Basics of Biology
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Lecture 38
Digestion (Part III)

Hello, everyone. This is Dr. Vishal Trivedi from Department of Biosciences and Bioengineering, IIT Guwahati. And what we were discussing, we were discussing about the living organisms and in this context so far what we have discussed, we have discussed about the classification of the living organisms, then we have also discussed about the evolution and in the couple of previous modules, we have also discussed about the cellular structures of these organisms and then we also discussed about the biomolecules and how these biomolecules are regulating different types of cellular processes.

And in the current module we are discussing about the digestion, so where we are actually going to, we are discussing about how the complex food material is going to be converted into the small and the monomeric units and so that these monomeric units can be absorbed and then they are actually going to be utilized for the different types of processes, whether they are going to get into the metabolism and they will actually going to produce the energy or whether they are actually going to be the constituent of the building block.

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So, what we, so the whole purpose of the digestion is that it is actually going to convert a complex food into a simple monomer. And this can be achieved by having a well developed machinery. So, that we have discussed in the previous two lectures. We discuss about the anatomy of the digestive system, and then we have also discussed about the different types of glands. So, with this we actually have the very clear idea what is the machinery of the digestive system and how it is actually going to help in digesting or achieving the purpose of converting a complex food into a simple sugar. Now, let us recap that what is the requirement of the digestion.

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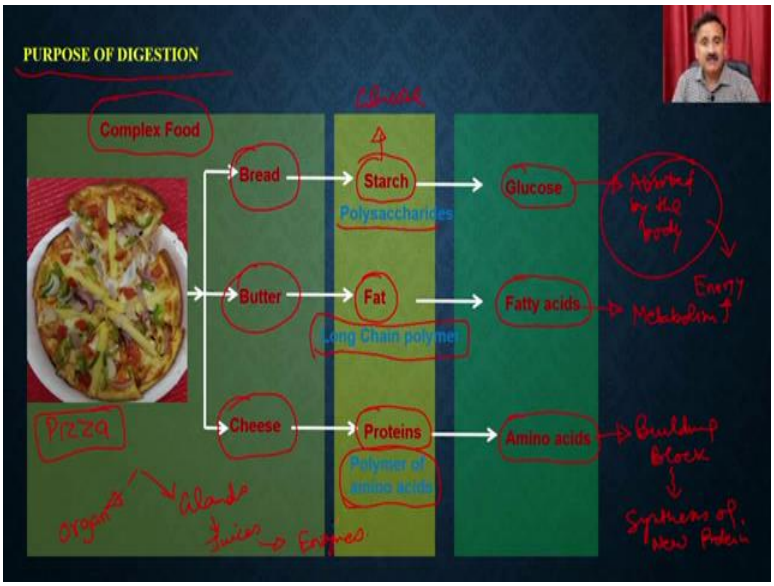

So, the purpose of the digestion is that it is actually going to convert a complex food into the simple monomeric unit. So, you can see that we have taken an example, last time also we have taken an example of the pizza which is actually a very, very complex food where you have the different types of the food materials, you have the bread, you have the butter, and then you also have the cheese and the bread is made up off of the starch which is actually a polysaccharide. So, it is actually made up off of the multiple unit of the glucose.

And once you do the digestion it is actually going to get converted into the monomeric unit glucose and this glucose is actually going to be get absorbed by the body and that is how it is actually can be utilized downstream for the different types of purposes whether it can be utilize into the carbohydrate metabolisms, like the glycolysis, Kreb's cycle, pentose phosphate pathway, and that is how it is actually going to produce the energy.

Similarly, you can have the butter and the butter is made up off of the fat and the fat is the long chain polymers, which actually contains the glycerol and the fatty acids and these fat are actually going to be get converted into the monomeric fatty acids. And these fatty acids are also going to enter into the metabolism and that is how that is also going to convert or produce the energy.

Similarly, the cheese, cheese is made up off of the proteins and the proteins are the polymer of the amino acids and that can be converted into the amino acids and the amino acids are actually going to be contribute in terms of the, they are going to be a part of building blocks, which means they are actually going to utilize for synthesizing the newer and newer proteins into the host and that is how it is actually going to help in terms of building the or synthesis of the new proteins.

Now, when we are discussing about the digestive system, what we have discussed is that it actually has the two components, one is it actually has the elementary canal where you have the different types of organs like the or different types of chambers, where you are actually going to have the digestion process and then it also going to have the glands which are actually going to secrete the different types of juices. And these juices are actually going to contain the different types of enzymes. So, let us see what are the different types of enzymes which are going to be secreted into the elementary canal.

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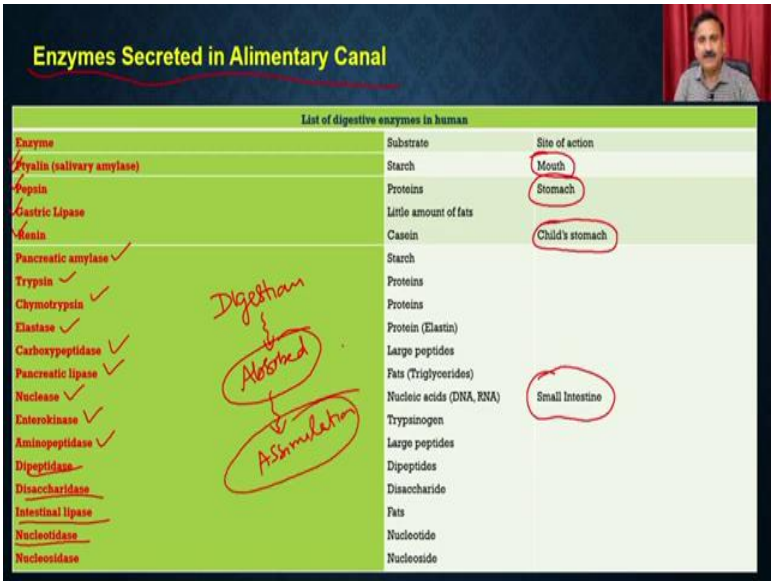

So, these are enzymes which are going to be secreted into the elementary canal. You have the ptyalin which is going to be secreted into the buccal cavity, then we have the pepsin, gastric lipase and the renin which is actually going to be secreted into the stomach. And in some cases renin which is actually a very, very exclusive enzyme which is going to be only present into the stomach of the child.

Then we have the huge amount list of the enzymes what is present into the small intestine, where you have the pancreatic amylase, trypsin, chymotrypsin, elastase, carbopeptidase, pancreatic lipase, nucleases, enterokinases, amino peptidases, dipeptidases, disaccharidase, intestinal lipase, nucleotidase and nucleosidase and all these are actually going to be secreted into the small intestine and they are actually going to digest.

So, now, with this brief introduction, we are going to now discuss in this current like lecture, how these enzymes are actually going to contribute into the digestion and what how you are, once you have the digested product, how it is actually going to be absorbed into the elementary canal so that this observed material is actually going to be participate into the downstream assimilation reaction.

