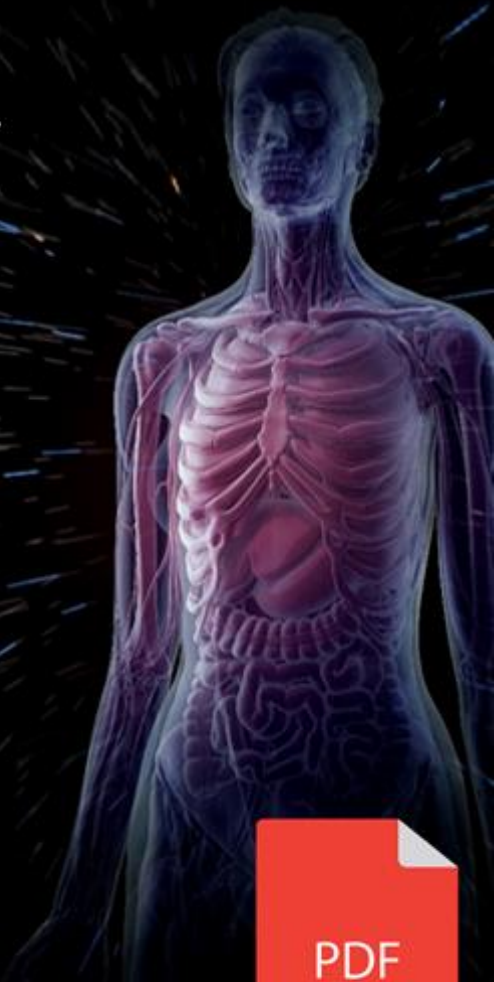
A-Level

Applied General Science

Unit 4 – The Human Body

THE HUMAN BODY



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1(a) – The Digestive System and Diet

From this chapter, you will get an understanding of key concepts of the digestive system and diet. You will also look at the applications of these concepts.

The Digestive System – The Basics

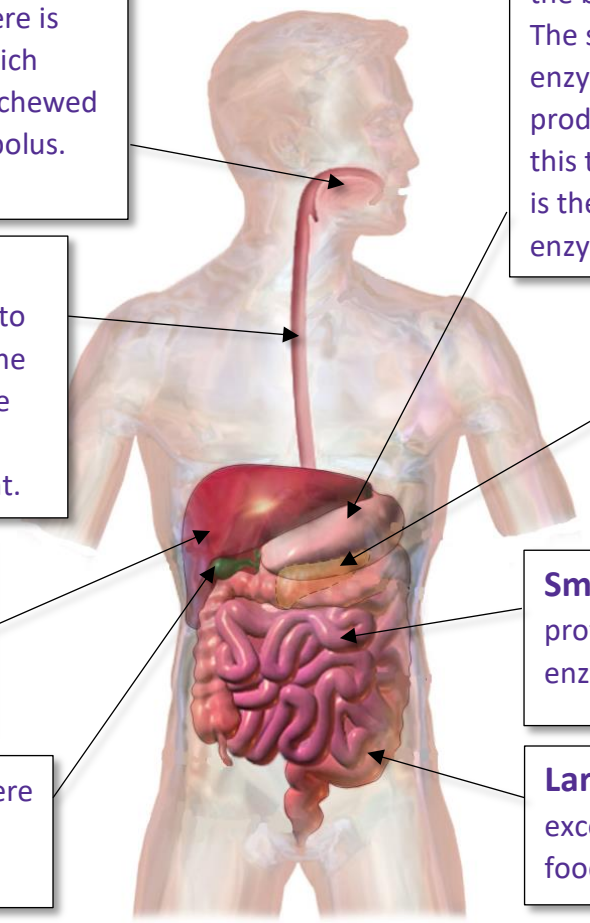
Digestion is the process of breaking down food into soluble products. These soluble products are then absorbed into the body. This process occurs in the digestive system. The breakdown of food is done mechanically and chemically (through chewing and digestive enzymes).

Mouth – The salivary glands release saliva that moisten the food. There is amylase enzyme in the saliva which breaks down starch. The food is chewed into a small ball. This is called a bolus. The bolus is then swallowed

Oesophagus – A tube that transports food from the mouth to the stomach. The muscles that line the oesophagus contract to move the bolus along by peristalsis. Mucus may be used as a lubricant.

