The Skeletal System

Speaker: Suzanne Keller

Alright today we're going to talk about the skeletal system. So let's begin by talking about what the skeletal system is. It's the internal frame of the body, and includes not only bones, but also cartilages and joints. So it functions by providing structure, and it also allows for body movement at the joints. So muscles as we talk about those in the next chapter, will typically cross a joint to help move at a joint. But for right now we're just providing the structural components with joints that allow for movement. And really the skeletal system is essential for protecting structures. So the rib cage, for example, protects organs, the spine protects the spinal cord, the head, the cranial vault, protects the brain. And so on. Also bones produce blood. So the marrow in some bones produces blood cells. Bones by definition, they have matrix because they're connective tissue. They store nutrients like minerals and salts. So there's a lot going on in the skeletal system.

Now as usual we have a list of learning outcomes. These learning outcomes will apply to all of the video lectures comprising the chapter on the skeletal system.

So let's begin by talking about the parts of the skeletal system. So we have the bones or the skeleton, containing joints. There are also cartilages in that system. So cartilages are going to either line the ends of bones or help connect areas of bone. For example, in the nose, right, the tip of your nose is made of cartilage, whereas further up, like where your glasses would sit, is made of bone. There are cartilages at your ribs that help hold your ribs to your sternum in the front, but allow a little bit of flexibility. There are cartilage pads between your vertebrae to help absorb shock. So we're going to talk about those three kinds of cartilages and where they occur.

And then we also have ligaments, now notice we're not mentioning tendons. We'll talk about tendons in the muscle section, because tendons connect muscle to bone but ligaments connect bone to bone. And so there will be places where we'll talk about ligaments. We will also divide the skeletal system, as we discuss the bones themselves, into two parts. So we have an axial skeleton and appendicular skeleton and we'll define those a little bit later.

So the functions of bones, or you can think of this as the functions of the skeletal system itself. So we're supporting the body, that one is obvious. We are protecting soft organs. That's also obvious if you look at the skull or the rib cage. Now movement, I want you to be very careful how you say this. Bones do not cause movement, that will be counted wrong. Muscles **cause** movement. Bones **allow** for movement and if you want to be very clear so you don't get this confused, bones allow for movement *at joints*. Bones can store minerals and fats and some bones are involved in forming blood cells.

Now in the human body, there are 206 bones, and before anyone freaks out you're not going to have to learn all the individual names of all 206. But we are going to talk about many of them and I'll explain why it's not really 206 that you have to learn, so that may seem daunting at this moment but it won't be. For now we're going to talk about the two types of bone tissue. So we have compact bone and spongy bone. Now in this figure, compact bone is what its name implies, it's compact. It's dense, there's not a lot of spaces. Whereas spongy bone looks like a sponge, it’s light and airy. So compact bone is homogeneous meaning it looks like it's all one thing. Homogeneous. It's dense, it's very smooth. Spongy bone has needle like pieces called trabeculae. So each one of these you can think of them like struts. Those are trabeculae. And lots of open space.

Now bones can be classified based on shape. First of all, bones based on shape are not going to be complicated. So probably all of you can look over this figure, hear how I'm going to describe things and you're done with this part, right. So looking at the shape if you could hold a three dimensional humerus, you would see that it's a long bone. It's like a short club actually. Irregular bones, right. This part is round but this part sticks out all over the place. So a vertebra is irregular. The hip bone, right, this is irregular in shape, doesn’t really fit any of these other categories. Short bones, right, at the ankles and the wrists, and there are few bones that while they could be called short are more likely to be called irregular in the skull. And then we have flat bones. So like your sternum, right, and you're not holding it, so it's hard to tell, but it's not very wide on the edges. So these categories are going to be relatively obvious. So if you're wiffle-waffling between, OK, is this bone a short bone or is it irregular? If it's not much taller than it is wide, it's a short bone, if it has pieces that are sticking out in weird places, it’s an irregular bone. So don't over think that.

