



7 HUMAN NUTRITION

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- 7.3 MECHANICAL DIGESTION
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[VIEW EXAM QUESTIONS](#)

YOUR NOTES



7.1 DIET

Balanced Diet

- A balanced diet consists of all of the food groups in the correct proportions
- The necessary food groups are:
 - Carbohydrates
 - Proteins
 - Lipids
 - Vitamins
 - Minerals
 - Dietary Fibre
 - Water

FOOD TYPE	FUNCTION	SOURCES
CARBOHYDRATE	SOURCE OF ENERGY	BREAD, CEREALS, PASTA, RICE, POTATOES
PROTEIN	GROWTH AND REPAIR	MEAT, FISH, EGGS, PULSES, NUTS
LIPID	INSULATION AND ENERGY STORAGE	BUTTER, OIL, NUTS
DIETARY FIBRE	PROVIDES BULK (ROUGHAGE) FOR THE INTESTINE TO PUSH FOOD THROUGH IT	VEGETABLES, WHOLE GRAINS
VITAMINS	NEEDED IN SMALL QUANTITIES TO MAINTAIN HEALTH	FRUITS AND VEGETABLES
MINERALS	NEEDED IN SMALL QUANTITIES TO MAINTAIN HEALTH	FRUITS AND VEGETABLES, MEATS, DAIRY PRODUCTS
WATER	NEEDED FOR CHEMICAL REACTIONS TO TAKE PLACE IN CELLS	WATER, JUICE, MILK, FRUITS AND VEGETABLES

 7 HUMAN NUTRITION

7.1 DIET cont...

YOUR NOTES



Specific vitamin & mineral requirements:

VITAMIN / MINERAL	FUNCTION	SOURCES
VITAMIN C	FORMS AN ESSENTIAL PART OF COLLAGEN PROTEIN, WHICH MAKES UP SKIN, HAIR, GUMS AND BONES DEFICIENCY CAUSES SCURVY	CITRUS FRUIT, STRAWBERRIES, GREEN VEGETABLES
VITAMIN D	HELPS THE BODY TO ABSORB CALCIUM AND SO REQUIRED FOR STRONG BONES AND TEETH	OILY FISH, EGGS, LIVER, DAIRY PRODUCTS, ALSO MADE NATURALLY BY THE BODY IN SUNLIGHT
CALCIUM	NEEDED FOR STRONG TEETH AND BONES AND INVOLVED IN THE CLOTTING OF BLOOD DEFICIENCY CAN LEAD TO OSTEOPOROSIS LATER IN LIFE	MILK, CHEESE, EGGS
IRON	NEEDED TO MAKE HAEMOGLOBIN, THE PIGMENT IN RED BLOOD CELLS THAT TRANSPORTS OXYGEN	RED MEAT, LIVER, LEAFY GREEN VEGETABLES LIKE SPINACH



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Causes & Effects of Vitamin & Mineral Deficiencies

SUBSTANCE DEFICIENT	CAUSE	EFFECT
VITAMIN D	LACK OF SUNLIGHT, FISH, EGGS, BUTTER IN DIET	CAUSES RICKETS – WHERE BONES BECOME SOFT AND DEFORMED (THIS IS BECAUSE VITAMIN D IS NEEDED FOR ABSORPTION OF CALCIUM INTO THE BODY WHICH IS A KEY COMPONENT OF BONES AND TEETH)
IRON	LACK OF LEAFY GREEN VEGETABLES, RED MEAT, LIVER	CAUSES ANAEMIA – WHERE THERE ARE NOT ENOUGH RED BLOOD CELLS SO TISSUES DO NOT GET ENOUGH OXYGEN DELIVERED TO THEM (THIS IS BECAUSE IRON IS A KEY COMPONENT OF HAEMOGLOBIN)



7 HUMAN NUTRITION

7.1 DIET cont...

YOUR NOTES



Effects of Malnutrition

- **Malnutrition** is caused by **not eating a balanced diet**
- There are different types of malnutrition depending on the cause of the imbalance
- They include:
 - **Starvation**
 - **Coronary heart disease**
 - **Constipation**
 - **Obesity**

