>> Deb Feickert: Okay, everyone. So, our topic today, the cell. We– most of us have been talking already, a step ahead, about tissues. But that's okay. We can do this. We don't mind looking at things a little bit out of order. And this actually on the cell, this discussion on the cell, should be review for everyone because you talked or should have talked in great detail in general biology or human biology or the combined anatomy and physiology class that is a prerequisite to anatomy, about the cell. So we're going to move through pretty quickly actually. And just treat this as a review. So, here we go. Let's start with the idea of again, a definition. And here is the definition of cells. And the underlying words, as always, are important. As always, hopefully you've had a highlighter nearby so that in your notes or on the lecture outline, you can be highlighting some things if I emphasize them. And so what we're defining, cells, they are structural and functional units in all living organisms. That is, we've talked about structure and function a lot already, so structural means it is/are the cells of a living organism, and we're talking about human organism, it is the cells that give the form, the shape, the size, of the organism. And it is the cells that provide the function of everything that keeps a living organism alive. So, everything that happens to allow life for us as a multi-cellular organism takes place inside of our cells. So, that definition, structural and functional unit, is the form, function, the form and shape and size, along what is everything about us that keeps us alive? All of that happens inside of our cells. We sometimes call them, because of that, the building blocks of the human body. That's specifically having to do with this structural component. That we build cells and join cells together to build this– this structure called the human body. So in our adult bodies, we have about 75 trillion cells. And about half of those are human cells. And about half of those are bacterial cells. So if we're talking about just the cells that give us our structure, those are certainly about the 37, somewhere, it's usually somewhere discussed as between 30 and 37 trillion actual human cells that give us our structure. Functionally, certainly, we– those 37 or so trillion bacterial cells do have functions within our body. And we often think of bacteria as being pathogens and negative. But in our body, most of the bacteria actually have roles to play and are important for our wellbeing. Each cell in the body performs a very specific function. We're going to talk about that in a bit. And so here is what we want to say about each cell within our body. The shape of the cell, and we're going to look at some examples. We've already looked at– some of us have already looked at some examples in lab. But the actual shape of a cell and its anatomical characteristics, and what that primarily means is what type of organelles, any specialized organelles, the number of organelles that we find in each particular cell, determines the function of that cell. So both its shape, its form and organelles. So we're going to use an example to start today. And then we're going to finish with this same example. So we're going to talk about sperm cell versus ciliated epithelial cells. And certainly the shapes are completely different. And their jobs are completely different. But they're both human body cells. And so– or I should say human cells. And so, what we're going to see is this idea of the shape of a cell and along with the characteristics, the organelles that we find that are within and along the cell,

actually bring about the specialized function of the cells. We'll come back to this idea at the end as our example. We talked about the [inaudible], when we're studying anything, the suffix is -ology, and the study of cells is cytology. So when we look–

[Inaudible]

Thank you. Thank you. So, when we are looking at an animal cell, which is the [inaudible] that we are– okay. I'm just going to wait one second. Um, I could not see the screen now, [inaudible] muted. Please mute. Hold on everyone. Thank you. Okay. Back to what I was– we were talking about with the cell. And I'm sorry but this is amazing. I want you to just realize how amazing this is. Human body cells are anywhere in the range of one to 100 micrometers in diameter. And a micrometer is one one-thousandth of a millimeter. And I want you to think about the size of a millimeter, it's about, look at your finger, it's about the width of a finger nail. that is a micrometer. Or excuse me, a millimeter. A micrometer is one one-thousandth of that diameter. That's how teeny-tiny our cells are. And so everything that we're going to talk about, all of the organelles that we're going to discuss, are within that teeny tiny space of one to 100 micrometers. It's incredible. The cell. And the jobs that it does. So please keep that in mind as we move through our discussion today. It's incredible! So, here's some common characteristics of cells. All cells perform general functions that are necessary to sustain life. And so what can we say? General. There's that word, general. All cells are going to separate something called a cytoplasm we're going to discuss in a moment from the fluids that surround the cell. Alright? So