Lesson Description

In this lesson, we revise:

- nutrition in various animals
  - Herbivores, Carnivores and Omnivores
- the two different types of human digestion
  - Mechanical
  - Chemical

Key Concepts

Nutrition in Animals

- Nutrition is defined as the sum of the following processes – ingestion, digestion, absorption, assimilation and egestion.
- Some definitions that you need to know:
  - Ingestion is the process where food is taken in
  - Digestion is the process where large molecules are broken down into smaller molecules either mechanically or chemically.
  - Absorption is the process where the molecules move through the intestinal walls (small intestine) into the blood vessels.
  - Assimilation is the process where nutrients are moved into and used by the cell.
  - Egestion is the process whereby unused nutrients are eliminated from the digestive system.

- Human nutrition is a well studied subject. In Life Orientation and Naturals Sciences you would have discussed healthy diets and the correct nutrition for humans. Below is a reminder of human nutrition – a food pyramid.

![Food Pyramid](image)

*Fig. 5.1 A food pyramid of recommended daily servings*

*(Solutions for all Life Sciences, Grade 11, Macmillan, p145)*
- Humans use carbohydrates for energy, proteins for amino acids and fats for protecting vital internal organs as well as acting as a reserve energy source.
- The important minerals we need are calcium, phosphorus, iodine and iron.
- Food is produced by plants (autotrophs) through the process of photosynthesis as we have learned in the last two weeks.
- **Herbivores** are mammals that consume plant material. Their dentition and digestive tract have adapted to consuming large amounts of plant material.

![Herbivore Skull Diagram](https://via.placeholder.com/150)

*(Solutions for all Life Sciences, Grade 11, Macmillan, p146)*

The dental formula for sheep is as follows:

\[
\begin{align*}
0.0.3.3 \\
4.0.3.3
\end{align*}
\]

(Remember that a dental formula only shows the teeth for half a jaw)

- This formula shows that the sheep has 8 incisors on the lower jaw which meet the horny pad of the upper jaw. There is a large gap or diastema between the incisors and the premolars. There are 6 premolars and 6 molars.
- The herbivores must consume a large amount of plant material to gather enough energy and nutrients. This is because the carbohydrates in the plant are protected by cellulose which the digestive system has difficulty breaking down. There are enzymes and bacteria in the digestive system that break down the cellulose allowing access to the carbohydrates.
- **Carnivores** are meat eating mammals that have to hunt, kill and tear apart their prey to eat.

![Carnivore Skull Diagram](https://via.placeholder.com/150)

*(Solutions for all Life Sciences, Grade 11, Macmillan, p147)*
They have the following dental formula:

\[
\begin{align*}
3.1.4.3 \\
3.1.4.3
\end{align*}
\]

- The distinctive feature of carnivores is the carnassial teeth. The upper fourth molar and the lower first molar have sharp knife-like edges that slide past each other and slice through flesh.
- Carnivores are predators and they expend a large amount of energy hunting for their food. Meat is low in carbohydrate but rich in other nutrients. Meat is easier to digest than plant material so carnivores have shorter digestive systems than herbivores or omnivores.
- The size of an open jaw is fairly large in comparison to the head. The teeth are modified for grasping, tearing and chewing tough meat.
  - The canines are long and sharp and are used for the killing of prey and tearing of the flesh.
  - The molars are sharp and uneven and they are used for chewing the tough meat.
  - Finally, the carnassials teeth have knife-like serrated edges and they cut and slice the meat off the bone.
- Omnivores have digestive systems and dentition that is adapted to eating both plant and animal tissues.
- New world monkeys have slightly different dental formulae to old world monkeys and humans. A new world monkey such as the Emperor Tamarin has the following dental formula:

\[
\begin{align*}
2.1.3.2 \\
2.1.3.2
\end{align*}
\]

- The old world monkeys and humans have the following dental formula:

\[
\begin{align*}
2.1.2.3 \\
2.1.2.3
\end{align*}
\]

(Solutions for all Life Sciences, Grade 11, Macmillan, p148)

- Because there are so many different omnivores, the dental formulas can vary slightly but each one will have the same basic pattern – incisors to cut meat, canines to grasp and tear meat and molars to crush and grind plant matter.
Structure of the Human Digestive System

- Humans eat for two reasons – energy and nutrients to keep the body healthy. Energy is consumed in the form of carbohydrates or lipids. The other nutrients absorbed contribute to the formation of proteins and enzymes as well as the general upkeep of the body e.g. calcium for bones and muscle.
- The diagram on the next page shows the digestive system or alimentary canal of a human. There are two distinct openings for ingesting (mouth) and egesting (anus) food materials.

