LESSON 2

the SKELETAL SYSTEM

Your skeleton supports you so you can stand up, play sports, and do many other things.

I'm sure you've seen a picture of a skeleton many times in your life. It can seem scary until you consider the fact that a skeleton spends all day with you – even at this very moment, there is a skeleton with you! A skeleton (just like one in a book or museum) never leaves you alone, no matter where you go or what you do. It's inside you all the time. If you removed all your skin and muscles, you would be mostly skeleton. Of course, you wouldn't enjoy life much without your skin and muscles, but it's true that a creepy skeleton is inside you. If that makes you shake a little, let's just imagine life without a skeleton. If you had no skeleton, you would flop around like an octopus. You would have no form or structure; you would look like a blob on the ground. Let's see what you would look like.

Try This!

Shape a human figure from a lump of clay. Give it long, thin legs and arms; put a large head on its shoulders. Go ahead and squish the head flat because that's what your head would look like if you did not have a skull. Now see if the figure can stand up on its own. If you made your figure correctly, it will not be able to stand.

Next, break a few toothpicks into different sizes. Insert the toothpick pieces inside your human figure like bones. You will probably need to rebuild your figure, inserting the toothpicks as you add each body part. Compare your second human figure to your first one. Did the toothpicks help the second figure stand up? They should have. The toothpicks acted like bones in the clay figure's skeleton. They gave it support so it could stand.

A clay figure needs a "skeleton" of toothpicks in order to stay standing.

So aren't you glad you have a skeleton inside you? It's a good thing you do, because your skeleton is an amazing creation of God! The bones in your body do more than just stand you up and keep you looking good. God made the **skeletal** (skel' ih tuhl) **system**, the network of bones inside of you, to do lots of other important things. You could never take out all your God-given bones and replace them with manmade bones, because the manmade "look-a-likes" could never perform all the mind-boggling duties of a single bone. Besides keeping you from flopping around like an octopus on the ground, let's see what else your bones do.

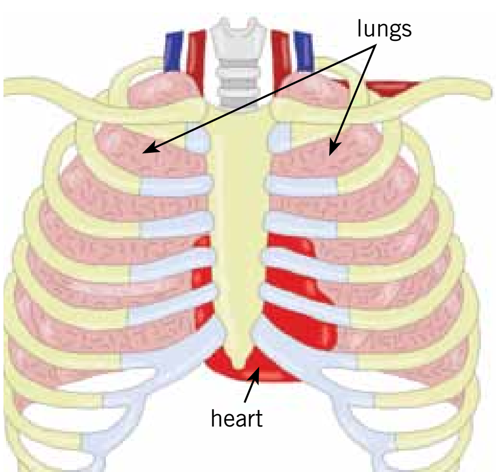
Your skull protects your brain.

What Do Bones Do?

In addition to supporting you and giving you your shape, bones also protect some very delicate organs in your body – ones that you would want to have protected – like your brain, your lungs, and your heart. Think about it: without your **skull**, every little bump on your head would damage your brain, and you wouldn't be able to think very well anymore. If you fell too hard, well, your brain would simply get mushed. That would be terrible! Your skull, though it may not be pretty, is absolutely one of the most important groups of bones in your body.

Try This!

God was wise to create you with a thick skull to protect your brain, but He didn't stop there. God also put a special layer of fluid between your skull and your brain for added protection. Let's see how this protection works. You will need: two eggs, a plastic container (with a lid that seals tightly) that's only slightly bigger than the eggs, some water, and some masking tape. In this experiment, the eggs are going to represent a brain. Place the first egg in the container. Seal the lid. Jog around the room, shaking the container. What happened? The egg went splat, didn't it? Now wash out the container and try the same thing with the second egg, but this time you will add some protection. Fill the container to the very tip top with water. Place the egg in the container and seal it closed with some masking tape. Now jog around the room in the same way as before. Carefully open the container. What happened to the egg? Hopefully, it didn't break, because the water helped to protect it from damage. Now you know one of the reasons God placed that special fluid between your skull and your brain!

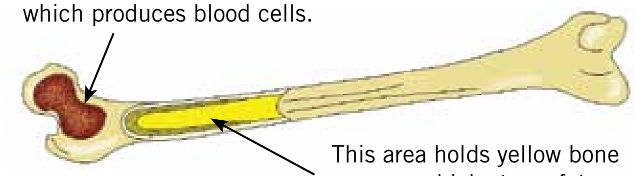


Your rib cage protects your heart, lungs, and other organs.

You're beginning to realize how God designed some of your bones to protect you from harm. Did you know that if you didn't have a special cage around your heart and lungs, even a small fall could collapse your lungs or make your heart stop working? Do you know what the cage is called? It's called your **rib cage**. We'll go over the bones of your rib cage (and many others) in just a little while.

Got Blood?

So bones give your body shape, and they protect important organs. Do they do anything else? Absolutely! Do you think blood is an important thing to have? Let me assure you, it really, really is. You'll learn all about blood in a later lesson. Have you ever wondered where all the blood in your body comes from? If you bleed, your body has to make more blood. How does it do that? Amazingly, your *bones actually make your blood cells*. Can you believe that? Bones are like little blood cell factories. Without your bones, your body would run out of blood pretty quickly, because blood cells don't live very long. So, now do you see why you couldn't take out the bones God made and replace them with manmade bones? God designed the bones to do a lot more than meets the eye!



Blood cells are made in the red bone marrow found in many bones, and fat is stored in the yellow bone marrow.

Warehouse Wonder

Bones have another function: storage. Like warehouses, they store important things your body needs, such as fats, which scientists call **lipids** (lip' idz). A lot of people try to limit the amount of fat they eat in order to lose weight. However, without an adequate amount of fats, your body would not work properly. That's why your bones store them. Bones also store **minerals** (min' ur uhlz). Yes, just like the earth, you have minerals stored deep inside you. Your body actually uses them to function. For example, one mineral, **calcium** (kal' see uhm), helps to keep your heart beating regularly. It also helps your mind to think and understand the world around you. One time, my grandmother began to forget a lot of things. She forgot my name. She forgot how to make a cup of coffee. We thought she was in real trouble. The doctor found out that she wasn't getting enough calcium. So, they gave her calcium and guess what? All of a sudden, she was back to normal. At the time, none of us knew how important calcium was. We must have calcium to be healthy, so we can be thankful that God created our bones to store it.

Drinking milk is a good way to get the calcium you need.

Even though your bones store calcium, you need to take in some every day. If you don't, your body takes the calcium stored in your bones and uses it to help your heart beat, your brain think, and many other important things. Can you guess what happens to your bones if your body takes too much of their calcium stores? Well, your bones become weak and can be easily broken. Calcium (in the form of a hard material called **calcium salts**) makes your bones strong and sturdy, so make sure you get some calcium every day!

Do you know what foods contain calcium? The main ones are yogurt, cheese, and milk. In fact, three glasses of milk a day will meet most of your body's calcium needs. There are other sources of calcium like spinach, salmon, and ice cream, but milk has more calcium per serving. It's important to get as much calcium as you can today, because about 90% of the calcium stored in your bones is put there by the time you turn 18 years old. People who don't get enough calcium when they are young often develop a disease called **osteoporosis** (ahs' tee oh puh roh' sis). This disease results in weak bones with lots of tiny holes in them. Many people with this disease have bones that break very easily. A fall that would not hurt you very much could actually break one of their bones!

Bone Brawn

Since we're on the subject of bones, let's talk about strong bones for a minute. Having strong bones is very important. As you have probably already guessed, strong bones don't break as easily as weak bones. Besides calcium, what makes your bones strong? Well, one thing is exercise. The more you use your bones, the stronger they become. Bones that are not used become weak and frail. This can happen to astronauts in space. Without gravity, they just float around, not exercising their muscles or bones much at all. If they didn't do something about that, their legs would become too weak to support their bodies when they returned to earth after a long mission in space. To help avoid this, they strap themselves to machines and run, but they still lose some bone, because running without gravity isn't nearly as hard as running with gravity.