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So, when we talk about the digestion, so if you want to understand our digestion, we have to understand the different types of processes what is happening into the different chambers. So, if

you take the elementary canal, the elementary canal can be divided into the five or four actually the chambers.

So, it can be divided into the four chambers, like the first chamber is the buccal cavity which is actually or the mouth, so that is the first cavity where the food is going to be travel. And then the second cavity is the stomach. In between they are actually going to have the esophagus which is going to travel or which is going to function as a pipe which is actually going to take the food from the buccal cavity into the stomach. And from the stomach it is actually going to go into the small intestine. So, that is the third chamber where you are actually going to have the digestion or the absorption.

And then from the small intestine it is actually going to enter into the large intestine and the large intestine is actually going to terminate into the last part and that is last part is called as the anus or the rectum. So, large intestine will terminate into the rectum or the anus which is actually the opening of the rectum.

So, these are the five chambers. You have the chamber number one which is called as the buccal cavity, the chamber number two which is called as the stomach, the chamber number three which is called as the small intestine, the chamber number four is a large intestine and you can also have the chamber number five which is the rectum and the anus, but sometimes people are also considering that part is a part of this large intestine.

So, these are the four portion where you are actually going to have the digestion. So, in the buccal cavity you have the first is actually going to food is going to enter. So, this food is actually a very, very large in size. So, this food has to be first converted into the smaller pieces so that the enzyme what is present into the stomach, small intestine and are going to act on.

So for that purpose the buccal cavity has the couple of the tools actually for that. So, buccal cavity is actually going to have the, so this food is actually going to be processed by the teeth and they are also going to be processed by the saliva and they are also going to be processed by the tongue. And you know that the purpose of these three material.

So, teeth is actually going to be required because they will help in the chewing so that the food is going to be converted into the small particles. And these small particles are actually going to be

combined by the saliva so that they are actually going to form a bolus. This small bound form of the particles or the food is called as the bolus.

And this bolus is actually going to be bring it below the teeth by the help of the tongue. So, the tongue has the two function. It is actually going to direct the direction of the bolus so that it is actually going to you know go for the mastication and it is actually going to come under the teeth so that it can be chewed up and then the food is going to be converted and the teeth is, the tongue is also going to give you the sense of taste, because the sense of taste is very important to enhance the appetite.

Now, once the food is going to be converted into very small, small, small, small particle and they will present as a bolus, that bolus is actually going to travel from the buccal cavity. So, that bolus is actually going to travel along the esophagus. And within the esophagus you have no processes or the tools except that the, it has a saliva or the mucus and that is actually going to be helpful in terms of the passage of the bolus from the buccal cavity to the stomach.

And within the stomach you have the different types of enzymes. So, you are actually going to have the enzymes which are actually going to participate into the digestion of the protein. You are actually going to have the enzyme which are going to participate into the digestion of the lipid. And then you are also going to have the enzyme which may or may not actually going to, which may actually participate into the digestion of the carbohydrate.

Now, apart from this, which in the, within the buccal cavity also it is actually going to have the one of the enzyme which is called as the ptyalin. And the ptyalin is also going to start the digestion of the carbohydrates and that is going to convert the complex carbohydrate into the different types of sugar and that is going to participate. So, the sugar is going, sugar digestion is going to start from the buccal cavity and whereas in the stomach it is actually going to have the digestion of the proteins, lipids and as well as the carbohydrate.

Now, once you have this partially digested food that will enter into the small intestine. And within the small intestine it is actually going to have the enzyme, it is going to have the supply of the bile juices and that is actually together these two are actually going to help in the digestion of the protein, it is going to help in the digestion of the lipid and it is actually going to help in the digestion of the carbohydrate, and it is also going to help in the digestion of the nucleic acid.

Remember that you are actually going to, when you are taking the food, you are also going to have the very minor fraction of the nucleic acid and all these are going to be digested by the different types of enzymes which are present into the, which are going to be secreted into the small intestine and the bile juices.

From this, apart from this the all these digestive products are actually going or the monomeric products are actually going to be absorbed into by the small intestine. So, you are going to have the machinery which is actually going to help in terms of the absorption of the small, within the small intestine.

Now, whatever the undigested or unabsorbed material is going to be that is going to be transferred from the small intestine into the large intestine, which means all the waste material is actually going to be digested or waste or I will say the undigested material is actually going to be transferred from the small intestine into the large intestine. And within the small intestine, large intestine, you are actually going to have the two function. You are actually going to have the absorption of the water, because in this undigested food you are going to have the large quantity of the water so that water has to be absorbed and apart from that some very small quantity of the vitamins are also going to be digested into the small intestine.

And even if you remember, we were discussing about the large intestine. The large intestine is actually having the colon, cecum and rectum. So, that is, within the colon you have the different areas and the main purpose of the large intestine is that it is actually going to absorb the water as well as the vitamins. And then after that the undigested waste or the waste material is actually going to be stored into the rectum and the rectum is actually going to have the opening which is called as the anus and then from here this undigested food is actually going to be defecated.

So, this is just an overview of the how the digestion and absorption is going to take place. So, it start from the buccal cavity, then it is going to the food will, the undigested food will enter into the stomach and then the stomach is also going to utilize the different types of enzymes and digest and then from the stomach it will enter into the small intestine and small intestine is the major area where you are actually going to have the extensive digestion of the protein, lipids, carbohydrate and nucleic acid, and then here you are also going to have the absorption. So all the

monomeric unit what is going to be produced into the small intestine is also going to be absorbed by the small intestine, within the small intestine.

And then you, whatever the undigested food that it is going to be transferred into the large intestine and the large intestine is actually going to suck up all the water and as well as some remaining amount of vitamin and then it is going to have the only the undigested waste material and that is going to be not of useful for the that particular human beings and that is how it is actually going to be removed in the form of the feces.

So, let us discuss how the different biomolecules are going to be digested. So, we have the four different types of biomolecules. We have the proteins, we have the carbohydrates, we have the lipids, and then we also have the nucleic acid, which is actually going to be digested into the food so that you are actually going to get the raw material for these biomolecules and then you can actually be able to use that raw material as per the requirement in the system. So, let us start with the protein, how the protein digestion is going to take place when the proteinaceous substances are going to be traveled from the buccal cavity and to the stomach and the large intestine.