(Solutions for all Life Sciences, Grade 11, Macmillan, p150)

- There are two types of digestion that the human digestive system uses:
  - Mechanical and
  - Chemical

- **Mechanical digestion** starts in the mouth with the teeth chewing the food and the tongue working the food into a ball (*bolus*) for swallowing.
- The Biological name for chewing is mastication.
- The bolus is moved to the back of the mouth and pushed into the oesophagus where more mechanical digestion occurs in the form of peristalsis.
- Peristalsis in the process where muscles in the wall of the oesophagus contract and relax antagonistically. This means when one muscle contracts. The other muscle relaxes and so it continues alternating contracting and relaxing.
- Peristalsis also happens in the stomach and the rest of the digestive tract to push the food along.
- Another form of mechanical digestion occurs in the stomach where the stomach muscles churn the food into a liquid called *chyme*. 
Chemical digestion uses enzymes to break the food into its basic chemical compounds for absorption by the body.

The enzymes control the chemical breakdown.

The enzymes are sensitive to temperature and pH. Different enzymes act in different pH levels in the various parts of the digestive system.

There are a large number of glands and organs associated with the digestive system. They provide chemical substances that enhance the chemical digestion of food.

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Where produced</th>
<th>Substrate</th>
<th>Optimum pH</th>
<th>End products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrases</td>
<td>Salivary glands, pancreas and small intestine</td>
<td>Carbohydrates (starch and disaccharides e.g. maltose)</td>
<td>6–7: Mouth 8: Small intestine</td>
<td>Monosaccharides, for example glucose, fructose and galactose</td>
</tr>
<tr>
<td>Proteases</td>
<td>Stomach lining, pancreas and small intestine</td>
<td>Proteins and polypeptides</td>
<td>3: Stomach 8: Small intestine</td>
<td>Amino acids</td>
</tr>
<tr>
<td>Lipases</td>
<td>Pancreas and small intestine</td>
<td>Lipids</td>
<td>8: Small intestine</td>
<td>Glycerol and fatty acids</td>
</tr>
</tbody>
</table>

On the next page is a diagram indicating where the enzymes associated with the digestive system are produced, where they act, their names and what they do. Be sure to learn the names, the places of action and types of action for each enzyme.
Saliva from salivary glands contains AMYLASE. Amylase digests starch into maltose.

Gastric juice from the gastric glands contains PROTEASE. Protease digests proteins into polypeptides.

Pancreatic juice from the pancreas mixes with intestinal juice and contains AMYLASE, PROTEASE and LIPASE.

AMYLASE – Digests maltose into monosaccharides

LIPASE – Digests fats into fatty acids and glycerol.

PROTEASE – Digests polypeptides into amino acids.

Mono-saccharides and amino acids are absorbed into the blood.

Fatty acids are absorbed into the lymph.

(Solutions for all Life Sciences, Macmillan, p157)
Absorption: Description and where it occurs

- Absorption is defined as the process where the products of digestion (small molecules) move through the wall of the small intestine into the blood vessels.
- Absorption can occur in the mouth, stomach and large intestine but the majority of the absorption occurs in the small intestine. Water is absorbed mainly in the large intestine.
- For absorption to occur properly, there are a few criteria that the small intestine must meet:
  - There must be a large surface area so that a lot of nutrients can be absorbed.
  - The surface of the intestine must be thin so that the smaller molecules can be absorbed.
  - There must be a good blood supply so that the absorbed molecules can be moved throughout the body.
  - The molecules inside the intestine must be in close contact with the surface – the molecules must be small.