TYPE	CAUSE	EFFECT
STARVATION	TAKING IN LESS ENERGY THAN IS USED (OVER A LONG PERIOD)	BODY STARTS TO BREAK DOWN ENERGY STORES – FIRST FAT AND THEN MUSCLE TISSUE, LEADING TO SEVERE WEIGHT LOSS AND EVENTUALLY DAMAGE TO HEART AND IMMUNE SYSTEM, INCREASING THE RISK OF MANY DISEASES
CORONARY HEART DISEASE	DIET TOO HIGH IN SATURATED FAT AND CHOLESTEROL	FAT DEPOSITS BUILD UP IN ARTERIES SUPPLYING THE HEART, REDUCING FLOW OF BLOOD TO THE HEART MUSCLE CELLS WHICH DO NOT WORK PROPERLY DUE TO LACK OF OXYGEN. CAN LEAD TO HEART ATTACKS AND DEATH
CONSTIPATION	LACK OF FIBRE IN THE DIET	FOOD LACKS BULK FOR MUSCLES TO PUSH IT THROUGH THE ALIMENTARY CANAL AND SO RISK OF DISEASES SUCH AS BOWEL CANCER ARE INCREASED
OBESITY	TAKING IN MORE ENERGY THAN IS USED	EXTRA ENERGY STORED AS FAT, WEIGHT INCREASES AND CONTRIBUTES TO DEVELOPMENT OF MANY DISEASES SUCH AS HEART DISEASE AND DIABETES

7 HUMAN NUTRITION

7.1 DIET cont...

YOUR NOTES



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Protein Energy Malnutrition

- In many countries in the world, droughts, natural disasters, wars and a poor economy can lead to mass malnutrition in large areas of the country
- The two types of malnutrition most common in these situations are termed '**protein energy malnutrition**' (PEM) and they are:
 - **Kwashiorkor** – caused by a **lack of protein** in the diet, most common in children under 2.
 - Often caused by poverty as high protein foods tend to be more expensive and scarcer.
 - Children suffering from kwashiorkor are always underweight for their age but they often have a swollen abdomen as their diet may contain a lot of carbohydrate
 - **Marasmus** – the most severe form of PEM, where there is a **lack of both protein and energy** in the diet.
 - People suffering from this have a much lower body weight than normal and look emaciated

Dietary Needs of Different Individuals

FACTOR	DIETARY NEEDS
AGE	THE AMOUNT OF ENERGY THAT YOUNG PEOPLE NEED INCREASES TOWARDS ADULTHOOD AS THIS ENERGY IS NEEDED FOR GROWTH CHILDREN NEED A HIGHER PROPORTION OF PROTEIN IN THEIR DIET THAN ADULTS AS THIS IS REQUIRED FOR GROWTH ENERGY NEEDS OF ADULTS DECREASE AS THEY AGE
ACTIVITY LEVELS	THE MORE ACTIVE, THE MORE ENERGY REQUIRED FOR MOVEMENT AS MUSCLES ARE CONTRACTING MORE AND RESPIRING FASTER
PREGNANCY	DURING PREGNANCY, ENERGY REQUIREMENTS INCREASE AS ENERGY IS NEEDED TO SUPPORT THE GROWTH OF THE DEVELOPING FOETUS , AS WELL AS THE LARGER MASS THAT THE MOTHER NEEDS TO CARRY AROUND EXTRA CALCIUM AND IRON ARE ALSO NEEDED IN THE DIET TO HELP BUILD THE BONES, TEETH AND BLOOD OF THE FETUS
BREASTFEEDING	ENERGY REQUIREMENTS INCREASE AND EXTRA CALCIUM STILL NEEDED TO MAKE HIGH QUALITY BREAST MILK

