Animal Physiology
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Lecture – 39

Welcome back to the NPTEL lecture series on animal physiology. So, in the last section we talked about the pancreas, and we talked about the exocrine secretion of the pancreas. So, today what we will do? We will talk about the endocrine secretion of pancreas. So, in the last class, I did the complete anatomy of the pancreas and I showed you the highlights of langerhans, and within highlights of langerhans, the alpha shells and the beta shells. So, today we will talk about the different functions, endocrine functions of these and how they regulate the glucose metabolism in our body. Just a mild recap before we proceed further.

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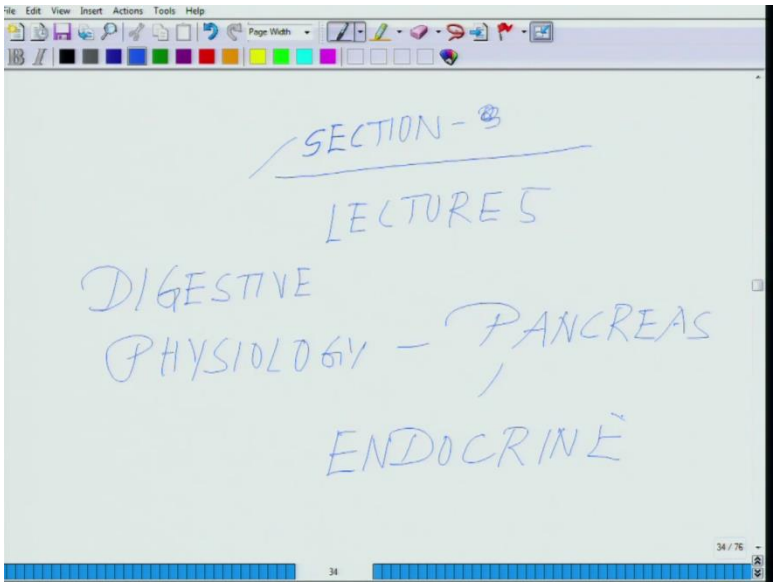

So, you are into section and this is lecture 5, section digestive physiology and we are into the section of pancreas and endocrine functions.

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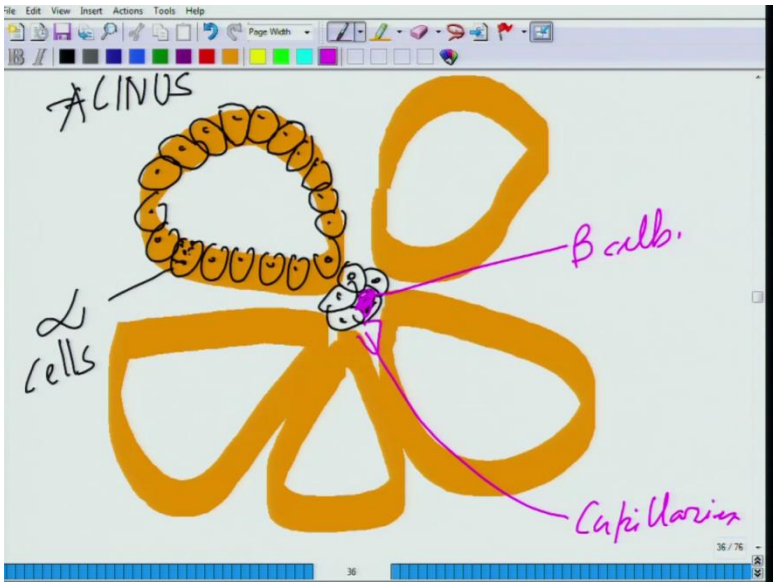

So, in the last class I drew this. So, I am redrawing it for you, something like this what we drew? So, these are the duct in the pancreas and where the cell sitting like this. So, these are the acinus and you have some of these cells, which are the alpha cells and there are few other cells in close proximity, where the structure is more like in a compact structure like this. So, these are the beta cells and then you have, this is the cross section I am showing. They are here the capillaries, which are supplying the blood out there and this whole structure is called the…

So, this is the recap of the pancreas cross section which I drew last time, and I told you that some of these cells are involved in the endocrine function. So, the major hormones which are secreted by pancreas are insulin and glucagon, what they do. So, before I draw the schematics try to understand. So, whenever we take any food, say for example, you are taking bread or rice or something, which is rich in carbohydrates. So, what essentially happens is that, carbohydrate is broken down into small sugars. The smallest sugar or the function sugar which body utilizes is glucose, it could be glucose, fructose, gelatos, mannose likewise you know.

So, then this glucose, so automatically what happens, when we are eating. So, within the blood, the glucose level shoots up, when the glucose level shoots up, body has to have a mechanism to pull the glucose inside into some storage vessel, why is it is, first of all you understand, why there is a, why it is essential the body cannot have lot of glucose in

the blood. Because, if the concentration of glucose goes up, what essentially happen, when the urine is formed, see urine will have lot of glucose. And if urine has lot of glucose in it, then glucose will pull a lot of water molecules from your body along with it.

So, you will be urinating at a faster rate and you will be losing a lot of water. In that process, what will happen is that, a person will be dehydrated and if this proceeds further, the person will have serious problem. And this is exactly what happens, patients suffering from diabetes; you have heard this word that I know. Diabetes is kind of very prevalent and as a matter of fact, India is the capital is considered as a capital of diabetes, because there are way too many diabetes patients in the years to next couple of decades, this will be a huge challenge for India

So, essentially a body needs a mechanism by which it can pull the glucose, those glucose molecules back to some storage area, how body does so... So, whatever you are eating, there are certain signals which are generated, by the nervous system, by surrounding cells and everything, that request pancreas to secrete insulin. And insulin promotes absorption of glucose molecule both by the liver, as well as the other organ, where glucose is converted into glycogen, which is a polymer of glucose and much more stable, which cannot be utilized directly.