a separation of the external environment and the internal environment of the cell. All cells exchange materials. So they are going to bring in nutrients, reduce waste, bring in water, bring in oxygen, and release CO2. So all cells have this capability to exchange materials. All, most all, I'm going to say almost all here, we'll talk about in a section that some of you already know about. But almost all of our cells house and protect our genetic material, DNA. Absolutely essential. And all cells coordinate and regulate activities of life. And so what does that mean? If we remember the characteristics of the cell that get– make a cell what we call alive, some of those characteristics are, right, metabolism. All cells undergo metabolism. All cells undergo homeostasis. Cells grow and repair. They synthesize molecules and cell parts. So they repair internal organelles. So those are just kind of general all cell activities. But on top of all of that, they also have their specialized function. So they do these regular everyday activities, but then they also have their specialized functions to keep us alive. Crazy, amazing, and important. So when we're looking at cells in the human body, we have one of two types. There are two categories of cells in the human body. Large-scale categories. A cell is either a sex cell, also called a germ cell or a reproductive cell, and in our body those are called sperm in males and ova or eggs in the female. All other cells, if it's not a sperm or an egg, is a somatic cell. And the word somatic means body, or soma, means body. So, somatic cells are all of the other cells in the body. So we either have sperm/egg or we have somatic cells. And all of the cells that we're talking about in histology of course would be somatic cells. So let's start in our discussion of the cell by talking about its outside covering, the cell or plasma membrane. We can use those two terms interchangeably. We can either say cell membrane or plasma membrane, they mean the same thing. So we're going to give it some descriptors. We know that a cell membrane is a semipermeable phospholipid bilayer with embedded proteins. We can say that the cell membrane is soft and flexible and gel-like. So now, as we're talking about things like composition, and we said that ways that we could describe composition or the structure of any particular item we're talking about, we said that we could talk about things like its form, it's shape, or physical characteristics, or we could talk about chemical characteristics. So as I'm looking at all of these words that describe the cell membrane, I should be able to pick out which things are chemicals and which things are physical descriptions. And so as I'm looking at this, my two words that are chemical in nature, jot it down to the sides, see if you've got it. Would be phospholipid and proteins. And then anything that would be describing the form or the physical characteristics of the cell membrane would be semipermeable, bilayer, embedded, soft, flexible, gel-like. So those kind of– the difference in knowing what a chemical component would be versus what a physical characteristic would be, this is a good place the see that. So we've seen this before, this should be reviewed. This phospholipid bilayer with embedded proteins. This is the inside of the cell, this is the outside of the cell. The importance of course of a phospholipid bilayer with embedded proteins is that that's what brings out this semipermeable nature. And so, we're going to look at some of these structures as we go and describe what their specific functions are. So with the cell plasma membrane, four major functions of just the cell membrane, this is how good the cell membrane is. So, it creates a physical barrier. And physical barrier to what? That means that it keeps the cytoplasm inside and separates it from the stuff outside. And remember what that word is, extracellular. So our cells are surrounded by fluid and that fluid that's outside of the cell is extracellular, or remember the alternate choice there is intercellular. So the cell membrane keeps the cytoplasm in and the extracellular material out. The cell membrane is the structure that regulates exchange with the environment. And so again, things like the transport of molecules into and out. So we're talking about nutrients, waste products, those are the types of material– gases. Those are the types of materials that may go in and out of the cell as necessary. And that happens at the cell membrane. The cell membrane controls that. The cell membrane has a sensitivity and communication ability where it– and this is partly some of those embedded proteins have this sensitivity communication ability. So the receptors in the cell membrane made of protein can respond to molecules that come into contact with them, so something, let's say, like a hormone. As a hormone is circulating through the extracellular material, if a hormone comes in contact with a signal molecule on a particular cell, that that cell would react to that hormone, that is how that signal is indicated. But the other thing that those protein– embedded proteins do is they communicate with other cells of the same type. So, that, cells of the same type, how do they know? How does a cell know to make a tissue with another cell just like