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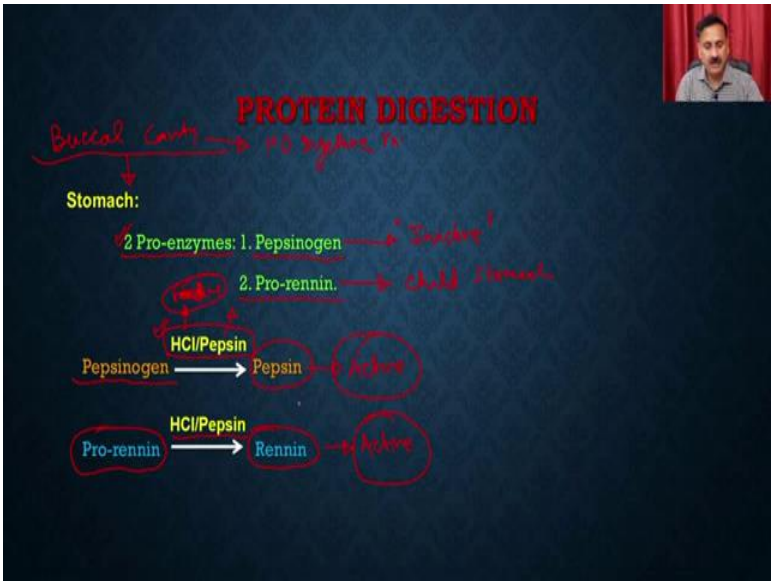

So, protein digestion you are actually going to have no, so within the buccal cavity there is no enzyme. So, there will be no digestion or there is no digestive reactions what is going to take place into the buccal cavity. But once the protein will enter into the stomach, the stomach has the

two enzymes, so two pro-enzymes. These two pro-enzymes means, the pro-enzyme means the enzyme which is actually going to be present in the inactive form.

So, you have the two pro-enzymes, one is called as the pepsinogen, the other one is called as a pro-renin. And pro-renin I think we discuss is only present in the child, so child's stomach. And so these two enzyme has to be activated first then only they are actually going to act on to the proteinaceous substances.

So, the pepsinogen is actually going to be activated by the HCl or the acidic environment and then it is actually going to form the pepsin. And pepsin is actually active enzyme which is going to participate into the protein digestion because it is going to digest the proteins. Then similarly, the pro-renin, the pro-renin the HCl and the pepsin is actually going to activate the pro-renin and that is how it is actually going to form the renin and that renin is also going to have the active enzyme.

So, once you generated the active enzyme within the stomach, because remember that you require the acidic environment. So we require the secretion of the HCl. And if you recall, when we were discussing about the secretion of the different glands and all that. So, HCl secretion is directly linked to the feeding actually. So, it is actually linked to the feeding. As soon as you start feeding something, as soon as you start eating something, that induces the secretion of the HCl.

So, if HCl is secreted, there is a very small amount of pepsin is going to be present and that combination is actually going to activate the pepsinogen, which is going to be secreted from the gastric glands, and then it is going to form the active enzyme. So, once you have the active enzyme, they are actually going to participate into the different types of digestive reactions.

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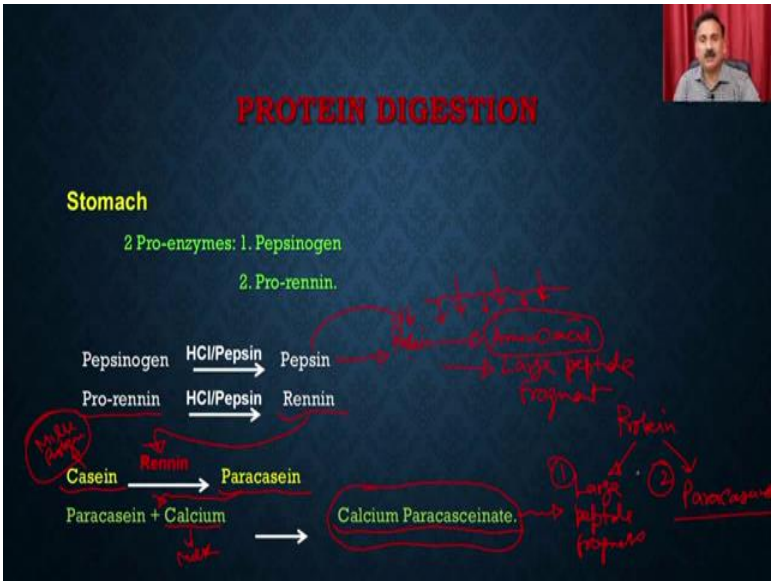

So, these are the, so pepsin is actually going to act on to the protein. So, it is going to convert the protein into the amino acid. But the pepsin is very specific. So, pepsin is only going to generate not the amino acid but they are also going to generate the large peptide fragments. So, if, because you have to have the large peptide fragment, because the pepsin is going to have the very specific site, and then after specific sites, you can imagine that if you have a protein like this, the pepsin is going to act on the different, different areas and that is how it is actually going to generate these peptide fragments and these are the pepsin.

Now, once you activate the pro-renin to form the renin, the renin is actually going to act on a specific protein which is called as the casein or you can, in a common word you also going to call this as a milk protein. So, casein is a protein which is present in the milk. And that is how the renin secretion is only possible in the child or the infants.

So, the casein in the presence of renin is actually going to form the paracasein. And then the paracasein, when the paracasein is going to interact with the calcium which is also going to be present in the milk it is actually going to form the calcium paracaseinate and that calcium paracaseinate is actually going to be further down into the protein digestion.

So, now, what you are going to have after the protein digestion within the stomach is you are, from the protein you are actually going to have the two products, you are actually going to have the large peptide fragments and you also going to have the paracaseinate. So, these are the two

things what we are going to generate when the stomach. So, these are the two products which are going to be transferred further into the small intestine.

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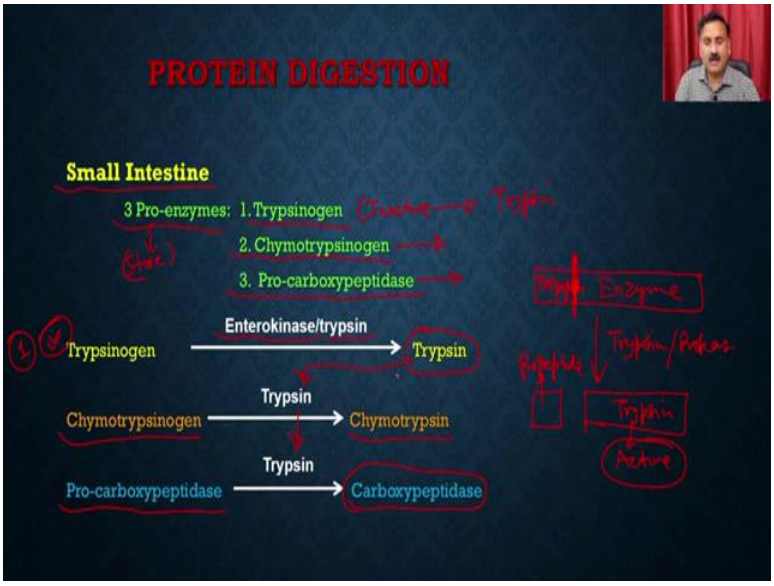

Now, within the small intestine, again, we have the different types of pro-enzymes. So, we have the three pro-enzymes, one is called as the trypsinogen, which is an active form of the enzyme and the trypsinogen is going to be activated to form the trypsin. Then we have the chymotrypsinogen. The chymotrypsinogen is actually going to form the chymotrypsin. And then we also have the pro-carboxypeptidase which is actually going to form the carboxypeptidase.

