Animal Physiology
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Lecture – 09
Bone & Cartilage – I

Welcome back to the lecture series Animal Physiology. So, we are in week 2. So, first three classes of the week 2 we have talked about the integumentary system the next 2 classes of this week we will concentrate on cartilage and bones. So, before getting into cartilage and the bone let us ask a question to ourselves have we ever wondered all our the sole structure of our body with 2 lams 2 legs the unique shape of the skull these are all governed by a solid framework and we call that as skull or skeleton surface did it ever cross your mind that when possibly the skeleton actually developed like in the development phase what I meant by that we are conceived as sperm and a egg fertilize from a zygote and then moves on it forms an embrave and then likewise at what stage the this framework takes a rigid structure.

So, to tell you by the sixth week of the development like fertilize egg is formed. So, the baby is conceived 6 is the week down the line approximately it can say one and half month the framework what you call as a skeleton is already formed, but it is not very rigid interestingly at that stage no bones were formed framework was there, but there was no bones what does that mean. That means the initial framework which is formed in the mother's womb at the sixth week by the sixth week I should say is not the real bones the framework is of cartilage there was a framework it is a whole shape of the whole say for example.

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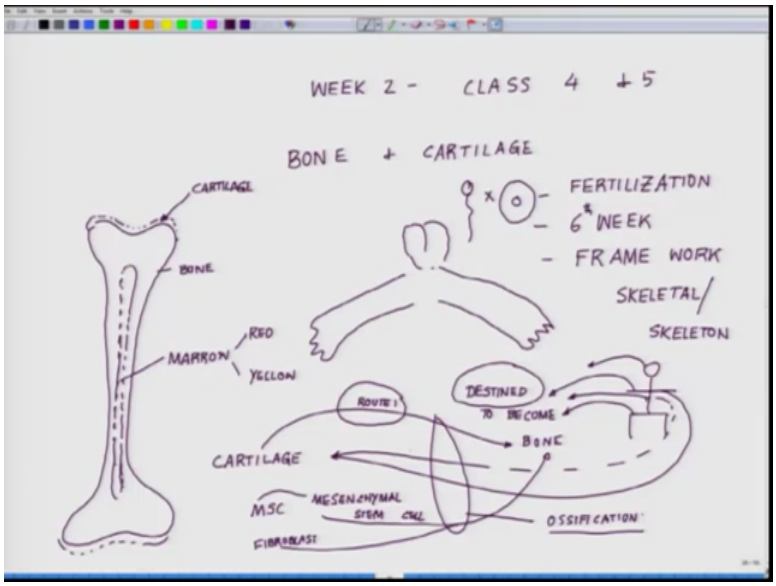

So, let us it initiate with; so we are into week 2 and this is class 4 followed by will be the class five. So, today what we are dealing with is bone and cartilage. So, where I was, so, I told you that you know you have this framework this framework of bony structure is formed, but that was not really a bone the treamy network was at that stage or is at that stage is of cartilage, but then what is cartilage?

So, let me give you few facts and then we will explore each one of these facts in the mother's womb by sixth week I mention. So, there are few things which will highlight first by post fertilization; fertilization where you have a sperm crossed with an egg and it fertilize; by sixth week skeletal framework; I am just writing framework a skeletal or skeleton framework skeletal or you can also call it skeleton framework is already formed.

So, in other word like this whole framework; it is in a cartoon have drawn a cartoon those this framework is already form and this we chart destine these structures structure of the skull structure of the leg and (Refer Time: 05:00) and all this things these where all destined to become bone, but initially they are destined mark this what they are all destined to become bone, but initially all this structures where cartilage and there are 2 processes by which a bone is form one processes is a cartilage is transformed into a bone. So, those who all are non vegetarian those who have a chicken or mutton or something non they must have seen a bone or those who are even non vegetarian, so, vegetarian

must have seen a structure of the bone right you must have seen or those who you know maintain dogs the dog bone you must have seen a model of the bone.

So, you will see the structure is something like that right and the top of it there is one small layer kind of a structure which is kind of a elastic kind of a structure out here which you can see that structure most of the time or parents or somebody will tell us that is a cartilage that is indeed is a cartilage, but what is cartilage will come to that and this is the main bone and those who are very good in atomy or meet an atomy they know that there is a kernel. So, this whole structure is hollow and they one call that as the marrow area which is also called the marrow or bone marrow and there are 2 kinds of marrows which will be dealing later one is red marrow the other one is yellow marrow we will come later what does those words me.