Now, talking about the gross anatomy of a long bone. So we're going to talk about the parts of a long bone because many of your bones are long bones, and then we’ll talk briefly about other bones in a moment. So on this figure, this is a lovely figure to walk you through these parts and get you acquainted with the terminology. So a diaphysis, the diaphysis is the shaft. Notice it goes from right at the end where it starts to widen, right, starts to widen. So, diaphyhsis, the shaft is this entire length. So if you were grabbing this bone you would hold it on the diaphysis. It's longer than it is wide. It's composed of compact bone. So notice it's dense, not holey. This is spongy bone, this is compact bone, and there's a medullary cavity. So there is an open space in the center.

The epiphysis, which is singular, epiphyses is plural, those are the ends of the bone. So those are enlarged. So where it widens on each end, and it's composed mostly of spongey bone. Notice, it doesn't say entirely, but mostly. So because these are wider to have all compact bone in this area would make them extremely heavy. So having a bit of spongy bone helps lighten them up. But doesn't detract from the strength. So examples of long bones, the humerus, the ulna, the femur, the radius, the tibia, the fibula, your ribs. (Correction: ribs are flat bones.)

Now as we talk about the parts of a long bone we need to talk about the layers. So on the very outer most layer of a bone we have periosteum. And that's going to be the covering on the outside of the diaphysis for a long bone. It would just be on the outside for a flat bone, for example. It’s made of a fibrous connective tissue. So notice this periosteum layer is held on by Sharpey’s fibers. So these fibers represent the glue that holds the periosteum to the actual bone tissue surface. Those are also called Sharpey’s fibers or perforating fibers, so that secures it. There are also arteries that go through the periosteum and right into the bone, so bone is very vascular tissue. And that's what supplies the bone with its nutrients. Now in this figure we are representing yellow marrow. So this would be fat storage.

Some bones will have red marrow, which is involved in blood cell production. And finally, we have the articular cartilage. So on the surface of each epiphysis, we have a layer of hyaline cartilage, and do be sure that it's hyaline cartilage, which will create a glassy marble-like surface on the surface of the bone which allows for smooth, fluid motion at the joints. So that's smooth fluid motion, the whole point here is to decrease friction because where there is friction, there could be pain and inflammation and tissue damage.

Along the diaphysis, I mentioned the medullary cavity earlier. So it's a cavity that opens and is containing some version of marrow, either yellow marrow or red marrow. So in children up to age 7, most of their long bones contain red marrow. As they grow, only certain bones contain red marrow. So in an adult, it's mostly the heads of the long bones. Like the head of the humerus, the head of the femur, and the pelvic bones that contain red marrow, and most of the other bones containing yellow marrow in an adult. There's also endosteum. So remember “endo” refers to inside. The endosteum is just like the periosteum, but periosteum is around the bone and endosteum is inside the medullary cavity.

Now bone markings are structures that are surface features and these surface features typically have different functions depending on whether there are holes or crevices or projections. And typically they'll be either sites of attachment for muscles, tendons, and or ligaments, or a place for a nerve or blood vessels to poke through an area. So the categories of bone markings are something that I'd like you to learn. So consider each of these a vocabulary word. So you will not be asked, “Tell me the bone markings on the femur” those specific bone markings are not something you have to spend your time on, but you will be asked “What is a projection? What is a process? What is a trochanter? What is a fissure, etc.?” So just a guideline in this is not true every single time, but for the most part it is, so it can help. Projections and processes, so things that grow out from the bone surface, think of them as lumps and bumps, often begin with the letter ‘t’. Trochanter, tubercle, etc. Depressions or cavities, so indentations in the bone, dips, often begin with ‘f’. Fissure or foramen. Now before I continue, there is a table in the chapter in your book that talks over the types of bone markings. So I would recommend you refer to that and just email your instructor if you have further questions.

