SCIENCE

Unit 1

Human Health and Safety

Acknowledgements:

Editors:	Marissa Rolnick, Tony Lelliott
Writers:	Allistair Clacherty
	Erna McCarthy
	Helen de Wet
	Jenny Woolway
	Sharika Banwa
Artwork:	Nelrie Pieterse
Layout:	Lidia Kruger

Contents

Specific aims	Lesson 3 Cells, Tisssues, organs and systems		
Knowing science: Content	Cells in the human body	Tissues in the human body	Systems in the human body
Investigating science			Discovering how things work
Science in society			
Science process skills	Tabulation (Activity 12); modelling (Activity 13)	Diagrams; parts to the whole (Activity 14)	Tabulation (Activity 16)
Language skills			

Specific aims	Lesson 4 Sexual reproduction in humans			
Knowing science: Content	Male and female reproductive organs	Female reproductive cycles	Fertilisation, pregnancy, birth	Contraceptives
Investigating science		Data response (Activity 22)		
Science in society			Responsibilities while pregnant	Quality of life; responsibilities
Science process skills	Diagrams (Activity 19), tabulation (Activity 18)	Graph interpretation (Activity 21, 22)		
Language skills				Essay writing (Activity 24)

Specific aims	Lesson 5 Genetics and inheritance				
Knowing science: Content	The cell cycle	DNA	Protein synthesis	Genes and inheritance	Genetic disorders
Investigating science				Genetic crosses	
Science in society				History of genetics	Genetic counselling and sensitivity
Science process skills	Diagram analysis (Activity 26)	Diagram analysis (Activity 29)	Diagram analysis and process description (Activity 31)	Punnett square and cross diagrams	Surveys (Activity 33)
Language skills	Comparison tables (Activity 28)		Comprehen-sion (Activity 30)	Terminology	

Specific aims	Lesson 6 Energy and the Human Body		
Knowing science: Content	Energy from the sun	Human nutrition	Cellular respiration
Investigating science			
Science in society		Healthy eating choices, nutrition in society	
Science process skills	Chemical equations		Chemical equations
Language skills	Mindmapping		

LESSON 1

Chemicals of life

About this lesson

About two thousand years ago, the Ancient Greeks wondered what would happen if you kept dividing a substance into smaller and smaller bits. Could you go on dividing something into smaller bits forever or would you reach a point at which no further division was possible? They reached the conclusion that matter must be made of tiny, indivisible particles although they had no direct evidence for this. Scientific research, over the years, has supported the idea that all matter is made up of particles.

You will see how atoms combine with each other to make thousands of different substances and learn about the different kinds of substances that make up the bodies of living organisms.

Finally, you will focus on three of the most important groups of organic molecules that are found in living organisms: carbohydrates, lipids and proteins.

In this lesson you will:

- discover what molecules make up living organisms
- distinguish between inorganic and organic compounds and name the different inorganic and organic compounds important to living organisms
- examine the organic compounds important to living organisms
- identify the monomers and polymers of the different groups of organic molecules
- list the characteristics of carbohydrates, lipids and proteins

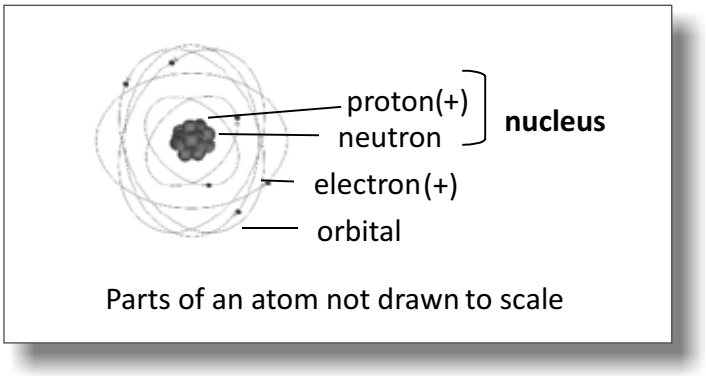
Organic and Inorganic Compounds

What are compounds?

atom:
smallest unit particle of a specific type of matter
molecule:
combination of two or more atoms bonded together
element:
substance with only one kind of atom present
compound:
substance made of more than one kind of atom
atomos:
Greek word meaning indivisible

You need to be able to use and distinguish between three terms: elements, molecules and compounds.

