**Basics of Biology**
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**Lecture 37**
**Digestion (Part II)**

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 properties of the living organism. And in this context so far what we have discussed, we have discussed about the classifications, evolutions and many other topics in the previously discussed modules.

And in the current module, we are discussing about the human physiology. So, what we were discussing, we were discussing about the digestive system, circulatory system, muscular system, nervous system, endocrine system and the excretory system. And in the current module, we are discussing about the digestive system. So, if you recall what we have discussed in the previous lecture, we have discussed about the anatomy of the elementary canal.

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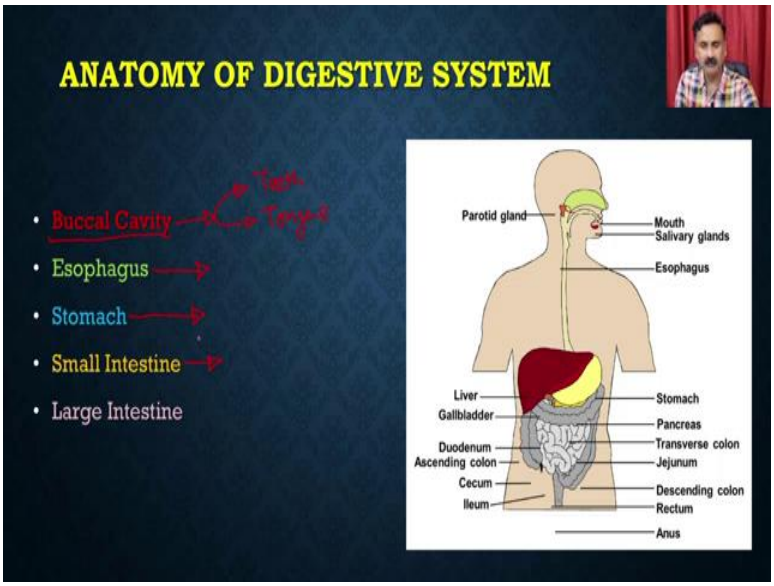


And in that context we have, so far what we have discussed, we have discussed about the buccal cavity and within the buccal cavity we have discussed about the teeth. We have discussed about the tongue and we have also discussed about the different types of structures what are present and the function of the teeth as well as the tongue. And then we have discussed about the

esophagus and the esophagus we have discussed about the anatomy and as well as the function of the esophagus.

And then subsequent to that we have also discussed about the stomach, the structure of the stomach and what are the different types of sphincters are present in the stomach so that they actually stop the flow or they actually direct the flow of the food within the food vacuoles. And then in the today's lecture we are going to discuss some more aspects related to the anatomy of the elementary canal. So, let us start our discussion about the anatomy with the discussion about the structure and the function of the small intestine.

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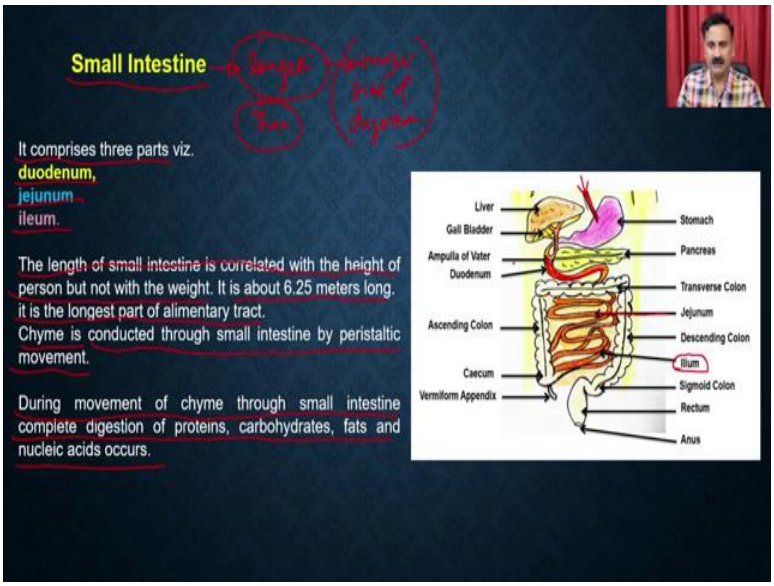


So, small intestine, small intestine is actually is comprised of the three parts and it has the three parts such as the duodenum, jejunum and the ileum. So, what you see here is this is the stomach. So, this is the esophagus from where the food is going to enter into the stomach and then from the stomach you have the pyloric sphincter and from there this is the portion what you is called as the duodenum and this portion is a L-shaped structure and that is actually going to connect the stomach to the inner part of the small intestine.

And then the other part is called as the jejunum which is this part. What you see here is actually the jejunum. And then the last part of the small intestine is called as the ileum. The length of the small intestine is correlated with the height of the person but not with the weight. So, it is about

6.25 meter long. So, it is actually the longest intestine in the body. So, this is the longest intestine and this is the very thin and long. It is the largest longest part of the elementary track.