7 HUMAN NUTRITION

7.2 THE ALIMENTARY CANAL

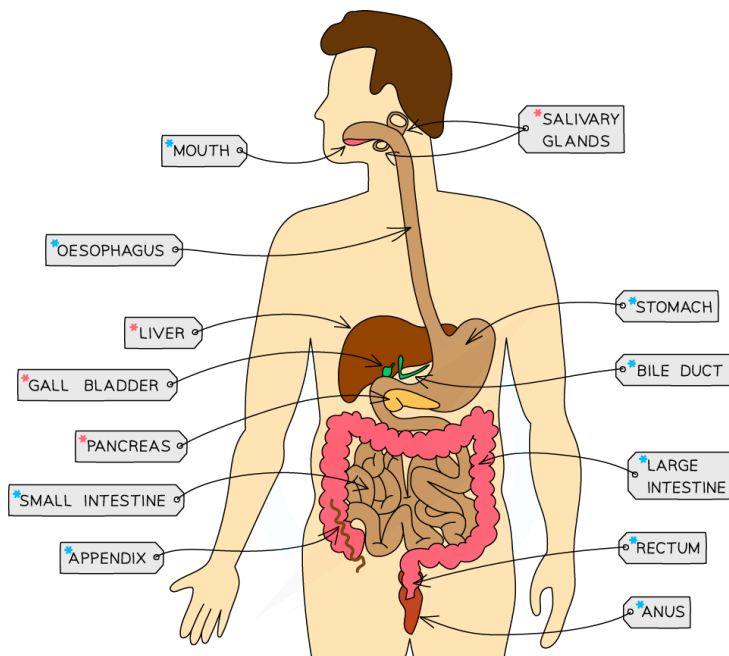
YOUR NOTES



The Stages of Food Breakdown

- Food taken into the body goes through 5 different stages during its passage through the **alimentary canal** (the gut)
- **Ingestion** – the taking of substances, e.g. food and drink, **into the body through the mouth**
- **Mechanical digestion** – the breakdown of food into smaller pieces **without chemical change** to the food molecules
- **Chemical digestion** – the breakdown of **large, insoluble molecules** into small, **soluble molecules**
- **Absorption** – the movement of **small food molecules and ions** through the wall of the intestine **into the blood**
- **Assimilation** – the movement of digested food molecules **into the cells of the body where they are used**, becoming part of the cells
- **Egestion** – the passing out of food that has **not been digested or absorbed, as faeces**, through the anus

Structure & Function of the Alimentary Canal



* = PART OF ALIMENTARY CANAL, THE PASSAGE ALONG WHICH FOOD PASSES THROUGH THE BODY

* = ACCESSORY DIGESTIVE STRUCTURES

The human digestive system



7 HUMAN NUTRITION

7.2 THE ALIMENTARY CANAL cont...

YOUR NOTES



STRUCTURE	FUNCTION
MOUTH / SALIVARY GLANDS	<p>THE MOUTH IS WHERE MECHANICAL DIGESTION TAKES PLACE</p> <p>– TEETH CHEW FOOD TO BREAK IT INTO SMALLER PIECES AND INCREASE IT'S SURFACE AREA TO VOLUME RATIO</p> <p>AMYLASE ENZYMES IN SALIVA START DIGESTING STARCH INTO MALTOSE</p> <p>THE FOOD IS SHAPED INTO A BOLUS (BALL) BY THE TONGUE AND LUBRICATED IN SALIVA SO IT CAN BE SWALLOWED EASILY</p>
OESOPHAGUS	<p>TUBE THAT CONNECTS THE MOUTH TO THE STOMACH</p> <p>WHERE THE FOOD BOLUS GOES AFTER BEING SWALLOWED</p> <p>WAVE – LIKE CONTRACTIONS WILL TAKE PLACE TO PUSH THE FOOD BOLUS DOWN WITHOUT RELYING ON GRAVITY</p>
STOMACH	<p>FOOD IS MECHANICALLY DIGESTED BY CHURNING ACTIONS WHILE PROTEASE ENZYMES START TO CHEMICALLY DIGEST PROTEINS</p> <p>HYDROCHLORIC ACID IS PRESENT TO KILL BACTERIA IN FOOD AND PROVIDE THE OPTIMUM PH FOR PROTEASE ENZYMES TO WORK</p>
SMALL INTESTINE	<p>FIRST SECTION IS CALLED THE DUODENUM AND IS WHERE THE FOOD COMING OUT OF THE STOMACH FINISHES BEING DIGESTED BY ENZYMES PRODUCED HERE AND ALSO SECRETED FROM THE PANCREAS</p> <p>PH OF THE SMALL INTESTINE IS SLIGHTLY ALKALINE – AROUND PH 8 – 9</p> <p>SECOND SECTION IS CALLED THE ILEUM AND IS WHERE ABSORPTION OF DIGESTED FOOD MOLECULES TAKES PLACE</p> <p>THE ILEUM IS LONG AND LINED WITH VILLI TO INCREASE THE SURFACE AREA OVER WHICH ABSORPTION CAN TAKE PLACE</p>
LARGE INTESTINE	<p>WATER IS ABSORBED FROM REMAINING MATERIAL IN THE COLON TO PRODUCE FAECES</p> <p>FAECES IS STORED IN THE RECTUM AND REMOVED THROUGH THE ANUS</p>
PANCREAS	<p>PRODUCES ALL THREE TYPES OF DIGESTIVE ENZYME; AMYLASE, PROTEASE AND LIPASE</p> <p>SECRETES ENZYMES IN AN ALKALINE FLUID INTO THE DUODENUM FOR DIGESTION TO RAISE PH OF FLUID COMING OUT OF THE STOMACH</p>
LIVER	<p>PRODUCES BILE TO EMULSIFY FATS (BREAK LARGE DROPLETS INTO SMALLER DROPLETS) – AN EXAMPLE OF MECHANICAL DIGESTION</p> <p>AMINO ACIDS NOT USED TO MAKE PROTEINS BROKEN DOWN HERE (DEAMINATION) WHICH PRODUCES UREA</p>
GALL BLADDER	<p>STORES BILE TO RELEASE INTO DUODENUM AS REQUIRED</p>

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7.2 THE ALIMENTARY CANAL cont...