And the activation of these enzymes is also going to be very different. So, first the trypsinogen is actually going to be activated. So, you have the enterokinase which is also a protease and a combination of the residual trypsin is actually going to activate the trypsin within the small intestine.

Similarly, the chymotrypsin, so this trypsin what is going to be synthesized or what is going to be present is actually going to activate the chymotrypsinogen and it is actually going to form the chymotrypsinogen. Then we have the pro-carboxypeptidase that is also going to be activated from the trypsin and it is going to form the carboxypeptidase.

Now, what is mean by that activation is that in a pro-enzyme what you have is you have the two regions. One is you have the enzyme. So, this is going to be the enzyme. And in the front of this

enzyme you are actually going to have the pro-peptide. This pro-peptide is actually blocking the activity of the enzyme.

So what you are supposed to do is with the help of the trypsin or any other protease if you chew up, then what you are going to do is you are going to have the two fragments. One is you are going to have the pro-peptidase, pro-peptide and it is actually going to form the active enzyme, like the trypsin. And this trypsin is now going to be active. So, this is what is going to be called as the activation and that is why this is actually going to be regulated by the amount of the enterokinase or trypsin which is present in the small intestine.

And why the small intestine is keeping these enzymes in a pro-enzyme because it is safe to store the enzyme in a inactive form, because they are, they will not going to start eating the proteins, because the stomach or the small intestine is also made up of protein and lipids and carbohydrates. So, if you have the active enzyme, they may actually going to damage the elementary canal as well.

So that is why they are actually going to be stored in the form of the inactive form and whenever there is a requirement they are actually going to be activated by this mechanism and that it is going to participate into the downstream digestion. Now, from this once you have these enzymes got activated then you are actually going to utilize them for the protein digestion.

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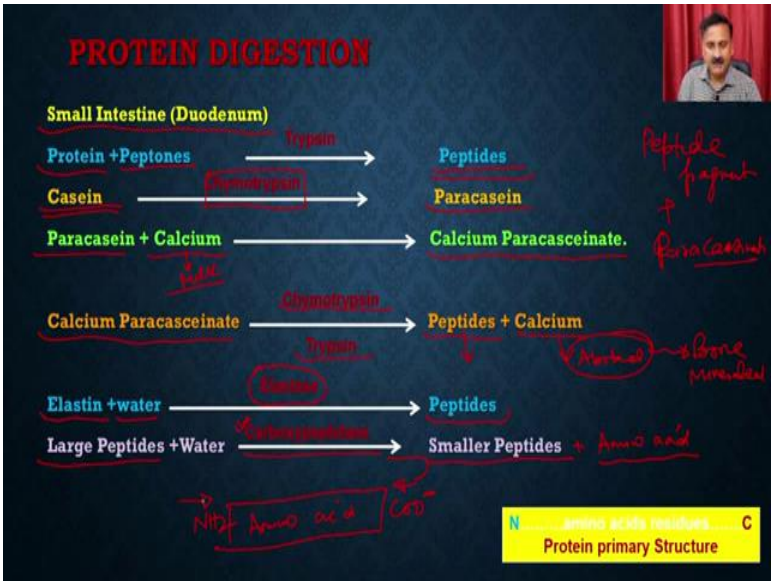

Now, remember that we have generated the peptide fragments in the stomach, so in the peptide fragment, and then we also have generated paracaseinate that is actually going to enter into the small intestine and in the small intestine we have the region which is called as the duodenum. So, in the duodenum, the protein or the peptones, like the peptide fragments, will actually going to be chewed up by the trypsin and then it is actually going to form the peptides.

Similarly, the casein which is now it can be transferred from the stomach into the small intestine is also going to be act by the chymotrypsin and it is actually going to form the paracasein. And that the paracasein when it acts with, when it reacts with the calcium which is present in the milk is actually going to form the calcium paracaseinate. So, the same reaction what is happening in the stomach, the same is going to happen in here also.

And then the calcium paracaseinate is actually going to be act by the chymotrypsin and as well as a trypsin. And when the chymotrypsin and the calcium paracaseinate is going to be act by the trypsin and the paracaseinate it is actually going to form the peptides and the calcium is actually going to be released and this calcium is actually going to be absorbed and that is going to be utilized for the bone mineralization.

Now, then we also have another kind of protein which is called as the elastin. So, if you are actually non-vegetarian and if you are taking the animal food, the elastin is a protein which is going to be present. So, elastin is a protein which is present in the, into the meat. And elastin is also going to be digested by an enzyme which is called as the elastase. And so with the help of the water elastase is actually going to digest the elastin to form the small peptides.

Then the large peptides which are going to be synthesized either from the stomach or the small intestine is actually going to be digested by the carboxypeptidase. So, you know that the protein is having sequence of amino acids. You have a sequence of amino acids. And on this side you have the amino group, whereas on this side you have the carboxyl group. So, what you can do is if you want to generate the small peptides or even if suppose you want to generate the amino acid, what you can do is you can start chewing the protein from this side.

So, if a protease is actually going to start chewing the protein from this side, then that protease is going to be called as the carboxypeptidase. So, carboxypeptidase is actually going to start chewing the protein from the carboxyl side. And that is actually going to generate the smaller

peptides and you are also going to generate the amino acids. Similar to this we can also have the aminopeptidase which is actually going to start chewing the protein from the amino side.

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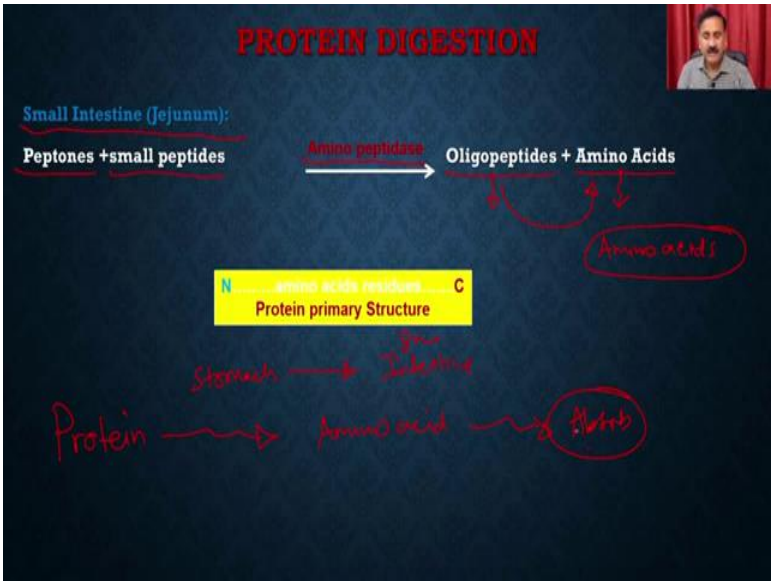

So, that is going to be present in a different portion of the small intestine which is called as the jejunum. So, in the jejunum the peptones and as well as the small peptides are actually going to be act by the aminopeptidase and that aminopeptidase is then going to generate the oligopeptide or the amino acids. It means, now, the protein digestion is almost over. If you continue the activity of the aminopeptidase, these all oligopeptide is actually going to be converted into the amino acid. So, ultimately what you are going to get after the protein digestion is the different types of amino acids which are going to be present into the jejunum. And from here they are actually going to enter into the next part of the small intestine. So, this is all about the protein digestion.