Substances that are made of only one kind of atom are called **elements**. All the atoms in one kind of element are the same, but they differ from the atoms in another element. The way in which they differ lies in their number of protons and electrons. A hydrogen atom has one proton (and one electron). A helium atom has two protons (and two electrons). A carbon atom has 6 protons (and 6 electrons).

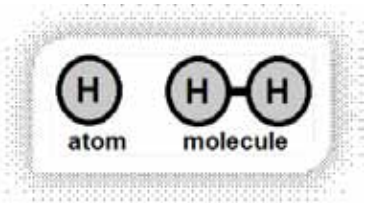


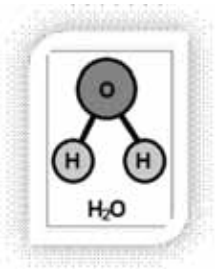
Parts of an atom not drawn to scale

Atoms are too small to see. However, scientists have hypothesised and suggested descriptions of atoms. One of the models of atomic structure proposed by scientists states that at the centre, there is a nucleus made up of protons and neutrons.

Protons have a positive electrical charge whereas neutrons are uncharged. Much lighter particles called electrons move around this nucleus at high speed. Electrons carry a negative charge equal, but opposite to the positive charge of the protons.

Atoms of most elements do not normally exist on their own as individual atoms, as they are unstable in this form. More usually, atoms tend to combine with each other and become more stable. Simple **molecules** are produced when atoms of a single element combine together. For example, two atoms of hydrogen can combine to form a stable molecule of hydrogen. The chemical symbol for a hydrogen atom is H, but the chemical symbol for a molecule of hydrogen is H2.





Model of a water molecule

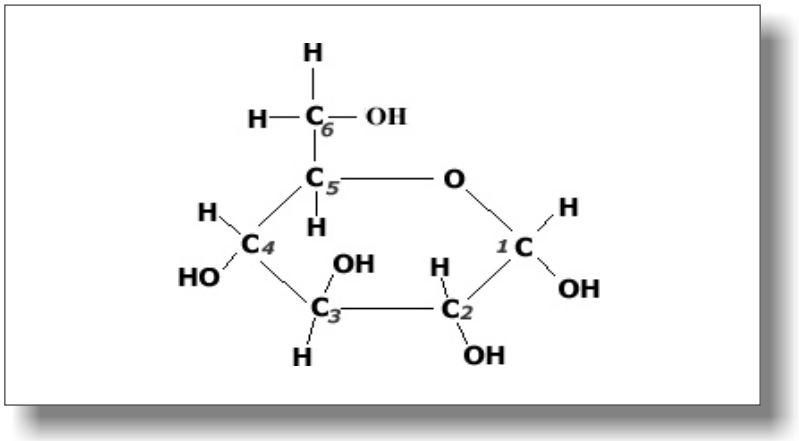
Sometimes atoms of different elements combine together. Two hydrogen atoms can combine with an oxygen atom to form a molecule of the **compound** known as water. Water is a very simple compound and a very small molecule. Some compounds are made up of hundreds or thousands of atoms and a number of different elements.

ACTIVITY 1

Exploring the compound called glucose

Study the **chemical formula** of the very important compound called glucose.

> ***chemical formula:*** *an abbreviated way of showing which elements are contained in a molecule and the numbers or ratio of types of atoms present*



Glucose has the chemical formula $C_6H_{12}O_6$.

1. How many different elements are in this compound? Name them.

2. How many atoms of each element are present in one molecule of glucose?

3. The structural chemical formula shows us how these atoms are arranged in a molecule of glucose. How many carbon atoms are arranged in a ring structure?

4. Can you locate each of the twelve hydrogen atoms and six oxygen atoms in this diagram?

5. Which is the most common element in this molecule?

6. What do the numbers 6 and 12 refer to in the chemical formula $C_6H_{12}O_6$?

ANSWERS ON PAGE 115

What kinds of molecules are important to living organisms?

All living things are made up of molecules. This table shows the elements that are found in the greatest percentages in living matter and some of their uses.

The new terms in this table are explained in the work which follows.

