Animal Physiology
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Lecture - 30

Welcome back to the NPTEL lecture series on animal physiology, so I have given you, so today we will be discussing the digestive system. So, I had given you complete outline of the digestive system starts with the mouth. The food travels through the esophagus goes to the acid rich compartment of a stomach from there it moves to small intestine. And then via were the maximum absorption taking place an then moving into and absorbed to move into large intestine. And there are also some degree of absorption taking place, and then what so ever is not absorbed to rejected by the body is excreted in the form of feces. And in that whole track I have shown you that there are different organs, liver, pancreas as well as a well the very moment you swallow the food.

There are salivary glands which secreting whole bunch of fluids, which leads to essentially helps in the one second, which essentially helps in the digestion of the food. So, the way we will go I have given you the complete outline, and we have already talked about the sympathetic and parasympathetic. And the paratactic movement of the food along this whole track and I have highlighted. The cross section of the di track or digestive track so what we will do today we will divide the, this into 2 or 3 parts. The part 1 we will be talking what we will be discussing. Now, is the first set of chemical reactions which in the form of saliva from there what we will do. So, see you have to realize 1 thing this whole thing is basically a chemical reactor you can kind of comprehend. It as a chemical reactor were you have the input coming in a form of food and the output going as which cannot be utilized by the body.

And in that whole process there are channels were the major component of the food in a form of amino acid carbohydrates fats lipids. These are absorbed and these are absorbed by the blood vessels, which are surrounding this whole tube. So, what we will do first? So, we will start with the saliva we will talk about essentially the composition of saliva what saliva does second. We will talk about the formation of the saliva what how it is been controlled regulated third. What leads to the secretion of saliva these are the 3 things what we will be discussing in this class. And I will try to make it as diagrammatic

as possible. So, that you kind of get a feel exactly what is happening instead of you know getting into technicality of it. So, that will enhance your imagination.

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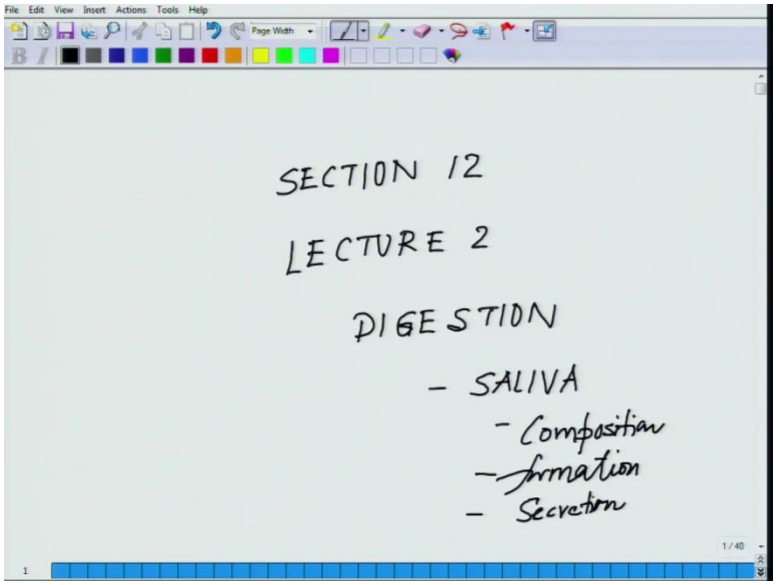

So, let us start with it we are into the section 12 of lecture 2 of the digestion so we will be talking about the saliva. So, we will be talking about composition of saliva that is the first thing we will be dealing then we will be dealing with formation of saliva. And then the secretion so why the secretion is very important is this. So, all of you must be aware that whenever we see something some good food you know we started salivate which is we start doing like that how that happens there is a whole range of a neuronal control which regulates that thing or we do not like some food.

We say yekh I do not want to eat that all this things are regulated by the higher centers of the brain. And so in other words essentially what does that mean is. That all your salivary glands which are present are all innervated by neurons by the sympathetic and parasympathetic, which are eventually regulated by the higher centers of the brain. It is a very well coordinated a kind of a very well coordinated signal response by virtue of which we respond to different kind of foods in a different way. So, now let us first of all talk about the composition essentially the composition going to the composition.