So, now this is the major mechanism by which glucose is being pulled out from the blood stream. But, now the body is in a starved state, body needs glucose. Suppose, you are running for a, you are coming from a long distance run or you know, you have done lot of hard work and you do not have glucose at that point in your blood stream. So, there is the opposite set of signals, which are generated within the body. And those signal links to the secretion of another hormone, which is secreted by the pancreas itself called glucagon, what glucagon essentially does? It out to smarts the insulin signal and leads to the breakdown of the glycogen which was restored.

So, again the blood glucose level goes up, till the body utilizes it for all it is maintenance requirement, but again insulin is there, it is the check post. So, it is the insulin glucagon check post, which regulates the blood sugar level. And if there is a problem in this check post then this leads to either hypoglycemia, where there it is lack of a sugar in the body or hyperglycemia, when there is excess sugar in the body, in the body means in the blood

stream. So, these are the two extreme situations and hypoglycemia or hyperglycemia is being regulated.

The check post is insulin and glucagon and the master organ which takes care of it is your pancreas. So, this is the overall summary, so what I will do now. I will just draw these things. So, that it kind of you know, it gets engraved into your understanding and in future, if you want to do on in depth study of this, then you can go further. So, coming back, so these are the and of course, we will be highlighting, that weak cells produce what, what alpha cell does, what beta cell does and how these things, all being regulated.

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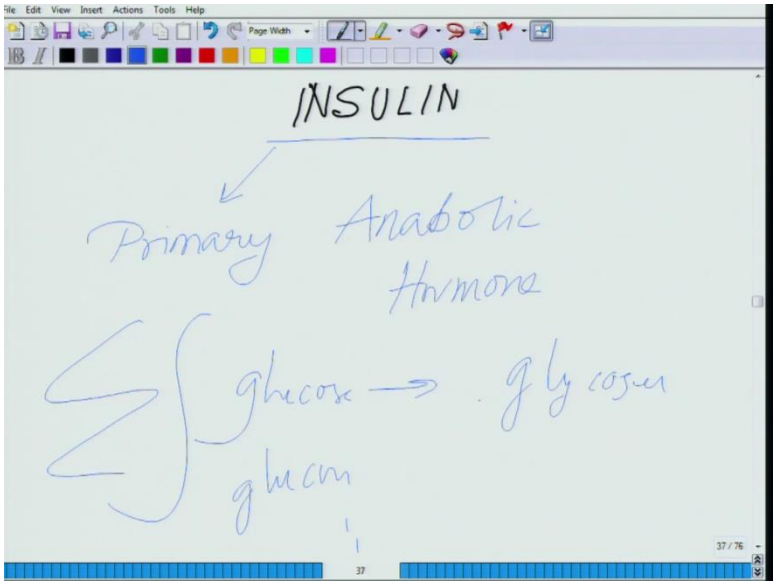

Back to the slides, so basically, what is essentially happening is, insulin could be considered as the primary anabolic hormone. So, since I have been introduced this term anabolism, anabolic, what is the meaning of anabolic? There are two words anabolic or catabolic. Anabolic means when from small, small pieces you are building something. Say for example, you have individual bricks you are making a building that is an anabolic process. Catabolism process is that you break the building.

So, when the glycogen is forming from individual glucose moiety that is called anabolic, anabolism or anabolic activity and when glycogen is broken down into individual glucose components that is called catabolic activity. So, insulin is an anabolic enzyme, which leads to the addition of the glucose, glucose and likewise to glycogen this. So,

integration or summation of this leads to the formation of glycogen. So, that is why, it is called an anabolic hormone.

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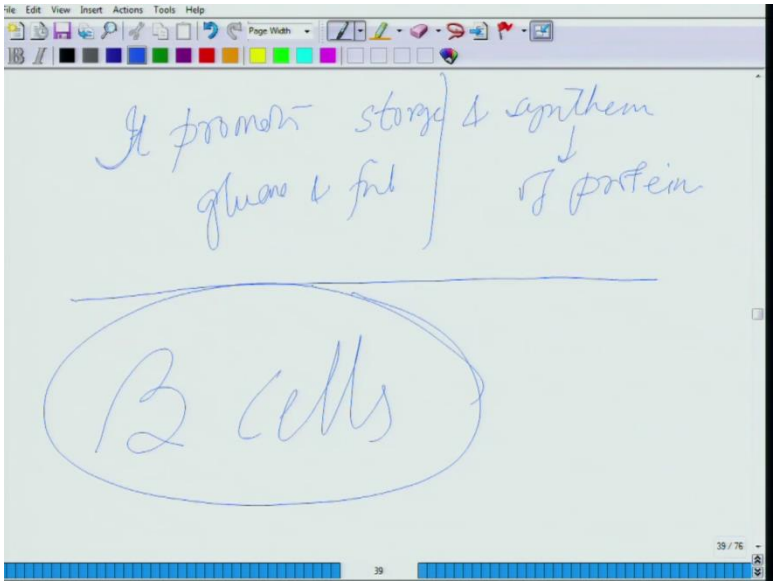

And second thing is that, it promotes the storage of the glucose, fat and synthesis of protein, storage and storage of glucose and fat and synthesis of protein. So, it is secreted by the… So, I showed you that is alpha cells and the beta cells. So, it is the beta cells of the langerhans who in the pancreas, which are involved in the secretion of the insulin. And this name, it has got from a transcription factor, this langerhans cells.