So, protein is actually going to start from this then from the different types of enzyme what is present in the stomach or what is going to be present into the small intestine, it is going to be get converted into the amino acids and these amino acids are then going to be absorbed for the further utilizations, whether they are going to be utilized for the synthesis of the different types of proteins as per the animal requirement or it is actually going to be utilized for the other kinds of activities like the protein can be, amino acid can be utilized even for some of the synthesis of the reactions or something like that.

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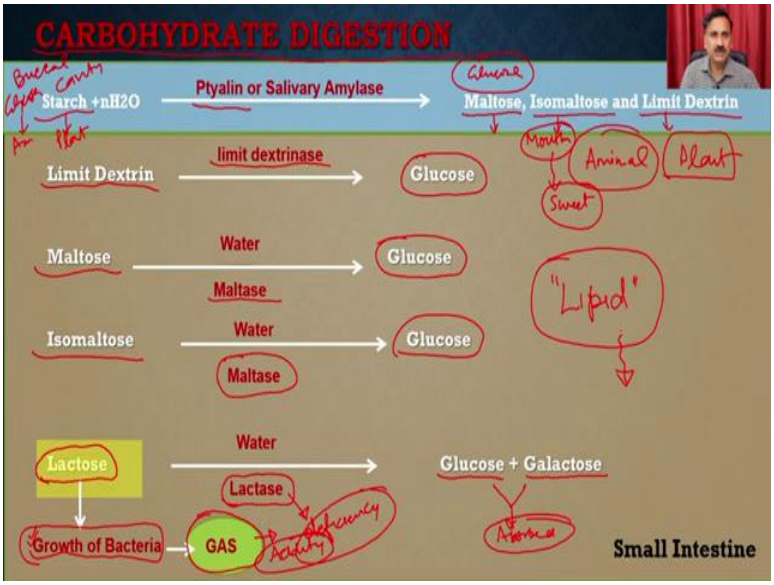

Now, let us move on to the next biomolecule and the next biomolecule is the carbohydrate. So, what is, how the carbohydrate digestion is going to take place. So, the carbohydrates can, you can, we can have the carbohydrates, you can have the different types of carbohydrate, like we can have the carbohydrate from the animal sources or we can have the carbohydrate from the plant sources.

So, the first thing is the carbohydrate digestion starts from the very early on. Starts from the buccal cavity itself, because in the buccal cavity the starch which is actually a plant carbohydrate or you can also have the glycogen which is actually a animal carbohydrate is actually going to enter into the buccal cavity and within the buccal cavity the starch is going to act by the salivary amylase or the ptyalin and that is going to convert the three products. It is going to form the maltose, isomaltose and limit dextrin.

So, these are the three products what is going to be synthesized into our mouth. And because they are being synthesized in our mouth and very small portion it is also going to generate the glucose. So, if you actually going to have this because of this only it is actually going to give you the sweet taste because when the glucose is going to interact with the taste receptors, then only it is actually going to give you the sweet taste.

Now, this will move on into the small intestine so there will be no digestion in of the carbohydrate into the stomach. From here it will enter into the small intestine and within the

small intestine the limit dextrin is actually going to be digested by the enzyme which is called as the limit dextrinase and that is going to convert that into the glucose. Similarly, the maltose what is going to be formed by the, in the buccal cavity is going to be processed by the enzyme which is called as the maltase and it is going to form the glucose.

Then the isomaltese, isomaltase is also going to be processed by the maltase and it is going to form the glucose. And we also have the sugar which is called as the lactose. And this lactose is also going to be processed within the small intestine by an enzyme which is called as the lactase and that lactase is going to convert into the glucose and the galactose. And if there is a deficiency of the lactase, like if there is a deficiency of the lactase, then there will be a accumulation of the lactose. And if there will be an accumulation of lactose, then that is actually going to be a sugar which is going to attract the growth of the bacteria.

And if there is a growth of bacteria, the bacteria is going to start utilizing the lactose and that is going to produce the different types of the byproducts. And these, one of the byproducts is that it is actually going to start synthesizing the gas. And that is the main reason that the lactose intolerance is actually been responsible for the production of gas into the small intestine and within the elementary canal, and that is also going to cause the severe acidity and other kinds of reactions.

So, if there is a lactase enzyme present, the lactose is going to be metabolized and it is going to form the glucose and galactose which is actually going to be absorbed. But if it is not going to be present, or if there will be inefficiency of the lactase enzyme or if there is a deficiency of the lactase enzyme, the lactose is going to accumulate.

So in undigested lactose when it is going to be accumulate within the small intestine, it is actually going to allow the growth of the bacteria and that bacteria when it is going to start utilizing the lactose it is going to start producing the gas, because they, once the bacteria is start utilizing the sugar it is actually going to form the byproducts, for example, the many types of the sugar.

You might have seen that when we are actually doing the carbohydrate metabolism, you are actually producing the large quantity of the carbon dioxide. But in the case of bacteria, they can actually be able to synthesize even other different types of gases also. And that gas is actually

going to accumulate into the elementary canal. And that is going to cause the discomfort. So that is why the, and that is also going to cause the acidity. So that problem can be improved or can be rectified simply by supplying the large quantity of lactose, lactase into the system.

Now, let us move on to the third biomolecule and the third biomolecule is called as the lipid. I am sure you still be able to recall when we were discussing about the structure of the lipids, but since we are discussing about the lipid digestion it is better to first see the how the structure of the lipid is in the, how the structure of the lipid.

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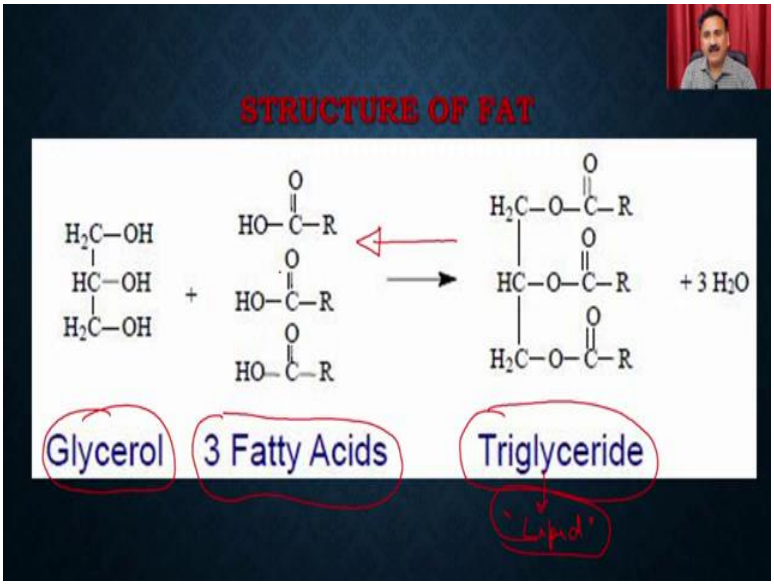

So, the structure of the lipid is having the two components; one is the backbone which is the glycerol. And when the thrall is added with the three different types of fatty acids then it is called as the triglyceride and that triglyceride is nothing but the lipid. And lipid is, so if you want to do the fat digestions, what you have to do is you have to first, you have to add the enzyme which actually going to convert them into the fatty acid and the glycerol and these two products actually can be readily be absorbed by the machinery.