YOUR NOTES



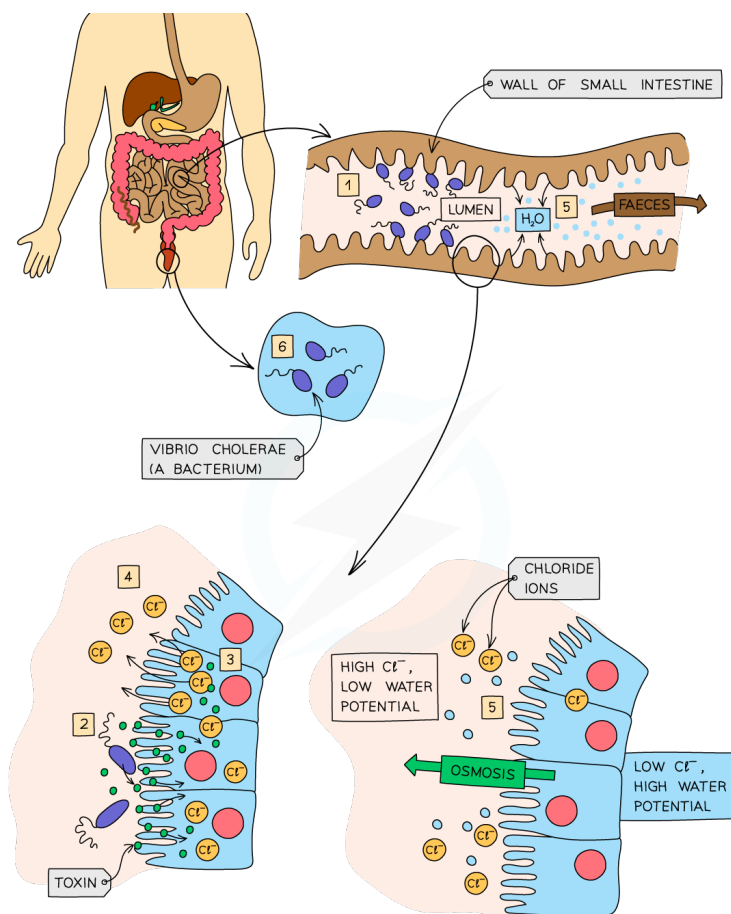
Diarrhoea Causes & Treatment

- Diarrhoea is **the loss of watery faeces from the anus**
- If it is severe and continues for a long time, it can **lead to death**
- Severe diarrhoea can cause the **loss of significant amounts of water and ions** from the body, causing the tissues and organs to stop working properly
- It can be effectively treated by **oral rehydration therapy**
- This is a **drink with a small amount of salt and sugar** dissolved in it
- There are many causes of diarrhoea, one of which is infection with **Vibrio cholerae bacteria**, which causes the disease **cholera**



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How Does Vibrio Cholerae Cause Diarrhoea?



How cholera leads to diarrhoea



7 HUMAN NUTRITION

7.2 THE ALIMENTARY CANAL cont...

YOUR NOTES



EXTENDED ONLY cont...

- Ingested via **infected water or food**, if it enters the small intestine it can cause illness in the following way:
 1. Bacteria attach to the wall of the **small intestine**
 2. They produce a **toxin**
 3. The toxin stimulates the cells lining the intestine to **release chloride ions** from inside the cells into the lumen of the intestine
 4. The chloride ions accumulate in the lumen of the small intestine and **lower the water potential** there
 5. Once the water potential is lower than that of the cells lining the intestine, **water starts to move out of the cells** into the intestine (by osmosis)
 6. Large quantities of water are lost from the body in **watery faeces**
 7. The blood contains **too little chloride ions and water**

7.3 MECHANICAL DIGESTION

Mechanical Digestion: Basics

- Mechanical digestion is the **breakdown of food into smaller pieces** without chemical change to the food molecules
- It is mainly carried out by the **chewing** action of the **teeth**, the **churning** action of the **stomach** and the **emulsification of fats** by **bile** in the duodenum

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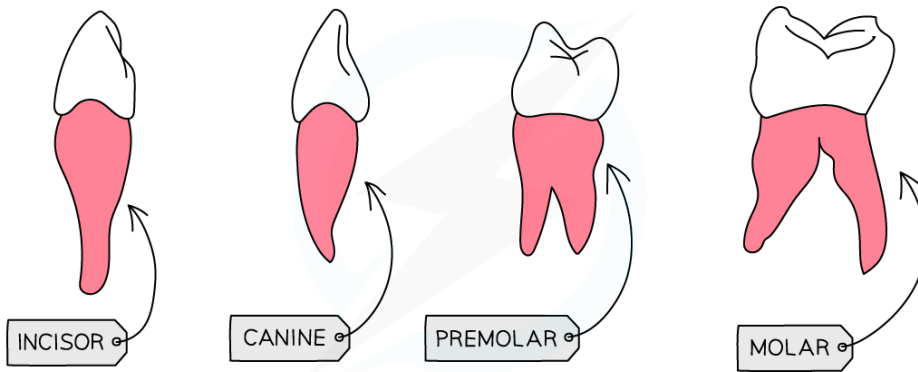
7.3 MECHANICAL DIGESTION cont...