The chyme which is going to be formed in the stomach when the food particles are going to be further reduced in size by the churning events or peristaltic moment within the stomach and then it is going to mix with the acid and all other kinds of secretions within the what is present in the stomach and that whole part is called as a cyme.

So, chyme is conducted through the small intestine by peristaltic movements. During the moment of the chyme through the small intestine, the company digestion of the protein, carbohydrate, fats and nucleic acid is going to be occurred. So small intestine is a major site of the digestion. So, it is a major site for digestion.

And that is why the small intestine is also been well connected to the different types of the hormones and different types of salivary secretory glands and all that. So, you can see that the pancreas is also connected to the small intestine. It actually delivers the some of the enzymes into the small intestine and then also the liver and other glands are also being connected to the small intestine.

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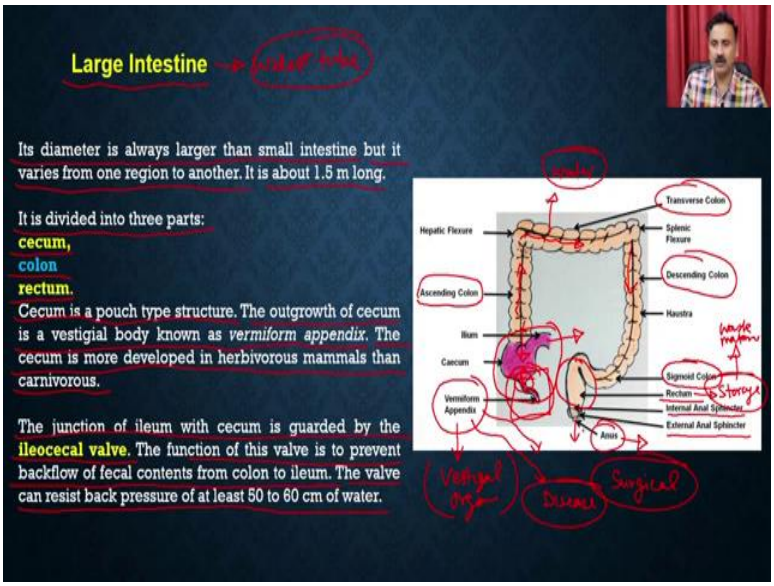


Then let us move on to the other structure which is called as the large intestine. So, large intestine is actually the widest tube in the elementary canal. And its diameter is always larger

than the small intestine, but it vary from the one region to another. It is about 1.5 meter long and it is divided, so the large intestine is being divided into three parts, one is called as the cecum, colon and the rectum. So, what you see here is the large intestine where you have the, this is the portion which is called as the cecum. So, it is actually been connected to the small intestine.

And this lower portion what you see is a pouch like structure, which is also called as the vermiform appendix. And there is a thin membrane which actually does not allow the food particles to enter into the vermiform appendix, because the vermiform appendix is a vestigial organ and that is, vestigial organ.

So, it is going to be present in the human and this is functionally active in the herbivores where they are actually going to use that for the digestion of the cellulose and other kinds of material. But that since the, we do not have the enzymes which can actually be able to digest the cellulose so that is why this particular portion is being non-functional or it is actually been considered as a vestigial organ.

So, the vermiform appendix is separated from the cecum by the help of a membrane like sheets, and whenever this membrane like sheet is actually going to be disrupted or it is going to be damaged, then the food particles actually enters into the vermiform appendix. And that is how when the food is entering into the vermiform appendix and it actually allows the growth of the bacteria, then it actually causes a disease or it actually causes a disease which is called as the appendicitis.

So, then in that case, the appendix is actually going to be swelled and then it is actually going to cause the lot of pain. And the only solution to this particular disease is that you can actually be able to use the surgical procedure and then you are actually going to remove the vermiform appendix, because the vermiform appendix does not have the functional role in the digestion. It can be removed without any trouble to the digestive system.

So, cecum, cecum is a pouch type structure. So what you see here is a pink color structure, what you see here is a cecum. The outgrowth of the cecum is a vestigial body known as the vermiform appendix. The cecum is more developed in the herbivorous mammals than the carnivorous. The junction of the ileum with cecum is guarded by the ileocecal valve. The function of this valve is

to prevent the backflow of the fecal content from the colon to ileum. The valve can resist back pressure of at least 50 to 60 centimeter of water.

So, cecum is then connected to the colon and the colon has the three part. You can have the ascending colon, you can have the transverse colon and then you also can be having the descending colons. These colon is actually is a part where the undigested food material is going to be present and that undigested food material is actually going to travel into the these three tubings of the cecum. And during this process from the undigested material, the water is going to be absorbed and that is why you see here that there is a ileocecal valve which actually is going to protect the backflow of the waste material back into the cecum.

And this, as I said here, the cecum is well developed into the herbivorous because it is required for the digestion of the cellulose, but it is less developed into the carnivorous because the carnivorous does not eat the plants. And colon is the major site from where you are actually going to see the absorption of the water and the waste product is actually going to be get converted into the feces and then these feces are actually going to be get collected into a pouch like structure which is called as the rectum.