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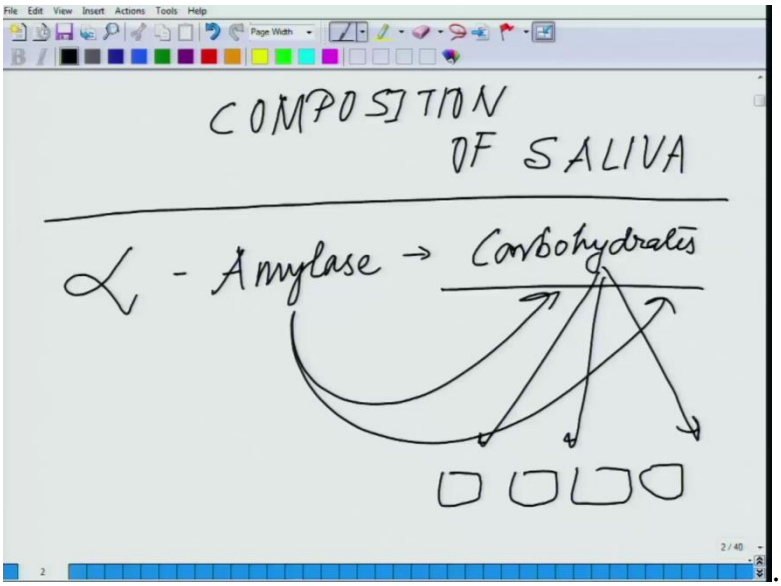

Let us go to the second slide the composition of saliva there are different composition of saliva different component of saliva some of the important component off course, includes. So, I will be highlighting some of the important component so alpha amylase so what alpha amylase does. So, alpha amylase essentially takes care of the carbohydrates. It is a major source basically in other row what it does it breaks it down into smaller components. And that is the major function so whenever you take something.

Say for example, you take a chunk of sugar or a sweet this is the alpha amylase is which goes started binding all over the place. And it start to you know cut the long poly peptide chains of these different carbohydrates into small, small, small, small pieces into small component. It is the more, smaller you go chances of that, it is being absorbed is more, more bulk it is lesser are the chances that it will be a it will be absorbed. So, fast apart from it always remember one thing saliva has certain role to play in oral hygiene it has some very interesting role to play we will come to that.

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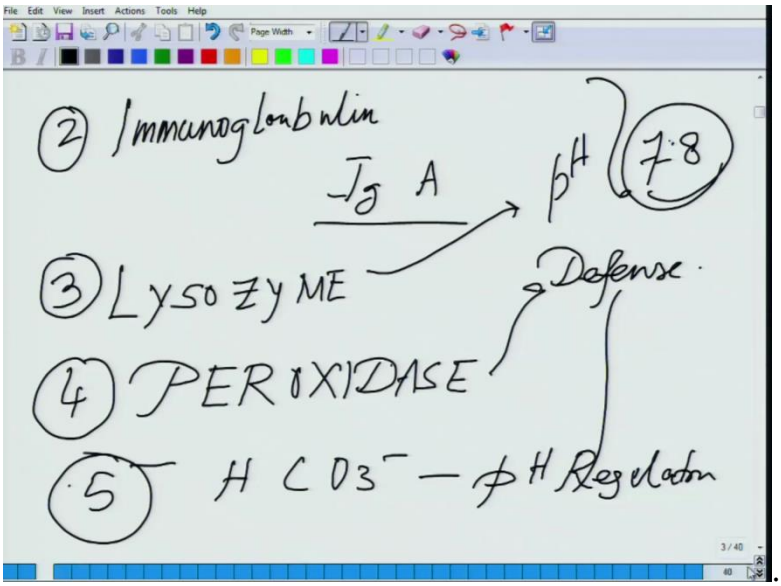

So, from here we will move on to the next component of that then you have certain immunoglobulin which are present which are immunoglobulin immunoglobulines are Ig A Ag A are present. There then you have think called lysozyme second component and this is the third component t then you have peroxidase. This is very important you all must have seen this you know. There are different peroxidase which are used for say for example, you take a food slightly contaminated with some pathogen bacteria or something. It is not that every time you fall ill, because body at every level has a difference mechanism it can take care of different pathogen. So, till it fails you would not fell ill so this peroxide is what it does if the food has some of these micro contaminant peroxide is tries to go and chop it off that is the function of peroxidase.

So, that is what I told you it has a role in the oral hygiene if your mouth has lot of bacteria or something you will spelling foul in your breath when you do like this. But your peroxidase concentration is right and peroxidase good manages to take care of this bacteria. And everything there are some which are helpful there are at here are some which are not helpful. So, peroxidase play plays that role apart from peroxidase what we have is peroxidase. Than we have very high concentration of HCO 3 minus this is involved in the pH regulation the major role and peroxidase is in the defense mechanism. So, do lysozyme so these are the major component and the pH of this whole thing is approximately 7.8.