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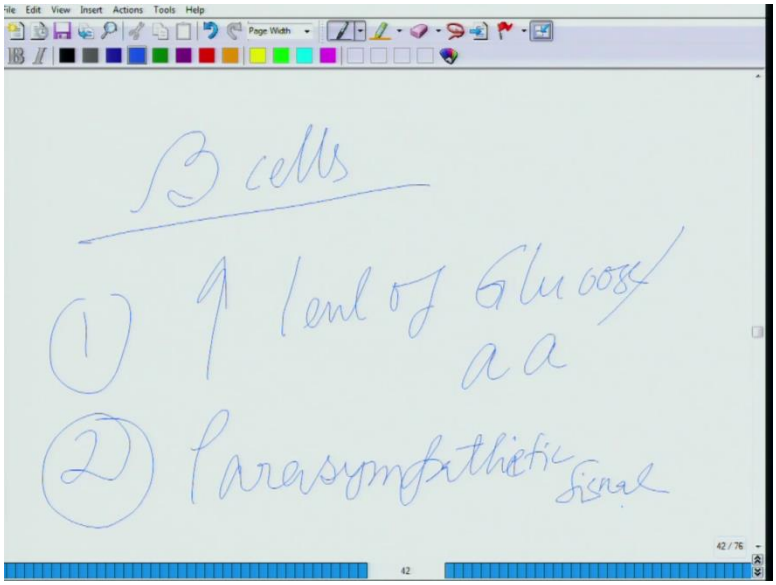

So, what regulates it? one second. So, first an increase, as I was telling you increase level of glucose first thing, second thing or increase level glucose or amino acids. Second thing, there is a parasympathetic signal with signal.

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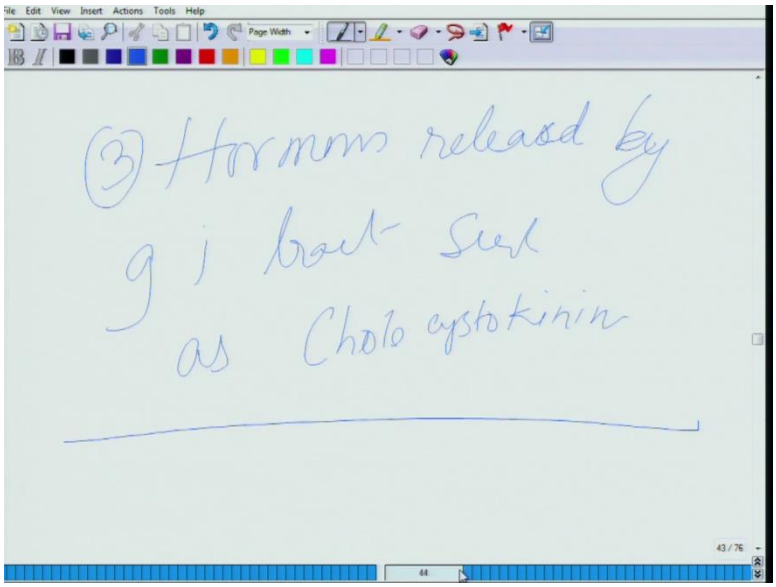

And the third thing is hormones released by g i tract, such as Chole cystokinin. So, these are the three major factors, which leads to the secretion of a insulin, but then what insulin essentially does. So, some of the things, what insulin does is that, it promotes the diffusion of this glucose moieties into different storage areas, maybe in the muscle, the liver and several other places. So, let us enumerate those, what are the different roots what insulin follows, out of that what are the different approaches insulin follows to kind of you know, channelize the glucose at different storage units.

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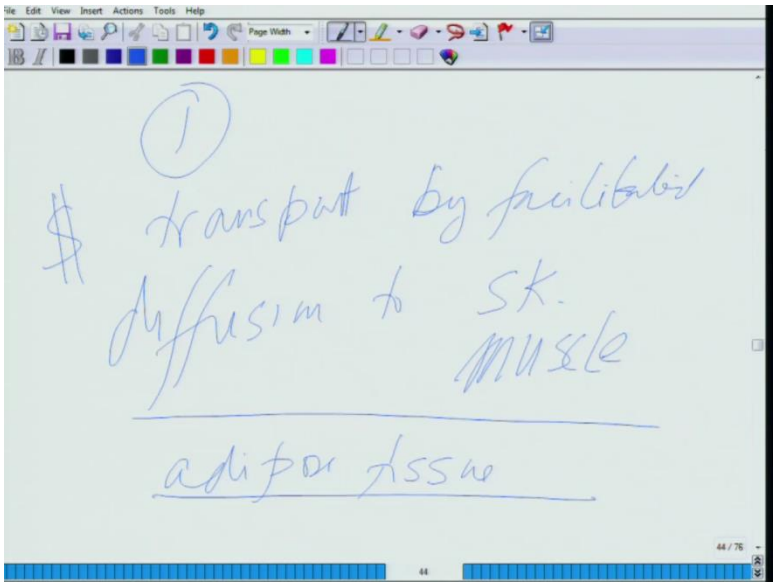

Let us enumerate that in the slides. So, the first thing it as is stimulates. So, it is stimulating transport by facilitated diffusion to skeleton muscle, where you need a lot of energy to adipose tissue that is in your buttocks and all other places, where there is a lot of adipose tissue.