And then the last portion of the cecum is, a last portion of the colon is actually going to be called as the sigmoid colon. And this sigmoid colon is terminally going to form the pouch like structure which is called as the rectum. So, rectum is actually going to serve as a storage organ for the feces or the waste material.

And then the last portion of the rectum is actually going to be get open outside in the form of the anus. So, anus is the, is going to be a hole on the body which actually going to use for secreting out or excreting out the faces. But this hole is actually going to be regulated by the two different types of the muscles. So you are going to have the internal anal sphincters and you are also going to have the external anal sphincters. These muscles or these valves are actually going to regulate the activity of the hole so that it actually can open and close during the removal of the feces.

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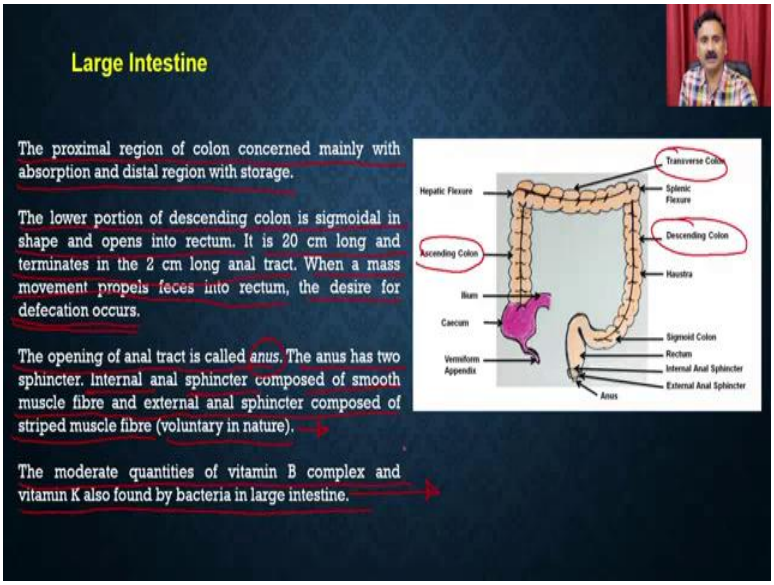


So, the proximal region of the colon concerned mainly with the absorption and the distal region with the storage. So, what you see here is the colon is actually been as ascending colon, transverse colon or descending colon and these are very wide compared to the cecum or other part of the large intestine and the portion is that it actually going to allow the absorption as of the water material. The lower portion of the descending colon is sigmoidal in shape and it opens into the rectum. It is a 20 centimeter long and terminates in a 2 centimeter long anal track. When a mass movement propels feces into the rectum there will be a desire of the defecation occurs.

So, if there will be a pressure on this particular anal track then it is actually going, then the person is going to have the desire for the defecations. The opening of the anal track is called as the anus. And the anus has the two sphincters which is called as the internal as well as the external sphincters and they are composed of the smooth muscle fibers and the external anal sphincter is composed of the striped muscle fiber, which is voluntarily in nature. It means you can actually be able to control the opening and closing of this particular anus by your own will and that is how it is actually going to allow the person to go for the defecation process.

The moderate quantities of vitamin B complex and the vitamin K are also found in the bacteria which is going to be present in the large intestine. So, large intestine is also providing the suitable environment so where these commensal bacteria or these symbiotic bacteria are actually going to propagate. So, they are actually going to take up all the undigested material and they are

actually going to use that for their own nutrition and in return it is actually going to form the vitamin B complex and as well as the vitamin K.

And all these vitamin B complex and the Vitamin K is actually going to be absorbed and that is how they are actually going to provide the, in return they are actually going to provide the nutrition into the organisms. So, this is what we have discussed the major parts of the elementary canal.

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Now, let us move on to the next portion and the next portion is the we are going to discuss about the different types of glands, because the main purpose of the elementary canal is that it is actually going to take up the complex food material like we have taken an example of the pizza and pizza is going to be composed of the bread and lipids and it is actually going to have the protein also, like it going to have chief.

So, these glands are actually required because they are actually going to secrete different types of secretions and these secretions are going to contain the different types of chemicals like, or the enzymes and these chemicals and the enzyme is required for the proper digestion of the food material. So, let us start with the secretory glands. So, we are going to start from the buccal cavity.

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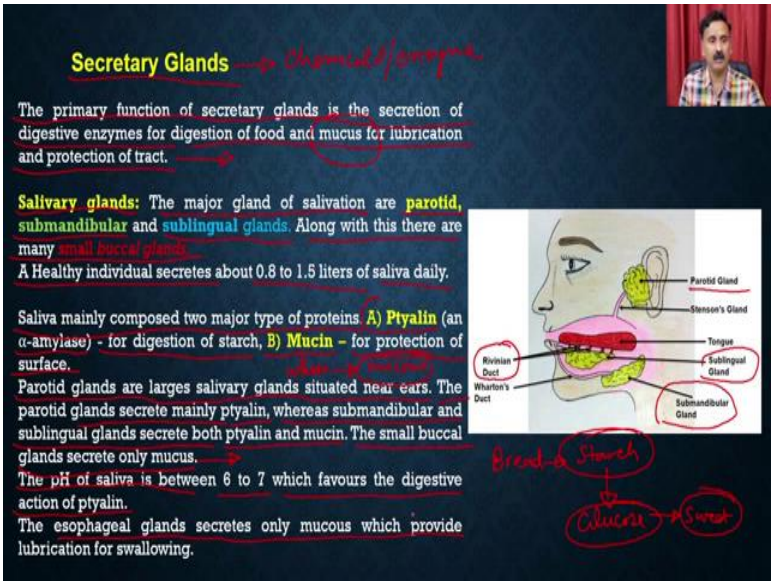