YOUR NOTES



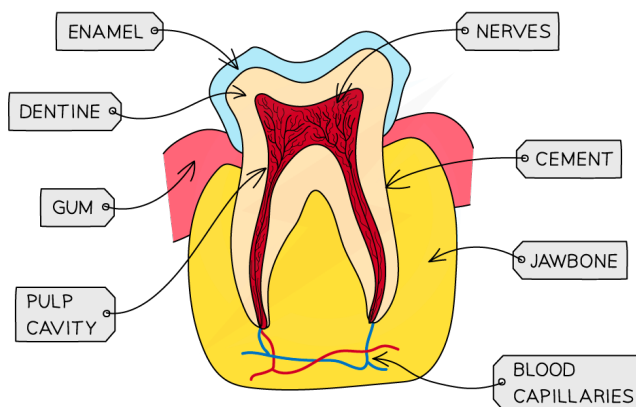
Types of Teeth

- Teeth are held firmly in the bone of the jaw
- They are used for chewing to increase the surface area of the food so that it can be exposed to saliva and other digestive juices and broken down more quickly
- The differing shapes and sizes of teeth enable them to perform slightly different functions:
- Incisors – chisel shaped for biting and cutting
- Canines – pointed for tearing, holding and biting
- Premolars and molars – larger, flat surfaces with ridges at the edges for chewing and grinding up food



Types of teeth

Structure of a Typical Tooth



Structure of a typical tooth



7 HUMAN NUTRITION

7.3 MECHANICAL DIGESTION cont...

YOUR NOTES



Dental Decay

- Tooth decay and gum disease are both caused by **bacteria**
- Many bacteria live in the mouth and most are harmless, however some form a **sticky film** with saliva, called **plaque**, which coats teeth and the areas where they attach to gums
- To begin with, plaque is soft and easy to remove, however if it hardens and forms **tartar**, it cannot be removed by brushing
- Tartar around the edges of teeth and gums can allow bacteria to work their way into roots, causing **gum disease** and loss of teeth
- If **sugar** is left in the mouth after eating, bacteria in plaque will feed on it
- They use it in **respiration** and turn it into **acids**
- The acids gradually **dissolve the enamel coating** of the teeth, working its way into the **dentine**
- Dentine is softer than enamel and so **dissolves more easily** and quickly
- This is **tooth decay** and if not dealt with, can cause painful infections and loss of teeth

Dental Health

- **Reducing the amount** of sugar eaten can prevent tooth decay
- **Brushing teeth regularly** removes the buildup of plaque that can cause gum disease and removes the sugars in the mouth so bacteria cannot turn them into acids and cause tooth decay
- Teeth should be brushed with a **fluoride toothpaste** as this helps to strengthen enamel and reduce damage from acids
- **Regular visits to a dentist** ensures that any signs of gum disease or tooth decay can be dealt with promptly

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7.4 CHEMICAL DIGESTION

YOUR NOTES

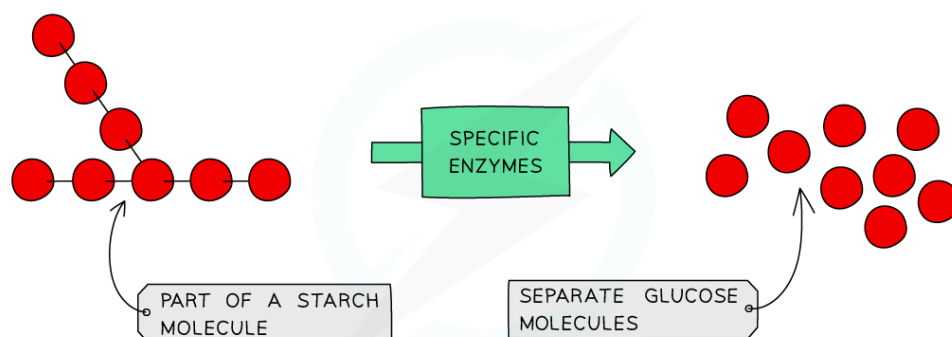


Enzyme Action in the Alimentary Canal

- The purpose of digestion is to **break down large, insoluble molecules (carbohydrates, proteins and lipids) into small, soluble molecules that can be absorbed into the bloodstream**
- Food is partially digested **mechanically** (by chewing, churning and emulsification) in order to break large pieces of food into smaller pieces of food which **increases the surface area for enzymes** to work on
- Digestion mainly takes place **chemically**, where bonds holding the large molecules together are broken to make smaller and smaller molecules
- Chemical digestion is controlled by **enzymes** which are produced in different areas of the digestive system
- There are three main types of digestive enzymes – **carbohydrases, proteases and lipases**