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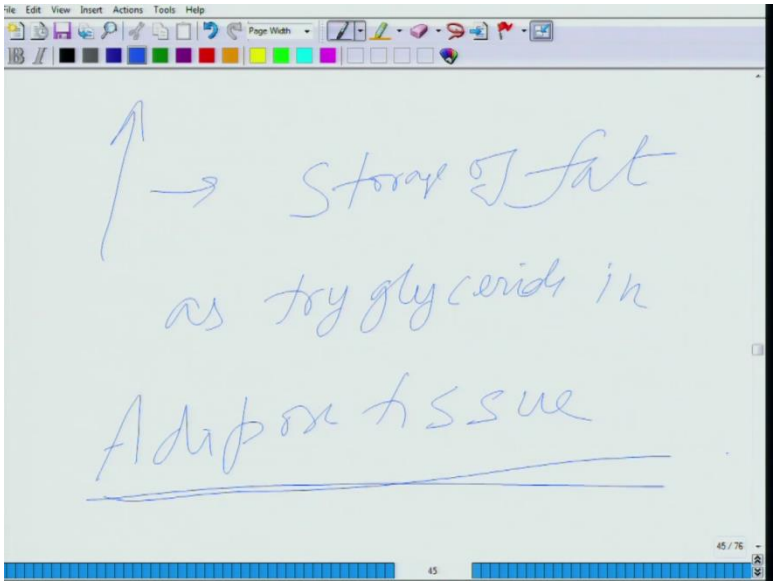

And insulin also increase, insulin also increase the storage of fat as try glyceride in adipose tissue. So, these are the major function of insulin, in terms of how it mobilizes the different individual units like glucose, fatty acids, amino acids likewise. And

eventually in that whole process, some of these amino acids or even to glucose. So, these are the overall schematics, how the insulin functions secreted by the beta cells of the highlights of langerhans and what the alpha cells does. So, those are the cells, which are involved in the secretion of glucagon.

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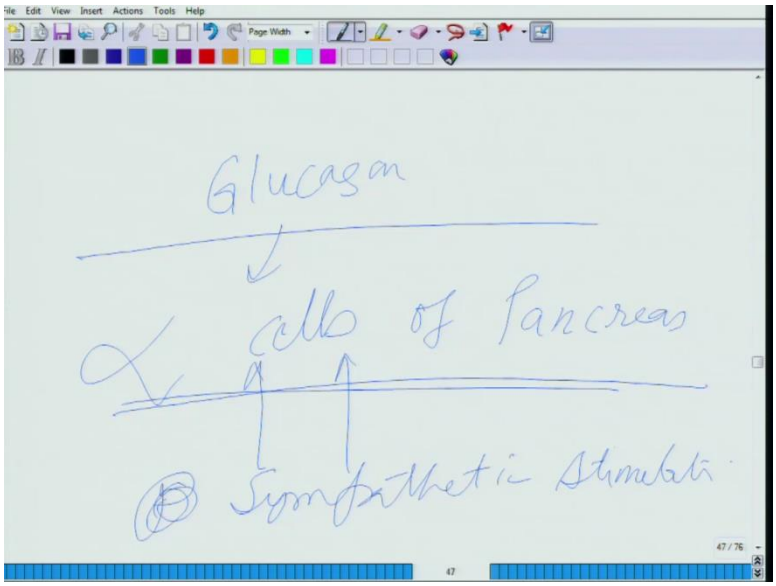

So, let us enumerate the function of glucagon in the slide now. So, glucagon which is basically secreted by the alpha cells of pancreas and this is in response to the secretion is in response to sympathetic innervations, sympathetic stimulation. So, here I wish to highlight something, if you just remember the previous slide. The insulin secretion of the stimulated by the parasympathetic and glucagon stimulation is influenced by the sympathetic. So, I told you while, I was teaching you sympathetic and parasympathetic, they have opposing function.

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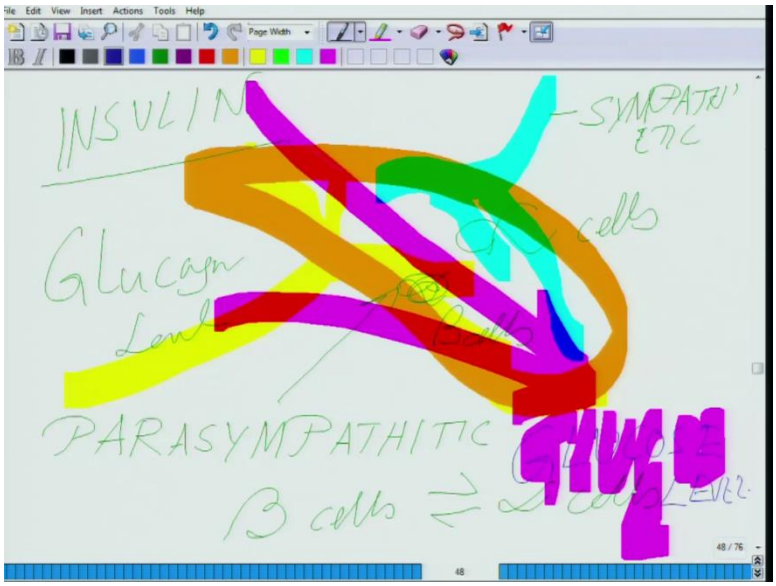

So, look this is a situation, where on the same organ. So, if I just put it in terms of, so if this is a structure of the pancreas. So, it has two sets of innervations which are coming, one set which is and the other set is like this, this is how the whole thing is being regulated. So, these are the parasympathetic, which are influenced the beta cells and these are sympathetic, which are influences the alpha cells. And there is always and dynamic equilibrium between the secretion of alpha and the beta cells, which regulates essentially the insulin and glucagon level. And that essentially, actually controls your glucose.

