Basic Course in Ornithology
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Lecture -6
Anatomy

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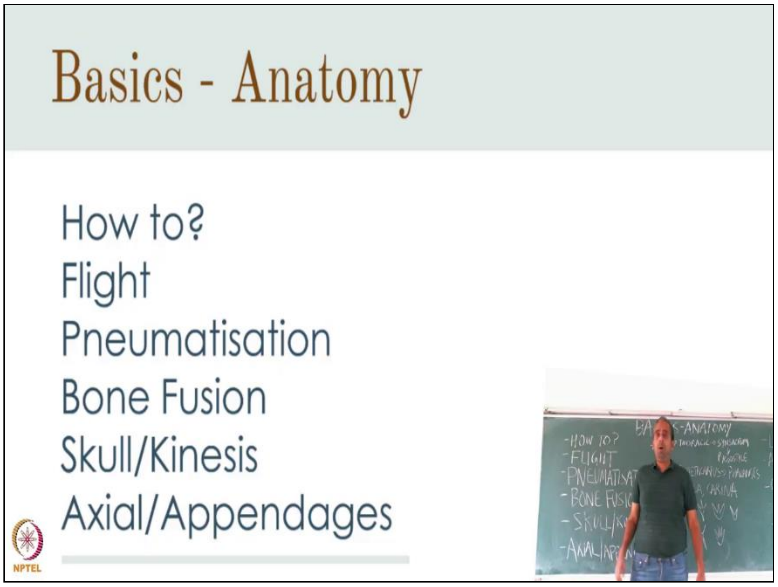

Hello everyone, today's lecture is going to be about the very basics of bird anatomy. So, think of this as a primer to all the basic concepts you need in order to become an ornithologist. So, this lecture is not comprehensive given the time constraints, I am not going to be covering all aspects of bird anatomy but I am going to be covering some of the most important basics that you can find out about as you go forward with this course.

Now, it is important to remember birds much like mammals have a digestive system, they have a nervous system that functions much the same way as we do with some important differences which you will hear about in my lecture on colour. You will also hear about differences in their song control system at some point during this course and there are other important differences as well. Certain physiological systems of birds like the water conservation system I am going to talk about in my next lecture on physiology.

But today I am just going to talk about the most important ways in which birds differ from mammalian physiological systems that all of you will be familiar with from school and college curricula. And with that in mind we are just going to give you a basic overview of the demands that drive changes in anatomy of a bird and how we study them. All right? So, with that in mind, let me begin my lecture by asking a simple question how do you study bird anatomy? All right?

Now that is a very important question and that is something that has been a classic part of ornithology for well over 200 years. Remember that, and in those days you did not study anatomy from photographs in fact you still cannot study anatomy from photographs and that is where museum specimens come in very handy. So, people used to go out to the field and collect specimens, they still do. And if you want to study the skeletal anatomy, the skeleton of the bird you actually put these specimen into a a sort of a tank with these beetles in them they're called dermestids, d-e-r-m-e-s-t-i-d if anyone is interested.

They are Carrion eating beetles that will eat all the flesh and leave the bones. So, that you have them nice and cleaned to study skeletal anatomy. If you wanted to study muscular anatomy you stain them and dissect them, if you want to study other internal systems you dissect the birds digestive system or the brain and you can study all of these questions using that. Now in the modern day it is not always easy to get permission to collect a specimen in fact sometimes it is almost impossible.

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So, can you use existing specimens and collections to study anatomy? Yes, you can! There are now more modern tools available to study anatomy you can for instance put a specimen in an X-ray and take a 2D slice of the bird to see its skeleton, you can also get this information in 3D you put the bird in a CT scanner using X-rays you can image the entire bird and reconstruct its skeletal systems in three dimensions, you can also study soft tissues using CT scanning you just have to stain them first.

So, that they are dense to X-rays and once they are dense to X-rays you will be able to see all of the skeleton that you need to see sorry all of the soft tissue that you need to see. And once you have gotten an understanding of bird anatomy and you will get reading material on this as well the important thing to remember is that what has largely driven bird anatomy is flight and the demands of flight because birds evolved flight pretty early on in their.. in their evolution.

And as a result of flight many birds have dispersed throughout the world to far-flung places they inhabit very extreme environments and that is an important thing to remember because even birds that have since then lost the ability to fly like Penguins or Ostriches retained several of the adaptations that enabled birds to fly in the first place. Let us talk about two of these in particular one is called pneumatization.