Carbohydrases: Basics

- **Amylases** are produced in the **mouth** and the **pancreas** (secreted into the **duodenum**)
- Amylases digest **starch into smaller sugars**



The digestion of starch



EXTENDED ONLY

Carbohydrases

- **Amylase** is secreted into the alimentary canal in the **mouth** and the **duodenum** (from the pancreas) and digests **starch to maltose** (a disaccharide)
- **Maltose** is digested by the enzyme **maltase** into **glucose** on the membranes of the epithelium lining the small intestine

7 HUMAN NUTRITION

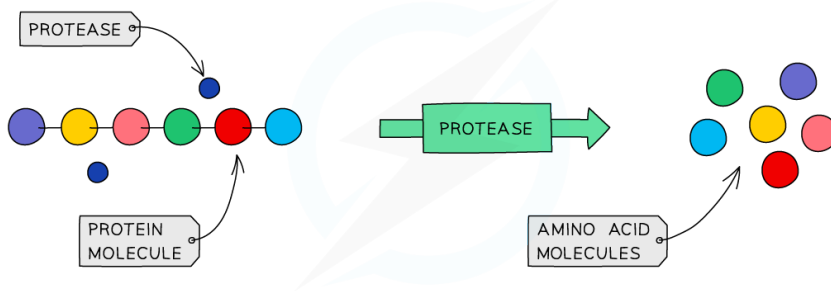
7.4 CHEMICAL DIGESTION cont...

YOUR NOTES



Proteases: Basics

- Proteases break down **proteins into amino acids** in the **stomach and small intestine** (using an enzyme produced in the pancreas)



The digestion of proteins



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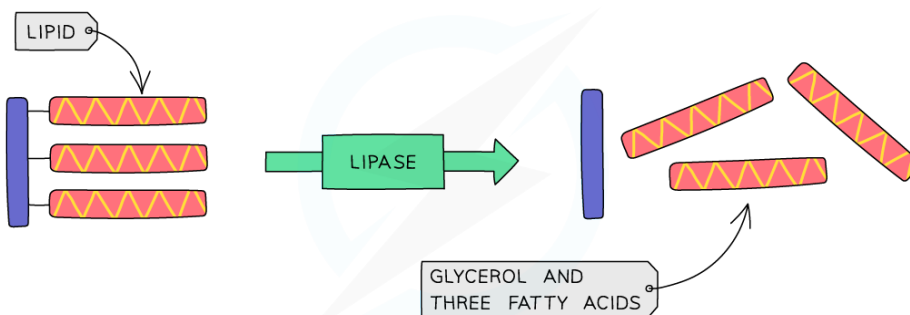
Proteases

Protein digestion takes place in the stomach and duodenum with two main enzymes produced:

- Pepsin** is produced in the **stomach**
- Trypsin** is produced in the **pancreas** and secreted into the **duodenum**

Lipases

- Lipase** enzymes are produced in the **pancreas** and secreted into the **duodenum**
- They digest lipids **into fatty acids and glycerol**



The digestion of lipids

7 HUMAN NUTRITION

7.4 CHEMICAL DIGESTION cont...

YOUR NOTES



The Role of Hydrochloric Acid

- The Role of Hydrochloric Acid
- The stomach produces several fluids which together are known as **gastric juice**
- One of the fluids produced is **hydrochloric acid**
- This **kills bacteria** in food and gives an **acid pH for enzymes** to work in the stomach



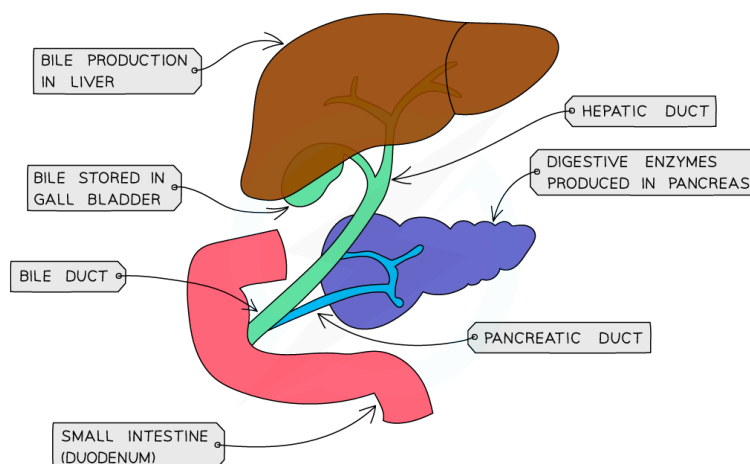
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How is a Low pH Helpful in the Stomach?