it? Because it has protein communicators in the cell membrane that recognize each other. And that's how tissues are built. And as a structural support. So the cell membrane gives structural support so that the cell can maintain its shape and the organelles are always properly placed. We sometimes think that organelles are fleeting freely in the cytoplasm, and there are a few that do that, but most organelles have a specific placement within the cell. So let's talk about the cytoplasm. General term for anything that's inside the cell. Two primary components. The cytosol is the, okay, first time I've used this prefix. Intra-, inside. So we said extra means outside, inter means in between, intra means inside. So the fluid inside the cell is the intracellular fluid. We're going to use this prefix all semester, please do not confuse intra that we're seeing here with inter that we've talked about already. They are not the same thing, in fact they are the opposite thing. So if you mean intra, you need to say intra. Intracellular. And if you say inter instead, that's wrong. So, the cytosol, very thick solution. Again, it's a fluid. Lots of fluid, lots of fluid are primarily made of water in human beings. And so this is a thick solution of primarily water. But then all of these organic molecules, right? Proteins, fats, and carbohydrates are three of four of our organic molecules, and some inorganic salts. The other component of the cytoplasm are the organelles. And so organelles are permanent structures that are embedded within the cytosol and every single organelle has its own function and its own shape and form. Its own structure. So let's talk next about organelles. And let's start with the nucleus, usually start with the nucleus when you talk about organelles. And here's– okay. Here we go. How would I describe the structure? The structure of the nucleus is a porous sphere. So when you describe the structure of something, its form, its shape, when you say the words that describe it, it should like put a picture in your mind. You should be able to picture it. And so you should be able to picture what porous sphere looks like. And of course, the word porous has to do with pores. Right? Teeny tiny holes. So it's a sphere with a bunch of teeny tiny holes. And here are the jobs of the nucleus. It holds our genetic material. Which is called chromatin. So chromatin, usually when we talk about chromosomes, we just think about DNA. But our genetic material's actually called chromatin, the chemical that makes up our genetic material is called chromatin. Which is DNA plus proteins. So a lot of times, and I do this myself, a lot of times when we talk about genetic material, we might just say DNA. And that's okay, because everybody knows what we're talking about when we say that. But our genetic material's actually DNA plus proteins. And this molecule is called chromatin. Chromatin then forms a structure called a chromosome. So, the genetic material's called chromatin, and chromatin forms what are called chromosomes. Which are condensed, coiled versions of the chromatin that we see during mitosis. What else is happening at the nucleus? It controls the activities of the cell and its organelles. So remember, we have all of the general activities of the cell, metabolism and homeostasis, and growth and repair, et cetera, et cetera. But we also have the specialized functions of that cell. An example would be, let's just talk, we've been talking about the heart a lot, it's a good example. Because we can picture it and know what we mean. So the cells, not all, but most of the cells of the heart are cardiac muscle. And so cardiac muscle cells do all the things that all cells do, metabolism and homeostasis and exchange of materials, but they also have this specialized function, which is contraction. Shortening, causing movement. The pumping of blood. So that's what we mean when we say that all cells have the general functions of cells, plus their own specific function. The nucleus controls all of the activities of any particular type of cell. And lastly, the nucleus contains a specialized structure called a nucleolus. Where we're going to find groupings of a material called RNA. Which stands for, you know this, ribonucleic acid. And these masses of RNA are going to make ribosomes. And ribosomes are another organelle that we'll discuss in just a bit. So, three important functions of the nucleus. So as we look at some of these diagrams that we're going to see from the book, we will see the– here's the nucleus, here are the pores, so that's the porous sphere, here's the nucleolus within it. And here's a microbe photograph of the nucleus and nucleolus. You've seen this before, I just wanted to show it to you again. Love chromatin, this is what we're talking about. The DNA shown is this blue thread, and the proteins that help to make the chromatin, called histones. So DNA plus protein equals chromatid. Our next organelle is called endoplasmic reticulum. For the sake of ease of taking your notes, we're going to give it an abbreviation, ER. But let me say this for the first time, I'll remind you of this before your first exam as well. Please do not use abbreviations on a test. You are graded on spelling and so, please write things out. Now I may tell you that there's some abbreviations