Now moving on to the microscopic anatomy a spongy bone. So we spent a lot of time talking about the gross anatomy of a long bone. Now we're going to talk about the microscopic anatomy of spongy bone. So in particular we're in this airy, lots of open spaces bone, not the very dense smooth compact bone. OK, so just for right this minute. Now trabecula, or trabeculae if plural, are these needle-like bone struts. These bone struts are actually produced so that they help support, like little pillars, in the directions of stress. So much like an airplane wing is not solid, it has a frame, spongy bone has a frame, but is not solid. So the open spaces are filled with blood vessels and nerves passing through and then this would also be filled in with marrow. So if you can imagine yellow marrow filling the places between these trabeculae, that would be a normal area of spongy bone in an adult.

Now if we zoom in on the microscopic anatomy of compact bone. There are few more parts to talk about. So an osteon, this is the term that I will use, you might ask your instructor if they use Haversian system more often. These are both names for the same thing. So I think it's in everyone's best interest to at least recognize both terms. An osteon is the structural and functional unit of compact bone. So you could add “and functional” here if you wanted to do. So an osteon is sort of like, if you had legos, one lego that's building compact bone would be one osteon. Now in an osteon there are different canals. So these are passageways for blood vessels and nerves. There is one called the central or Haversian canal, which is open at the center of an osteon, along its length.

So let me just go forward here. So if this is the length of an osteon, the central canal would be this large hole that goes down through the middle. So a central canal here, a perforating canal here, which is perpendicular. So those perforating, or Volkman’s, canals are perpendicular to the central canal and carry blood vessels and nerves out into further layers of that osteon. So these are layers of bone matrix. Just like in this one, you can see the central canal, right? There is nutrition or blood vessels and nerves carried out further to other layers.

There are also structures called lacunae, singular would be lacuna, and lamellae or one lamella. So lacunae are cavities that have osteocytes. So see where these little cells are located, you can see the nucleus, right at the top of my cursor. This is an osteocyte, which is a bone cell that is tasked with taking care of the matrix right round it, and it lives in this little pocket called a lacuna. Those lacunae are arranged in concentric rings. And in between them are layers of bone matrix called lamellae.

Between the lacuna, these little tiny canals represented by these lines are called canaliculi, for plural, or one canaliculus, meaning a really tiny canal. So that is another way that even smaller blood vessels and nerves can get through to communicate with these cells.

Now taking you back to this figure. So we've talked about one osteon contains a central canal, lamellae, in between those lamellae would be lacunae with osteocytes. We have that Haversian canal or central canal, we have Volkmann’s or perforating canals, and then we zoomed in to look at some of the layers or rings. Much like a tree has rings, osteons have rings of lamellae, which are made of bone matrix. And then those tiny canals, so the canaliculi.

Now, as a human grows and develops, there are many changes that happen in the skeletal system. So in an embryo, the skeleton is primarily made of hyaline cartilage, and that will continue during much of development until this cartilage begins to be replaced by bone, in a process called ossification. So cartilage will remain in some areas, however, so the bridge of the nose we talked about or more the tip of the nose, parts of your ribs, the joints. So we're going to have hyaline cartilage throughout the skeleton but by birth, most of the hyaline cartilage that was making up the skeleton itself has been replaced by bone.

Now, bone growth happens in a special way. So there are structures called epiphyseal plates, which allow for growth of long bones throughout childhood. And an epiphyseal plate is a combination of bone and cartilage. So new cartilage is formed on one side and older cartilage is converted to bone on the other side. So we're extending the diaphysis but we're keeping the epiphysis the same. So let's take a look at that. So bones are remodeled and lengthened until growth stops, right? So let's look at this left hand side of this figure, just bone growth. So we're growing in length. So on these cartilages both the articular cartilage and the epiphyseal plate, which you can see is represented by some cartilage here. So we're going to add new cartilage on the epiphysis side, and then on the diaphysis side we're going to chew away the old cartilage and we're going to replace it with bone. So we're basically moving this epiphyseal plate toward the end. We're also extending the end by adding to the articular cartilage on the outside, and then replacing just the inner lining of articular cartilage with bone. So we've essentially, moved everything up toward the end, and just extended this diaphysis by a little bit of bone. OK, but this epiphysis is maintained.

