Biomechanics
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Lecture - 51
Tissues and Types of Tissues

Vanakkam. Welcome to this video on biomechanics. In this video, we will be starting our discussion on mechanics of biological materials. So when I say biomaterials or biological materials, all the materials that make up this body. We are focusing on human biomechanics, so all the materials that make up the human body are the materials of intersperse. What are the properties of these materials?

So mechanical properties. Properties means, there are many properties. For example, optical properties. But in this course, we restrict our attention to the mechanical properties of these materials.

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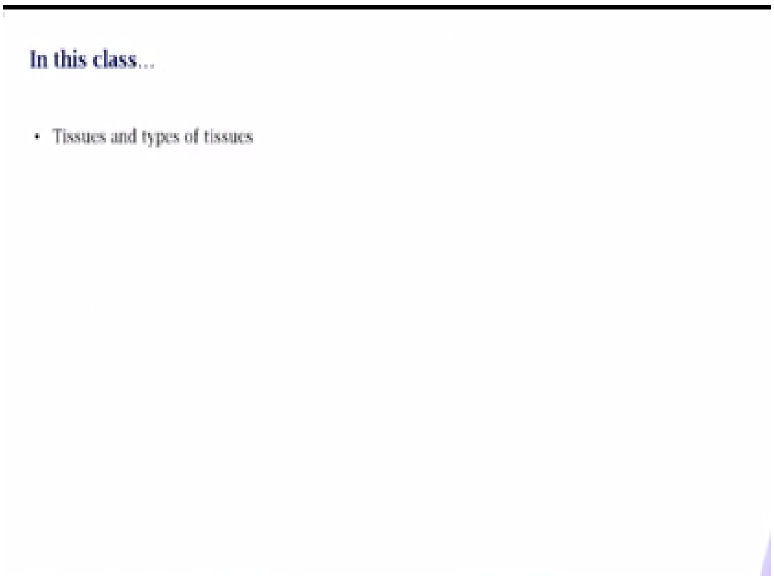

So in this video, we will be focusing on the tissues and types of tissues.

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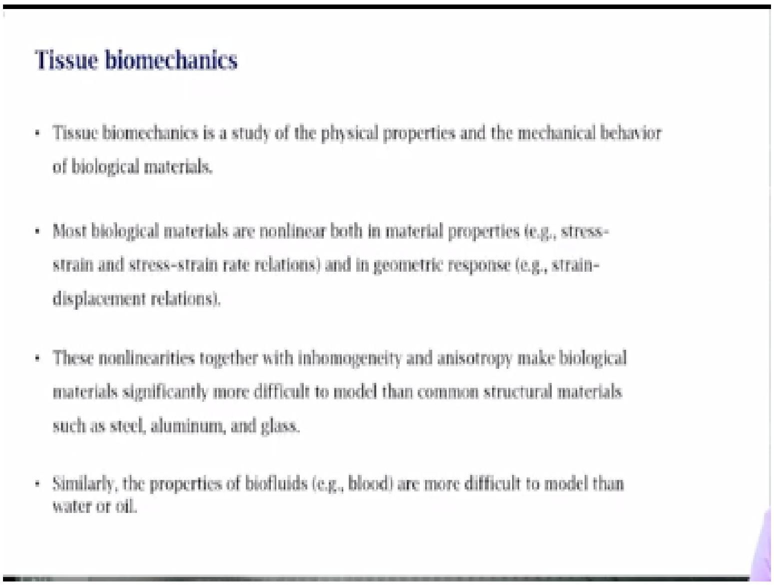

So biomechanics of tissues or tissue biomechanics, what is this? This is the study of physical properties and mechanical behavior of these biological materials. So most biological materials are not linear in either in material properties. For example stress, strain or stress strain rate relationships or in geometry properties, geometric responses such as strain and displacement relations.

Whereas in engineering the materials of interest or at least we deal with those materials of interest that have linear properties, at least in engineering or those materials that have linear properties are the ones we use predominantly as engineering materials. But biological materials are not chosen by us. These materials are existent, they are there.