that are okay to use, I'll always let you know if there are certain ones that it's okay to use. If I don't tell you, though, you need to write things out. So endoplasmic reticulum. Alright, here we go. This is telling me two things. It's giving me the structure and the location. So endoplasmic reticulum are wavy channels, right? You should be picturing something, that's the structure. And its location is it connects the nucleus to the cell membrane. So that's where we're going to find endoplasmic reticulum. There are two types. Smooth endoplasmic reticulum is smooth because it has no, there they are in these little organelles we'll discuss in a bit, ribosomes. If there are no ribosomes attached, it looks smooth under the microscope. The main job of smooth endoplasmic reticulum is to make and move fats and carbohydrates. So it's synthesis and transport. Our other endoplasmic reticulum then is rough endoplasmic reticulum and it's called that because it looks rough. Under the microscope. Because it does have ribosomes attached. And main job here is to make and move, and the underlined word is important here, temporarily stores proteins. So we mentioned this a moment ago. Fats, carbohydrates, proteins, are three of the four of what we call organic molecules. So just remembering that the organic molecules are the molecules of life. They are large-scale molecules, fats carbohydrates, proteins, how do we get them into our body? In the food we eat. Right? And so we take the food in that we eat and it gets broken up, broken up, broken up smaller, smaller, smaller. And it's absorbed into our digestive tract. And our cells use the components that make up these particular organic molecules. So, fats, carbohydrates, proteins. Why would rough endoplasmic reticulum make, move, and temporarily store proteins? Because we're going to find in just a few minutes is that ribosomes that are attached, ribosome's job is to produce proteins. The other thing that can happen off of a rough endoplasmic reticulum, remember what these are, wavy channels that connect the nucleus to the cell membrane. We may get a secondary organelle forming called a perioxisome. So, let's look at the endoplasmic reticulum first and we'll talk about peroxisomes. So here's my nucleus. And then here are these wavy channels. Rough with ribosomes attached, smooth, no ribosomes attached. We can see all of these ribosomes that we're noticing along the endoplasmic reticulum, but here's the other thing to note. It's not just on the endoplasmic reticulum where we'll find ribosomes. All of these in cytoplasm are all ribosomes. And again, ribosomes, we'll get to in a second, ribosomes make proteins. We need proteins for everything. Almost everything about us, in terms of our form and function, takes place because of the presence of proteins. So we'll come back to that in just a second when we talk about the ribosomes. So peroxisomes, what is it, what does it do, where is it coming from? So how would we describe it? Remember, we are looking at these descriptors. And we're going to call it a small, round sac. And any small, round sac in the cytoplasm of the cell is called the vesicle. So it's a very specific type of vesicle with a specific name, perioxisome. And where's it coming from? It's coming off of that rough endoplasmic reticulum. So, what's the job of a perioxisome? It contains enzymes that detoxify harmful substances. So a couple of things we need to make side notes here. Enzymes, enzymes, enzymes. Enzymes are what we call biological catalysts. And you know what a catalyst is, a catalyst is a chemical that speeds up a reaction, a chemical reaction. So enzymes speed up chemical reactions inside of living systems. Meaning that without the enzymes, the reaction would occur, but it probably wouldn't occur at a fast enough rate to keep us alive. So, everything that happens inside of our cells to keep us alive happens in the presence of enzymes. And now going back to the statement I just made about proteins, all enzymes are proteins. So, every chemical reaction that keeps us alive takes place because of an enzyme and all enzymes are proteins. Detoxify means to make not harmful. Okay? So it makes not harmful harmful substances, a perioxisome. The enzymes in a perioxisome. So, what is an example of this? Hydrogen peroxide. Okay, I'm just going to do it quickly. But I love peroxisomes and the enzymes that they contain. You know what hydrogen peroxide is, it's in the brown bottle underneath the sink in your bathroom. When you pour it on a cut, it bubbles. Here's why it bubbles. In your body, when your cells undergo metabolism, one of the products, byproducts that is formed, is hydrogen peroxide. Inside your cells. That's a problem because hydrogen peroxide is actually toxic to our body cells. What the heck? So we have to have this enzyme that will negate and make less harmful the hydrogen peroxide that is being formed in our cell. And the enzyme that does that in all of our cells is called catalase. So, when you cut yourself, what happens? You have broken open cells. The catalase is released. When you pour hydrogen peroxide into that cut, the catalase forms a chemical reaction with the hydrogen peroxide, and the hydrogen peroxide becomes water and oxygen, which are the little bubbles. And that's what happens