Liver – Where bile is produced. Bile is responsible for neutralising stomach acid and emulsifying fats

Gall Bladder – Bile is stored here and then released into the small intestine when needed



Stomach – The stomach pummels the bolus with its muscular walls. The stomach produces a protease enzyme called pepsin. It also produces hydrochloric acid. It does this to kill bacteria and to ensure it is the optimal pH (pH 2) for the enzymes

Pancreas – Produces amylase, protease and lipase enzymes. These are then released into the small intestine

Small Intestine – Produces protease, amylase and lipase enzymes to complete digestion

Large Intestine – This is where excess water is absorbed from the food

Bond-Making and Bond-Breaking of Carbohydrates, Proteins and Lipids

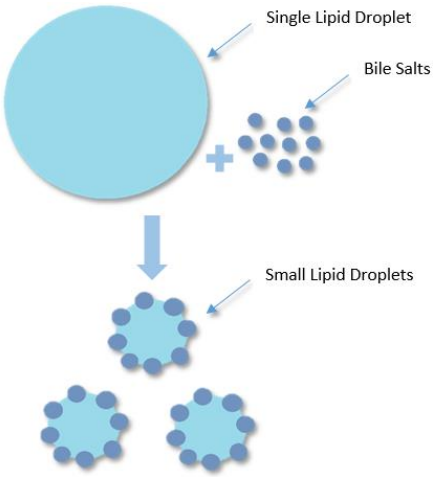
The Bond-Making and Bond-Breaking of Carbohydrates

Amylase – An example of a digestive enzyme is Amylase. Amylase catalyses the breakdown of starch, a combination of two polysaccharides. The polysaccharides are made from long chains of alpha-glucose molecules. Amylase catalyses hydrolysis reactions that break up the glycosidic bonds in starch in order to produce maltose. Maltose is a disaccharide. The salivary glands produce amylase and release it into the mouth. Amylase is also produced in the pancreases where it is then released into the small intestine.

Membrane-bound Disaccharides – membrane-bound disaccharides are another example of enzymes. They are attached to cell membranes of epithelial cells that line the ileum (small intestine). The ileum is the final part of the small intestine. They help to break down disaccharides into monosaccharides. This also involves the hydrolysis of glycosidic bonds.

The Bond-Making and Bond-Breaking of Lipids

Lipase enzymes – Lipase enzymes catalyse the breakdown of lipids. It causes them to become monoglycerides and also fatty acids. This process involves the hydrolysis of the ester bonds found in lipids. Lipases are mostly produced in the pancreas where they are then excreted into the small intestine. This is where they start to act.



Bile salts – Bile salts are made in the liver. The purpose of bile salts is to emulsify lipids. Bile salts work by breaking down lipids into several droplets. These droplets have a larger surface area than the single lipid droplet. Because of the larger surface area, there is now more for the lipases to work on. The monoglycerides and fatty acids stick together with the bile salts. This forms small structures called micelles.

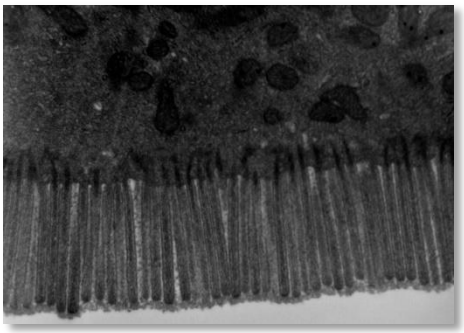
The Bond-Making and Bond-Breaking of Proteins

Proteins are broken down by a combination of peptidases. Peptidases are enzymes that catalyse the conversion of proteins into amino acids by hydrolysing the peptide bonds between amino acids.

Endopeptidases – Endopeptidases hydrolyse peptide bonds within a protein. Trypsin and chymotrypsin are endopeptidases and are synthesised in the pancreas. They are then secreted into the small intestine. Another example of an endopeptidase is Pepsin. Pepsin is released into the stomach by cells in the stomach lining. Pepsin works in the hydrochloric acid in the stomach as it cannot work in non-acidic conditions.

Exopeptidases – Exopeptidases hydrolyse peptide bonds at the end of protein molecules. They remove an amino acid from proteins. Dipeptidases are also an exopeptidase but work specifically on dipeptides. They separate two amino acids that make up a dipeptide. It does this by hydrolysing the peptide bond. Dipeptides can often be found in the cell surface membrane of epithelial cells in the small intestine.