And so we study these within the framework of our studies that we do with mechanics of engineering materials like what you would do for mechanics of materials, you study the biological materials within the same framework that you have for studying mechanics of materials in general.

But materials or most of these mechanics of material studies involve engineering materials and are developed for studying engineering materials. So those are essentially those that have these linear properties either in material properties or geometric relations or both, in most cases both.

So these nonlinearities in these biological materials along with other restrictions or other constraints, such as inhomogeneity and anisotropy make the biological materials lot more difficult to model and to study than the common structural materials or the common engineering materials such as steel, aluminum and glass, right. So what is inhomogeneity?

Homogeneity means that the material property is same throughout. It is the, it does not matter where you sample from. In that bulk of that material, wherever you sample from the property remains the same. Actually, even in engineering materials this is a challenge. But in biological materials, this is almost never found, homogeneity is almost never to be found.

The other one is isotropy. That is, if I study a property in a particular direction, and if I find that to have a certain characteristic in a particular direction, the material has the same property in the other two dimension that I have not studied. Such materials are isotropic. Many of the engineering materials of interest for us are isotropic materials.

Whereas, the materials that we use in biology or the materials that we study as biological materials are not isotropic. That means, you study the material property in one direction that is something, that characteristic is something, the same material you study in a different direction, in a different dimension, the property is completely different. So the material property and the way it responds to stress or forces depends on the direction in which you are studying.

This is called anisotropy or the nonexistence of isotropy. Isotropy is not there in biological materials. This is called anisotropy, right. Whereas in engineering materials, this is almost never the case. In engineering materials you have isotropy. So it is enough if you study in one direction, then you can generalize the properties to other directions.

So that is you can assume isotropy in many engineering materials. Also the properties of fluids in the biological system or the biological fluids or the bio fluids are rather hard, very challenging to model when compared with some oil or water or some fluid flow. So it is not a simple fluid flow problem, there is more to that. So the biological material property comes into the picture not just for solids, but also for fluids.

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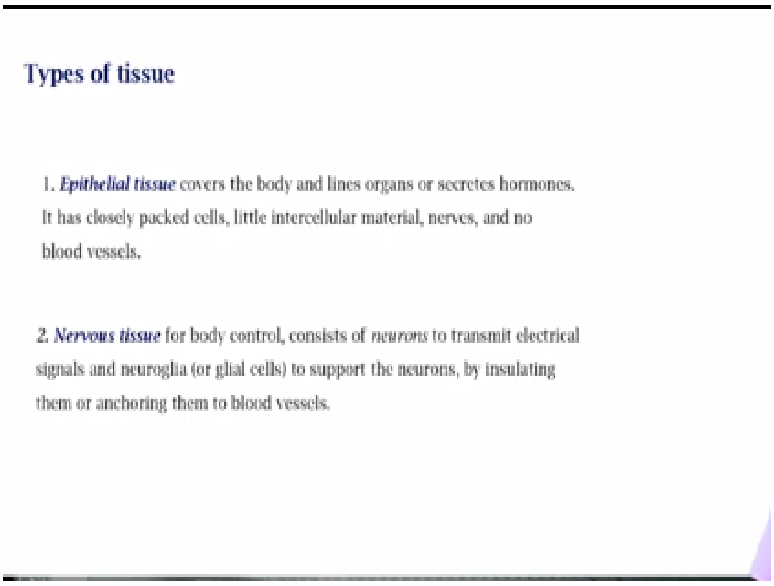

There are many types of tissues and there are many ways of classifying tissues. One common way in which tissues are classified is by their function like what they do. Skeletal tissue, muscle tissue, nervous tissue and so on. So they have specific functions and based on that they are classified. But here we restrict our attention to material properties. So we classify this as per the material property viewpoint.