So, secretory glands are actually going to secrete the chemicals and they are also going to secrete the enzyme. The primary function of the secretory gland is the secretion of the digestive enzyme or the chemical for the digestion of the food and the mucus for the lubrication and the protection of the track. So, remember that the mucus is also very important. It actually protects the, our own body for the harsh teat, harsh chemical what is going to be present. So, let us start first with the buccal cavity.

So, in the buccal cavity what you see here is we are actually going to have the different types of glands. You are going to have the parotid glands, you can also going to have the sublingual glands, you can also have the submandibular glands, then you can have the all different types of ducts which are actually going to, which are going to take up the secretion from these glands and then they are actually going to be secreted. So, salivary glands, let us start with the salivary glands.

So, the major gland of the salivations are the parotid glands, submandibular gland and the sublingual glands. So these are the sublingual glands. Along with this there are many small buccal glands. A healthy individual secretes approximately 0.8 to 1.5 liter of saliva every day. Saliva mainly composed of two different types of proteins, one is called as the ptyalin or alpha amylase, which is required for the digestion of the starch or the sugar. And that is why when you see that when we are taking a complex food, it actually give us the sweet taste. So, if we take, for

example, if you eat the bread, bread is actually going to be made up of the starch. But the starch is not sweet, starch is actually a polymeric, polymer sugar so it is not sweet.

So, with the help of the alpha amylase the starch is instantly going to be get converted into the glucose or the dextrose and that glucose is actually a sweet in taste. So once it get converted into glucose, that glucose is actually going to go and bind into the, onto the taste buds, onto the tongue, and then it is actually going to give you the sweet taste.

Apart from that you also have the another protein which is called as the mucin. So, mucin is a protein which is for the protection of the surface. So, mucin is a protein which actually going to mix up with the mortar, and then it is actually going to form a mucus. And that mucus is actually been required for making the food. It is actually going to bind the food particle so that they will remain together, so that the action of the teeth is actually going to be more optimal and more better. Apart from that the mucus is also going to make the track smooth so that they will be actually going to move very nicely.

Parotid glands are the large salivary glands which are situated near the tongues, near the ear. So this is the place where you going to have the parotid glands. The parotid glands are secreting mainly the ptyalin or the alpha amylase, whereas the submandibular and sublingual glands secrete both the ptyalin as well as the mucin. The small buccal cavity secretes only the mucus.

The pH of the saliva is between the range of 6 to 7 which favors the digestive action of the ptyalin. The esophageal glands secrete only the mucus which provides a lubrication for the swallowing. So, apart from these buccal cavity, you can also have that gland in the esophageal, esophageal region and that only secretes the mucus which actually going to lubricate the food particles or the bolus and that is how it is actually going to help in swallowing.

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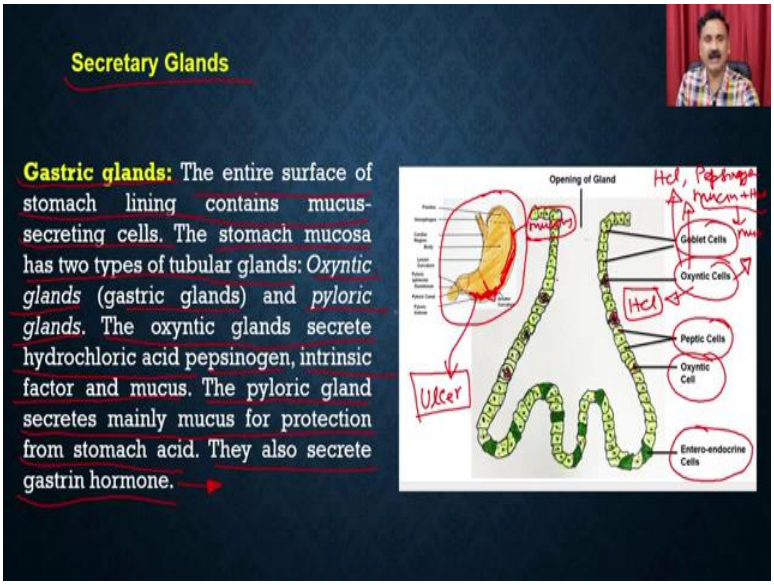


Now, let us move to the another region which is called as the stomach. So, in the stomach you are going to have the gastric glands. So, in the stomach this is the, you see structure of the stomach. And on this structure you are actually going to have the gastric glands. And the gastric glands are actually being composed of the goblet gland, oxyntic gland, peptic cells, oxyntic cells, and the entero-endocrine cells. The entire surface of the stomach lining contains the mucus secreting cells. The stomach mucosa has two types of tubular glands, oxyntic glands or the gastric glands, and the pyloric glands.