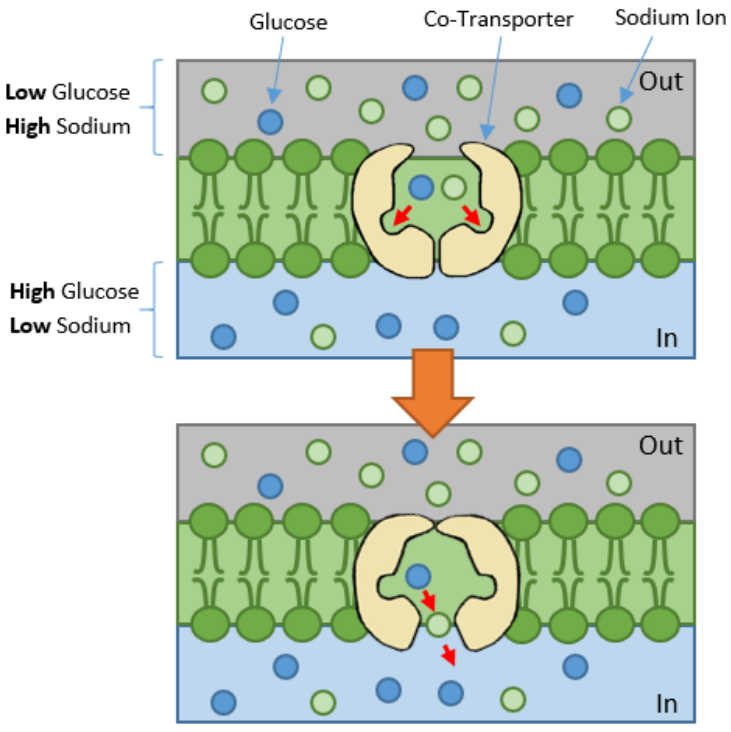
How the Structure of the Small Intestine Allows for Efficient Absorption



The small intestine is around 20 feet long (around 6 meters). This large surface area allows it to absorb as many nutrients and small soluble products of digestion. The surrounding layer of the small intestine is also made up of villi. These are small hair-like structures that increase the surface area even more which allows more of the products of digestion to be absorbed. It also has a very thin wall. This means it is easier for the nutrients to diffuse across. The small intestine is well supplied with blood meaning that the nutrients can diffuse into the blood and be carried away which maintains the concentration gradient. Each of the epithelial cells contains microvilli which further increase the surface area

How the Process of Co-Transport Absorbs Glucose and Amino Acids

Glucose is absorbed by active transport with sodium ions. This is done through the use of a co-transporter protein. Cotransporter proteins bind two molecules at the same time. The concentration gradient of one of the molecules is then used to move the other molecule against its own concentration gradient.



Amino acids are absorbed similarly. The sodium ions are actively transported out of the epithelial cells into the ileum. They are then diffused back into the cells through sodium-dependent transporter proteins. When they do this, the amino acids are transported along with them.

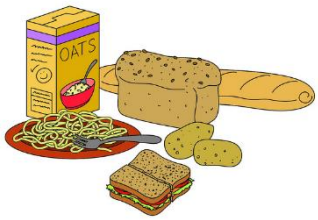
The Effect of Gastrin on Digestion

Gastrin is produced by G cells. G cells are found in the lining of the stomach and upper small intestine. Gastrin stimulates the stomach to release gastric acid when you eat a meal. The gastric acid helps the stomach to break down proteins from the food and absorb certain vitamins. Gastric acid also works as a disinfectant that kills most of the bacteria that make it to the stomach. This helps to reduce the risk of infection in the gut.

When you are about to eat, nerves in your brain are stimulated which signals for the release of gastrin into the stomach. Gastrin can also be signalled to be released when the stomach starts to stretch, certain foods are present (e.g. proteins) or an increase in pH levels. The production and release of gastrin decrease when the hormone 'Somatostatin' is released when the stomach empties and the pH of the stomach becomes too acidic.

Macronutrients and Micronutrients

- ***Macronutrients*** are a class of chemical compounds that humans consume in the largest quantities. They also give humans the bulk of energy. The three primary macronutrients are carbohydrates, proteins and lipids. The uses of these macronutrients are as follows:
  - ***Carbohydrates –*** Carbohydrates are the body's main source of energy. This is because they are easily utilised by all the tissues and cells that require energy. Carbohydrates can be stored in the muscles and the liver for use when required.



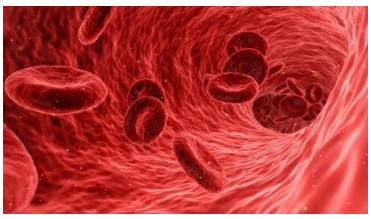
  - ***Proteins –*** Proteins are broken down into amino acids. These amino acids are used in protein synthesis where they can be used to produce specialised proteins such as transport protein, structural protein or contractile protein.

