in and out, or swallow and digest a snack, muscles are at work.

We rely on both voluntary muscles, that we choose to control, and involuntary muscles, that act on their own. To walk or run, we use voluntary muscles in our legs to put one foot in front of the other. Involuntary muscles are at work whether or not we think about them. They keep our hearts beating, lungs breathing, and intestines digesting.

If you think of the body as a machine made of levers, wheels, cogs, and hinges, the muscles are the strings and belts that move all the parts of the machine. Like bones, muscles grow with us, getting bigger as we do. Lots of moving and different types of exercise running, jumping, swimming, dancing, playing—will help grow strong muscles.



Take a closer look: tap the bicep or calf muscle. Drag the arm or leg. What happens?

The bicep and calf muscles wrap around bones like ropes, protecting them and helping them move so we can do things like raise our arms and wave hello.

Bend your arm up and flex your bicep to show your strength and you can see how muscles work in pairs. When your arm is bent at the elbow, the bicep—on the top of your arm—contracts and shortens. The tricep—on the underside—relaxes and lengthens. To straighten your arm, the opposite happens: the bicep relaxes and the tricep contracts.



DISCUSS

What parts of your body have muscles?

How are your muscles connected to other parts of your body?

What do your muscles help you do?

How do your muscles grow and get bigger?

Do you know of any muscles in the circulatory, respiratory, and digestive systems?

Urogenital system

GET STARTED

The urogenital system includes the urinary system, which makes you pee, and reproductive organs, which help people make babies.

The urinary system is a tinkle factory. Pee production begins in your kidneys: the kidneys filter out toxins, extra salt, and water from your blood and manufacture urine to get rid of the waste. The cleaned blood is sent back to the heart to begin another adventure through the body. The urine travels down the urinary tract: from the kidneys, through the ureters, into the bladder (where it might rest for a bit), out the urethra, and into the toilet.

The reproductive organs live near the urinary tract. The structure and function of male and female reproductive organs are different but complementary; they work together so humans can reproduce. It's an effective process: a new baby is born every eight seconds!



Take a closer look: tap the magnifying glass or the bladder. Tap the kidneys to see how blood and urine travel in and out of the kidneys.

The kidneys are blood cleaners. Every minute, the heart pumps about one liter of blood through the renal artery and into a network of capillaries. In the kidneys, over one million tiny nephrons, the capillaries and intertwining tubes that provide exits for waste products, filter the blood.

While clean, toxin-free blood is sent back to the heart through the renal vein, the toxins have to find their own way out. Urochrome, a yellow-colored byproduct of the filtering process, combines with the waste materials and water to make urine that swishes through the urinary tract.

Although two kidneys are useful, we only need one to do all this work. Every day, these beanshaped organs produce about one to two liters of pee in a rainbow of yellows. It's important to keep the kidneys working properly—drinking plenty of fluids helps.

Swipe down on the top of the bladder. Where does the urine come from and where does it go?

The bladder is a storage container for pee. As the bladder fills up, it expands, but can only hold so much. When it gets close to full capacity, nerve endings in the bladder walls send signals to the brain: when you gotta go, you gotta go. But your brain waits till you're ready (usually hovering over a toilet) to send your bladder the signal to let loose.

In both the male and female systems, urine exits down the urinary tract through the urethra. Male urethras are about twice as long as female urethras.



Move the slider once to reveal the male reproductive system. Slide twice to reveal the female reproductive system.

The reproductive systems are essential for the creation of life. This is the gist: boy parts create sperm while girl parts make eggs. On the fortuitous occasion that these cells meet and the sperm fertilizes the egg, chromosomes combine, and a cluster of cells called a zygote is formed. A zygote can eventually grow into a baby.

Male sex organs, the scrotum and penis, live outside the body. The pouch-like scrotum protects two testicles so they can make millions of sperm cells and hormones. From the testicles, sperm travel through a long tube called the epididymis, into the vas deferens where they mix with fluids from the seminal vesicles, bulbourethral glands, and the prostate glands. These fluids help nourish and carry sperm—the mixture is semen. In ejaculation, semen departs the penis through the urethra. And, if they're in the right place at the right time, sperm travel to find and fertilize an egg.

In contrast, female sex organs, the vagina, uterus, fallopian tubes, and ovaries, are mostly inside the body. There are two openings: the urethra and the vagina. Pee leaves through the urethra in girls, just as it does in boys. The vagina has a few special jobs. Protected by a cover called the vulva, the vagina is like a two-way path: the penis can travel in to deliver semen, and menstrual blood and babies can travel out (the latter with a bit of stretch).

While boys produce millions of sperm cells every day, girls are born with hundreds of thousands of eggs in their ovaries. These eggs rest until puberty. Then, ovulation begins: hormones trigger the ovaries to release an egg down the fallopian tubes and into the uterus about once a month. To get ready to host a potentially fertilized egg, the lining of the uterus preps with extra blood and tissues. If the egg is not fertilized by a sperm cell, it dries up. The egg and extra blood and tissues from the endometrium are then released through menstruation. If a sperm cell fertilizes an egg, the egg will continue into the uterus and settle in its rich lining. The uterus protects and nourishes a growing fetus. When the fetus is fully developed and ready, the uterus's super strong muscular walls help push the baby out into the wild world.

DISCUSS



What do your kidneys do? Why do you pee? What controls your bladder? How are male and female reproductive organs different? What travels through all the tiny tubes in the reproductive systems? How do male and female organs work together? What makes the uterus a good place for a baby to develop?