There's something else besides calcium salts and exercise that makes your bones strong: it is a nutrient called **vitamin D**. You can get this from the things you eat and drink, but your body also *makes* this nutrient when you get out in the sunlight. If children do not get enough vitamin D, they can get a condition called **rickets** (rik' its). Rickets is common in countries where food is scarce and children are hungry. It also occurs in the United States when children are indoors a great deal and do not get enough vitamin D from what they eat and drink. Rickets, like osteoporosis, causes bones to be very weak and easily broken. In addition, the bones don't form properly. A child with rickets will often have deformed bones, like leg bones that become severely bowed. When a person doesn't get enough of the right kinds of nutrients, we say that the person is suffering from **malnutrition** (mal' new trish' uhn).

Now please understand that calcium is just one of many minerals you need for a healthy body. As a result, your bones store other minerals as well. Your body needs **phosphorus** (fos' fur us). You can get phosphorus from whole-grain cereals, fish, milk, and green vegetables.

Astronaut Jeffery N. Williams aboard the International Space Station is exercising so his bones don't get too weak while he is in space.

Your skeleton has joints in it, which allow you to move your body in many interesting ways.

Let's Get Moving

The last thing bones do is probably one of the most important to you. Your skeleton is composed of many **joints**, which allow you to move. Of course you need muscles to move the bones in your skeleton, but without your joints, your muscles wouldn't do you much good at all. For right now, however, we are going to concentrate on your bones. We'll talk about your muscles in the next lesson. I know that you probably like to move around and so do I. So, I'm going to keep my skeleton. How about you?

Tell someone what you have learned so far. Include all the things bones do for your body.

Bone Anatomy

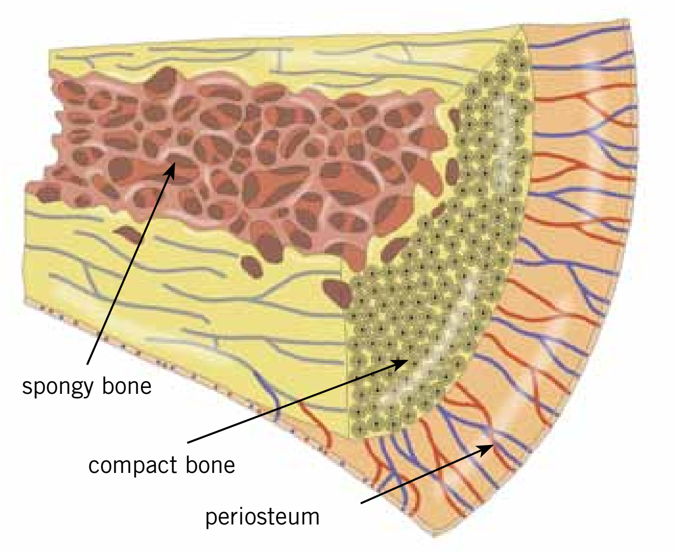
Have you ever been to a museum and seen skeletons of animals or people? Actually, your bones don't look *exactly* like those skeletons. That's because your bones are alive, and living bones look different from dead bones. How are your bones alive? They're alive because they're made up of living material – material that is constantly working, growing, and repairing itself all the time. Bones are made of cells! Bone cells, to be exact! Let's look at the anatomy of a bone.

On the Outside

The outside layer of a bone is a thin, tough membrane called the **periosteum** (pehr' ee ahs' tee uhm). As you can see from the drawing below, it is filled with nerves and blood vessels. The nerves sense pain. Yes, bones have feelings too! When someone breaks an arm, it's the periosteum that's screaming, "Ouch!" The blood vessels take nutrients to the bone and take out the trash – the waste made by the bone cells. The periosteum also helps in the building of new bone. Did you know your body is constantly building new bone and destroying old bone? Scientists call this **remodeling**. It's like when you play with Legos. You tear down part of a Lego structure and build other parts onto it. Sometimes this makes the structure better and stronger; other times it doesn't. It's the same with bones. How well your bones get remodeled depends on what you eat and how much exercise and sun you get. We'll discuss how that happens in just a minute.

Made to Last

The next layer of a bone is the thick, hard layer called **compact bone**. When you see a skeleton or a single bone, this is mostly what you are looking at. The living layer of periosteum has died, dried up, and peeled off the bone. This leaves just the compact bone on the outside. Compact bone is so durable that it can last for thousands of years if preserved correctly. It is smooth and hard, made of many layers of calcium-rich minerals and a tough fiber called **collagen** (kol' uh juhn). These materials are woven together to make bone the second strongest material in your body (you'll learn about the strongest material in Lesson 4). In fact, very few things on earth are as strong as bone. Have you ever held a steel pipe in your hands? If you have, you know that a steel pipe is unbendable. It is so strong that builders use it to create skyscrapers. Of course, it is really heavy, too. Pound-for-pound, however, your bones are actually stronger than steel! But even more amazing is the fact that, though bones are stronger than steel (on a per-pound basis), they are still fairly flexible. That's partly because God placed something called "spongy bone" on the inside.



This bone has three main layers: the periosteum, compact bone, and spongy bone. Bone marrow fills the spaces between the spongy bone.

Bouncy Bone

Under the compact bone layer is a network of pores and tunnels interconnected in a pattern that makes the bone strong yet resilient (rih zil' yent – able to bounce back after being compressed). This network of bone tunnels is called **spongy bone**. Why did God design our bones to be resilient? Well, have you ever had anything fall on you? One time, when I was young, a car door slammed on my hand. Ouch! That really hurt. But it didn't break my hand! Do you know why? Because the bones in my hand were resilient enough to compress and then bounce back without breaking. God designed our bones to withstand a certain amount of pressure, because He knew that sometimes our bones would have some pressure put on them.

In the Marrow

Do you have any idea what is on the very inside of many of your bones? If you break open a fresh chicken bone, you'll find out. There's a hollowed-out cavity with some fluid inside – just like in one of your bones. You see, on the inside of many bones is a cavity filled with a thick fluid called **bone marrow**.

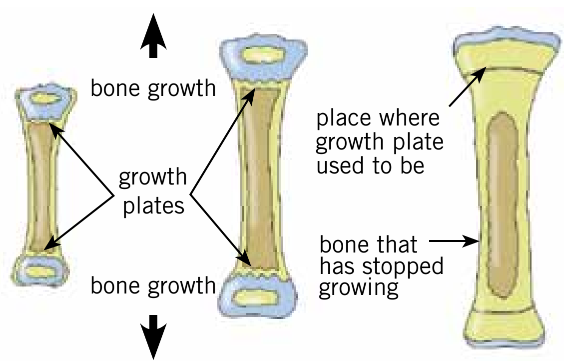
There are two kinds of bone marrow: red and yellow. **Red bone marrow** is the kind in which blood cells are made. When you cut yourself and bleed, your body needs to replace that blood. Well, your red bone marrow helps your body make more blood by providing it with new blood cells. This is important even if you don't cut yourself, because some of your blood cells (the red ones) aren't very hardy. They die of old age after only four months, so the red bone marrow must constantly produce new blood cells to replace the ones that are dying.

The **yellow bone marrow** stores up lipids. Do you remember what lipids are? Fats. These fats are used throughout your body to perform many important functions. In fact, the cell membrane you studied in the first lesson contains a lot of fat. Without fat in your diet, there would be no cell membranes. Without cell membranes…there would be no cells. No cells would mean no you. Thank God He made fat!