So, one second that is essentially controlling your glucose level. It is a very tightly controlled regulated mechanism. So, then what is diabetes? Diabetes is a situation when the beta cells of langerhans either fail to secrete insulin, the capacity to secretion of insulin is compromised or they get damaged, because of some situational pancreatic or something like that. So, that is the situation, when your body is continuously is unable to regulate the insulin level, unable to regulate the glucose level and lot of glucose is being lost, through a urine.

And they are by leading to excess amount of fluid loss from the body, which has its effect ((Refer Time: 18:08)). It has it is effect on the blood volume, on a blood pressure, on a dehydration, on all every chemical reactions within the body, every biochemical reactions within the body. So, if you see a diabetic patient, there are lots of complications

associated with this whole process. In those complication I think by this time should be clear to you, why those complication arise, because the blood volume or the water volume is being compromised, body is unable to regulate it.

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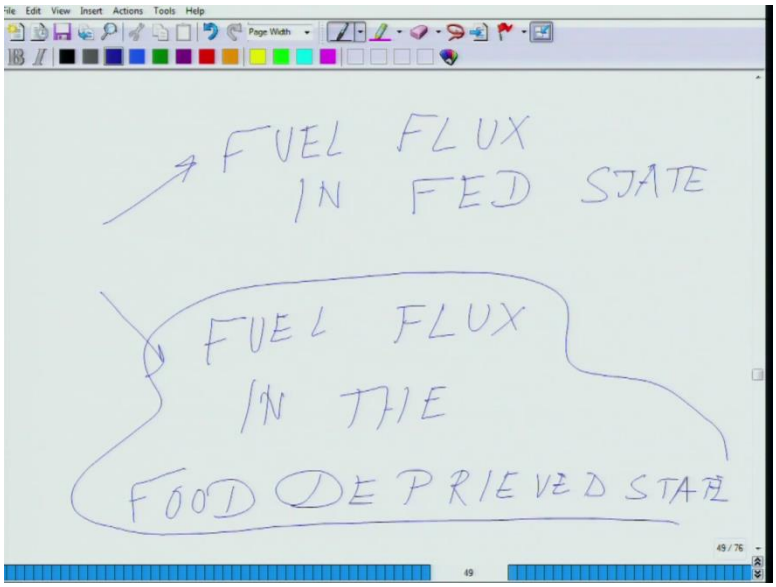

So, coming back to the slides, so this is pretty match is where we are setting and if I had to put it in terms of. So, there are two terms which may those of you go through different text will come across one is called the fuel flux in fed state, and the second is that fuel flux in the food deprived state. So, both of them explains exactly, what I was trying to tell you, fuel flux in the fed state. So, when there is a fuel flux. So, in other word, what I was telling you in the beginning, while you take a food, it gets broken down by the digestive system into smaller components, in case of proteins.

And it broken down into amino acids, in the case of big lipids; it gets broken down into fatty acids, cholesterol. And in case of carbohydrate, it broken down into which is the major chunk of our food actually, the bulk of our food, it gets broken down into simple carbohydrates like glucose, gelatos, mannose, maltose likewise. So, that is the situation, which we call as a fuel flux and when there is a fuel flux, there is a increase in the insulin secretion. And then the next situation, when there is a fuel flux in the food deprived state. So, that is the time when a glycogen has to be broken down into small pieces.

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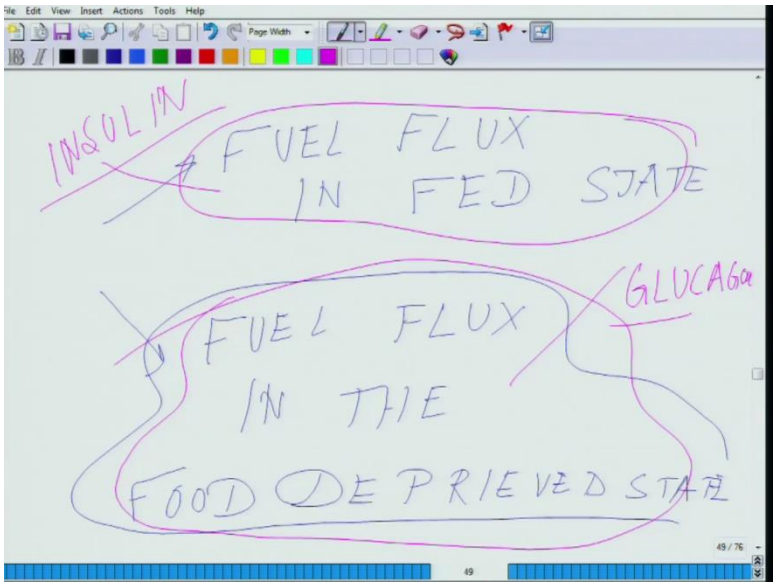

So, that is when, so what we talked about. So, is this situation, fuel flux in the food deprived state is regulated by glucagon and this one is being regulated by insulin. So, this is basically are the two mechanisms which regulates, your bodies glucose level all the time and thereby helping you to maintain the balance.