Immune system

GET STARTED

The immune system keeps your body healthy. It fights off common illnesses that spread easily through sneezing and touching, including colds, the flu, and strep throat. Your immune system also fights infectious diseases (like Lyme disease and HIV) which are more difficult to get, and diseases that can't be transmitted (like cancer).

Your immune system includes defenses you can see (your skin) and those you can't (microscopic cells). The immune system keeps disease outside of the body: coughs and sneezes can expel germs. And, the immune system fights disease inside: the body's white blood cells attack viruses and bacteria (germs).

Whether you're well or ill, the immune system is hard at work.



Drag germs to the body. Can they get inside?

The body has a bunch of exterior barriers to keep germs from getting in. These barriers stop germs before they get started, beginning with the surface barrier — your skin. Germs can't get past skin unless it's scratched, cut, or burned. In the app, drag a bandage to the body to help keep germs out of wounds.

If germs are swirling around places your skin doesn't cover — your mouth, eyes, or other body openings — mechanical and chemical defenses kick in. Coughing, sneezing, and watering eyes push germs out and away. Urine, mucus, and gastric acid can also trap and send germs out.

Take a closer look: tap the magnifying glass. Then, tap the bacteria or viruses to make them multiply. How are they similar? How are they different?

Bacteria and viruses both trigger a response from the immune system. It knows they're invaders that can cause illness. But, bacteria and viruses look and behave differently.

Under a microscope, many viruses look sharp and spiky. In the body, they need to find a home — a host cell— to replicate and produce more viruses. In the app, when a virus infects a cell, the cell turns the color of the virus as the virus spreads.

If you get a close look at bacteria, you might see round blobs with slimy coatings. Many have thin hairs (pili) and/or flowy tails (flagella) to help them move. Unlike viruses, bacteria don't need a home; they can float all throughout the body and multiply on their own.

Take a closer look: tap the mouth or nose. Drag macrophages to the bacteria or viruses. What happens?

If germs get past the body's exterior defenses, the body's second line of defense — the innate response — kicks in, and macrophages are on the attack.

Macrophage means big eater in Greek, and they're aptly named. Macrophages are white blood cells that patrol the body and eat any bacteria or virus-infected cells they find.



Take a closer look: tap a lymph node.

Lymph nodes live along the lymph vessels. They're primary response centers for fighting infections. When a germ enters a lymph node, the white blood cells inside activate, multiply, and leave to fight infections throughout the body.

These white blood cells are part of the body's third line of defense, the adaptive immune response. They include B-cells, T-helper cells, and T-killer cells, and are all known as adaptive white blood cells.





In the lymph node: drag a bacterium and match its marker to the marker on an adaptive white blood cell. What happens?

Unlike macrophages that attack any bacteria or virus-infected cells they find, each type of adaptive white blood cell detects and fights a specific antigen marker on a bacterium or virus. You can see their respective markers with matching shapes — called antigens and receptors — in the app.

When an adaptive white blood cell is matched to its bacterium, it launches into action. B-cells produce antibodies that surround and prevent germs from reproducing, T-killer cells destroy germs, and T-helper cells call other cells into action.



In the lymph node: watch the adaptive white blood cells exit the lymph node. How do they attack germs?

Once activated, adaptive white blood cells work quickly together, coordinating their efforts to target a specific enemy. Activated adaptive cells can also clone themselves while attacking, accelerating their power and response. And once they've defeated an infection and all germs are gone, some adaptive cells stay active, circulating through the body. These remaining adaptive cells are memory cells. If that same bacteria or virus returns, memory cells can identify and attack it immediately.

As their name suggests, adaptive cells constantly adapt in order to detect new and different types of invaders, helping the body respond to all kinds illnesses and infections.



DISCUSS

What makes us sick?

What habits can help us stay healthy?

How does your body protect you from germs?

What kinds of cells defend your body from germs?

How do white blood cells detect germs?

Are all germs the same?

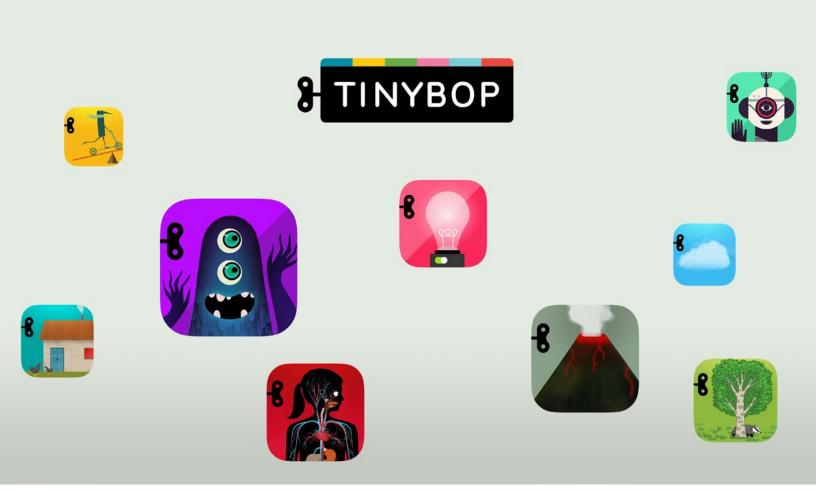
What travels in and out of the lymph nodes?

Why is the immune system able to respond quickly when the same germs return?

Thanks for playing **THE HUMAN BODY**.

If you have feedback or questions about **THE HUMAN BODY** Handbook, let us know at support@tinybop.com.

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