Now you know about bone anatomy.
Tell someone everything you can remember before moving on to the next section.

Bone's a Growing!

Now put on your thinking cap because we are going to get a little technical here. There are some really important cells living in your bones. They all begin with "**osteo**" (ahs' tee oh), because "osteon" is a Greek word that means "bone." The cells that make new bone are called **osteoblasts** (ahs' tee oh blasts'). Osteoblasts lay down new layers of bone, giving you more bone. How do they do it? Actually, they use a few ingredients that you provide! They need you to get plenty of minerals (like calcium) and exercise. They also need protein to make collagen, and they need vitamin D. Your body can make vitamin D when your skin is exposed to sunlight, or your body can get it from some foods. With all the right ingredients, those osteoblasts are having a blast making your bones bigger and stronger!



Long bones grow because of growth plates at the ends of the bone.

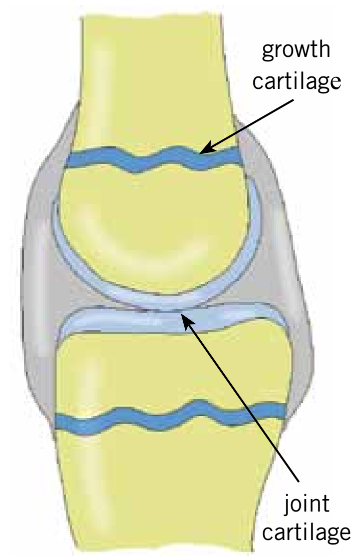
What if your bones never grew any longer from the time you were a toddler? You would be super short. Bones grow longer in special places called growth plates. On long bones (like arms and legs), growth plates are near the ends of the bone. So, bones don't grow from the middle, they grow from the ends.

This is the way it happens: when you go through a growth spurt (children grow in spurts as well as gradually over time), a substance called **cartilage** (kar' tuh lij) begins to stack up on the growth plate. Feel the bridge of your nose. It has no bone; it is made out of cartilage. Cartilage is firm but resilient and absorbs shock very well. God also put cartilage on the ends of bones that come into contact with each other. Working like a shock absorber, that **joint cartilage** keeps your bones from getting hurt when they rub against one another. Try this experiment to help you understand.

Try This! Go to your kitchen or bathroom counter top and slap it with your hand - but be careful not to slap it too hard! Now place a pillow or a cushion on the counter top and slap it again. Did the cushion help you from feeling the shock of your hand slapping against the hard counter? That's part of what cartilage does between your bones.

So, you have joint cartilage between your bones at your joints, but you also have growth cartilage that forms your bones' growth plates. When your bones need to grow, cells in the cartilage of the growth plate make the growth plate get thicker. Soon, when it has a big enough stack of cartilage, the cells that were producing the cartilage die, and osteoblasts come to take their place so they can turn the dying cartilage into bone. As a result, you get taller! Your arms and legs get longer! Before you know it, you're looking *down* at mom instead of *up* at her!

Believe it or not, you can actually get an injury to your growth plates that can stop your bones from growing. When my pastor was a teenager, he accidentally stepped into a hole while running in the woods. He broke the growth plate in his tibia, one of the bones in his leg. That part of his leg quit growing, while the rest of his body (including his other leg) continued to grow. His other leg grew two inches longer than the leg he injured! This isn't as likely to happen today, because modern medicine can treat such bone injuries and help the bone grow normally.

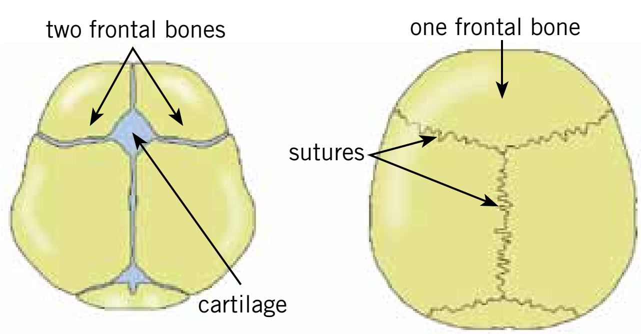


When bones rub against each other like they do in this knee joint, the joint cartilage at the end of each bone acts as a firm cushion.

Deep and Wide

In addition to growing longer, your bones also grow wider. Have you ever noticed that your wrist is a lot smaller around than your dad's wrist? Well, that's because bones get wider as they get longer. Here's the way it happens: the osteoblasts lay down new layers of spongy bone right under the periosteum. This spongy bone is then "filled in" to make compact bone. At the same time, different bone cells, called **osteoclasts** (ahs' tee oh klasts') eat away at the spongy layer on the inside of the bone. This widens the cavity inside the bone as the bone gets wider. This kind of bone growth happens even more when you exercise, as long as your body weight isn't too low and you eat plenty of healthy foods.

Have you ever wondered when you'll stop growing? If you're a boy, you'll keep growing in height until you're about 18 years old. Girls stop growing in height around the age of 16. But here's something interesting to think about: at nine years old, a boy is 75% of the height he will be as an adult. On the other hand, a girl is 75% of her adult height at seven years old. So girls grow a bit faster and stop growing a bit earlier than boys.



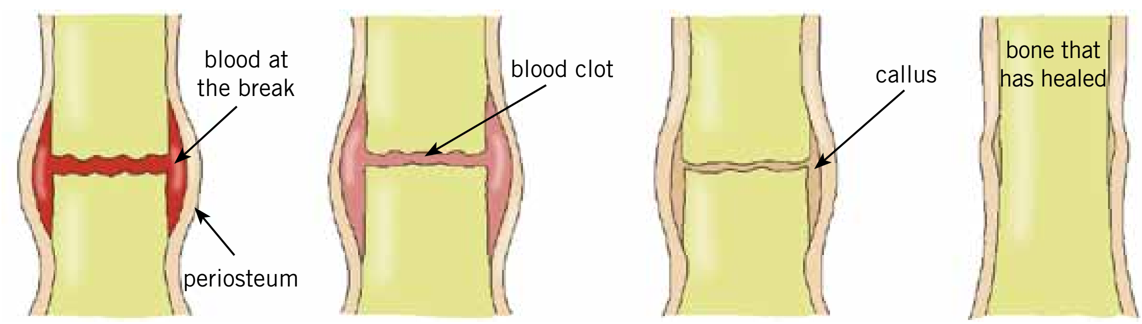
There are five visible bones on the top of the infant skull shown on the left. They have fused to four bones in the adult skull on the right.

Bones do more than just grow longer and wider as you become an adult. Believe it or not, a baby is born with about 300 bones, but an adult has only 206. Wait a minute! What happened to all those baby bones? I'm going to let you take a guess by looking at drawings of a baby skull and an adult skull. Do you see what happened to the bones from infancy to adulthood? The bones **fused** together. In other words, two (or more) smaller bones became one bigger bone. This happens when the cartilage between the bones turns into bone, joining them together.

Even once your body has finished growing, your bones are being constantly remodeled. Remember the Legos we talked about? They're always being reconstructed and rearranged. You see, under the stress of everyday activities (walking, running, biking, etc), your body reshapes your bones so they can give you the best support for the kinds of activities you do most often. Even as you sit reading this book, calcium and phosphorus are being removed from some areas of your bones and deposited into others. This is an amazing design God chose for our bones! Let's see why.