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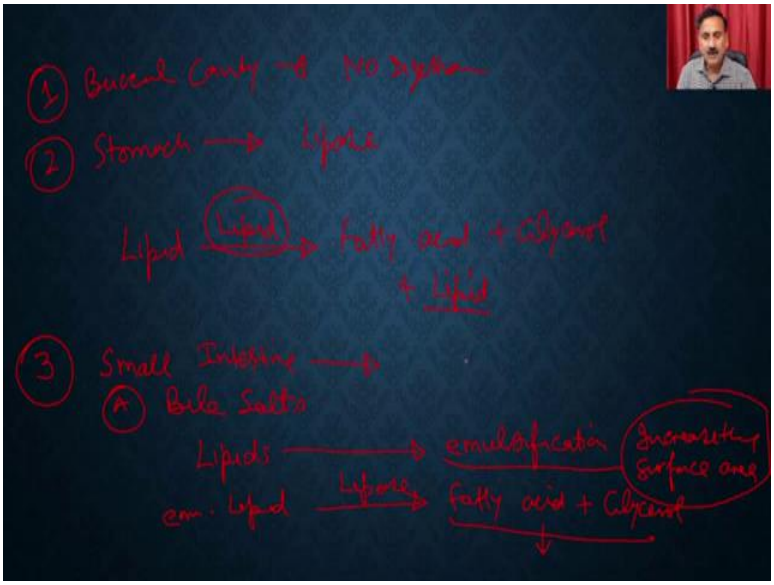

So, as far as the fat digestion is concerned, the fat digestion is, there is no fat digestion in the buccal cavity. So, within the buccal cavity there is no digestion. So, fat is actually entering into the stomach. So, within in the stomach you have the enzyme which is called as the lipase. So, lipase is actually going to act on the lipids and it is actually going to convert the lipid into the fatty acid plus glycerol. But the efficiency of the lipase what is present in the stomach is way low. So, that is why apart from this you are also going to have the large quantity of undigested lipid and that is going to be transferred into the third component or the third compartment that is called as the small intestine.

And within the small intestine, we are going to have the two things. One, we are actually going to have the addition of the bile salts. And what the bile salts are going to do is they are actually going to act on the lipids and they are actually going to form the emulsification. So what is mean by the emulsification is that it is actually going to increase the surface area. So once it increased the surface area, it is actually going to good for the enzyme to act on. So, it is going to emulsified the lipids.

And once the emulsified lipid is going to act by the enzyme, so once you have the emulsified lipids, it is going to be act on the enzyme by the lipase and that is going to convert the lipase into, the lipids into the fatty acid and glycerol. And these are the monomeric units. So, they can

be absorbed by the small intestine. Apart from the small intestine there is no digestion of the fat into the other parts of the elementary canal.

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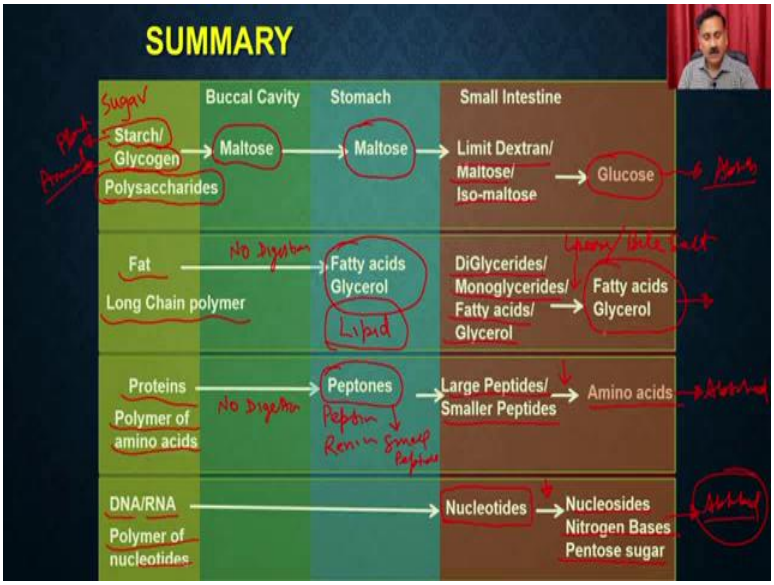

So, now, let us summarize what we have discussed or the digestion of the other molecules. So, once you start with the sugar, you can actually start the sugar which could be starch or it could be glycogen. Starch is plant-based sugar, whereas the glycogen is the animal based sugar. And by that all these they all are falling into the category of the polysaccharides. So, when they will enter into the buccal cavity, they are going to be converted into the maltose, isomaltose and the limit dextrines.

This maltose is then going to be enter into the stomach and the stomach there is no digestion so it will remain as such. But in the small intestine, the limit dextrine or the maltose or the isomaltose, which is going to be formed within the buccal cavity is then going to be formed as the glucose and that glucose is actually going to be absorbed by the small intestine.

Similarly, with the fat, so fat is actually a long chain polymers that contains the glycerol and as well as the fatty acids. So, it is going to have the no digestion into the buccal cavity. So, in the buccal cavity, you are not going to have any digestion. But in the stomach, because of the lipase action, it is going to form the fatty acid and glycerol, but a large quantity of the lipid is still going to be remain as such as the digested lipids.

And then in the small intestine whether we have started with the diglycerides, monoglycerides, fatty acid or glycerol, they all are going to be get converted into the fatty acid and glycerol by the action of the enzyme lipase in the presence of the bile salt and that is going to be absorbed by the body.

Then as far as the protein is concerned, which is actually a polymer of the amino acids, there is no digestion in the buccal cavity. So, there is no digestion the buccal cavity. But it is going to be digested by the pepsin as well as the renin by and that is going to convert the form the peptones. So, peptone is nothing but the small peptide. And this peptone is then going to enter into the small intestine so whether we started with the large peptides or whether we form, started with the small peptide that is going to be converted into the amino acids by the action of the many of the proteases like the trypsin, chymotrypsin, carboxypeptidase, aminopeptidase, elastase and all that. So, ultimately, the amino acids are going to be absorbed.