Now I am sure all of you know where I am getting at because most of you have heard that birds have air spaces and light bones. That is true. So, birds have big air spaces in their bones that make them much lighter and give birds that extra make it make it less work for them to be able to fly. Now birds that run on the ground have to be careful too because light weight does not mean brittle you cannot have brittle bones.

You have to have lightweight bones but with a high resistance to impact stresses and that is a trade-off that governs how birds take to the air how they stay in the air and how some of them do not stay in the air when they are on the ground. Because if you have brittle bones you can make them really really light in order to get off the ground but they should not become brittle because otherwise when you run on the ground you are going to give yourself stress fractures and stress fractures obviously are not a good thing for the bird.

So, pneumatization is a trade-off between making your bones light and not making them brittle. And as long as they are light enough to get the bird off the ground, they function very well in flight. The other way birds have of making their skeleton lighter is to do away with unnecessary joints and bones that get in the way and that they accomplish by bone fusion. So, bird's skeletons do not necessarily have all of the articular joints and sutures that our bones do they are instead heavily fused.

And we are going to look at some examples of that across the bird world. Now I am sure most of you are familiar with the very basics of the human skeleton. So, we will describe the various aspects of the bird skeleton in order to get an understanding of how bone fusion has actually happened in this particular group of vertebrates, the birds. All right? Now broadly you can call the skeleton three kinds.

I am sure you all know this there is the cranial skeleton there is the axial skeleton and there is the appendicular skeleton. The appendicular skeleton is the one we will get to last but let us start by talking about the skull of the bird. Now the skull of the bird is a very heavily fused and highly modified structure. If you look at the skulls of fishes, reptiles, mammals you can see sort of a steady process where you can figure out where the bones have gone.

Birds as you will know by now are an offshoot of Theropod reptiles they arose from a separate stock than the one that gave rise to mammals and the reason there is been so much confusion about the true ancestor of birds is because their skeletons are so highly modified and nowhere is this more apparent than in the skull where the bones have all fused to give lightweight but strong protections and strong brain cases. Right?

There is still one thing that they retain now as you know as I am speaking my lower jaw is moving outwards like a hinge in order for me to produce sounds. Birds are primarily capable of one form of cranial kinesis and that is the bill as you will know instead of jaws with teeth many birds have bills the bill is a bony structure with a keratinous covering over it, it is called the rhamphotheca.

So, write that down and look it up if you're interested there is a keratin covering over the bill but the bony part of the bill the upper jaw is fused to the skull. The lower jaw sits with a bone that is called the quadrate and the quadrant bone rotates like so. So, imagine if this is the bill, I am going to do this way the quadrate bone rotates such that the lower jaw falls out and that is the main form of kinesis that the bird's skull is capable off.

And bills come in all shapes and sizes. Right? As you very well know you have got the Avocets bill- that is up curved, you have got the curl use build that is down curve, you have got thick seed crushing bills, you have got nectar feeding bills, you have got insectivores that snap and trap insects and in all of these cases it is important to note that all of this is driven by the quadrate articulation. So, it causes the lower jaw to drop out and the bill can perform a diverse array of functions.

It is not just the bones obviously there are muscle attachment points and other things that act like springs to return things to their original position because if they were not there you would have the jaw fall out and it would never be able to get back. So, you have got jaw muscles that can pull the cranium back to its original position and that is the fundamental basis of what you need to understand about bird skulls.

Moving on to the axial and appendicular skeletons, will see that there are a number of adaptations here that also increase this light weightedness of the skeleton and its ability to power flight. Let us talk about the axial skeleton for a bit now. What is the axial skeleton primarily made of the vertebrae that form the spine. They articulate with the skull here and if you remember human vertebral columns, you have got cervical, thoracic or lumbar, you have got sacral or sacral vertebrae and you have got the caudal or the tail vertebrae right.

Now in birds, you have got a very large number of cervical vertebrae in some words up to 14 and they are all independent of each other, they are all articulated. In fact, they are very flexibly articulated which is why some birds like Owls can turn their heads all the way around all right without breaking their neck, you and I cannot do that this is as far as I can turn my head but Owls and other birds can turn their heads all the way around.