Broken Bones

Have you ever thought about how amazing it is that God's creations repair themselves, while man's creations typically don't? If you break a plastic leg on a toy, it pretty much stays broken. But that's not the case with the wonderful body God created! Amazing things happen when you injure yourself. In fact, your body is specifically designed to fix itself. Even broken bones fix themselves! You may be wondering why people have to wear casts if bones just repair themselves. Well, the cast holds the bones in place and sometimes pushes the two broken pieces of bone closer together so that healing happens faster. You've probably noticed that people who are badly hurt try to keep the injured area of their body from being jostled. A cast serves the same purpose – it keeps the broken parts of the bones from moving. The support it provides promotes healing and helps relieve the pain a broken bone can cause. Even ancient people understood that keeping broken bones from moving decreased pain and also sped up the healing process. Before modern casting materials were invented, broken bones were kept still with wood splints wrapped in cloth, or tree bark, or linen stiffened with a variety of items including egg whites, flour, starch, or wax. Eventually, people began using plaster of Paris. For a long time plaster was the standard casting material, but now most doctors use fiberglass, because it is lighter, more durable, and faster to apply.



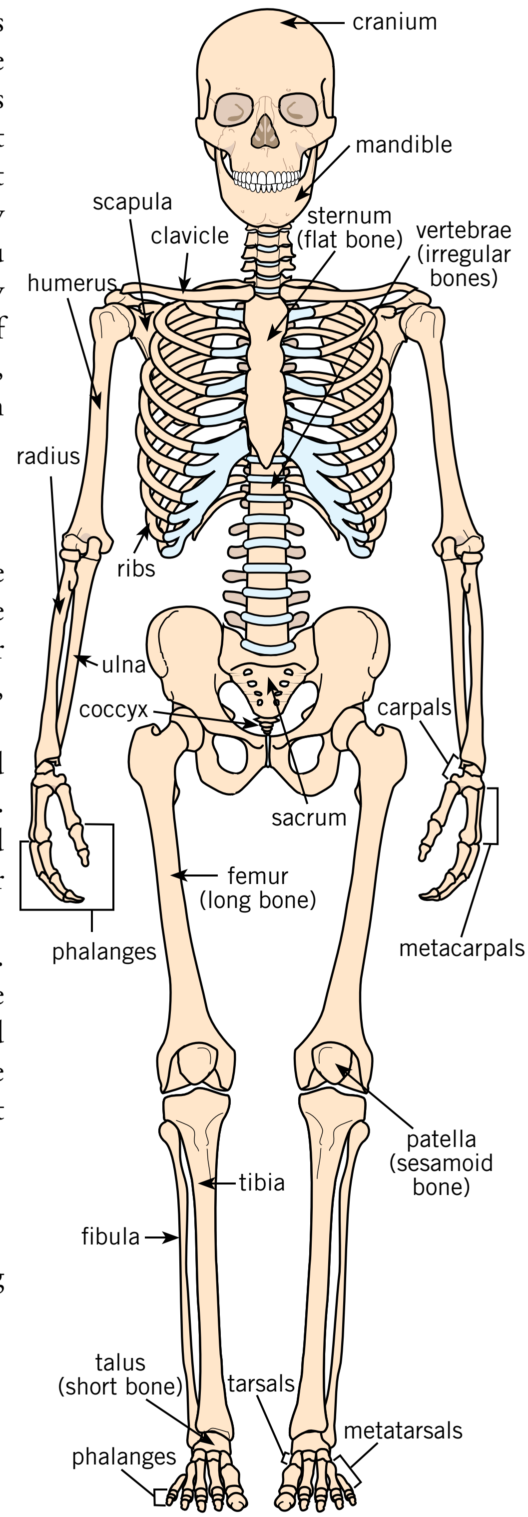
A broken bone heals by forming a blood clot that allows osteoblasts to come in and make a callus, which is then remodeled into normal bone. The new bone is nearly the same as the old one, but might be a bit thicker at the point of the break.

So, how does a bone heal itself? First think about what happens when you cut your skin – a scab forms, and eventually, new skin grows back. This process starts with a clot of blood forming at the site of the injury. The same thing happens when a bone is injured. When you break a bone, it bleeds. The blood settles between the bones and makes the periosteum bulge out. Then a clot forms. Osteoblasts come into the clot and start making new bone. The bone fills in the space between the bones but also the bulge under the periosteum. This is called a **callus** (kal' us). Over time, the osteoblasts absorb the callus and produce bone that is very similar to the original. When you put a cast on a broken bone, it keeps the bone ends close and the callus unbroken so your body can remodel that bone more quickly and get it back in action.

Take some time to tell someone what you learned about bone growth, remodeling, and healing.

Bone Basics

How do you suppose the bones in your skull are different from the bones in your fingers? Although all bones in your body are made of the same material, they are obviously different shapes and sizes. Can you guess which is the longest bone in your body? Look at the skeleton on the right to find your answer. Did you figure out that it's your thigh bone? That bone is called your **femur**. Don't worry, in a little while we'll do an activity to help you learn the names for many of the bones in your body. Do you know which is the smallest bone in your body? There are three teeny tiny bones in each ear. All three of them could fit on a dime with lots of room to spare. They are called the **malleus** (mal' ee us), **incus** (ing' kus), and **stapes** (stay' peez). The smallest one is the stapes, measuring 2.5 mm long. Use your ruler to see how long that is.



Shapin' Up

As you can see, your bones have many different shapes, and scientists have given names to them. For example, **long bones** are – well, long. They are longer than they are wide. We've already discussed one long bone, the femur (your thigh bone). Other long bones are found in your legs, arms, fingers, and toes.

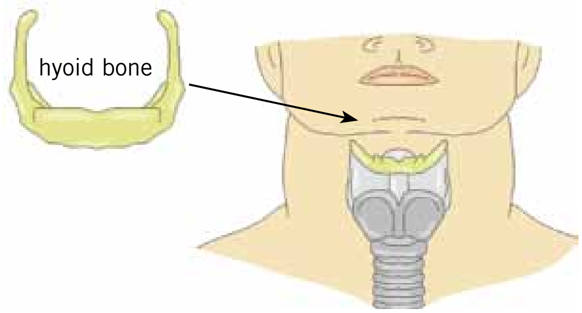
Short bones are…you guessed it…short. They're usually around the same height and width. Short bones are found in the ankle and wrist. **Flat bones** are another kind of bone. The bones in your skull are considered flat bones. They are not round and thick like the bones in your legs. Your sternum and ribs are also flat bones.

Sesamoid bones are small and usually rounded, like small stones. There are some tiny ones in your hands, but the easiest one to find is the **patella**, or knee cap. Stand up and bend over to feel your knee. Feel around until you find a bone that moves back and forth. That's your patella! The rest of the bones, like your vertebrae, are called **irregular**, because they don't fit any of the other categories.

Connect the Bones

Have you heard the bones song? When I was a kid, we used to sing this song a lot. Here's a part of it:

Ezekiel cried, "Dem dry bones!"
"Oh, hear the word of the Lord."
The toe bone connected to the heel bone,
The heel bone connected to the foot bone,
The foot bone connected to the leg bone,
The leg bone connected to the knee bone,
The knee bone connected to the thigh bone,
The thigh bone connected to the back bone,
The back bone connected to the neck bone,
The neck bone connected to the head bone,
"Oh, hear the word of the Lord."



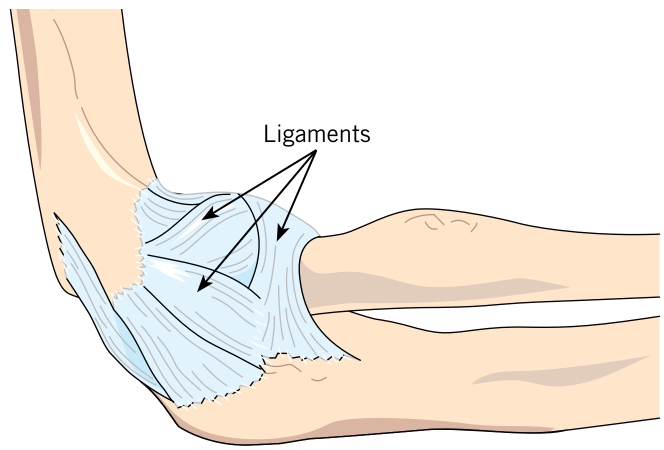
The hyoid bone is connected to cartilage of the larynx (lar' ingks), but not to any other bone.