- The low pH kills bacteria in food that we have ingested as it **denatures the enzymes in their cells**, meaning they cannot carry out any cell reactions to maintain life
- **Pepsin**, produced in the stomach, is an example of an enzyme which has a very low optimum pH – around **pH 2**
- The hydrochloric acid produced in the stomach ensures that conditions in the stomach **remain within the optimum range** for pepsin to work at its fastest rate

The Role of Bile

- Cells in the **liver** produce bile which is then stored in the **gallbladder**



Bile production and secretion

 7 HUMAN NUTRITION

7.4 CHEMICAL DIGESTION cont...

Bile has two main roles:

- It is **alkaline** to **neutralise the hydrochloric acid** which comes from the stomach. The enzymes in the small intestine have a higher (more alkaline) optimum pH than those in the stomach
- It **breaks down large drops of fat into smaller ones**. This is known as **emulsification**. The larger surface area allows lipase to chemically break down the lipid into glycerol and fatty acids faster



EXAM TIP

Emulsification is the equivalent of tearing a large piece of paper into smaller pieces of paper.

This is an example of mechanical digestion, not chemical digestion – breaking something into smaller pieces **does not break bonds or change the chemical structure of the molecules** which make it up, which is the definition of chemical digestion.

7.5 ABSORPTION

Absorption of Food & Water

- Absorption is the **movement of digested food molecules from the digestive system into the blood (glucose and amino acids) and lymph (fatty acids and glycerol)**
- **Water** is absorbed in both the **small intestine** and the **colon**, but most **absorption of water** also happens in the **small intestine**
- Absorption takes place in the second section of the small intestine, the **ileum**



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How is the ileum Adapted for Absorption?

- The ileum is adapted for absorption as it is **very long** and has a **highly folded surface with millions of villi** (tiny, finger like projections)
- These adaptations massively **increase the surface area** of the ileum, allowing absorption to take place faster and more efficiently

YOUR NOTES



7 HUMAN NUTRITION

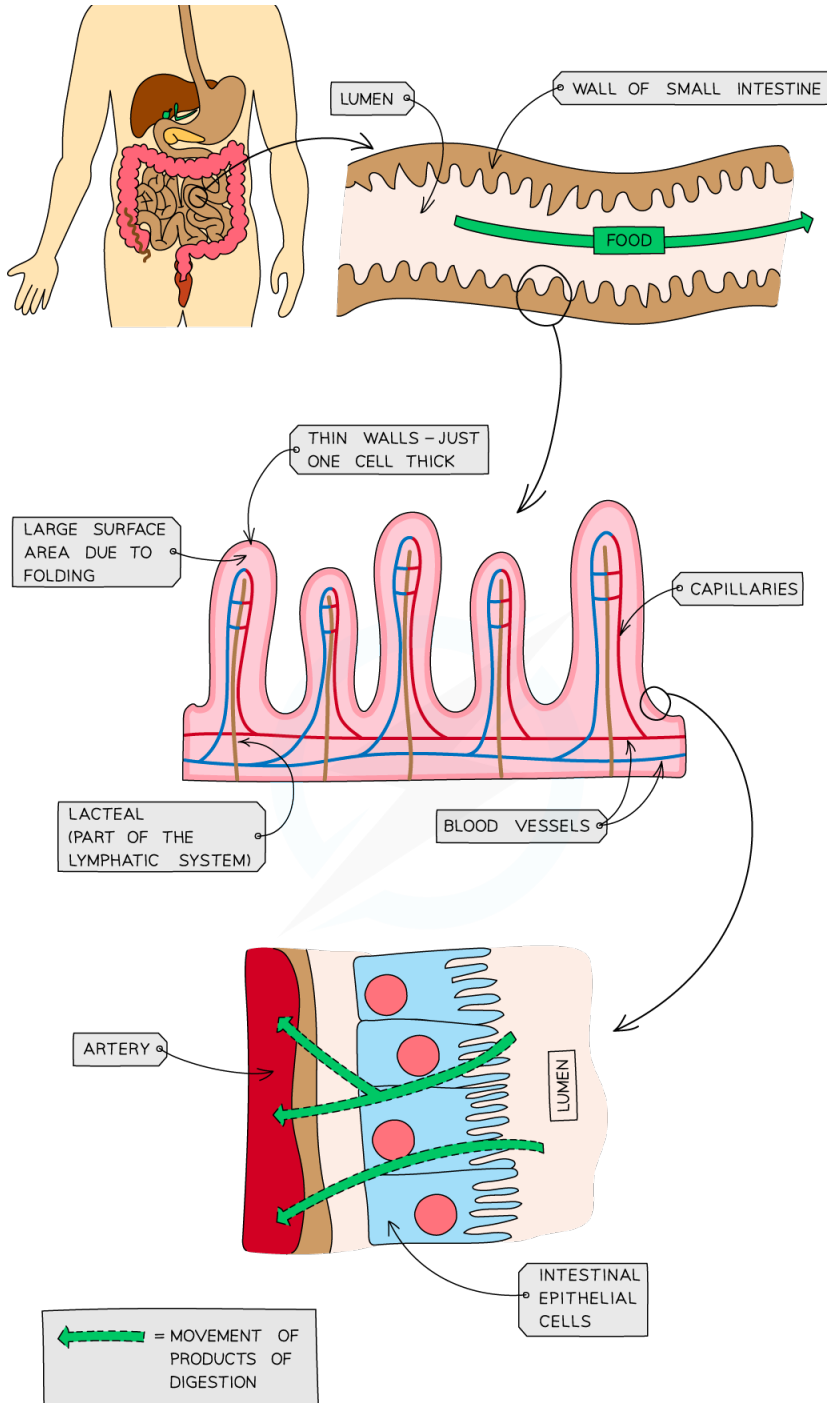
7.5 ABSORPTION cont...