The oxyntic glands actually secrete the hydrochloric acid, pepsinogens, intrinsic factors and the mucus. So, this is actually is the major cell which is actually going to secrete the HCl, then it is also going to secrete pepsinogen, which is actually an enzyme which is going to digest the proteins, and then it also has the intrinsic factors and the mucus. So, it is going to secrete the mucin which is going to form a complex with the water, and that is why it is actually going to form the mucus, and then it also going to secrete the intrinsic factor. So, intrinsic factor is also going to participate.

Then the pyloric glands, the pyloric glands are going to secrete mainly the mucus for the protection from the stomach acid. They also secrete the gastrin hormone. So, gastrin hormone is also is very important for the overall digestion. So, what you see here is that oxyntic acid is actually going to secrete very large quantity of HCl and you know that the HCl is a very

corrosive acid, but HCl does not affect the inner lining of the stomach, because the inner lining of having a protection by the mucus. So it is going to have a very thick layer of mucus. And this thick layer of mucus is actually going to protect the wall of the stomach.

Sometime what happened is then when there will be a damage of this vesicle like, then there will be a damage to this mucus structures, then the acid can actually be able to affect the epithelial lining, and that is actually going to be responsible for a disease, which is called as the ulcer. So in that case, it is actually going to make the wounds and then these wounds are actually going to allow the growth of the bacteria and once the bacteria is start growing then it is actually going to form the ulcer or the wounds actually. And then the person is going to have the discomfort, it is going to give the stomach pain and all that. So, that is why the mucus is very, very important in terms of protecting the elementary canal from the digestive actions and as well as the corrosive chemicals what is going to be secreted.

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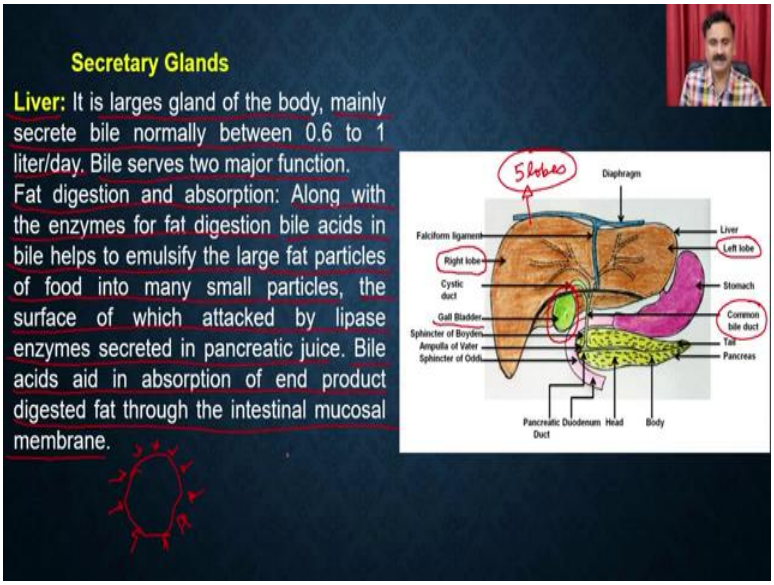


Now, let us move on to the next gland. So, the next gland is the liver. So, it is the largest gland of the body mainly secrete the bile normally between the 0.6 to 1 liter per day. So this is what you see here is the liver, which is actually going to be called as the largest gland in the human body. The liver has the five lobes and these five lobes are actually going to be almost the same. And all these five lobes are interconnected by the different types of ducts. So what you have is, what you

see is this is the right lobe and on the other side also you are going to see the left lobe and so you are going to have the five lobes together.

And then what you see here is a gallbladder. So, gallbladder is actually a storage pouch. So that is actually going to store the digestive enzymes and the bile actually. And the gallbladder is going to collect the bile and the gallbladder is connected to the, this common bile duct. So there will be a common bile duct which is actually going to take the bile from the gallbladder and then it is actually going to supply that into the small intestine.

So, bile actually serves the two major functions. It is required for the fat digestion and the absorption. So along with the enzyme for the fat digestion, the bile acid in bile helps to emulsify the large fat particles of the food into the small particles, the surface of the which attached by the lipase enzyme secreted in the pancreatic juice. The bile acids aid in the absorption of the end product digested food through the intestinal mucosal membrane.

So, what happened is that, even if you do the chewing and other kind of thing, you are actually going to generate the small fat particles, but these small fat particles are going to have a very small surface area. So what happened is that the acid what is present in the bile is actually going to react with these fat droplets and that is how it they are going to increase the surface area of the drop. So once you increase the surface area, the enzyme actually can get the more surface area to act. So, it is actually can act on the all the sites and that is how it is actually going to do the better digestion of the fat particles or the fat droplets.