This fun song teaches an important truth. You see, every bone in your body is connected to another bone. Well, that's not entirely true. There is one lone bone in your neck, called the **hyoid** (hi' oyd) bone, that isn't connected to any other bone. It is connected only to cartilage.

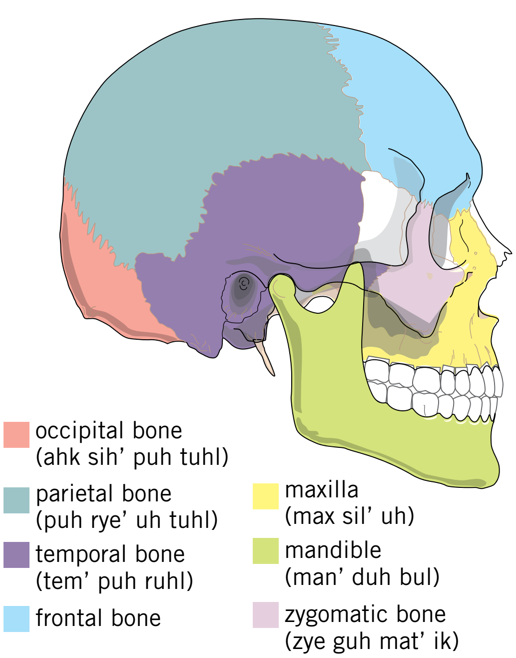
Ligaments

Bones are connected to one another by special tissues called ligaments. These tissues are made of tough collagen fibers that hold the bones in place at a joint. They limit the joint's motion so that the bones don't get too far away from each other. Because they can stretch a bit, however, they allow the bones to move farther apart from one another for a brief time before snapping back into place.

Because bones are connected to one another, they can affect each other. Did you know you can get a concussion (an injury to the brain) by falling on your **coccyx** (kok' siks), or tailbone, really hard? It's true. My son was wearing tennis shoes with wheels and fell on his tailbone so hard that it shook his brain and gave him a minor concussion! This may seem hard to believe, but if you bend over and run your fingers along your spine, you will feel the ridges all connected to one another – from your tailbone all the way up to your skull. Now you can see how my son's tailbone injury affected his brain, even though it was halfway up his body! This is also why shaking an infant is so dangerous.



These are the ligaments that hold the bones of the elbow joint in place.



There are nearly 30 bones in an adult's skull.

A Head of the Game

The part of your skull that protects your brain is called the **cranium** (kray' nee uhm). Although it feels like it's just one rounded flat bone, it is actually made up of eight bones (once all your infant bones fuse). These are important bones since they cover and protect your brain. Nevertheless, these bones fit tightly together. The place where any bone meets another bone is called a joint. So, even though your cranium does not move, it has joints. Joints that do not move are called **sutures** (soo' churz). We will learn about several other kinds of joints later on.

In babies, the sutures allow for brain growth. You probably remember that the sutures are not fused or sealed together in a baby. This is because the brain isn't its full size yet. As the brain grows, the cranium grows by being gently pushed outward by the brain. This way, the brain is always protected in its coat of armor, but the armor can grow with the brain! That's a marvelous plan designed by a marvelous God! Eventually brain growth stops, and the places where the bones of the cranium meet become fused at the sutures.

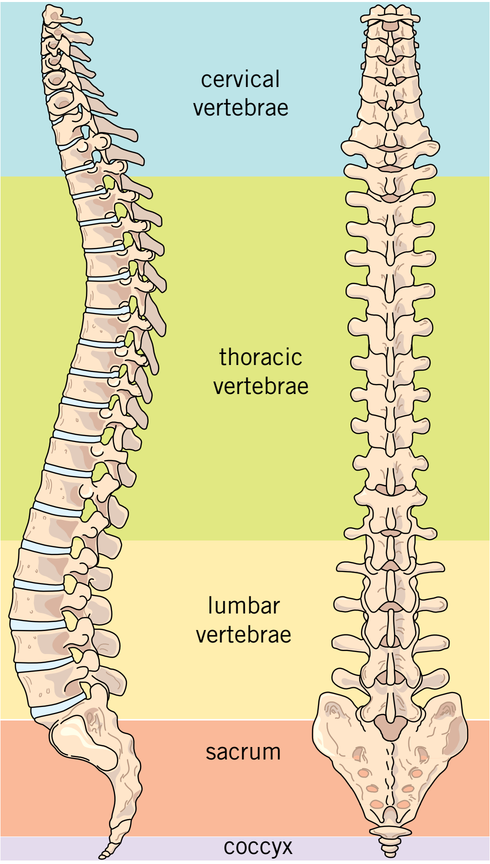
Let's Face It

Moving down from the cranium, you'll find your lovely **facial** (fay' shul) **bones**. Of the 14 bones in your face, all except one are attached to the other bones with a suture joint. In all those bones, only one bone moves. Can you guess which bone that is? Well, open your mouth really wide. Now do you know? Look at the drawing and tell me the scientific name for that bone. It's the **mandible**!

The three smallest bones in your body are located in the skull. Do you remember where? The ear! Do you remember their names? They are the malleus (sometimes called the hammer), incus (also called the anvil), and stapes (or stirrup). The alternate names I put in parentheses come from their shapes. Can you tell which is which in the picture on the right?

The malleus, incus, and stapes are so small they can fit on a dime, with room to spare!

If you were to look into some of the facial bones, you would find hollowed-out cavities called **sinuses** (sye' nuh sez). These "holes in your head" make your head lighter, and they are lined with special cells that produce **mucus** (myoo' kus). If you get a bad cold and your nose runs, it is probably the result of mucus draining from your sinuses, which empty into your nose.



The side view (left) and rear view (right) of the spinal column show how the vertebrae stack together.

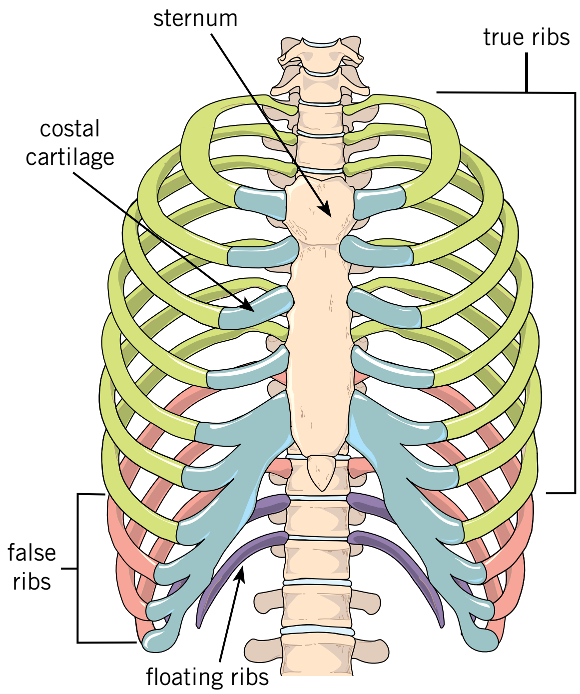
Shivers Down Your Spine

If you studied zoology, you learned that you are a **vertebrate** (vur' tuh brayt), meaning you have **vertebrae** (vur' tuh bray). What does all this mean? It just means you have a spine, which we call your **spinal column** or **vertebral column**. How many times in a row can you say vertebral column? I can only say it twice before I mess up.