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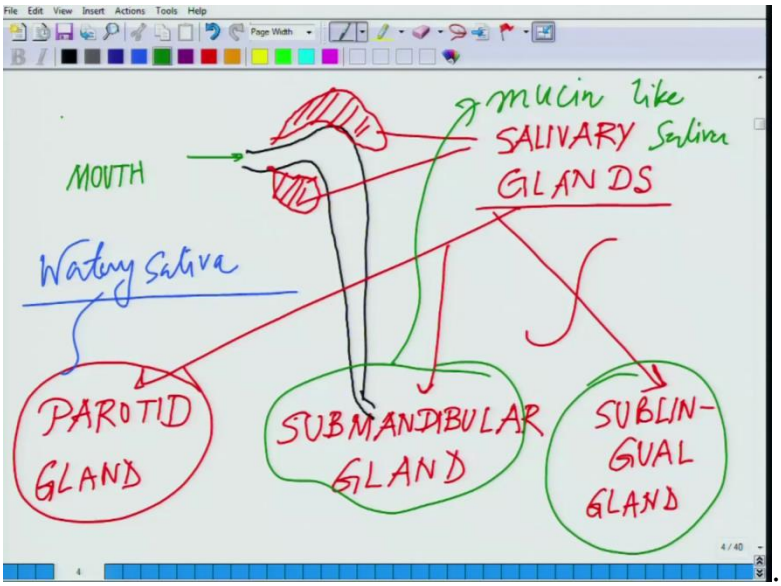

This is a around where ph of a 7 to 8 this is generally the ph of the saliva and if you kind of look at the anatomy how this looks like 1 second. The anatomy is something like this if this is the mouth and this is the gi track which is moving. So, out here you will see put up in a red out here you will see some of those organs which are sitting there. These are group of tree group of organs which form the, a. This is your mouth back of the mouth you have these salivary glands and. There are different salivary glands, which is present and they have different functions we will come to that there are 3 major salivary glands which are present parotid gland. And then you have submandibular gland, parotid gland some submandibular gland. And then you have sublingual gland and some total of this is parotid gland. They have different role to play this parotid just put it in blue this leads to more offer watery saliva.

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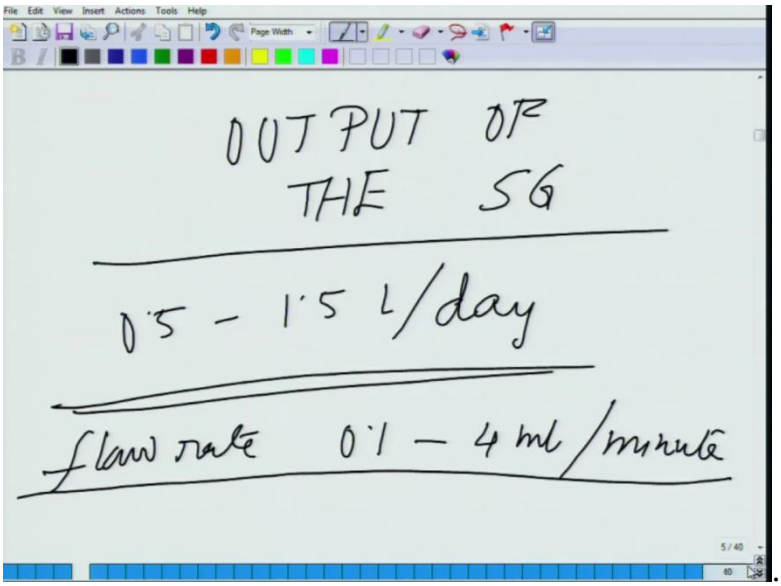

If different kind of secretion profile which is you know submandibular gland is more like put it in green mulching like saliva it is a polymer. And sublingual gland is basically the mucus more like mucus kind of secretion which takes place. And if you look at output of salivary gland output of the, I am just putting. It SG salivary glands is around 0.5 to 1.5 liters per day this is pretty much is the. And the flow rate of it saliva flow rate varies from 0 point 1 to 4 ml per minute. This is the pretty much is the, this how the saliva kind of a is kind of regulated or. This is the kind of amount of saliva, which is produced by the body by the mouth actually at any point of time.

Now, these structures which I just now drew for you submandibular sublingual and parotid they have very specific structure. And what we are going to deal now so now, we have I told you there are 3 aspects what I am going to cove. We will be talking about the composition of the saliva the organs which are producing saliva. And then we will be talking about exact formation of saliva these 3 what I mentioned parotids sublingual submandibular. They have specific cellular structures called acne they form this acinary structures are the one which involve in the synthesis of saliva.