Then we have the nucleic acids. So, nucleic acid we have not discussed in detail, because there is no digestion of the nucleic acid within the buccal cavity or the stomach. So, nucleic acid means we started with the DNA or RNA which is actually a polymer of the nucleotides. So, once the DNA and RNA are going to enter into the small intestine, so they will be going to enter in the form of the nucleotides and nucleotides are actually going to be converted by the different types of enzyme into the nucleosides or nitrogenous bases as well as the pentose sugar and all these are actually going to absorbed into the, within the alimentary canal or within the small intestine.

So, all the nutrient material is actually going to absorb by the small intestine. So, how the absorption is working actually? So, the small intestine is having a well defined and well developed machinery through which you can, they can be able to absorb the different types of the nutrients what are present into the food.

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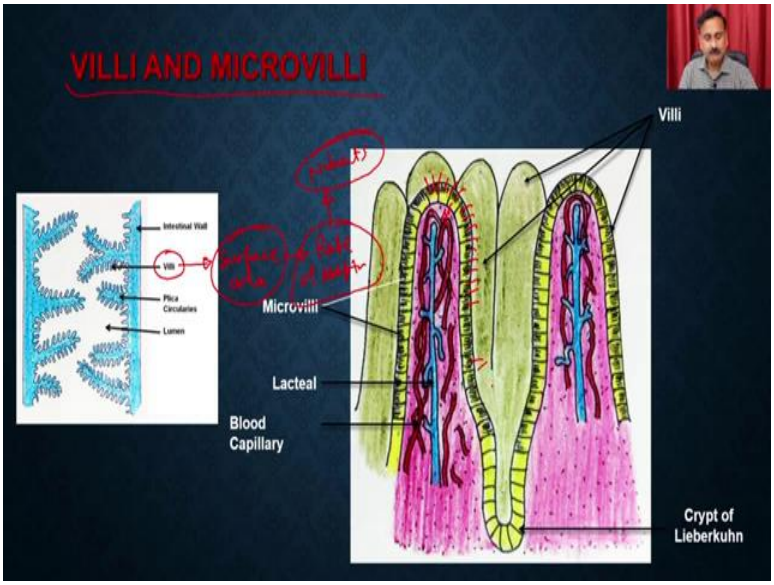

So, they actually have the villi and the microvilli. So, these are the intestinal wall which actually has the small quantity of the projections. So, these projections are nothing but the villi and villi are actually increasing the surface area. And that is, if you increase the surface area, the rate of absorption is actually going to be more. So, if you increase the rate of, if you leave the surface area, you are going to increase the rate of absorption and that is how it is actually going to absorb the nutrients from the food.

If you see the very detailed structure of the microvilli what you see here is that the individual microvilli is actually having the brush like protections and all these things like protections are increasing the surface area and they are actually having the extensive supply of the blood vessels. So, whatever the food material comes, they actually enter into this particular area and then they are actually been taken up by the different types of the blood vessels. So, then it will enter into the blood and then it is actually going to distributed throughout the body with the help of the circulatory system.

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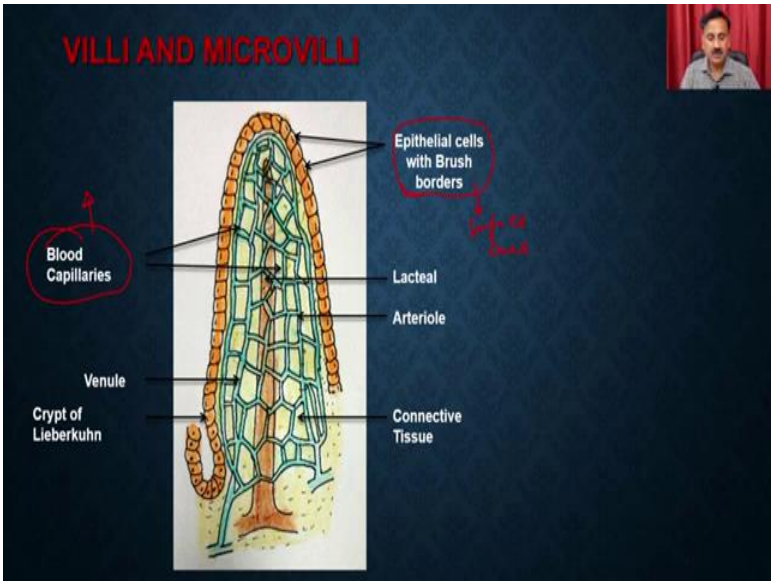

This is what you see here is the structure of the microvilli where you have the epithelial cells with the brush border. So, this actually is going to increase the surface area and that is actually going to help in the digestion, in the absorptions. Then you also have the very, very thin blood capillaries which are forming the extensive network within the villi and microvilli and that going to form the, going to have the, help in the taking up the nutrition from the food. Now, as far as the absorption is concerned, the mechanism of the absorption, so the food materials are actually following the different types of mechanisms.

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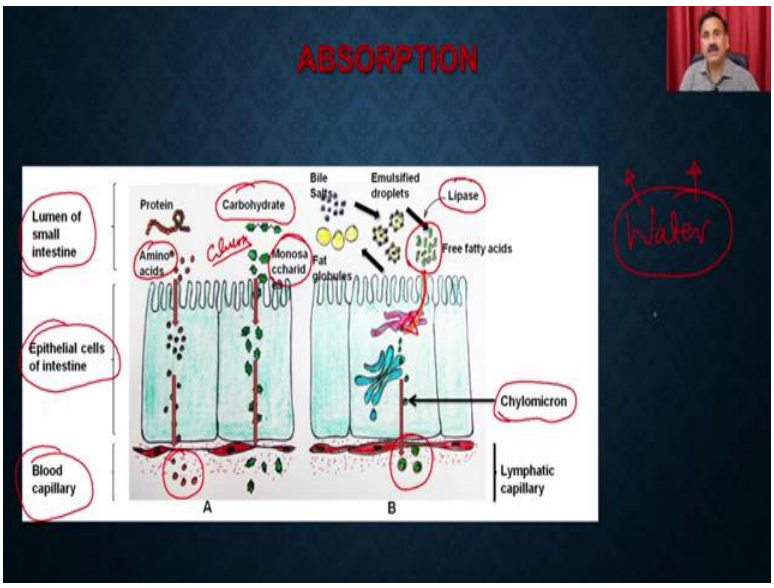

For example, the proteins. So, you see here. So, you have the three components one is the lumen of the small intestine, then we have the epithelial cells, and then we also have the blood capillary. So, these are the three partners which are or three active members which are actually going to participate. So, in the small intestine lumen, the protein is now going to be converted into the amino acids and these amino acids are actually going to take up by the epithelial cells and they will be actually given to the blood vessels. So, lower time the blood vessels, there is a extensive network of the blood vessels and they are actually going to be taken up.