Now as bones grow in length they also have to grow in width, which is called appositional growth. So as we grow in width, right, we're actually going to change shape a little bit. And this happens during bone remodeling, which can grow in width as well. So what we'll be doing is taking bone and chewing it away here and then adding it here, so that the diaphysis wall is a little bit thicker. And then we'll chew out a little bit to make that medullary cavity a little bit wider. So we're essentially adding structure in a place where it will prevent this bone from snapping in half at a weak spot. So each time we talk about adding bone or taking bone away, right. There are some new terms in here, so let's go through those. We have the epiphyseal plate, which is composed of hyaline cartilage and we're not dealing with that epiphyseal plate at this moment. Instead what we're talking about is the bone over here on the side. So basically we're going to reshape the edges. (Brief confusion, the transcript will pick up again.) So resorbing means we're absorbing bone matrix by osteoclasts, which chew away bone matrix at this dotted line. So we're taking this away. And then essentially this represents where the bone used to be, right, so basically we're thickening it as it gets longer, so that it's stronger. Just like the trunk of a tree gets wider as it grows taller.

So now we're going to add bone which is that appositional growth or growth in width, using osteoblasts, which build bone matrix. So this is new bone matrix going down here, and then we have this extra thick diaphysis wall. So we are going to chew away a little bit just to make that cavity wider and again, chewing away is done by osteoclasts.

Now here's a slide to summarize those bone cell types. So we talked about osteocytes, which are mature bone cells, they live in lacuna. Osteoblasts are builders or bone forming cells meaning they make bone matrix remember, this is a connective tissue. So they form the extracellular matrix. Osteoclasts chew away bone matrix. So they breakdown bone matrix for remodeling or to release calcium, which is one of the minerals stored in bone. And this is a process that happens your entire life. So even as adults, our bones are being remodeled regularly, so we have both osteoblasts and osteoclasts that are chewing a little away here and building a little here. And that's a normal process in bone throughout life.

Now bone fractures are breaks in a bone. So there are different types of bone fractures. Again, there's a figure in your book that talks about these, so you'll have to refer to your instructor to know at what level you should know them. For my classes, I simply want students to understand the difference and basically a definition of what the types of bone fractures are.

So closed or simple fracture is a break that just breaks, it doesn't penetrate the skin. This does not mean there won't be some tissue damage around the bone because they're likely will be, but it's different from an open, or compound, fracture in that there's an open wound as a bone penetrates the skin here and pokes out.

So bone fractures are treated by the processes of reduction and immobilization. So reduction, we're going to realign the bone ends. So, for example, with a break in a leg bone, whether it's simple or compound, a doctor would pull on it in a particular way which sounds rather painful and violent and it can hurt, but we have to realign those bone ends so that they can repair themselves. And we have to immobilize that bone with the cast, so that those ends stay in position while the bone heals. So reduction and immobilization.

And here's the figure or table showing some common fracture types. So again, for my classes, I would ask you to learn these words as vocabulary, and understand a brief explanation of what that might mean. Now be aware that this figure is not my favorite. Some of these represent multiple fragments whereas some represent crushing, bone crushing, right? This is not necessarily clear, so imagine so many tiny pieces that couldn't be assembled again, whereas the depressed fracture is where, for example, if a hammer hit a head and pushed a chunk of bone into the brain, that would be a depressed fracture. Impacted, right, so this particular part of the image is meant to represent impacted. So if someone tried to catch themselves from falling by putting their arm out, they could impact the shoulder joint. Or more likely, they would impact the clavicle and break it where the ends are forced into one another, to overlap. Spiral, these arrows are representing twisting. And greenstick are incomplete breaks.