So, what we will do I will just draw one of the generic acinary structure and I will show you I will kind of highlight the fact that how the formation takes place. And what are the signals which come so; it is what acinary kind of structure is. It is something like this say for example, there are secretes cell all around this cover it like this. And then there is a

duct, were all of them secrete and along the duct that fluid is formed. And that duct eventually opens up in the mouth 1 second just through. That through that duct the fluid is been secreted out and that fluid is in the form of saliva. And that secretion is controlled by the nerves system. So, that will be the third part of this class where we will be talking about what are the nerves impulse which sends signals asks that duct to open and secret.

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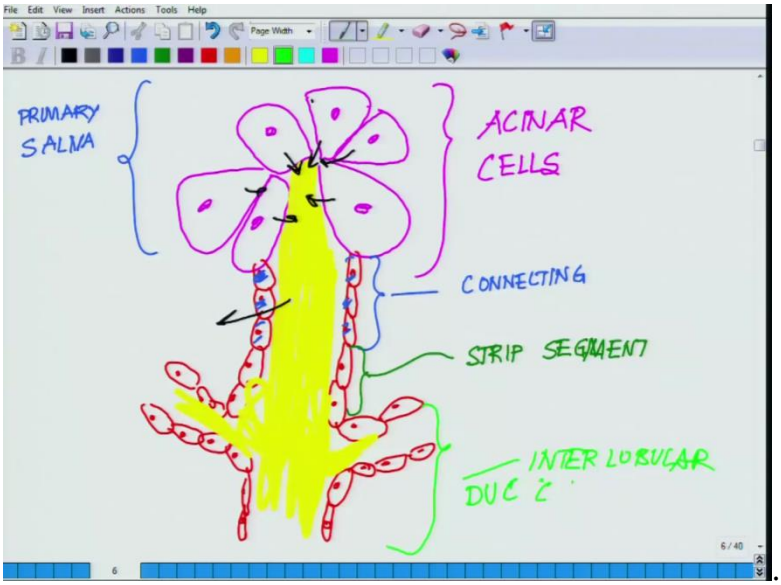

Now, what we will be doing? We are done with the composition we are done with the, a anatomy no. We will be talking about how the formation takes place in those duct let us getting back to the slides. The duct as I was trying to show you the duct look like more like this; this is kind of the structure of the duct like this. So, these are called this is where the primary saliva is formed. These cells what you see out here is kind of you know pyramidal kind of shape kind of cell body these are called acinary cells. From these acinary cells there is lining second set of cells which are present underneath are the lining out here. So, this is something like this these are called the connecting segments what I am doing. Now, is a individual lining individual cells which are forming lining of this.

Now, this part I will just put it in blue kind of you know just to give an idea this part is called connecting segment. Those are acinary cells which are involved in synthesis of saliva and this is where the primary saliva is formed as the saliva gets modified becomes like the. So, this is where let me just change it this is where the primary saliva is forming

and this saliva is actually flows down this. So, this is where all the secretions are taking place as I was trying to tell you this acinary cells are involved in. So, this is something like this and these acinary cells are essentially involved in the, they are involved in the secretions. We will come to that what kind of secretion the do and walls you see. There are lot of exchange which are taking place I will come to that so this is the, these are the connecting cells and.

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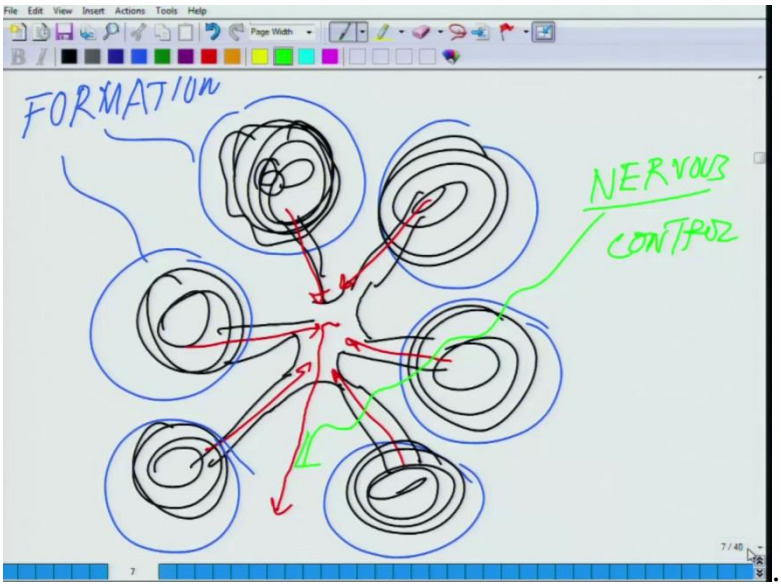