  - ***Lipids –*** Lipids can take the form of fatty acids, phospholipids and cholesterol in the body. Fatty acids are useful for storing energy and also providing a layer of insulation for the skin and organs. Phospholipids are chains of fatty acid and are used by the body to form cell membranes. Cholesterol is used by the body to produce hormones such as testosterone, progesterone and estrogen. Cholesterol can also help in the development of vitamin D in the body.

- ***Micronutrients*** are nutrients similar to macronutrients but are required in small quantities to ensure the body metabolises normally, grows normally and also ensures its physical well-being. Micronutrients are comprised of sodium, calcium, iron vitamin C and vitamin D. The uses of these micronutrients are as follows:
  - ***Sodium –*** Sodium is dissolved in the blood and helps maintain blood pressure. This is because it attracts and holds water in the blood. Sodium is also used in muscles and nerves. This is because muscles need an electrical current to function properly. These electrical currents can be generated by the muscles controlling the flow of electrically charged molecules (this includes sodium). This current is then used to stimulate the contraction of the muscles.

  - ***Calcium –*** Calcium is mostly used to keep bones and teeth strong (around 99% of the calcium consumed). The rest of the calcium is used for many different things including, cell signalling, blood clotting, muscle contraction and nerve function.

  - ***Iron –*** Iron is used to bind oxygen to red blood cells which allow the oxygen to be transported around the body. Iron is also used in the conversion of blood sugar to energy.



  - ***Vitamin C –*** Vitamin C is useful in many different ways. One of these ways is how it is used to produce collagen. Collagen is a substance that is used to give strength to the skin, bones and connective tissues around the body. Another use of vitamin C is to help the body produce skin, tendons, ligaments and blood vessels. Vitamin C can also be used to repair and maintain cartilage, bones, teeth and also to heal wounds and form scar tissue.

  - ***Vitamin D –*** Vitamin D is used to absorb calcium and promote bone growth. Vitamin D is also used by the body to help regulate the amount of calcium and phosphate there is in the body. The human body gets most of its vitamin D from the sun. It can also get vitamin D from foods such as oily fish, red meat, liver and egg yolks.

Nutrient Deficiency and the Diseases and Disorders That Can Develop

Carbohydrate Deficiency – When there is a deficiency of carbohydrates in the body, the body will be forced to utilise proteins and fats for energy. Carbohydrates are the bodies preferred source of energy so a deficiency of it can lead to feeling tired all of the time, constipation, nausea, headaches and bad breath. Acidosis will occur as a result of lipids being broken down for energy instead of glucose being broken down. This is because this produces ketoacidosis which increases in acidity in the blood and tissue around the body.

Protein Deficiency – When there is a lack of protein in the body, you may have trouble losing weight, gaining muscle mass, low energy levels, poor concentration and joint pain. A deficiency of protein can also lead to blood sugar changes that can lead to diabetes. Kwashiorkor can be caused by severe protein deficiency. Protein deficiency can also cause swelling of the gut.

Lipid Deficiency – If there is a lack of lipids in the body, this could lead to dry skin, poor body temperature regulation, mental fatigue and hunger (caused by lack of fat stores). Extreme lipid deficiency can lead to severe malnutrition which could be life-threatening.

Sodium Deficiency – A lack of sodium can cause altered personality, tiredness and confusion. A severe lack of sodium deficiency can cause seizures, comas or even death. The name given to this disorder is Hyponatraemia.

Calcium Deficiency – Lack of calcium in the body can lead to memory loss, muscle spasms, depression, muscle cramps and weak bones. The name given to this disorder is Hypocalcemia.

Iron Deficiency – The name given to iron deficiency is Iron Deficiency Anemia. The symptoms of this disorder are fatigue, weakness, pale skin, headaches, chest pain, fast heartbeat, shortness of breath and dizziness.

Vitamin C Deficiency – The symptoms of vitamin C deficiency include easy bruising, swollen gums, bleeding gums, inflamed gums, dry red skin and slow healing of wounds. One disease caused by vitamin C deficiency is Scurvy.

Vitamin D Deficiency – The symptoms of vitamin D deficiency include getting sick often, fatigue, tiredness, bone pain, muscle pain, depression and slow wound healing. Vitamin D deficiency can lead to rickets in kids. This disease can cause bones to become soft and also skeletal deformities.