The most abundant elements in living organisms		
Element	**Symbol**	**Importance**
Carbon	C	major element found in all organic molecules
Hydrogen	H	major element found in all organic molecules and water
Oxygen	O	major element found in many organic molecules and water; essential for cellular respiration
Nitrogen	N	major element found in all proteins and nucleic acids
Sulphur	S	important element in many proteins
phosphorus	P	ess ential element in nucleic acids and energy-rich molecules of ATP
Magnesium	Mg	important in some proteins in animals, but essential for making chlorophyll in photosynthesising organisms
Iron	Fe	essential part of haemoglobin (red pigment that carries oxygen) in animals with blood

organic chemistry: *the study of carbon-based molecules important to living organisms*
makro: *Greek for large*

Other elements such as potassium, chlorine, sodium and calcium are also important to living organisms.

Look again at the structure of glucose. Is it an organic molecule? Can you give a reason for your answer?

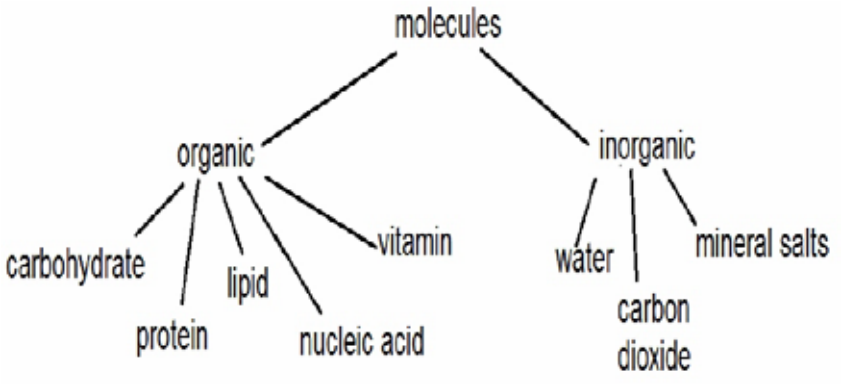
The most important element for living organisms is **carbon**. It is so important that scientists have named the study of carbon **organic chemistry**. Organic molecules must contain carbon atoms bonded to other carbon atoms and to hydrogen atoms. Other elements can then also be included in the molecule. Glucose is an example of an organic molecule because it has a number of carbon atoms bonded to each other. It also has hydrogen atoms bonded to the carbon. In addition, it has the element oxygen in the compound.

Glucose is a very simple organic compound. Most organic compounds are very large and complex. They are called **macromolecules**. Living organisms make organic molecules and need organic molecules for survival.

Inorganic molecules will not contain carbon atoms bonded to other carbon and hydrogen atoms. Inorganic molecules do not form large, complex macromolecules.

Inorganic molecules are usually simpler molecules that do not have the characteristics of organic molecules. For living organisms, some of the most important inorganic molecules are water (H_2O) as well as oxygen, carbon dioxide, nitrates and phosphates.

Cells of living organisms are made up of organic and inorganic molecules. There are different kinds of organic and inorganic molecules as shown in the following mind map:



mind maps:
diagrams that help you organise linked ideas and concepts so that they are easier to understand and learn.

Before you focus on these different groups in greater detail, let's see how much you have learnt!

ACTIVITY 2

1. Supply the missing words in each of the statements.

   a. An_____ has only one type of atom in its molecules.

   b. An _____ is the smallest part of an element that can have the characteristics of that element.

   c. A _____ is two or more atoms that are bonded together.

   d. A _____ is a substance made from different types of atoms.

   e. The essential element in all organic compounds is _____.

2. Decide whether the following statements are True or False. If the statement is False, explain why it is incorrect.

   a. If you could take a small piece of gold and break it into smaller and smaller pieces, you would eventually get a piece so small that billions of them would fit on the full stop at the end of this sentence. If these tiny pieces still have the properties of gold, each piece would be called a molecule.

b. If an atom of oxygen is split into even smaller parts, the smaller parts or components would no longer be oxygen. This is true for all atoms.

c. Atoms are the building blocks of the matter of all living organisms and non-living things in the world.

d. An element contains a number of different kinds of atoms.

e. Two or more atoms are usually joined together to form a molecule.

f. An atom that has two or more molecules bonded together is called a compound.

g. Most elements that make up the body of living organisms are found bonded into complex compounds.

h. If molecules are large and contain both carbon and hydrogen atoms, they are called inorganic substances.

i. Carbohydrates, proteins, lipids and nucleic acids are inorganic molecules.

j. Most organic molecules in living organisms are large, complex structures known as macromolecules.