Underneath the connecting cells you have called strip segment something called strip segment, which lies some were here strip segment. And underneath the strip segment is set of cell which are present out here which are call interlobular duct. So, before I go into that du duct interlobular du duct interlobular duct. So, now, way it works is something like this so there are these acinary structures like this. And all over and imagine these are the individual I have shown you only 1 individual structure and these are you know dumping like a drain.

Than it forms a major drain like this so what happens if you go back to the previous structures this is 1 unit. And when kind of duct like structures are formed there are multiple such unit I have just drawn 6 for you and these multiple units actually. So, here are the secretion secretion formation so this is the zone where the formation is taking place all this blue what you see I am rounding. These off these are the, were the formation is taking place and then there are the duct system through which all this fluid

is moving like this. This is the duct system which I was drawing in the previous slide from here all this is being secreted under the control under very tightly regulated nervous control.

This is the overall geometry so it is like this u have this acinary structure what I just now draw were this synthesis another 1 another 1 another 1 another 1 likewise. Then there is a huge duct and again side there is a huge duct coming. And another side which is a so there are multiple such units around this parotid sublingual. And the submandibular parotid sublingual glands that whole structure is called acinary structure were all this kind of secretion. And as a matter of fact all across geology or anatomy if you look at it this kind of duct structure fairly similar to this. There are lot of cells around they form a duct kind of thing and were it all secreted. And it moves ok coming back to next slide 1 second so what we will do now this one thing.

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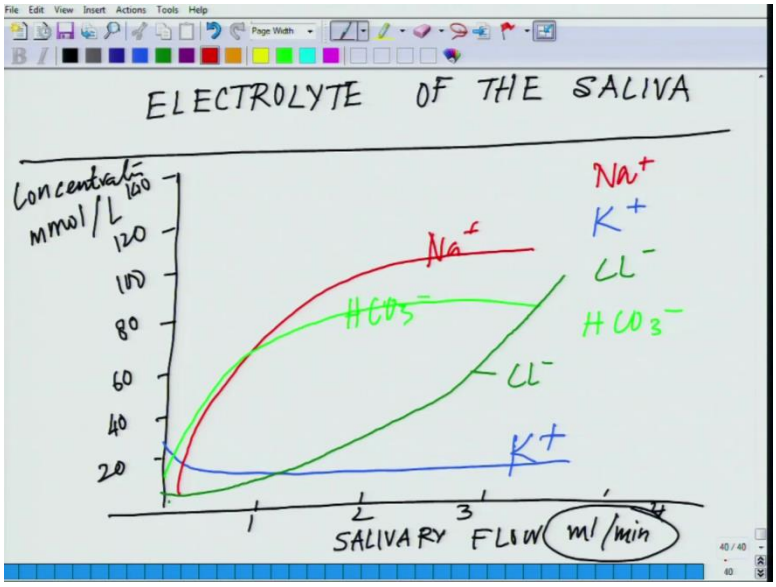

I just slipped of from my mind ado this will help you I told you the composition I did not tell you electrolyte in the saliva I will come to that. And again then again I will come back to the structure, because this will help you to realize something electrolyte of the saliva. And then we will come to the formation again because there is a very tightly regulated electrolyte concentration so the way x axis will be the concentration. And there is mili mol per liter just put it like this 20 40 60 80 100 120 140 this is 20 this is 40 this is 60 80 100 120.

Now, I will pick up 4 different colors for 4 different ions so I am picking up for sodium I am picking up red for potassium I am picking up blue for a chloride I am picking up green. And for h c o 3 I am picking up light green h c o 3 minus so if you look at it lets talk about. The sodium sodium concentration is something like this sodium a by the way. And the y x axis is your, is your showing your salivary flow salivary flow will be ml per minute 1 2 3 41 ml per minute likewise. And if you look at the profile of sodium sodium profile is something like this it goes up with this as secretion proceeds.

And if you look at the HCO 3 profile there also follows very similar trend like sodium slightly lower concentration like this where as if you look at the potassium concentration which is dark green. So, potassium will be something like that increases than it sorry something like this it remains far lower. And if you look at the calcium concentration this is very interesting which is shown by 1 second I did the potassium wrong I picked up the wrong color sorry redraw it actually so potassium is something like this and if you look at.