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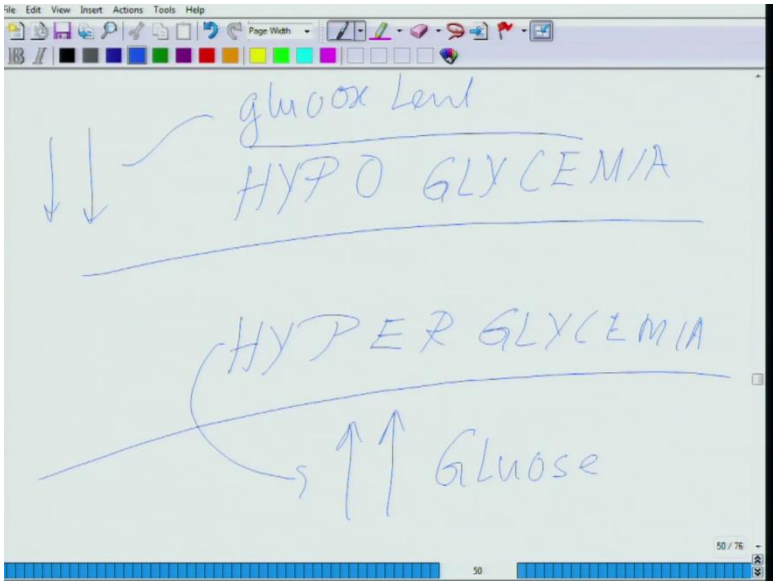

And there are two more terms, which is of importance are, which I have already mentioned is hypoglycemia and there is another called hyperglycemia. Hyperglycemia is the situation, when your glucose level is high in the body and hypoglycemia is a

situation, when glucose level is low in the body. So, based on this, the action of insulin and glucagon is regulated. Then how we test all these things in the clinic? There is something called a glucose tolerance test, what the doctor essentially does is that?

If the suspicion, what they will tell you, if they suspect that the glucose metabolism has been compromised in your body, what they will tell you. Though two tests they will tell, one is after fasting and one is after feeding. So, what they will do, they will ask you the tomorrow morning you come to the clinic or wherever you are giving blood sample. So, they will take a blood sample, after the whole night you have not eaten anything, early morning you go and you give a blood sample.

So, what the doctor will do, they will analyze the blood glucose level after fasting, this is after fasting. Then they will ask you, you take food and come back after two hours. This is the situation, when you had ((Refer Time: 23:01)) your body is fairly high in terms of glucose. So, then they will measure the glucose level. And then after sometime, they will measure again to see, whether the glucose level comes back to the original situation or not, where it was.

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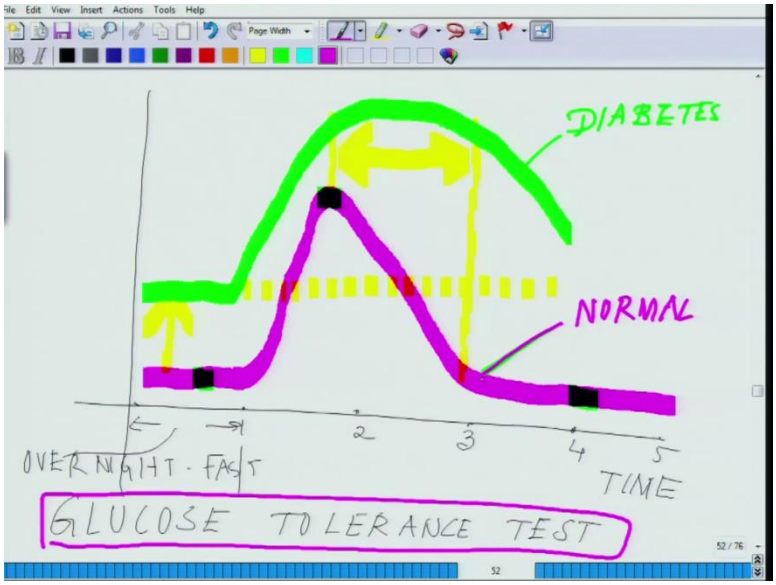

So essentially, the chart looks like this, draw it for you. So, it is something like this, if you draw it, so this is the overnight fast. So, if this is in terms of time, in terms of hour and this is we are talking about the glucose tolerance test. So, 1 hour, 2 hour, 3 hour, 4 hour, 5 hour likewise. So, this is an overnight fast, this is a situation of you have not ate

anything during night or after dinner you have not eaten anything. So, I am calling it overnight fast, after the overnight fast, so at this point, the blood your, it shows like this.

Then, as soon as you do a fasting, it goes up like this, and then after 3 hours, it is starts falling, because this is normal, this is how it is. So, if somebody picks up sample at this point, at this point and at says this point just fine. So, I know that it has come down to the baser level, but then what happens in a diabetic patients, how the profile changes. So, now what I will do, I will draw the profile of a person, who is having diabetic. So, in the case of diabetic patent, the profile goes like this, it goes like this. First of all, the baser level is higher, and then it goes up and it remains for long time and it cannot come back to it is baser level.

So, if you look at it is a baser level is somewhere out here for this individual. So, anyway he or she has a higher level and it is a still not coming back whereas, if you look at it in the other situation it has. So, if you look at it at this time, still it is maintaining. This is the zone why it is still maintaining whereas, if you look at it, this is filled in narrow, it is a kind of tipped. So, this is a case of, this is a diabetes, diabetic patients and this is the normal individual, and this glucose tolerance test gives you feel of what is exactly happening in your body. So, what are our options for a person, where he or she suffers from diabetes?

One of the option is that, if someone or other using a stem cell biology could be may pick up any cells of the body and you know make highlights of langerhans, beta cells of highlights of langerhans and put them back into the pancreas, which is a dream approach. Other than that, the only other option which is currently being practiced all over the world, people have to take insulin injection. They carry this insulin pouches with them and then they you know, they have certain sequence like you know, before taking food, they take an insulin inject or just after taking food or before to something like that.