But this is a typically a bone how it looks like. So, one route for the formation of bone is from cartilage. So, cartilage becomes a bone this is route one which is one of the most prominent route and there is another route where there are some series of the stem cells in our body which are called Mesenchymal stem cell in short they write it has MSC for you people just to remember this is called Mesenchymal stem cell. And sometimes even there are fibroblast which given the local environment transform into bone and it is not the whole cartilage of the body gets transformed into bone still there are cartilage wherever it is needed will come later into this these are the 2 ways by which bone is formed in your body.

Now, in order to understand the bone biology which is also called ossification over just remember this; what this formation of bone this process is termed as ossification in order to understand what is the genesis of the bone biology you have to understand from where it is formed. So, you have to understand what is cartilage.

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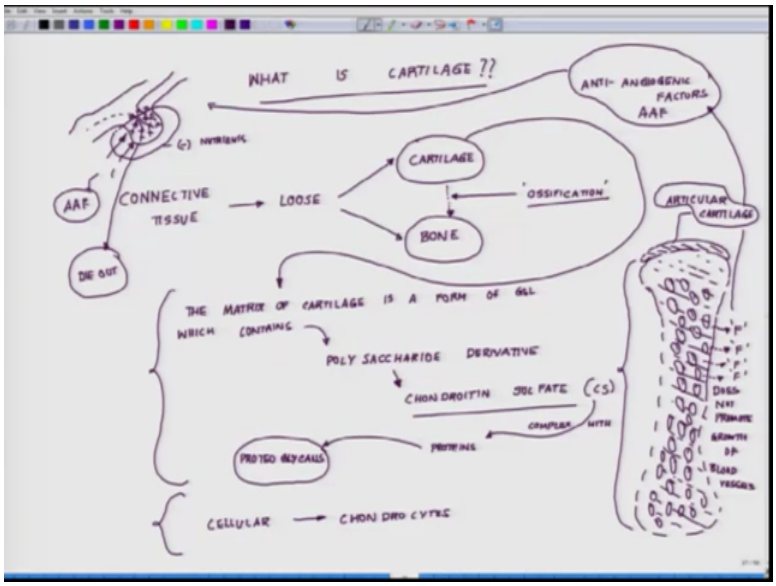

Once you understand what is cartilage understanding bone will be very easy now well I am asking this question what is cartilage let me just recall little bit of our first week when I mentioned that whenever and wherever it is needed I will refer to those tissue level of organisation. You remember there we talked about muscular tissue nervous tissue under the broad heading of connective tissues likewise we talked about loose connective tissue dense connective tissue.

So, the term connective tissue which includes blood and everything there is another term which is called a loose connective tissue and within the loose connective tissue for these 2 words. So, if you have to make a mind map. So, it is connective tissue and within connective tissue you have loose connective tissue within loose connective tissue you have cartilage and bone right and I mentioned you it is from the cartilage you can make bone this is the arrow and this process is called ossification clear.

Now, in order to answer what is the bone we have to first of all answer what is cartilage. So, let us start with cartilage how we define cartilage. So, this cartilage is basically the matrix of cartilage the matrix of cartilage and I have given you one example where cartilage is located if you remember it when I showed you the structure of the bone I told you that in an mature bone cartilage is located somewhere out here and there is a term which is used for this; this is called articular cartilage; articular cartilage fine.

Now, the matrix of cartilage is a form of gel which contains polysaccharide derivative polysaccharide derivative and once that polysaccharide derivative is called chondroitin sulphate and this chondroitin sulphate is one of the major component of the cartilaginous material chondroitin sulphate represent by CA; it forms a kind of a complex with the protein in the ground substances. So, it forms a kind of a complex with protein complex with protein thus forming term what we call as proteo glycans; proteo glycans and apart from this matrix if you one component of cartilage is matrix there is another component which is the cellular component and cellular component and cellular component of cartilage is called chondrocytes; chondrocytes.

Now, when you see a mature bone will be surprised that this whole bone you see this hash line here, initially this whole bone is nothing, but cartilage in a tissue initially at the sixth week when the whole framework is formed, this is how it was the whole think was cartilage and there was nothing called articular cartilage or (Refer Time: 14:45) cartilage; we will come into that the whole thing was cartilage the whole bone was nothing, but a cartilage in a material and there is a very interesting feature about cartilage; cartilage cells you see this cellular structure. So, what you see is the matrix and within the matrix you are having the chondrocytes sitting here like this, this is how the cartilage in a material is formed these circles are the chondrocyte fine.