Your spine is made up of all those hard bumps going down your back. Those bumps are donut-like bones called vertebrae. Can you count how many bumps you have? That's hard to do. Try it. Start right behind your neck and count each bump. Your neck has seven vertebrae. They are called your **cervical** (sur' vih kul) **vertebrae**, because "cervical" refers to the neck. There are twelve **thoracic** (thu ras' ik) **vertebrae** ("thoracic" refers to the chest) and five **lumbar** (lum' bar) **vertebrae** ("lumbar" refers to the lower back). That's a lot of bumps in your back! The spinal column is designed like this because inside the donut hole of each of those vertebrae is your **spinal cord** – coming from your brain and going all the way down your back. The spinal cord is an important part of the nervous system, which allows you to feel, walk, move, and talk. It's an important thing to protect.

Because of the way God designed the vertebrae to stack on top of one another, the spinal column can move in many, many different directions and still protect your spinal cord. Strong ligaments keep the vertebrae from falling off one another as the spine moves about. It's really an amazing design!

These 24 vertebrae also have cartilage discs between them to allow for shock absorption. The bottom two bones of the vertebral column, the sacrum and the coccyx, are made of flattened vertebrae that are joined together.



Most people have 12 ribs on each side of the rib cage, and most of the ribs are attached to the sternum with cartilage.

Baby Back Ribs

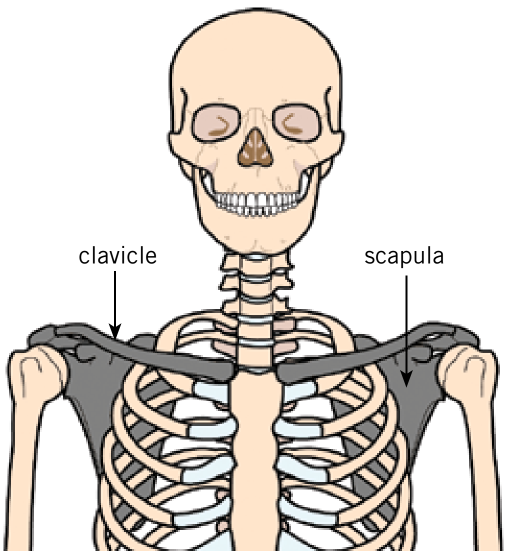
Most people have about as many ribs as they do vertebrae, but some people are born with more. Can you guess why your ribs are so important? I gave it away earlier. Your ribs guard your heart and your lungs (as well as a few other organs). God had to give them a unique "cage-like" design to do this, because your lungs don't stay the same size throughout the day. Put your hand on your rib cage and take a deep breath in and a deep breath out. Did you notice how your rib cage got bigger and smaller with your breathing? That's because in the front, your ribs are attached to your sternum with resilient tissue called **costal** (kos' tul) **cartilage**. This allows your rib cage to expand when you breathe. In the back, your ribs are attached to your thoracic vertebrae.

Look at the diagram of the ribs. Seven of your ribs are **true ribs**, five are **false ribs**, and the bottom two false ribs are called **floating ribs**. Let's find out why. Look at the top seven ribs, and see if there is anything different about them compared to the ribs below. The first seven ribs are true ribs because their costal cartilage attaches directly to the sternum. The next three have costal cartilage that attaches to the sixth and seventh rib. The last two ribs are called floating ribs because they are not attached to the sternum at all. Some people have an extra set of floating ribs, while others don't have any.

A Peck of Peppers

Have you ever heard people refer to the muscles on their chest as "pecs?" That's short for pectoral (pek' tur uhl) muscles, which are connected to the **pectoral girdle**. Your pectoral girdle connects your arms to your sternum (chest). The word "girdle" means "belt." So, the pectoral girdle is like a belt of bones around your chest and back. It includes the **scapulae** (skap' yuh lay), which are your two shoulder blade bones, and your two **clavicles** (klav' ih kuls), which we often call collar bones. Can you feel your clavicles? They are the bones right below your shoulders that lead inward to your throat. Now reach behind your back and feel your shoulder blades. Those are your scapulae.

Stop for a moment and name all the bones you have learned about so far. Name any others we haven't covered yet that you think you can remember.

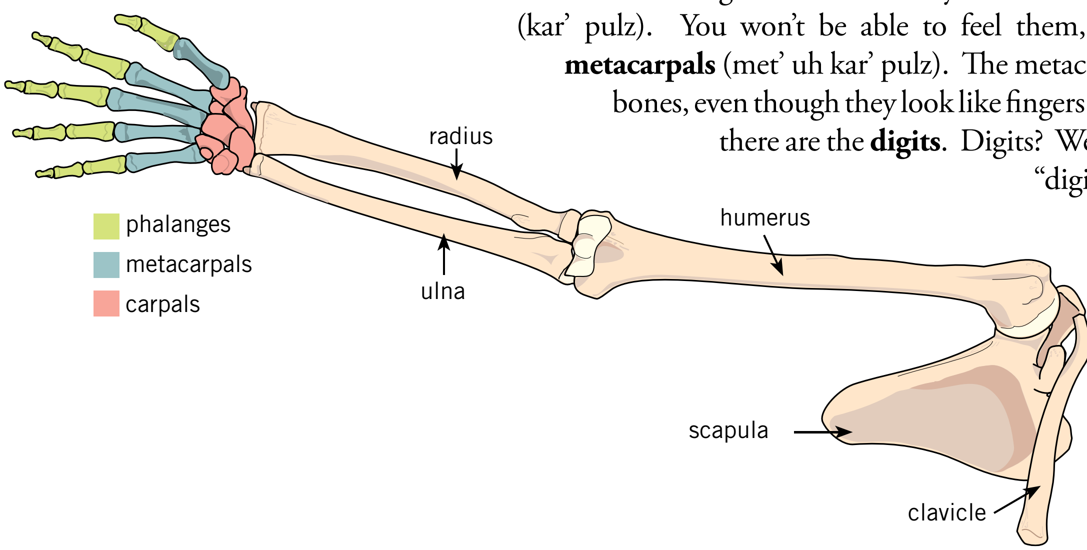


The clavicle and scapula form your pectoral girdle, which attaches your arms to your spine.

Armed and Dangerous

Now, let's study some long bones. Do you remember what classifies a bone as a long bone? It has to be longer than it is wide. The bones in your arms and fingers definitely fall into that category. Let's see if we can locate these bones. Beginning at your scapula, you'll find your first arm bone – the **humerus** (hyoo' mur us). Let's keep going down your arm. Although the upper part of your arm has only one bone, the lower part has two, the **radius** (ray' dee us) and the **ulna** (uhl' nuh). Can you find these two bones? It's easier if you search just above your wrist: your radius can be felt above your thumb, and your ulna can be felt above your pinky finger. Say the names of the bones as you feel them – it will help you remember them.

There are eight short bones in your wrist. They are called **carpals** (kar' pulz). You won't be able to feel them, but you can feel the **metacarpals** (met' uh kar' pulz). The metacarpals are actually hand bones, even though they look like fingers in the drawing. Finally, there are the **digits**. Digits? Well, scientists call fingers "digits." The bones in your digits are called **phalanges** (fuh lan' jeez). Feel your fingers and count the phalanges. You should be able to find three in each digit – except for your thumb, which has only two.



Try This!

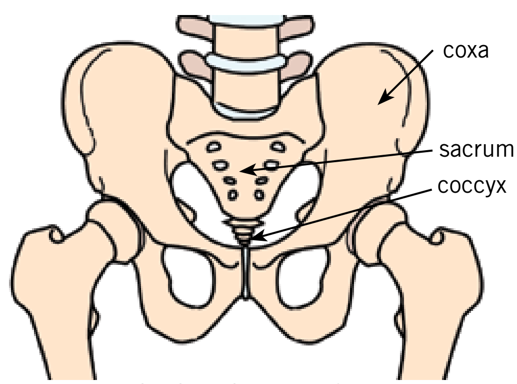
Your arms when spread out are nearly as long as you are tall.