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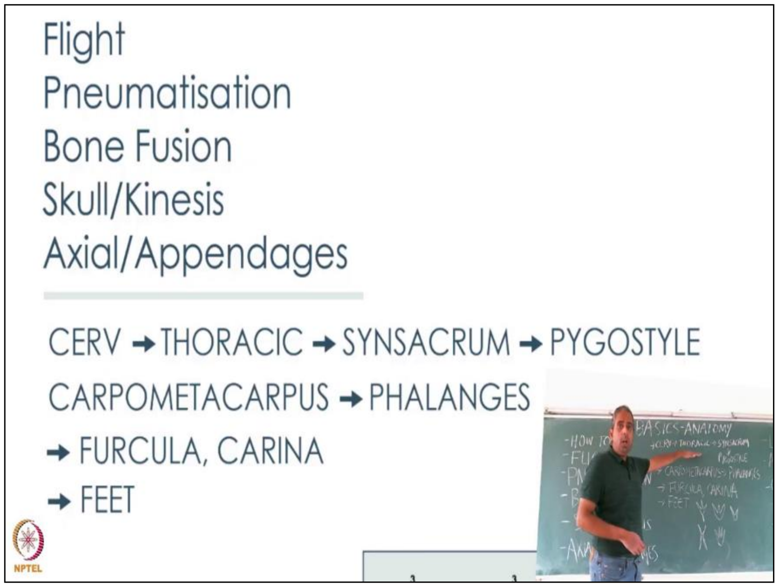

Then you have got about five fused thoraco-lumbar vertebrae, thoracic vertebrae let us say for now but these are fused and the sacral vertebrae are also fused into a single bone that is called the synsacrum. The synsacrum is a fused bone which articulates with the pelvis and the pelvis also consists of fused ilium, ischium, and pubis all fused into one pelvic bone. So, the synsacrum supports the pelvis and then articulates further down with the caudal or the tail vertebrae.

And the final tail bones consists of a few series of bones that is called the pygostyle. The pygostyle is the articulation point for the tail feathers and the tail muscles and that is where most of the tail of the bird comes from. It arises from the pygostyle like zone and muscle articulations around these attachment points lead to birds that can move their tails as a result.

But you can see there is a lot of bone fusion there as well there is also bone fusion at the front of the rib cage where the clavicular bones are fused into something called the furcula. I will get to the furcula in a minute. Just remember there is a lot of bone fusion going on at all of these levels all right. And nowhere is this more apparent than in the appendicular skeleton. Now my appendicular skeleton at least my four limbs, let me talk about for a minute has a humerus, a radius and ulna, carpals, metacarpals and five distinct phalanges.

Now birds go the same way they have got a humerus, they have got a radius and ulna, their carpals are all fused into a bone called the radial, never mind what it is called but remember this fusion here then there is a carpometacarpus, a single fused structure. And instead of five phalanges, the phalanges are all fused into a single point. So, if you look at a bird a appendicular skeleton, it looks something like this, you do not have distinct phalanges, you have fusion.

And this fusion a point is where the wing feathers attach and they attach all along this and the wing muscles. This provides lightweight yet flexible articulation points getting rid of sort of unnecessary joints if you will. So, that the bird's wings can attach to the sunflower it is a very specialized and very highly modified limb that is used to power flight. This is very different from the wing bones of bats and other animals that have evolved powered flight.

Bats of course retain the phalangeal digits they have just got a membrane across them. Birds have a very skeletally modified appendicular skeleton, as you can see. And these modifications extend all the way as I mentioned to the clavicular bone and also to the sternum. The sternum of birds is heavily enlarged, what is the sternum? It is the bone here, the breast bone it is called in birds it is heavily enlarged and possesses a keel, a keel like the front of a boat it is shaped like so, and this huge area sticks out this is called a carina and the carina the reason it so big and has such a large surface area is because the flight muscles attached between the furcula and the carina the thoracic muscles and they're massive in birds for their body size why are they. So, big because they are what moves the wings and as you know bird's wings move with a great deal of power and all that power is generated by the muscles.

And in order for those muscles to function as efficient levers they have to have sufficient attachment points. Now, birds like the Ostrich or the Emu that lose the power of flight end up having a greatly reduced carina. So, people who found extinct birds can use the size of the carina to determine whether that bird was flighted or flightless. The carina relative to body size becomes very small as do the muscles attached to it relative to body size.

Like the small Hummingbirds that have very powerful flight muscles have huge carina relative to their body size, in some hummingbirds the whole bird is that big and the carina is that big. So, it can be really big to power these huge muscles whereas in an Emu or anything that has lost the power of flight it becomes very small and highly reduced. Now birds also have hind limbs right the legs and feet.