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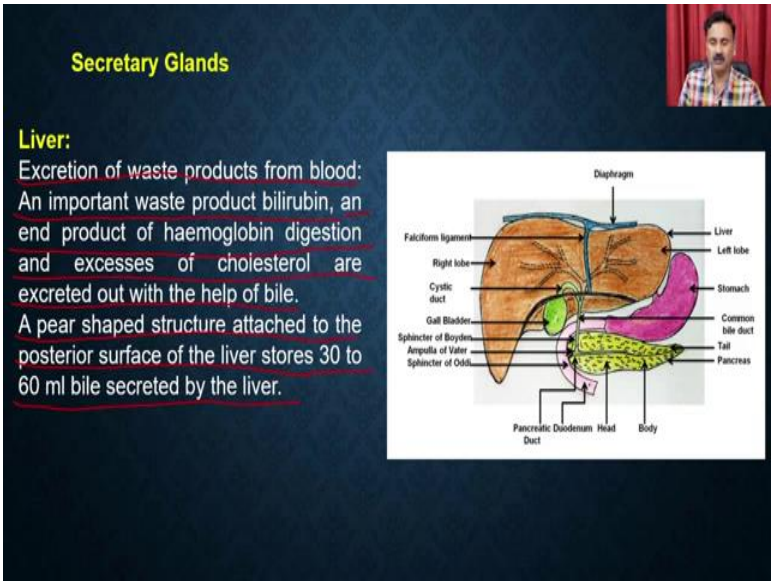


Then the excretion of the waste product from the blood, so liver also has alternate functions into the excretion part. An important base product bilirubin, an end product of the hemoglobin digestion and the excesses of the cholesterol are secreted out with the help of the bile. A pear shaped structure attached to the posterior surface of the liver stores 30 to 60 ml secreted by the liver. So, this is what you see here. This is a gallbladder which is actually going to store 30 to 60 ml of the bile which is secreted by the liver and whenever there is a requirement the bile what is present in the bile, gallbladder is going to be supplied into the elementary canal.

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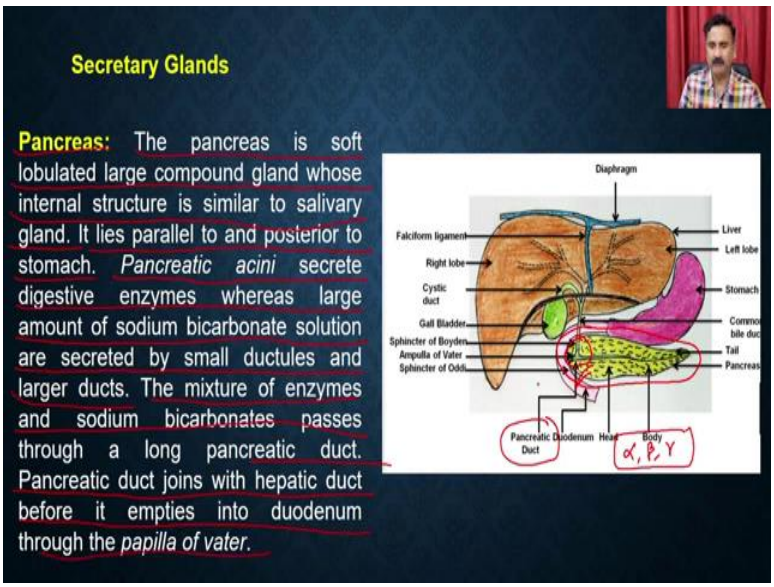

Then we have the another gland which is called as the pancreas. So, the pancreas is a soft lobulated large compound gland whose internal structure is similar to the salivary gland. It lies parallel to and the posterior to the stomach. So, what you see here is this is the pancreas what is present and it is a leaf like structure. And this is very soft and lobulated large compound glands, which actually going to contain the different types of cells. So, it is going to have the alpha cells, beta cells and the gamma cells and all these alpha, beta and gamma cells are actually going to secrete the different types of enzyme.

So, pancreatic acini secretes digestive enzymes, whereas the large amount of sodium bicarbonate solutions are secreted by the small ductules and the large ductules. The mixture of the enzyme and the sodium bicarbonate passes through long pancreatic duct. So what you see here is this is the pancreatic duct so this is the, so the pancreas has the two sides. It has the head on this side and the tail on this side and the, as I said, the pancreas is made up off of the alpha, beta and gamma cells and then the pancreas is connected into the elementary canal with the help of the pancreatic duct.

So this is the pancreatic duct what you see here and that is how it is actually connected. And then it is actually delivering the content into the duodenum. Pancreatic ducts joins with the hepatic ducts before it empties its content into the duodenum through the papilla of water. So this is what happened.