Similarly, you have carbohydrates. The carbohydrates are going to be converted into the monosaccharides, like the glucose, and the glucose is actually going to be taken up by the epithelial cells, and then they were actually going to give it to the blood capillaries. The uptake of the food, the blood vessels, the uptake of the fat is very different, because the fat is also, so for the fat, it is actually going to be emulsified by the bile salts and then once it is going to be emulsified, there will be an active action of the lipase onto these emulsified drops and that is how it is actually going to form the fatty acids.

And once the fatty acid is actually going to form, there will be active uptake of the fatty acid and that is how it is actually going to form the inside the epithelial cells, it is going to form the chylomicrons and these chylomicrons are the small droplets like structures and they will be actually also going to be delivered into the blood vessels and from the blood vessels they are actually going to be distributed throughout the body.

Apart from this absorption the, one of the major components what is going to be also absorbed on the food is the water, because the water is, there is a huge quantity of water what is present in the elementary canal and this water is very precious. So, the water has to be absorbed back into the body so that it is actually going to form the, it is going to provide the necessarily the water supply into the food, into the body. Water is actually actively participating into the many types of reactions inside the body like the metabolic reactions or synthetic reaction and all that. So water we cannot waste, because the water what is been present into the food has to be absorbed back and the water absorption is very, very easy.

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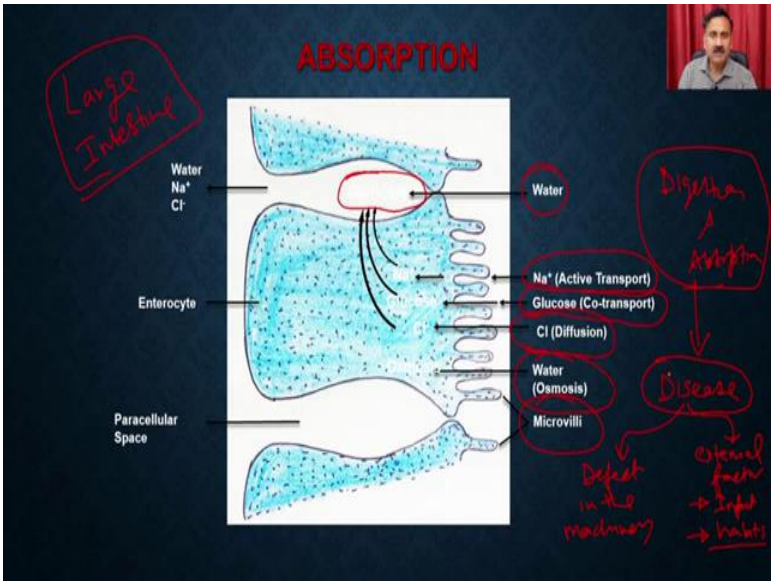

So, water is actually going to be absorbed by many mechanisms. One is that the water is actually going to enter into the, or crosses through by a mechanism which is called as the osmosis. In the other case the water also can be having the, can be absorbed by the either the active transport of the sodium, not only the water, the minerals are also going to be taken up by the large intestine. So, all these water absorptions is going to take place into the large intestine.

So, in the large intestine the water is either being taken up by the osmosis and or it is actually going to take up by the minerals like the sodium as an active transport or the, it can also be taken up by the glucose transport, chlorides and the water by the osmosis and all these microvillies are actually going to participate into these reactions. And that is how the sodium glucose, chloride and are actually going to be taken up from the food materials and that is how it will enter into the body. So, this is all about the digestion and the absorption of the food from the, of the food, the complex food material.

Now, when you talk about any machinery, when you talk about the any kind of apparatus, these apparatuses are under the ideal conditions they should do everything in a proper way. But in a, there are many cases when these ideal conditions are not being met and in those cases the person is start showing the malfunctioning of the elementary canal and this malfunctioning of the elementary canal is actually going to be responsible for the different types of diseases.

These diseases either could be due to the defect in the machinery or it could be a defect into the machinery by the external factors. So, this external factor could be the infectious agents or this external factor could be the different types of habits. For example, if you are taking a particular type of food materials and blah, blah, blah like that, that also can be responsible for the generation of disease conditions.

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So, let us very briefly discuss about the disease conditions. So, these are the some of the important diseases what is happening in the elementary canal. What you have is the jaundice, you can also have the vomiting, you have diarrhea, constipation, merriments, kwashiorkor, Ricketts, osteomalacia, then we also have the diabetes, acid flux, constipation, marmus, kwashiorkor, Ricketts, and osteomalacia.

So, all these diseases are actually being associated with the malfunctioning of the digestive system like, for example, the jaundice is a disease where you have the accumulation of the bile juices within the blood and because of that it is actually going to disturb the overall the metabolism of the person and that is how it is actually going to cause the death of the person and that jaundice is actually been associated with the liver dysfunction.

Similarly, we have the vomiting. You might have seen the kids are vomiting and other people are also that vomiting is because of the either the some kind of discomfort within the elementary canal and that induces the reverse peristalsis. So, if you have the reverse peristaltic movement

that is actually going to allow the motion of the food content rather than going inside, because in a normal situation what happened is that food is actually going to be present in the esophagus and then because of the peristaltic movement it is actually going to enter into the stomach and from the stomach also because of the peristaltic movement of the muscles, it will enter into the small intestine.

But if there are discomfort, there are pathological situations, the peristaltic movement would be in the reverse order, like normally the peristaltic movement would be in a way so that it is actually going to push the food like the downward. But if the peristaltic movement is going to be in the reverse order, then it is actually going to push the food in the reverse order. And if it pushes the food into the reverse order, it is actually going to come out from your mouth in the form of vomiting.

Similarly, the diarrhea, diarrhea is a disease which is why because of the loss of water and that is going to cause the dehydration and other kinds of issues and diarrhea can be of multiple types. Diarrhea could be where you have the infectious diseases or diarrhea could be of the non-infectious induced also. Constipation, then you are actually going to have the higher removal of water so that when you remove the high amount of the water from the feces, the feces are actually going to be very hard and then they will be actually going to have the difficulty in defecation.

Similarly, you have the marmus and the kwashiorkor. These are the two disease conditions where there will be a deficiency of the protein deficiency and protein, because of protein deficiency it is actually going to cause the malnutrition within the kids and that is how it is actually going to be, so they will actually going to have stunted growth and all other kinds of symptoms.

Similarly, we have the Rickets and osteomalacia these are also malnutrition induced diseases. So, these are the some of the diseases what we have discussed. We cannot discuss these diseases in detail because the time limitations and as well as they are actually required a very, very elaborated discussion about all of these diseases.

So, with this, I would like to conclude my today's lecture. In our, in this particular lecture, what we have discussed, we have discussed about the digestion and as well as the absorption of the

food material. While we were discussing about the digestions, we discuss about the addition of the protein, carbohydrates lipids, nucleic acids into the different chambers. So, when we discuss about the chamber-wise, it is going to give you a better idea how the different chambers are contributing into the digestion and as well as the absorption of the food material.

So, with this, we would like to conclude my lecture here. In our subsequent lecture, we are going to discuss some more aspects related to the human physiology. Thank you.