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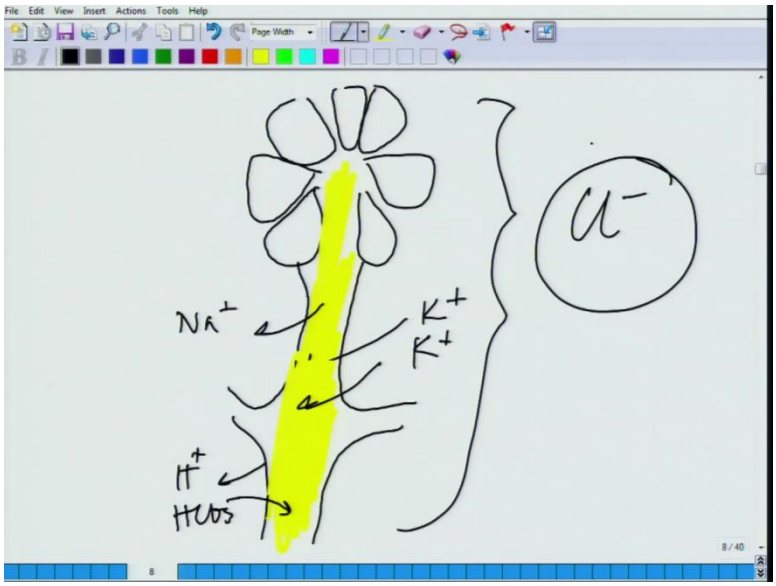

The chloride concentration so chloride concentration which is in dark green chloride concentration is very interesting chloride moves slowly. And it becomes like this so this is how the chloride moves this is your potassium. And then you have the sodium out here and this is the HC 3 so this is HCO 3 minus sign here you have the sodium. So, this electrolyte profile is very important, because now again I will be coming back to my, the

acinary structure were I was here I was. So, coming back to the acinary structure I will redraw that structure for you people so that we can talk about how this ionic.

Balance is maintained here so this is the duct which is getting formed and along the duct is the. And this is where all the saliva is getting this is where the saliva is moving and those are the acinary cells fine. So, now, along this there are, whole range of sodium and potassium and chloride channels and then movement is something like this. So, what you see essentially here so sodium moves out and there is a potassium which is moving in and.

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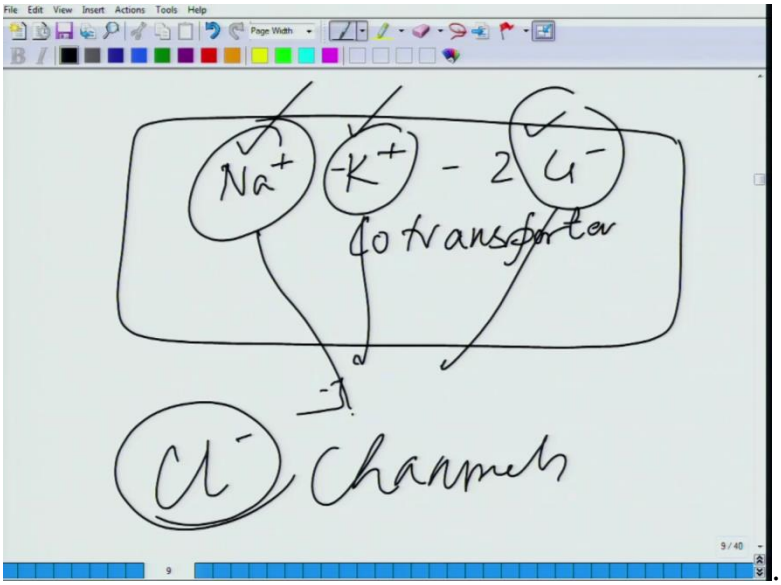

There are channels I will come in depth on those channels and h plus ions moving out and then we have HCO 3 moving in. And then we have mostly the potassium which is moving in and this whole process is being one of the major component in the saliva is the chloride. And chloride is being regulated here by a transporter called sodium potassium 2 Ca minus Co transport this is the major transporter which are present. So, if you look at it you are taking care of cat ions cat ions. And an ions negatively charged positively charged positively charged and this is all co transported along and they all enter inside the lumen inside the duct.