YOUR NOTES



EXTENDED ONLY cont...

Structure & Adaptations of a Villus



Adaptations of the small intestine



7 HUMAN NUTRITION

7.5 ABSORPTION cont...

YOUR NOTES



EXTENDED ONLY cont...

- **Microvilli** on the surface of the villus further increase surface area for faster absorption of nutrients
- Wall of villus is **one cell thick** meaning that there is only a short distance for absorption to happen by diffusion and active transport
- Well supplied with a **network of blood capillaries** that transport glucose and amino acids away from the small intestine in the blood
- **Lacteal** runs through the centre of the villus to transport fatty acids and glycerol away from the small intestine in the lymph



EXAM TIP

The way in which the structure of a villus is related to its function comes up frequently in exam questions.

So ensure you have learned these adaptations.

> NOW TRY SOME EXAM QUESTIONS

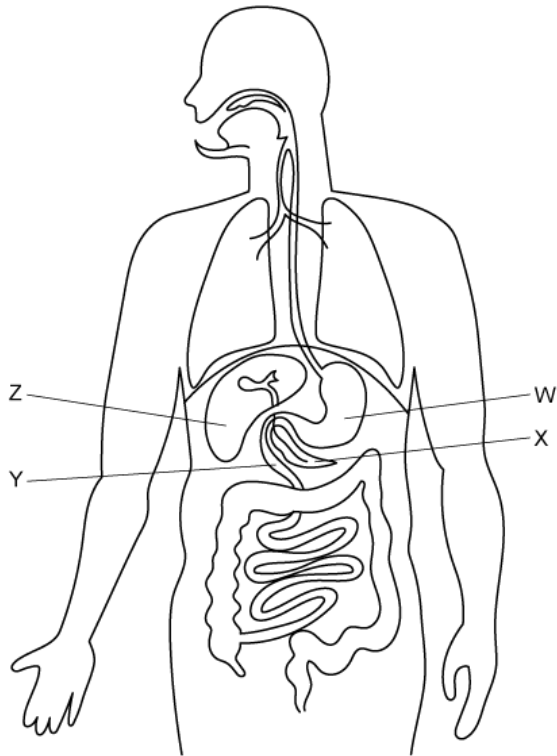
 7 HUMAN NUTRITION

EXAM QUESTIONS

YOUR NOTES

**? QUESTION 1**

The diagram below shows the organs of the digestive system.



In which organs does the digestion of proteins take place?

- A W & Y
- B W & Z
- C Z only
- D W & X

? QUESTION 2

A patient suffering with persistent diarrhoea calls a doctor.

What treatment should the doctor advise the patient to take?

- A Drinking pure water
- B Drinking a solution of sugar and salt
- C Taking antibiotics
- D Eating more protein



7 HUMAN NUTRITION

EXAM QUESTIONS cont...

YOUR NOTES

**? QUESTION 3**

Which of the following is a correct function of bile?

- A To emulsify proteins
- B To provide enzymes for the digestion of lipids
- C To neutralise the alkaline conditions of food entering the duodenum
- D To increase the surface area of lipids for digestion

? QUESTION 4

A student ate a meal which contained a type of biomolecule, X.
The digestion of biomolecule X started in the mouth, and finished in the duodenum.

What is the product of the digestion of biomolecule X?

- A Amino acids
- B Protein
- C Glucose
- D Starch

? QUESTION 5

Dietary fibre contains complex carbohydrates which cannot be broken down by enzymes produced in the human digestive system. Fibre passes through several structures after leaving the stomach.

In which order does dietary fibre pass through these structures?

- A Pancreas → duodenum → ileum → rectum
- B Duodenum → ileum → colon → rectum
- C Duodenum → pancreas → ileum → rectum
- D Ileum → duodenum → colon → rectum

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