Now, there is an interesting feature about this chondrocytes these chondrocyte secretes certain a specific factors these factors does not. So, I am representing factor with f these factor does not promote growth of blood vessels and there is a technical term for this, this is also called secretion of anti angiogenic factors and there is a huge significance of this anti angiogenic factors before we come to that. So by the sixth week when this whole framework is formed, so these cartilaginous bones are not having any form of blood innovation information one information 2 I mention here that these secrete certain factors called anti-angiogenic factors: anti-angiogentic factors are the factor which does not allow the blood vessels to grow.

So, this piece of information has a immense significance in cancer therapy whenever there is a cancerous growth at xyz location those cancer cells survives because they are continuously fed by the blood vessels all the nutrients all the debris are being removed, but think that these cancer tissue if they are exposed to an anti-angiogenic factor it will not allow the blood vessels to survive there it will kind of you know destroy them and in

that situation that cancer outgrowth which as form will die out in other word if I had to give a diagrammatic explanation say for example, there is this is the tissue and there is this cancer outgrowth which has taken place.

Obviously that has been you know supplied with blood vessels these are the blood vessels which are supplying it now out here you put your factor anti angiogenesis factor I am representing by AAF; AAF, there are several anti angiogenesis. So, what this will do this will kind of you know remove these blood vessels or kind of destroy these blood vessels and eventually this tissue which is an outgrowth out here will be divide of nutrients and theoretically speaking it should die out.

So, this is one of information which is very interesting about this particular cartilage material now the physical properties of the cartilage depends on 2 factors: factor one these are the physical properties.

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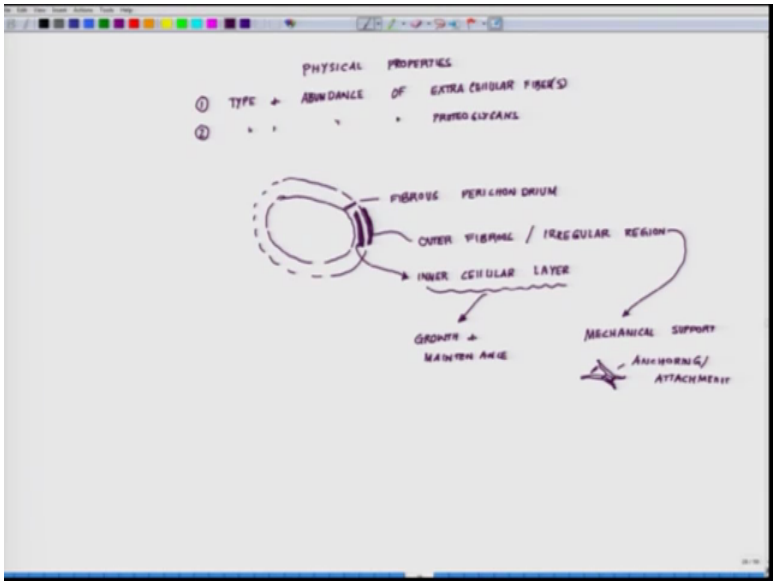

Factor one that is type an abundance of extracellular fibre type and abundance of extracellular fibre extracellular fibres and there is second point which is type and abundance of proteo glycans and we have already discuss what are proteo glycans in out previous slide. Now the cartilaginous material what you see is surrounded by fibrous pericardium it is surrounded by a this is a fibreous preica pericardium sorry pericardium and which is the outer fibres reason of irregular connective tissue this is that outer region of fibreous region of dense irregular connective tissue and there is a inner cellular layer

this is that inner cellular layer where as this is outer fibreous region fibreous irregular region.

This is the one which provides the mechanical support and helps in anchoring with other tissues say for example, this is one surface it as to anchor to another surfaces helps in this anchoring or attachment where as the cellular layer the inner cellular layer this helps in the growth and maintenance.