Did you know that you are about as tall as you are wide? That's true when your arms are stretched out at either side. You see, your arms together are about the same length as your entire body is tall. Get a tape measure. Now spread your arms out on either side and measure them from the tip of your middle finger on one hand to the tip of your middle finger on the other hand. Next, measure your height against a wall. The measurements should be nearly the same!

Girdles Around

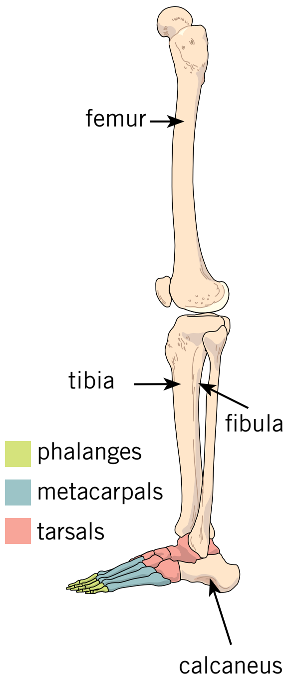
Moving on down the body, we find that there is another girdle just below your waist! It's your **pelvic girdle**. The pelvic girdle is much like the pectoral girdle, but most of the bones are larger and stronger. God designed them this way because they have to bear a lot of weight and support you as you run, jump, and rock climb – or whatever else you enjoy doing. And of course, those all-important legs attach to the pelvic girdle.

The pelvic girdle connects to your vertebral column and



The pelvic girdle is made of two coxae.

contains your hips, sacrum, and tailbone. Do you remember the name for your tailbone? It's your coccyx. Now, put your hands on your hips. Your hips are called your **coxae** (or **coxa** if you're referring to only one of them). When you put your hands on your hips, you put them on the upper part of the coxa on each side.



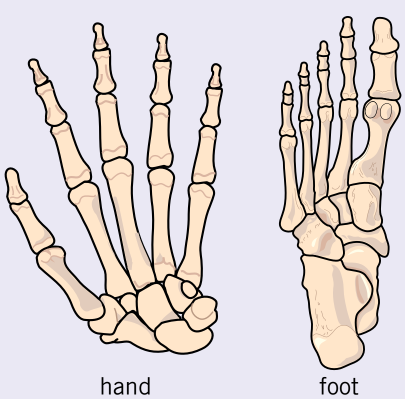
The Last Leg

Like the upper part of the arm, the upper part of the leg has only one bone. It's called the **femur**. Do you remember what is special about the femur? It's the longest bone in your body. Now look at the drawing of the lower part of the leg. It's a bit similar to the lower arm, isn't it? There are two bones there, the **tibia** (tib' ee uh) and the **fibula** (fib' yuh luh).

Learning the bones in your feet is pretty easy. They are a lot like your hand bones. Do you remember that your hands are made of carpals and metacarpals? Well, your foot is made of **tarsals** (tar' sulz) and **metatarsals** (met' uh tar' sulz). You have seven tarsals in your foot, including your **calcaneus** (kal kay' nee us), which is your heel bone. You don't need to learn the other tarsals, but look at the picture to see where they are located. Just like your metacarpals, your metatarsals look like your toes, but they are a part of your foot. Do you remember that your fingers are made of bones called phalanges? Guess what your toe bones are called? They're called phalanges too, just like your finger bones.

Try This!

Using the drawings on the left, count how many bones are in the hand and foot. Now multiply each number by two (since you have two hands and feet). How many bones are there? If you counted correctly, you would have found 27 in the hand and 26 in the foot. All together, that adds up to 106. Do you remember how many bones are in your entire body? There are only 206 once you are an adult. That means more than half of your adult bones are in your feet and hands! I guess God considers these important parts of your body! Think about how much you use your hands each day. You need them to create things, take care of yourself, and do your schoolwork, among other things. What about your feet? They are also important. How would you get from here to there, play sports, or dance without them?



Before moving on, review the bones of the arms, hands, legs, feet, and girdles. Tell someone else what you have learned.

Try This!

Just to get an idea of how important the bones of your hands and feet are, let's make your fingers a little less mobile and see how it feels to do daily activities without them working properly. Use masking tape to fasten your index finger to your middle finger on both hands. Now see how long it takes you to do some of your daily chores. I expect there are some things you can't even accomplish like this. When God designed your fingers, He knew exactly the best way to configure them, didn't He?

Try This! It's hard to remember all the bones we just covered, so we are going to do an exercise that will help you remember them. While looking at the drawing on page 45, touch each part of your body while saying the name of the bone. For example, you will touch the top of your head and say, "cranium." Okay, let's go! Name those bones! Saying the names aloud will help you remember the names of the bones.

Joint Venture

Your bones are wonderfully made, but without joints, you would be a statue – unable to move. Joints are the places where bones meet. Some joints are designed to allow a lot of movement; others allow just a little movement, and still others join the bones together but don't allow any movement at all. Do you remember the joints in your cranium? These suture joints don't move at all. God designed a special fluid to collect in the joints that move. It's called **synovial** (sih noh' vee uhl) **fluid**, and it allows the joints to move more easily.

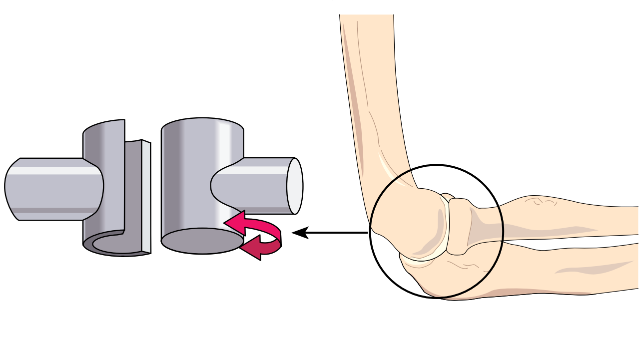
Without joints, you would be as stiff as this mannequin.

Try This! Rub your hands together really hard for one full minute. Do you feel how warm they have become? The rubbing action creates what we call friction, and friction generates a lot of heat. Now apply lotion to your hands and rub them together like you did before.

It's much easier to rub your hands against one another with lotion on them, isn't it? This gives you an idea of how the synovial fluid helps your joints. God knows all about friction, and He doesn't want that to be a problem for our joints. Without synovial fluid, the cartilage on the end of one bone would rub against the cartilage on the end of the other bone. The friction caused by this rubbing would harm the bones, so God made joints with their own friction-reducing fluid. Elderly people sometimes get a disease called **arthritis** (ar thry' tis). In some forms of this disease, the synovial fluid in their joints is thin and weak, making it painful to move them. Eventually, the bones are remodeled, becoming larger to deal with the extra wear and tear. This further increases the pain associated with moving their joints. Synovial fluid is quite important, isn't it?

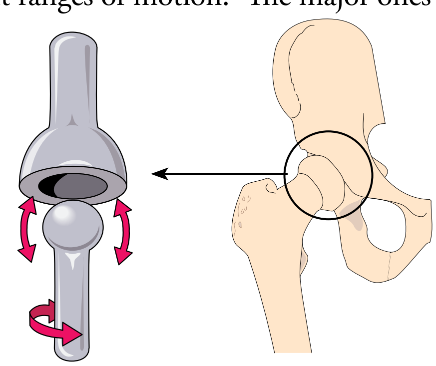
Kinds of Joints

There are different kinds of joints in your body, and they offer different ranges of motion. The major ones are:



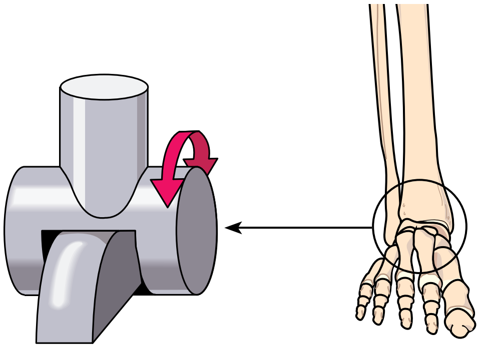
Hinge Joints

Elbows and knees are hinge joints. They offer a limited range of motion but are very stable.