inside your cell, too, that takes the harmful hydrogen peroxide and turns it into water, not bad for your cell, and oxygen, not bad for your cell. Fabulous! Love it. This is what a perioxisome looks like, right? Small, round sac called a vesicle. Golgi apparatus, also called Golgi bodies, and that is absolutely correct. Anything that you would say with the word Golgi, the description is flattened, stacked sacs, we'll look at them in a second. The old-timey way to describe that is if you had a bunch of paper bags and they were lying flat and you looked into the open end, that's what Golgi apparatus or Golgi bodies look like. And their job is to make change, put into a nice package, and move secretions. And again, particularly organic molecules, proteins, fats, and carbohydrates. And they can also form secondary, just like the rough endoplasmic reticulum can form secondary organelles, so can the Golgi apparatus. You might get secretory vesicles or transport vesicles. Or a particular vesicle called a lysozome. So secretory vesicle means this is going to be a vesicle that would attach to the cell membrane and release whatever the secretion is outside the cell. A transport vesicle would take the whatever's being made and utilize it inside the cell. And a lysozome is a specific type of vesicle, shown right here, my flattened, stack sacs. Golgi apparatus inside making, modifying, transporting organic molecules. But a lysosome in particular, a small, round sac, a vesicle that contains digestive enzymes. And so what's it going to digest? The enzymes inside of the lysosome are going to digest bacteria that enter the cell, render it less harmful, not harmful, and/or fuse with and recycle damaged organelles. So, it's going to digest the damaged organelle and then recycle the component parts to make new organelles. So lysosomes or secretory vesicle or transport vesicles come off of the Golgi apparatus. Lysosome. Ah! Another vesicle. The mitochondria, in terms of structure, we'd say are rod shaped. And their job is to produce large amounts of metabolic energy, which is called ATP. ATP stands for adenosine triphosphate. So metabolic energy means energy that is being used inside of living systems, metabolism. Inside the cell. This is review from biology, I'm just going to give you very simplistic, very simplistic equation for what we call aerobic cellular respiration. Where we take the food we eat, which becomes glucose, we add some oxygen from the air we breathe, and the presence again, enzymes, in a process of 36 separate steps, we would then get from glucose metabolic energy that could be used inside of our cell called ATP. We're going to get the release of heat, also an energy source, and then we're going to get some CO2 as a waste product and some water. And of course, we breathe the oxygen in and we breathe the CO2 out. The number of mitochondria, and this is true of all of our organelles, by the way, but let's just say here that the number of mitochondria that we have in any particular cell is going to depend on what are the energy needs of that cell? How much energy does that particular type of cell need? So certain cell types are going to have a whole bunch of mitochondria and others are going to have far fewer. And so, what are we talking about with that? And this is what we're looking at with the structure of mitochondria. So what does that mean? If I have a cell, group of cells, that need a constant supply of energy, that is something that never stops working. You can think of that, let's talk about it one more, well not one more time, we'll talk about it again. Your heart. Never stops working. Your lungs. Never stop working. There are certain tissues in your body that require an ongoing, constant supply of energy. They are going to have– those cells are going to have more mitochondria. Cells that don't require as much energy, aren't working all the time, not very many mitochondria. So, sadly, one of the tissues that doesn't have a lot of mitochondria, fat cells. Not a lot of energy needed. This is also a reason why it's difficult to get rid of fat cells from your body. Here they are, we talked about them several times, ribosomes. Ribosomes are extremely small, we've seen them already. Dense means they are solid. There is no open space. They're often described as looking like a granule. Like a grain of sand. And they make protein. Protein, protein, protein. We've already talked about the importance of protein. So we've seen this already, right? So we have all of these ribosomes along the rough endoplasmic reticulum, and then we have these free ribosomes. We need proteins for everything. The ribosomes that are free in the cytoplasm are used inside the cell. And the ribosomes that are attached to the endoplasmic reticulum, because it's a channel, a passageway, it can take these proteins to the cell membrane for export outside of the cell. Cytoskeleton. Cyto- means cell. So when we think of skeleton, we think of our bony skeleton, and certainly our cells don't have a bony skeleton. But what does a skeleton do? A skeleton provides structural support. It allows for movement. And so, the skeleton, I'm doing air quotes right now, you can't see me, but I am. The skeleton in the cell does the same thing. Structural support, allows for movement, so let's talk