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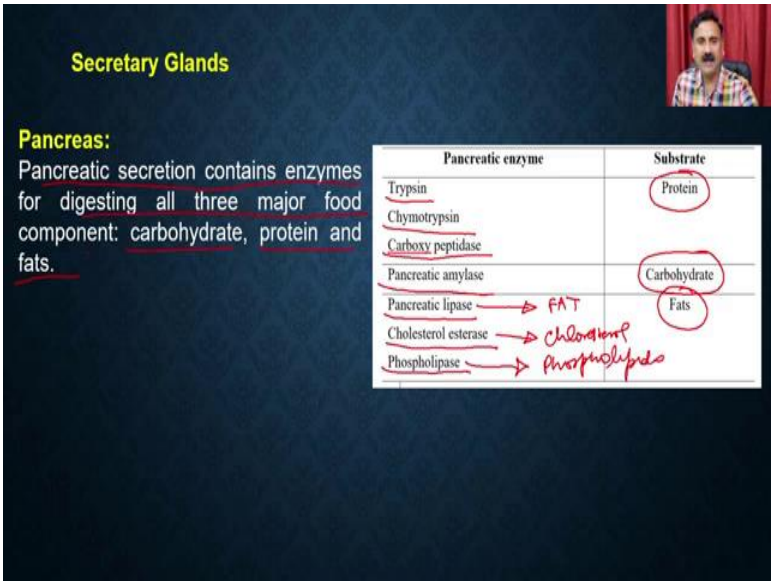

So, pancreas is secreting the many types of enzymes. So, pancreas secretes the enzymes for the digestion, all three major food products like the carbohydrates, proteins, and the fat. So, what you see here is these are the pancreatic enzymes.

So, pancreas is going to secrete the trypsin, chymotrypsin and carboxy peptidase, which is going to have the action on the proteins, then it also going to secrete the pancreatic lipase which is going to have the function on carbohydrate, and then it also going to secrete the different types of lipases like the pancreatic lipases, cholesterol esterase and phospholipases and they are actually going to function or the act on the different types of fats, like pancreatic lipase is actually going to act on the fat, cholesterol esterase is actually going to do the digestion of the cholesterol and the phospholipases are actually going to do the digestion of the phospholipids.

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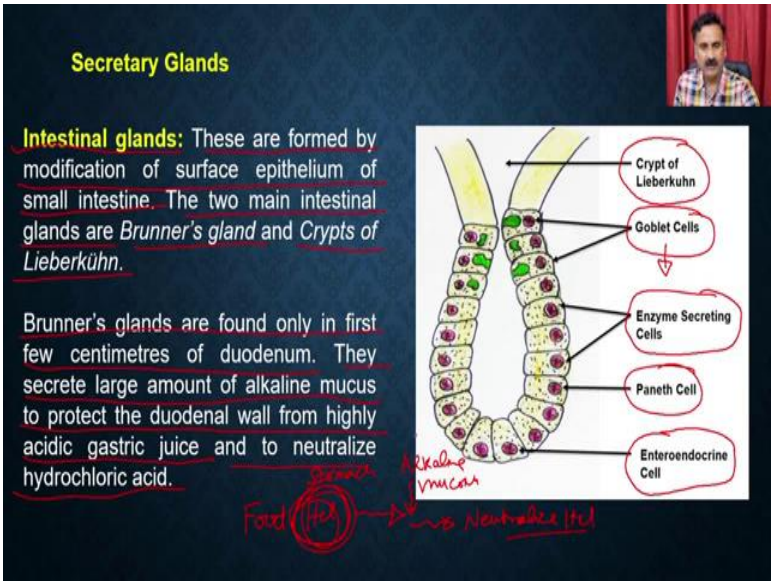


Now, let us move on to the next gland. So, the next gland is the intestinal gland. So, these are formed by the modification of the surface epithelium of the small intestine. The two main intestinal glands are the Brunner's glands and the Crypts of the Lieberkuhn. So these are the things what you see here.

So, in a typical intestinal land you are going to have the Crypts of the Lieberkuhn, you are going to have the goblet cells, which are actually going to be the major security cells, then you are also going to enzyme secretory cells, then you have the paneth cells and then you also have the entero endocrine cells, which are actually going to secrete the different types of hormones.

So, Brunner glands are found only in the first few centimeter of the duodenum. They secrete the large amount of the alkaline mucosa to protect the duodenum wall from the highly acidic gastric juice and to neutralize the hydrochloric acid. So, remember that you are going to get the food which actually going to contain the large quantity of HCl, because the HCl is going to be secreted by the stomach. So it is going to be from the stomach.

Now, this is HCl has to be neutralized because the enzyme what is present in the intestine or the small intestine are more active in the alkaline region. So that is why they are actually going to have to alkaline mucus, and that alkaline mucus is actually going to neutralize the HCl.