They take the insulin injection to ensure that the glucose molecules are being you know diffused into what I showed you, diffused into skeleton muscle, into liver and all other places, so that they could be stored. So, till regenerative medicine has a way to develop alpha cells, beta cells of highlights of langerhans or even alpha cells for if somebody as a glucagon on problem. So, till that time, we are solely dependent on insulin injection. So, that is the state of art currently across the world. So, maybe a time will come, when we

will have those regenerative medicines, where the cells will be able to synthesis, you we can put the cells back, which are beta cells have the ability to produce insulin, so this is one aspect.

So, from here, I will move on to the another major organ, which is, which plays a very big supporting role in the digestive system is the liver. In case of liver, part of it we have done, if you recollect while I was showing you how, liver has several functions. One of the major functions is that liver helps in getting eliminating the byproduct of a, one of the major byproduct of red blood cell degradation. So, I will just take a recap and then I will talk about few other things on.

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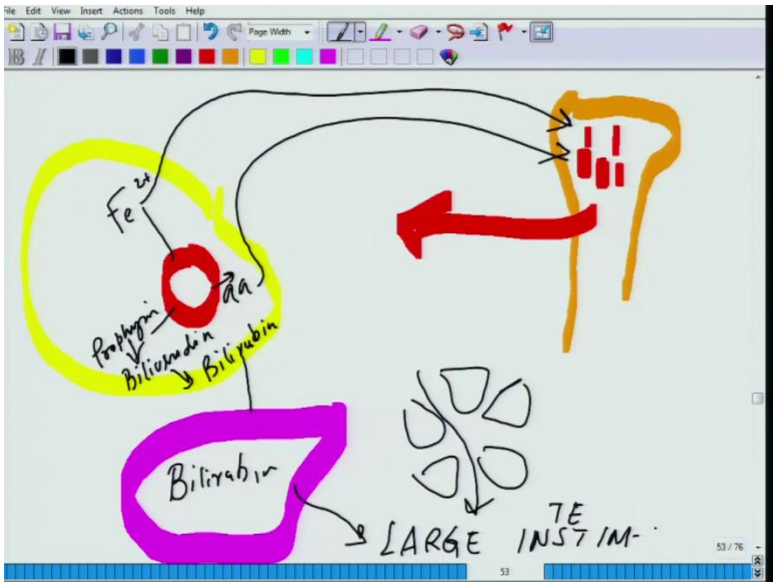

So, if you remember, while we were talking about the red blood cells like, I within the bone, these red blood cells are formed and these red blood cells have a life of 128 days. And I told you after 128 days, what essentially happens is that, their oxygen carrying capacity is reduced and these red blood cells are being engulfed by the white blood cells. And once there are engulfed into the white blood cells, so red blood cells have this haemoglobin.

Haemoglobin having force of unit alpha one, alpha two, beta one, beta two and in the center, you have a prophyrin ring, in each one these alpha, alpha beta, beta, they have a prophyrin ring. Within the prophyrin ring, there is an iron and is this iron to with the oxygen binds. So, iron has to be retained back by the body. So, the first thing happens

after, so this is essentially what happens here. So, these red blood cells come inside, this white blood cells which I am showing in yellow. So, here, here, here is the red blood cell inside and then what happens is this.

So, then this iron F e 2 plus, this iron using different seeder of votes is brought back, looking down into amino acids, which are again brought back to the bones, whereas the prophyrin ring is transformed into biliverdin and then this is made into bilirubin. And from here, this bilirubin is transported into the organ, what we are about to talk is into the liver. So, while actually this reaction now, prophyrin ring without.

So, the first thing which happens is that from prophyrin the iron is being removed and that process is promoted by oxidation reaction. Followed by that, there is an enzyme called biliverdin ((Refer Time: 31:18)) which leads to the transformation of biliverdin to bilirubin. And then this bilirubin along the blood vessels moves to the liver. In the liver what happens, they are two fates which bilirubin met out here in the liver. So, liver has this canal like structure, from where this bilirubin is essentially transported to the large intestine.

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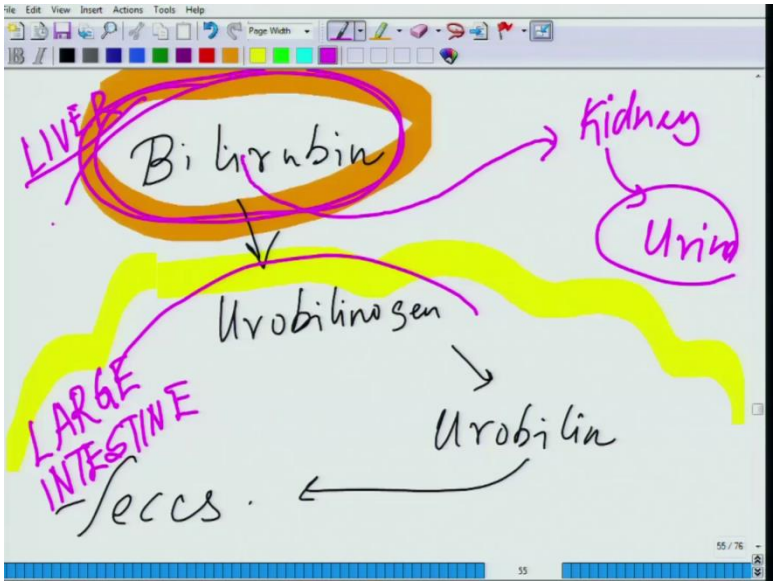

So, in the large intestine, bilirubin is formed into urobilinogen and then this is transforming to urobilin and this is excreted from the feces. This is one fate and there is other form of bilirubin, sterocobilunogin, sterocobulin and then that is being secreted, is being excreted through the feces. There is another fate. So, this is what is all happening

is what is happening in the, this is all what is happening in the large intestine. So, part of the large intestine and this is where the liver is standing. So, this is your liver and this is the large intestine and same by the same route, some of these bilirubin goes to the kidney and it is secreted by a urine.