So not completely as per the functional viewpoint, as you see in for example, when you are discussing various types of tissues that exist, that perform various functions. Here, we only restrict our attention to the material properties based on that we classify. The first type of tissue is the epithelial tissue. This is found everywhere, almost everywhere in the body. It covers the body and lines the organs and or secretes hormones.

This has very tightly packed cells and very little between cell material, there is no gap, there is no material between these cells. And they do not have blood vessels. These are called epithelial tissue. They are found practically everywhere in the body. Then you have neuronal tissue or the nervous tissue for control of bodily functions, right?

They have neurons that transmit electrical signals, or neuroglia the type of is a type of glial cell are those that cover and insulate the neurons right, and anchoring them and attaching them to the blood vessels. So they act as a mode of communication between the blood vessels and the neurons, these are called nervous tissue.

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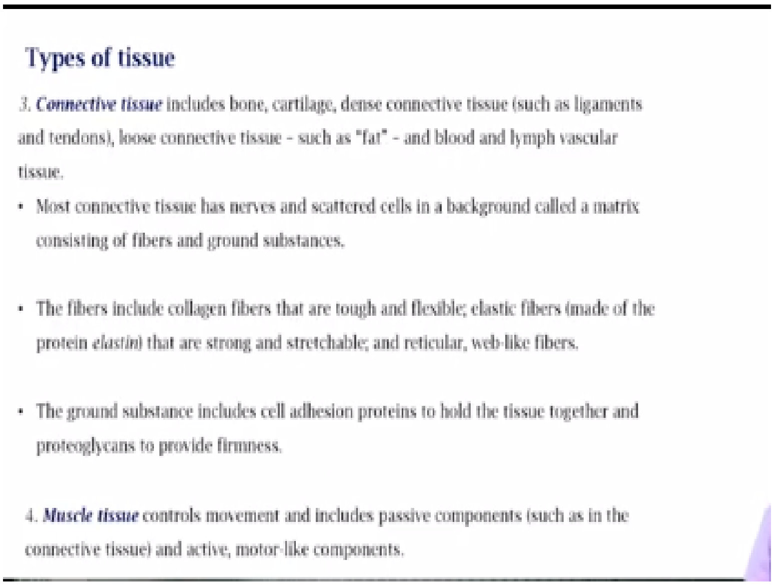

Then you have connective tissue, this is very commonly found and this includes bones, cartilage, and other dense connective tissue such as ligaments and tendons, and lose connective tissue such as fat; by the way fat is a type of tissue and blood and lymph vascular tissue. Most of the connective tissues they have nerves and scattered cells in a background called and what is called as a matrix.

So there are some substances spread around or scattered around. And they consist of fibers and some background substances or ground substances. These fibers can be of different types. They include collagen fibers that are relatively tough and flexible and elastic fibers. These elastic fibers are made of a special protein called elastin that are strong and stretchable and can be stretched and web like fibers.

So fibrous tissue come in many forms; collagenous, elastic, and web like. So fibrous tissue come in many forms; collagenous, elastic or web like fibers, okay? This ground substance are that which supports all this include adhesion proteins are those that attach the cell to the ground to hold tissues together, to put them together, right? And proteoglycans that provide some form of strength or firmness, right?

Then you have muscles or muscle tissue. These are active tissues that control movement. And they also have some passive components like you find in the connective tissue, like you find in the tendon, ligament type of this and active motor like components. So that means this muscle tissue has regular material properties that are present in any other connective tissue and also properties that are actively controlled by electric control.

So that means those properties that I can modify depending on some input, so these are very special materials, right. So whose properties change depending on the command that it is given. So these properties of this muscle can change. Wow, that must be something, right? But that is something that we have seen previously. How muscles develop tension, we have seen that, right?

That is because of conformational change that happens within a sarcomere. We have seen this right, conformational change that happen in a myosin filament attaching to the actin filament and then pulling, right? This is something that we have seen. These conformational changes are what lead to the so called active material property. So that is the active material property.