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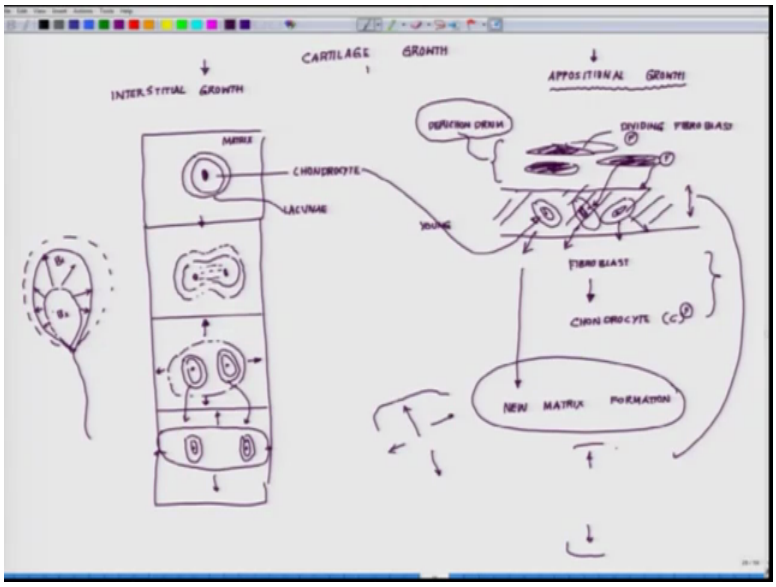

Next what we will talk about is the cartilage growth how cartilage growth take places because from after this only will have a fair idea how the bone is formed cartilage growth. So, cartilage growth take place in 2 by 2 process, one is called interstitial growth interstitial growth the other process is called appositional growth oppositional growth.

So, both these are slightly different from each other say for example, you think of a confined space where you have a cartilage inner tissue. So, let me draw it in 4 different stages. So, imagine this single box is one confined space and here you have a cartilage in a cell or chondrocytes. So, this is the matrix and this is the chondrocytes and this is the lacunae or the space where it is located now one of the waves they grow is this particular in that confined space this particular chondrocytes starts to divide while it is dividing, you are basically expanding the space. So, its dividing from single cell it is becoming 2 cells then within this space it creates a more lacunae or more empty space and you have 2 cells like this.

So, what you are essentially doing is that you are expanding on all the directions and while it does. So, these 2 daughter cells are formed they secrete a newer and newer matrix in and around them and their by you are spreading out and you are growing. So, as daughter cells secrete additional matrix they pushed a part and expanding the cartilage from within similar this is very similar to us say for example, I have a example of a balloon out here and within one balloon you are inflicting another balloon. So, what this balloon will do it is going to expand this one. So, always remember it by the analogy of the balloon.

So, this is if this is the first balloon b one there is another balloon which is b 2 which is expanding the balloon one. So, the next this balloon one will expand will further till it bust out this is one way why we does. So, there is a second one which is called oppositional growth oppositional growth is very interesting in the oppositional growth what you are having is that you have this young chondrocytes in the lacunae what we just now draw. So, this is the lacunae where this young chondrocytes are present and on top of it you have another cell type which is the fibroblast I am not putting any nucleus in them purposefully. So, that you make you understand I am shading, but they do have a nucleus and these are the dividing fibroblast.

Now, what happens and this is the young chondrocytes which is present their now these fibroblast this dividing fibroblast in close proximity and this is your perichondrium. You remember the perichondrium where we talked about in the previous slide this is the perichondrium area right now what happens this dividing fibroblast in close proximity. So, there are dividing fibroblast in close; close proximity with this chondrocytes they get converted. So, if I represent fibroblast as f these fibroblast get converted into chondrocytes.

So, fibroblast converted or differentiated into chondrocytes. So, let us represent those chondrocytes at c f at the superscript telling that they have come from the fibroblast. So, this is another way by which they grow and these fibroblast than become chondrocytes and become part of this layer and this result in the increase of the matrix this matrix I started to spend and what we eventually land up with is a new matrix formation. So, with this new matrix formation this whole cartilage layer keeps on expanding.

So, and these older ones started coming down into the matrix. So, that is how this matrix size eventually becomes much more bigger as it expands. So, these are the 2 ways by which the cartilage material divides. So, what all we cover today in this particular class we talked about what is cartilage what are the structure of the cartilage. And we talked about the 2 different growth mechanisms by which cartilage grows, and in the beginning of the class we talked about how from cartilage the bone is formed.

So, in the very next class what we will do we will talk about the different type of cartilage and how the bone is formed.

Thank you.