So, this whole process of bilirubin secretion is governed by the liver. So, if the liver ducts have some blockage or their architecture had some problem, because of cell damage or something. Bilirubin secretion is being compromised and bilirubin is yellow in colour. So, as soon as you remove the iron from the prophyrin and transform it into biliverdin, this is all yellow. So, that is why see, you see in a jaundice patient, they are yellowing in their fingers and likewise. So, that basically is because the body fails, the liver fails to throw away the bilirubin from the body. So, liver has a lot of role in terms of purifying the toxins from the body.

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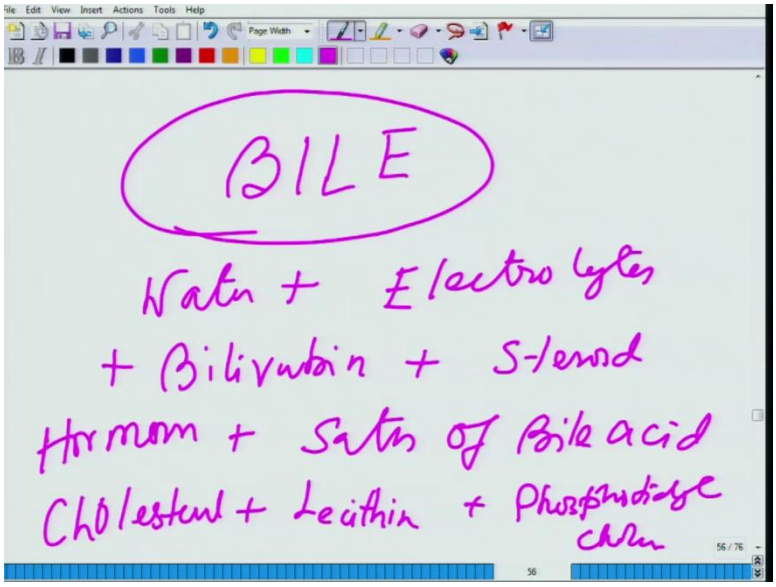

And there is another major secretion, which is made by the liver that is called bile secretion. So, bile has lot of fat emulsifying action, but what essentially bile is that, what are the different composition of the bile includes, apart from water, it has different electrolytes. Then it has as I have already told you, it has bilirubin, it has steroid hormone, it has salts of bile acid, it has cholesterol, it has lecithin, it has phosphodido choline likewise.

So, it is a very complex mixture, what is secreted by the liver in the form of bile. And this bile has a lot of fat emulsifying actions and it kind of helps assists in the process of digestion. So, this is briefly about the role played by liver and then we are into the last ((Refer Time: 35:43)) which is about a large intestine.

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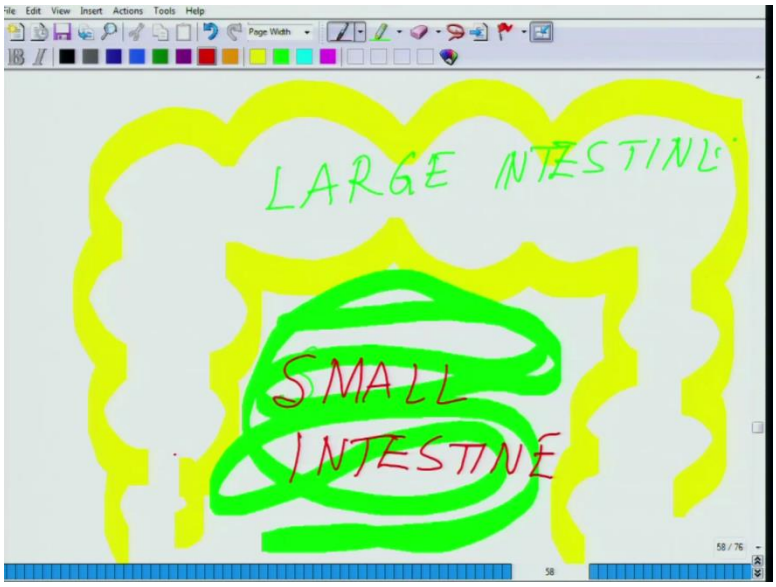

So, which is a fairly, it has a much larger. So, if you look at the cross section, looks like this. This is the large intestine and in between you see the small intestine which is embedded in between all the, so this large intestine. So, this is the large intestine and here, you have the small intestine. So, large intestine is mainly involved in extracting the last bit, which has a very limited absorption function as compared to the small intestine.

But, it ensures, as much as electrolytes and water which could be you know, conserved by the body, one of the major things it does. And apart from it, what it does is that, it ensures the different, these billirubins and all these things are called transformed into ((Refer Time: 37:06)) and everything and being excreted in the form of feces from the body. So, that is pretty much close in our digestive physiology. So, we will be doing little bit more, under the heading of metabolism and temperature regulation, little bit more.

We saw the tail pieces which I could not really cover out here. So, but that is gives you an overall idea about the role of sympathetic, parasympathetic nerves and the role of pancreas, role of liver, role of a small intestine, endocrine role of pancreas, exocrine role

of pancreas and salivary glands and stomach, through the conduit tube of esophagus. So, I will closing here. So, we will take over after this on the section on metabolism and temperature regulation. There are we will just do the rest of the different tails pieces, which are left.

Thanks a lot.