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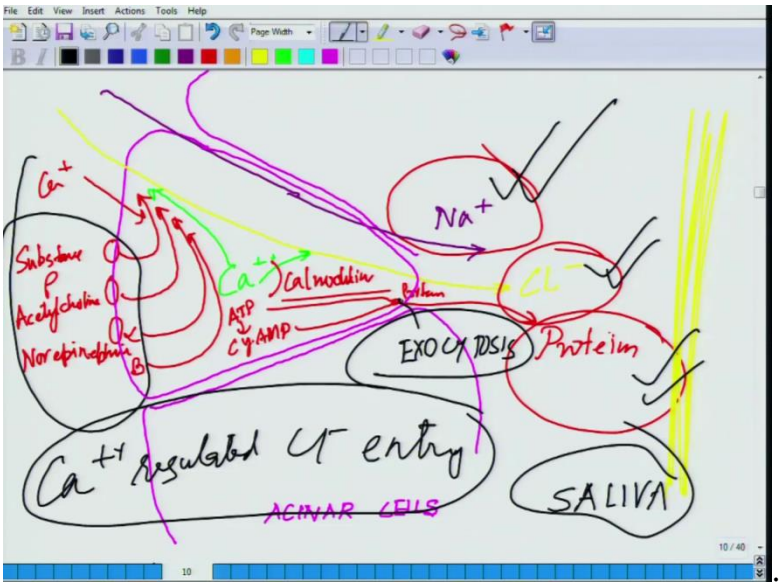

And there is a huge chloride channel population of chloride channels which are present there and these chloride channels are further regulated. Now, I will come on to the regulation part so what we will do in the regulation essential is that I showed you this structure. Now, at this stage what exactly is happening how the movement, are been regulated so we will be discussing that. So, if I highlight that part first picture I have showed you that now, I am highlighting the acinary cells the whole formation of the saliva. So, in these cells there are different of seen so these are the, I can just mark it acinar cells.

So, these cells need a lot of sodium to enter through flapulation of sodium is essential as I have shown you that is the highest concentration of electrolyte of saliva. And you need lot of chloride to get in so what regulates chloride this is very interesting to highlight here what is regulating? The chloride concentration chloride is been regulated by calcium and what essentially calcium does it stimulates. The chloride channels and calcium is regulated by another series of events, which I will be coming, but before that. There are other events, which are stimulating the entry of calcium into this game those are different receptors like you know substance p.

This is one kind of receptor acetylcholine, which we have talked about in a new muscular junction then you have norepinbin alpha. And beta sub types these all stimulates the entry of calcium they play a significant role in the entry of calcium once.

The calcium enters into the game calcium along with calmodulin dependent model stimulates. The chloride channels to be open and this calcium further gets activated by the cyclic amp. The presence of cyclic amp from amp I have talked about this cyclic amp with you guys the cyclic amp along with calcium leads to the secretion of certain proteins. So, these proteins are also entering here so now, we have proteins which are entering here and we have the chloride, which are entering here calcium which is entering here. And all this eventually form that whole saliva which is formed here this, what makes your saliva.

Now, if you look at that previous graph which I have showed you out here not this one not this one not this one may be the 40. If you look at this graph saliva has a huge concentration of sodium huge concentration of chloride N a C O 3 now if you look back out here. That will help you to one second now if you look at it so; this is where sodium is being getting though. So, there are gated sodium channels chloride is being regulated by multiple roots through calcium specially. And calcium is been regulated further by this different substance p acetylcholine norepinbin. And then that calcium not only regulates chloride entry calcium regulated chloride entry. So, this is very highlighting feature here calcium regulated chloride entry that calcium.

Further plays a role in secretion exocytose of so here exocytose of proteins so and this whole complex eventually links to the formation of saliva. So, this is what I wish to highlight that this is the very tightly regulated event where nervous system plays critical role in the formation of saliva. So, you see there is a role of norepinbin activating the alpha and beta agonistic receptors acidic colin activating. The cholinergic receptors see substance p all this 3 regulators are calcium concentration calcium higher calcium concentration regulates. The chloride entry the entry of chloride is further controlled by other mechanism, which are present in the form of transporters.

Whereas, the sodium enters directly and then the whole composition, the fluid in the presence of HCO 3 which is HCO 3 minus which is maintaining. The buffering the, it the presence of and then sodium you have this chloride. And then you have bunch of proteins which makes so it forms a very complex mixture of different electrolyte. And proteins and enzymes and even peroxides I told you the opposition. And pre oxides which makes it very essential that is the first set of chemicals to which a food is exposed to where it kind of started kind of making the food muse kind of thing, muse kind of

boles which eventually goes through your esophagus. And then it reaches the, your stomach were it is exposed to a very high acidic environment from 7 to 8 pH it goes all the way to 1.