Structure of the Microvillus

![Diagram of a villus and columnar epithelium cells]

(Solutions for all Life Sciences, Macmillan, p160)

- The walls of the small intestine have finger-like projections called villi.
- Each villus has a lining of columnar epithelium. The membrane of the cell on the inside of the intestine is folded into microvilli and these folds increase the surface area of the small intestine even further. There is only one layer of columnar epithelium so that it is easy for the small molecules to move from the lumen of the small intestine into the villus. The Goblet cells found interspersed amongst the columnar epithelium secrete mucous.
- Between each villus is found a krypt of Lieberkuhn. The krypts produce new cells to replace any cells that need to be replaced.
- Inside each villus you will find capillaries, a lacteal and a Brunners gland.
- The capillaries absorb and carry away the monosaccharides and amino acids while the lacteal absorbs and removes the fatty acids.
- The Brunner’s glands produce an alkaline solution which contains bicarbonate. This is to protect the small intestine from the acidic chime of the stomach. It also provides the correct pH for the enzymes of the intestine to work.
The Hepatic Portal System: Structure and Function

- The capillaries join to form venules. The venules join with venules from the stomach to become the hepatic portal vein. This system is known as the hepatic portal system.
- The hepatic portal veins transports amino acids and glucose molecules to the liver.
- The hepatic portal vein is unusual because it is formed by a series of capillaries that join together outside the liver and then split up into capillaries again inside the liver.

(Solutions for all Life Sciences, Macmillan, p161)
Assimilation: Description and where it occurs

- Absorbed nutrients are transported from the liver to the heart by the hepatic vein. From the heart the nutrients move to all parts of the body.
- The process where nutrients are taken from the blood and into the cells is called assimilation.
- Glucose is used in respiration to produce energy. Different cells will absorb different amounts of glucose. For example, muscle cells will absorb more glucose because more active and require more energy.
- Amino acids are absorbed by the cells where large amounts of proteins are formed. The amino acids can join to form enzymes, proteins or hormones.
- After absorption the nutrients all go to the liver except the fatty acids.

<table>
<thead>
<tr>
<th>Nutrient / Chemical</th>
<th>Process</th>
</tr>
</thead>
</table>
| Amino acids         | • Excess amino acids go through a process of de-amination.  
                        • De-amination is when the nitrogen is removed and ammonia is formed with it  
                        • The ammonia is moved to the kidneys which convert it into urea.  
                        • The urea is excreted in the urine. |
| Glucose             | • Excess glucose is converted into glycogen.  
                        • The liver stores the glycogen which can be converted back into glucose when needed. |
| Alcohol and drugs   | • The detoxification process changes alcohol and drugs from harmful substances into harmless substances  
                        • Excess alcohol over time causes the liver to work too hard and this leads to some parts of the liver not working. |
| Hormones            | • Once hormones have fulfilled their functions in the body, the liver breaks them down.  
                        • Examples are insulin, testosterone and oestrogen. |

Egestion

- Food that cannot be digested by the body must be removed.
- The process of removing the undigested food in the form of faeces is called egestion.
- Cellulose cannot be digested by the human body however it is still necessary for the human to consume cellulose to prevent constipation and the blockage of the large intestine.
Questions

Question 1
Below are skulls of various types of animals.

a.) In table form compare the four skulls above with respect to dentition and types of food consumed.

b.) Describe the process of mechanical digestion in the human from the moment of ingestion to egestion.

Question 2
Give the correct word or term for each of the following:

a.) the process whereby food is eaten
b.) the substance stored in the gall bladder
c.) the wave-like contraction of your oesophagus
d.) the breakdown of excess amino acids by the liver
e.) the group of enzymes that break down proteins
f.) the form in which glucose is stored in the liver

Question 3
Answer the following questions

a.) Name four processes involved in human nutrition.  (4)
b.) Define absorption.  (2)
c.) Describe how the small intestine is adapted to perform the function of absorption.  (10)
d.) Which organ plays a major role in assimilation?  (1)
e.) Name the vein that transports nutrients from the digestive system to the liver.  What is unique about this vein.  (4)