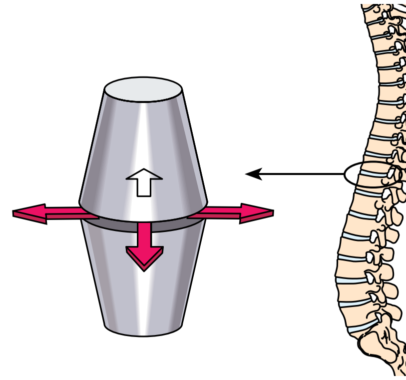


Ball-and-Socket Joints

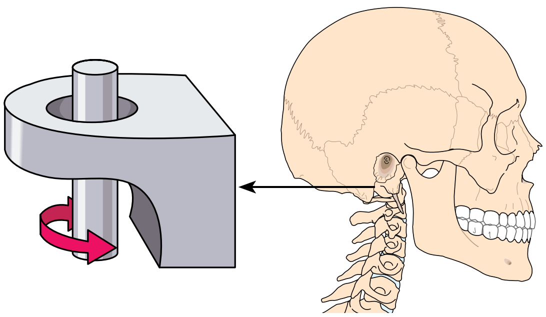
Hips and shoulders have ball-and-socket joints. They offer a wide range of motion but are less stable than hinge joints.



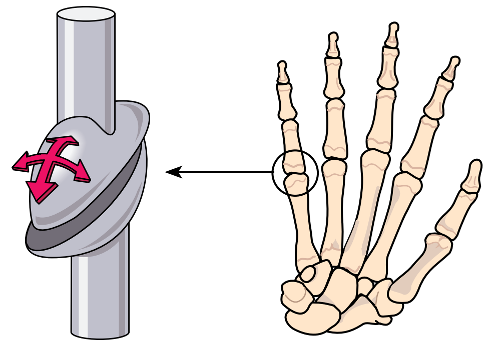
Saddle Joints
The ankle has a saddle joint. The range of motion is less than a ball-and-socket but more than a hinge.



Sliding Joints
Your vertebrae are connected with sliding joints. They allow you to bend and twist your back.



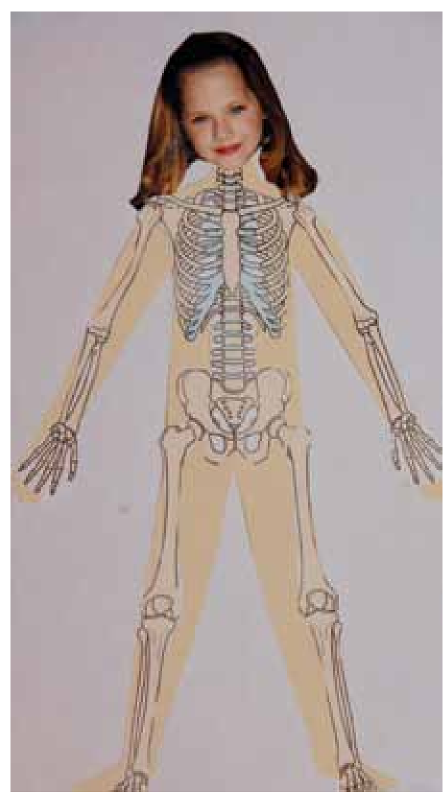
Pivot Joints
When you shake your head "no," you are using the pivot joint that connects your skull to your vertebral column.



Ellipsoidal (ih lip' soyd uhl) Joints
The joints that connect your phalanges to your metacarpals are ellipsoidal joints. They are like flattened ball-and-socket joints.

What Do You Remember?

Name the different things that bones do for your body. What is the periosteum? What mineral makes compact bone strong and hard? What is the bone tissue that forms tunnels and pores called? What are the two kinds of bone marrow? What are osteoblasts? Where are the smallest bones in your body found? Which is the longest bone in your body? What do ligaments do? What is the rounded part of your skull called? Can you name at least five other bones in your body by their scientific names? Can you name at least one kind of joint?



Notebooking Activities

For today's notebook assignment, find a picture of a skeleton that is not labeled and label all the bones you have learned about. Be sure to write down all the interesting facts you learned on another sheet of paper.

Personal Person Project

It's time to add some bones to your Personal Person. You should add an entire skeleton from the neck down. If you do not have the *Anatomy Notebooking Journal*, you can draw the skeleton on a white sheet of paper and glue it onto your person. If you have the *Anatomy Notebooking Journal*, there is a skeleton in the appendix for you to cut out and use.

Experiment
Analyzing a Chicken Bone

To better understand what bones are made of, we want you to experiment on a *chicken* bone. If we are studying the *human* body, why are we going to do an experiment with a chicken bone? Well, chicken bones are similar to our own. They are not exactly like human bones, but they are similar enough that we can learn a few things about our own bones by studying those of a chicken. Also, chicken bones are *a lot easier to find and experiment on!*

You will need:

- A cooked chicken wing
- A pair of rubber or plastic gloves
- White vinegar
- Two plastic containers with lids (just big enough for a chicken wing and some liquid)
- Plastic wrap
- A parent with a knife

1. Put on the gloves.
2. Using your fingers, remove all the meat from the bone. If you can't get it all off with your fingers, ask your parent to use the knife to help you. As you are doing this, see if you can see anything else besides meat. The meat is muscle, but the bones are connected with ligaments, and there is cartilage at the end of the bone. Can you see any cartilage or ligaments? Don't worry if you can't. That's not the main point of the experiment.
3. Look at the bones. Notice that there is one thick, long bone that connects to two thinner long bones. Does that sound familiar? It should – that's what the bones in your arm are like!

4. Cut or break the largest bone (remember, it's called the humerus) in half and look on the inside of the bone. Do you see something red there? What is that red stuff? It is the chicken's red bone marrow. That's where the chicken's blood cells come from.
5. Do you remember what material makes the bone strong? It's calcium. We are going to do an experiment that actually removes calcium from the bone to see what happens to it. Fill one of the containers about half full of vinegar.
6. Fill the other container about half full of water.
7. Pull the two thinner bones of the wing away from each other.

8. Put one of the two bones in the container that has water.
9. Put the other bone in the container that has vinegar.
10. Put plastic wrap over each container.
11. Put the containers aside for a few days.
12. Vinegar is an acid that will remove the calcium salts from the bone. Using a Scientific Speculation Sheet, make a hypothesis about any differences you think you will find between the two bones.
13. After three days, check your chicken bones. What happened? Record your results on your Scientific Speculation Sheet.

As you learned while you were doing the experiment, vinegar is an acid that destroys the calcium salts that make bones hard. After a few days in vinegar, then, the one bone lost a lot of its calcium salts. What did it feel like? It should have felt soft and rubbery. You see, bones are a mixture of a great many things, but as you learned in the lesson, collagen and calcium are two of the important ones. Collagen is flexible, and calcium salts are hard. Together, they make bones very strong, but somewhat flexible. When you get rid of the calcium, the bone is no longer hard, but it is still very flexible. The bone in the water might have been a bit cleaner than when you put it in there, but that's about it. It should have felt the same as when you handled it three days ago.

Your bones are strong and flexible because they are made from a mixture of strong calcium salts and flexible collagen.