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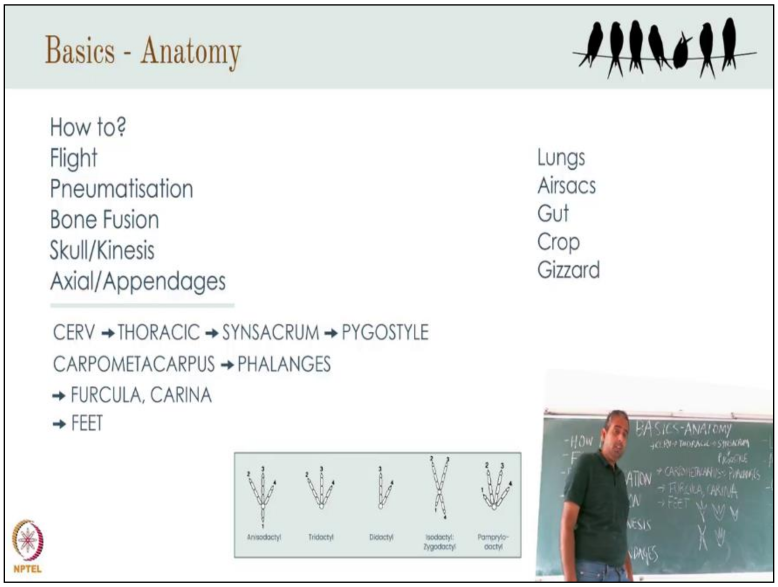

And these bones follow much the same articular pattern as our own bones do, all right until you get to the toes. The toes of birds do many different things, they can face in many different ways and you have many different classifications as a result of that. So, most perching birds are what you call anisodactyl they have got three toes facing in front and one toe facing backwards.

You have also got tridactyl - three toes facing forward and didactyl - two toes like the Ostrich facing forward try and did that you have got different kinds of toes. Now many birds are what you called isodactyl. Now what does iso mean they are symmetric and iso means they are not symmetric you have got three rows in front one toward the back. iso means that like Trogons and many other birds you have got two toes in front and two toes at the back.

Now these need not be perfectly symmetric you have got many different types of isodactyl feet I am just showing you the broadest kind here.

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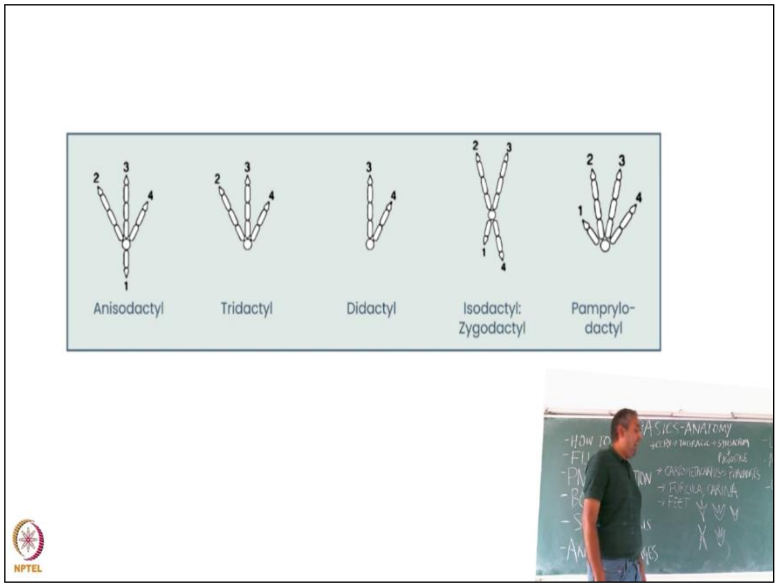

And then you have got a very specialized kind of foot that is found in Swifts and a few other birds where all four toes face forward like. So, this is called pamprylodactyl -for those facing forward. Now you do not need to remember this terminology this is just here for your interest and if you want to look up these terms you can actually see what the kinds of feet and perching devices that birds have are.

We might rather be more interested in you understanding how the demands of flight have led to basic concepts such as these happening and have overall affected the shape of the skeleton. So, ideally, I would want you to look at a skeleton and be able to say "aha that is what is happened here that is what is happened here" and think about it that way to know your way around the skeleton rather than necessarily remembering all of the specifics, okey, and that same holds true for most of the other systems and birds.

Now many of these systems are going to be covered in bits and pieces in subsequent lectures. So, I am not going to go into details of how a basic excretory or basic nervous system works. I am going to touch upon two things though - the respiratory and digestive systems of birds because they have got some special things that are not found elsewhere. Birds had lungs just like we do, but the lungs are only one component of their respiratory system above the lungs they have actually got two big air sacs the clavicular and the cervical air sac.