about it. The cytoskeleton is not bone, but little protein fibers called filaments. And those little protein filaments give the cell shape, structural support, and help with movement. Within– within the cell and if the cell itself moves. So, we're going to talk about two types, there are others, but we're going to talk about two. We have what are called microbe filaments. Microbe filaments are found in muscle cells and they are what form the contractile mechanism to allow the muscle cells to shorten. Bringing about movement. The other type are called microtubules. This word tubule, a tubule is hollow. And these are hollow. They're straight, they're hollow, they're bundled. And they have a couple of jobs. Because they're hollow, they're going to be transport channels. So materials can move through them. But they can also be used as structural support. And the microtubules are, if I have a cell that has cilia or flagella, they, the microtubules are what form those specialized structures on the outside of a cell. The microtubules are also what bring about the mitotic spindles that appear during mitosis. On the inside of the cell. So, we're going to be talking about microtubules and microfilaments. This is what the microtubules look like, bundled– so what did we say? Straight, bundled, hollow. This is what they look like. So with that in mind, let's talk about these specialized structures made from microtubules, cilia and flagella. Cilia and flagella are going to extend from the surface of some cells. Certainly few. Most cells don't have either cilia or flagella. But those cells that do, they have a purpose. So, cilia are going to occur in large numbers. They move materials along the surface of a cell. The flagellum– flagella is plural. A flagellum is longer than cilia and it usually occurs as a single appendage. So, that takes us back to the beginning of our discussion. We said let's talk about ciliated columnar epithelium. Versus a sperm cell. Very different in their shape. Lots of different, right? Here's my column shaped cell with cilia. Here are those goblet cells that we find interspersed. Versus a sperm cell. They look very different. And yet, they're both human cells. So what did we say? That the form, the shape of a cell helps determine its function. So, with columnar– ciliated columnar epithelium, the purpose here is the cilia help to move materials along the surface of the cell. And, their column shaped because they're going to absorb, in this case, we're going to talk about ciliated columnar epithelium in the digestive tract. There's lots of room to absorb materials. Versus I'm getting in as fast as I can. Right? Get in as fast as I can. That's my job. Very different. Both just as important. So, with that in mind, this is what we call the level of structural organization in the human body. We have what are called molecules, right? We discussed several of them today. We've got water, proteins, carbohydrates, lipids, salts, those are all molecules. We combine those molecules together into the structural and functional unit of life, called a cell. When we take groups of the same type of cell and join them together, that have a common function, that's called a tissue. So same cells with a common function, that's a tissue. When I take different tissues that have a common function, that's called an organ. So let's back it up a second. So we have, in our last example, we have what are called ciliated columnar epithelial cells. When we combine them together, and join them together, like we just saw, that's called a tissue. And when they're joined together, they have a common function in the digestive system, that function is to move materials along the surface and absorb nutrients. When we take different tissues, we'll take some ciliated columnar epithelium and some smooth muscle. And some simple squamous epithelium. And we put all of those together, we form an organ. So different tissues, so the organ that might be formed, the small intestine. And then if we take the small intestine, and large intestine, and the liver, and the esophagus, and combine all of those organs, different organs that are combined together with the same function, that is digesting materials that we take in as food, that's called a system. Okay? They're called organ system or system. So a group of different organs that have the same function is a system. And when we take all of the body systems, we take the digestive system and the respiratory system and the circulatory system and reproductive– all the systems. All of the systems. And combine those, we end up with the organism. And as I'm looking at these levels of organization, I'm going from least complex to most complex. Least complex to most complex. And it looks like this, right? This molecule is water. I combine all of the molecules that make up the cell, ciliated columnar epithelium, I take multiple ciliated columnar epithelium, and I get ciliated– I get columnar epithelial tissue. I take epithelial tissue and smooth muscle, connected tissues, I get the small intestine. And the small intestine to the large intestine to the stomach to the liver, I get the digestive system. And when I take all of the body systems together, I get the organism. And that is the end of our lecture. Okay, I'm just going to stop the recording.