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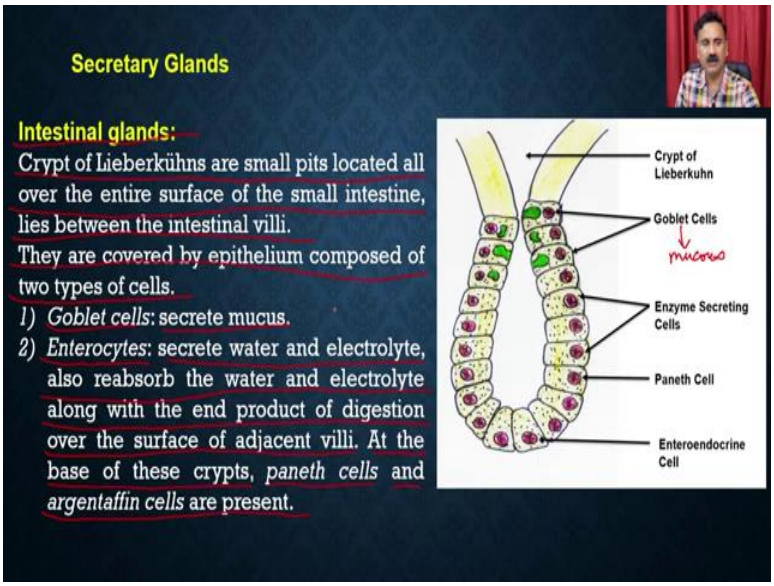


Now, let us move on to the next. So, intestinal glands, the Crypts of Lieberkuhn are small pits located all over the entire surface of the small intestine. They lies between the intestinal villi. They are covered by the epithelium and they are composed of the two different types of cells. They have the goblet cells which actually going to secrete the mucus, and then also going to have the enterocytes. So, enterocytes are secrete water and electrolytes and also reabsorb the water and electrolyte along with the end product of the digestion over the surface of the adjacent villi.

At the base of these crypts the paneth cells and the argentaffin cells are also being present and they are also contributing into the secretion of the different types of enzymes. So, now, let us see what are the different types of enzymes which are actually going to be present into the elementary canal.

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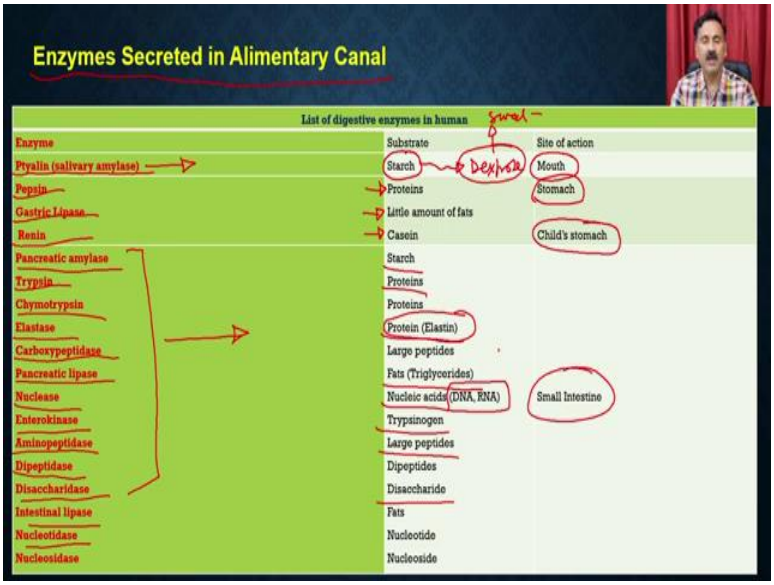


So, you have the enzymes which are actually going to be secreted by these secretory glands. So, staring from the buccal cavity, you are going to have the ptyalin which is actually going to be called as the salivary amylase. Then in the, so that the function of this is that it is actually going to digest the starch and it is going to convert the starch into the dextrose and that is how it is actually going to give you a sweet taste and that will be in the buccal cavity or the mouth.

Then you going to have the three enzymes like the pepsin, gastric lipase and the renin and all these three are actually going to act on the different types of substrates like the proteins, fat or the casoin proteins and they are actually going to be present in the stomach or the in the case of renin that is only going to be present in the child's stomach.

Then this is the small intestine where you are going to have the pancreatic amylase, trypsin, chymotrypsin, elastase, carboxypeptidase, pancreatic lipase, different types of nucleases, enterokinases, aminopeptidases, and all that, dipeptidases, disaccharides, intestinal lipase, nucleotideases, and the nucleosidases all these are actually going to act on the different types of substrates like the starch, proteins, specific proteins like the elastin or the fats like the triglycerides, nucleic acids such as the DNA and RNA, trypsinogens, large peptides and all that and they all are going to present in the small intestine.

So, what we have discussed so far, we have discussed about the anatomy of the elementary canal, we have discussed about the anatomy of the small intestine and as well as the large

intestine. And then subsequent to that we have also discussed about the structure as well as the function of the different types of secretory glands what are present in these, in the elementary canal. So, we discussed about the livers, pancreas, gastric juices or the, we discussed about the secretory enzymes into the buccal cavity and we also discussed about the intestinal glands.

So, with this discussion about the anatomy and function of these different components of the elementary canal.

I hope you will be able to understand the digestion process very nicely, and that we are going to discuss in our subsequent lecture. So, with this, I would like to conclude my lecture here. In subsequent lecture, we are going to discuss how these secretory products are actually going to digest the different food material. Thank you.