And then they have got two abdominal air sacs in the posterior as well. These air sacs you might imagine function in buoyancy because when they're full of air the bird becomes more buoyant like a swim bladder right in a fish. But that is not the case, birds actually have some very interesting utilities for these air sacs. What happens is when a bird breathes in that same air is not expelled until two breaths later. Allow me to explain.

When a bird breathes in the air goes straight into the posterior air sac. Okey. When it expels the first its breath this air does not come out it actually goes into a set of tubes called parabronchi and it stays there. Then the bird takes in another breath, when the bird takes in another breath this air goes to the front air sacs while the new breath goes straight into the posterior air sacs and then the bird exhales again and out comes this air.

So, the air goes posterior air sacs parabronchi one breathing cycle and then on the second breathing cycle it goes anterior air sacs and out. So, there is two things it means that the same volume of air stays inside the bird for longer which means that the bird can absorb more oxygen out of it, secondly it means that the flow of air is unidirectional, so there is no tidal mixing of air like our own lungs for instance in our own lungs old air and new air mix with each breath, a bird's lung does not have that because of the air sacs.

So, the air does not mix and you have got unidirectional airflow which is very good for getting the extra oxygen that you need to power a demanding activity such as flight. I am going to go into that in a little bit more detail in my lecture on physiology.

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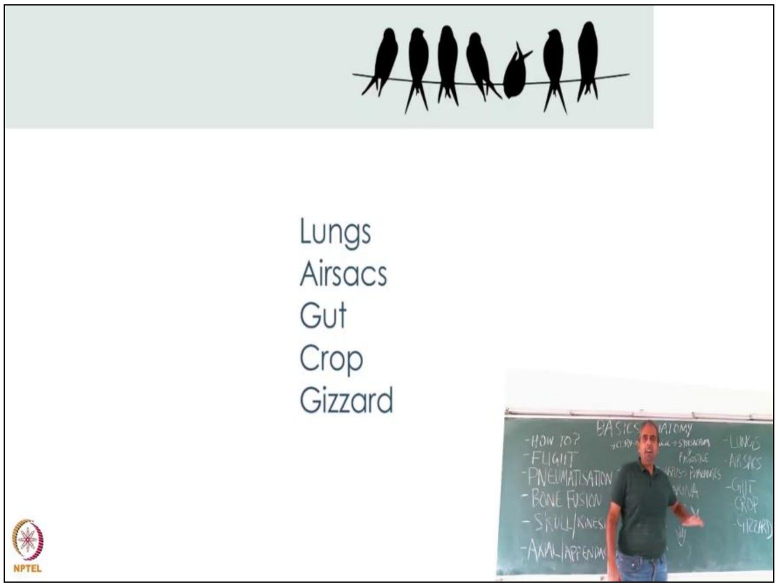

Bird’s guts also have certain specializations that you do not see as well. Now birds like Pigeons or Galliform birds, chickens basically have a pouch in the foregut called the crop. So, they can eat food really quickly store it in there and then digest it later they can also store food in their crop and regurgitate it for their nestlings. So, they have this storage pouch the crop that we do not possess and some birds actually can ferment food in the crop.

So, the there is a bird called the Hoatzin which actually has bacteria that ferment its plant food in the foregut, there are other birds that like us can ferment food in the hindgut we don't ferment food but ruminants do and they can they can actually ferment or digest food in the hindgut. Not so, the water birds also possess a gizzard which we do not possess and the gizzard is full of grit that grinds up the food because birds obviously cannot chew.

So, this grit actually helps grind up the food and make it more processed. So, that the digestive system can absorb nutrients better. That is why you will see many birds eating stones eating grit off the roads pigeons in particular will often come down on roads and tracks and they appear to be feeding there but what they are doing is picking up little bits of grit to help them digest their food. So, remember that there is a crop and a gizzard that helps digest food and birds are capable of digesting some very extreme things as you know many birds eat meat, many birds eat vegetables matter, many birds eat insects or fruit all of which sometimes are required to be processed especially hard tough foods.

And some birds eat very specialized diets like the Honey guide which eats beeswax and it has special bacteria that can help it extract the lipids from beeswax. So, that is my basic overview of anatomy of bird anatomy like I said this is not comprehensive, the idea is simply to give you an introduction that you can then go on and read more about and rather than getting hung up on terminology get more interested in the concept.

What is the bird using this anatomy for what do pneumatization and bone fusion do that supports various skeletal functions. And with that I will end my lecture on anatomy and we will move on in the next class to a sort of similarly brief overview of the basic principles of bird physiology, Thank you.