That is the shift the food experiences now, what we will do? We have talked about let us summaries what we have talked. We have talked about the composition of the saliva we have talked about the electrolyte composition we talked about the organs which are involved in making saliva. And the rate at which they make then we talked about the exact formation along. The acinar cells how the how along, this duct all these things are formed. Then we talked about role of calcium role of calcium calmotudune role of cyclic amp in exocytose along with calcium. Then we talked about what regulates the calcium entry and how calcium regulates the chloride concentration entry? So, now what we will do the third part last part of this class is we will talk about all the neuronal control which regulates salivary secretion in all body coming back to the slides. So, next slide is wile we will be talking about we will be drawing the…

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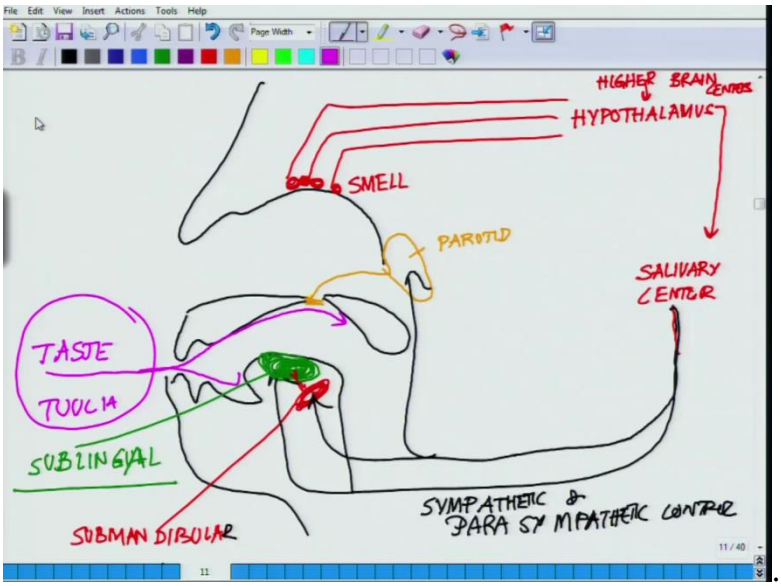

So, what we will do the easier way to draw is something like this because there are multiple receptors involved here. So, this is essentials you know because that also plays a critical role just draw it then ever thing will make sense to you guys. So, this is where you have the smell receptor coming because you know by smelling a food your saliva starts secreting. So, this are controlled and these are the smell, smell of a food and this is

controlled by hypothalamus. And which is further controlled by the higher centers of the brain higher brain centers this is the first level then that same hypothalamus controlling. The salivary centers from here to here you have let me put the some dark color to help you to understand here you have a parotid gland parotid.

And here you have just underneath your teeth out here you have the sublingual very close to it sublingual and very, very close to it some were out here just out. And this is all connected with each other by the way is submandibular glands. So, these all are connected from the salivary centers these all are connected by 1 second these all are connected by this sympathetic. And parasympathetic and further this all this also connected to the parotid these are the sympathetic and parasympathetic control. So, this is where all this controlees are taking place and apart from it there are another set of controllers which are present here which includes here whose receptors are all over here. This is those are the taste and touch they are all connected with higher centers of the brain.

So, essentially what is happening is that this whole thing is been controlled at multiple level is controlled by the higher centers of the brain which are telling hypothalamus to act or hypothalamus receives. The signal that it acts vice versa it is a 2 way traffic and underneath your salivary centers which are controlling all these secretion by employing the sympathetic. And the parasympathetic route were, is apart from it you have this smell centers you have the touch when the food comes in contact. And apart from it you have these taste buds which are also sending signals to the brain it is a very complex process. And a very complex computational process by which saliva formation is been regulated by the nervous system.

So, to summarize we talked about composition we talked about the electrolyte composition. We talked about were saliva is been formed and how it is been formed sodium channels which are there; There are sodium potassium chloride co transporters which are involved in it. And then we talked about the exact anatomical features of the acinary cells which are involved in the synthesis of the formation of the saliva along it is duct system. And we I tried to give you a visualization how the duct system really looks like. And here we are closing in the lecture by the different nervous system roots which are controlling the secretion process of the saliva. Thank you and next we will move on to after this to the stomach where we will be talking about exactly in the same fashion.

We will see what are the different secretion takes place, what kind of changes take place in the food once the food from 7 to 8 pH gets into a chamber which has a pH close to 1.

Thank you.