And then the regular passive material property. The passive material property is similar to the regular connective tissue, this is always there. The passive material property is always present. The active property is present only upon activation of this tissue, right? So this property can change depending on the situation, a very special type of tissue.

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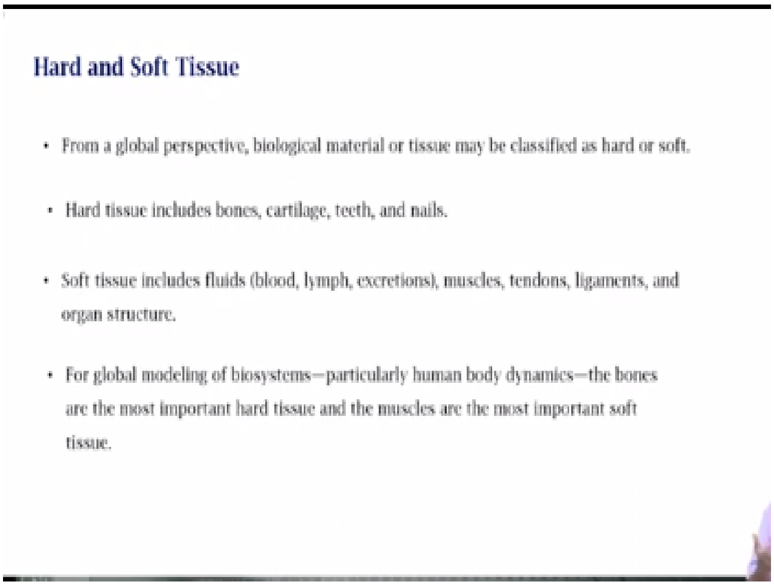

So broadly, we can classify biological materials as hard tissues and soft tissues. The hard tissues are those like bones, teeth, nail and cartilage. Soft tissues are those like blood, lymph, excretory material, muscles, tendons, ligaments, and other organs. So when you are modeling biosystems, you are mostly interested in the hard tissue and soft tissue. The hard tissue of interest for you is bone.

And the soft tissue of interest for us is muscles. Most important hard tissue is bone and the most crucial soft tissue is muscle. This is of interest for us.

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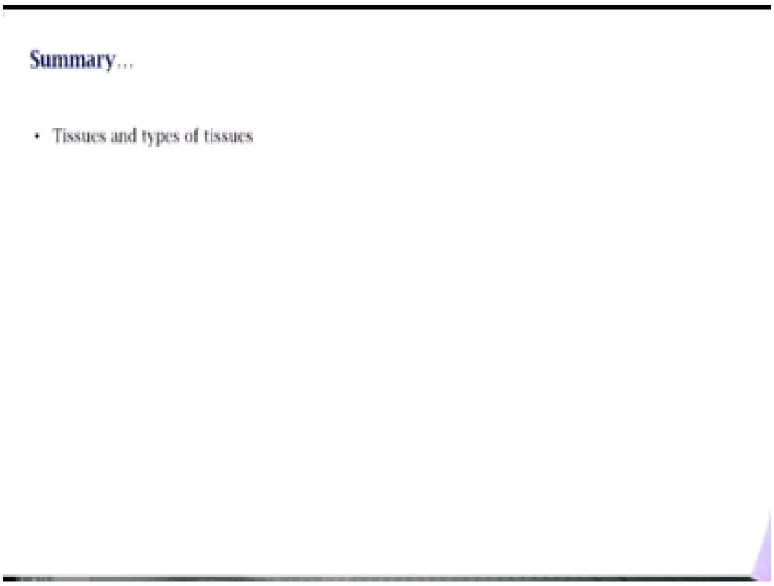

So in this video, we saw the types of tissue based on material properties. And we defined one special type of tissue whose material property can change depending on whether it is active or not. We also gave some examples of hard tissues and some examples of soft tissues and the most crucial or the most critical example of hard tissue and soft tissue.

Remember, the most critical hard tissue is bone and the most critical soft tissue is muscle. With this, we come to the end of this video. Thank you very much for your attention.