ANSWERS ON PAGE 115

Find out the structural chemical formulae for some simple inorganic and organic molecules. We have given you the structural formulae for H_2 and H_2O in this lesson.

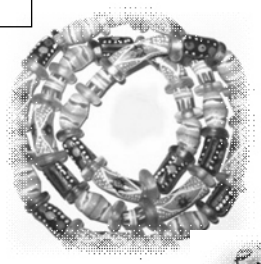
Use toothpicks, prestik, playdough, plasticine, clay or soft sweets to find ways of making some models that show the three dimensional structure of these molecules. Make sure the atoms in your models are colour coded and keyed so that someone would be able to identify the molecule using the key.

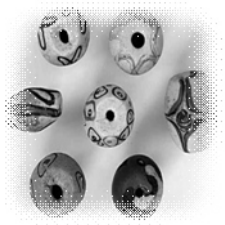
Some easy molecules to model are oxygen, water, carbon dioxide and as a challenge, see if you can model a glucose molecule.

COMMENT

Living organisms need both inorganic and organic molecules. Every time you breathe in, your body takes the oxygen (an inorganic molecule) out of the air. Oxygen is needed to convert the organic food molecule (glucose) into useable energy. Plants need carbon dioxide and water (both inorganic molecules) to make glucose. The bodies of living organisms are made up of simple inorganic molecules as well as very large and complex macromolecules which are organic.

What are monomers and polymers?





Monomers** are like individual beads. When all the beads are strung together they make a necklace – the **polymer.

Carbohydrates, proteins, lipids and nucleic acids are organic macromolecules formed out of smaller, simpler units. The macromolecules are called **polymers** and the building block units are called **monomers**.

Table illustrating the structure of some organic macromolecules

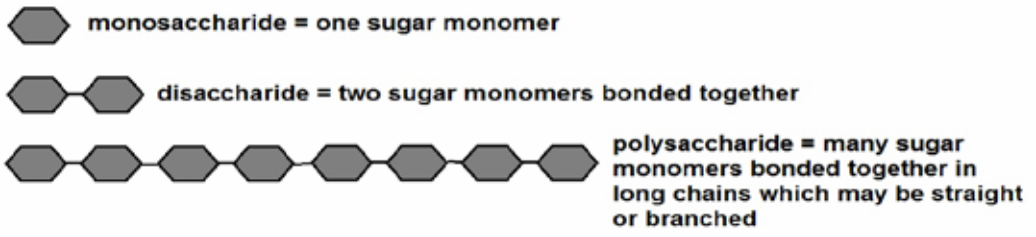
Organic group	Monomer	Polymer
carbohydrates	monosaccharide	polysaccharide
proteins	amino acid	polypeptide
lipids	fatty acids and glycerol	fats and oils
nucleic acids	nucleotide	nucleic acid

What are carbohydrates?

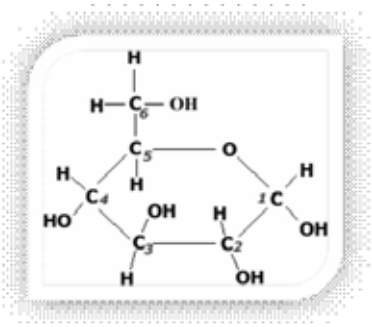
Sugars, starch, glycogen and cellulose are examples of carbohydrates.

They all contain the elements carbon, hydrogen and oxygen. The ratio of hydrogen to carbon is 2:1 (that means for every one carbon, there are two hydrogen atoms).

There are three kinds of carbohydrates:



Monosaccharides are called single or simple sugars because they cannot be broken into smaller molecules that are still sugars. They taste sweet and dissolve easily in water. Monosaccharides help in controlling the **osmotic balance** in cells.



Monosaccharides can have between three and seven atoms of carbon. Some common monosaccharides that are important in living organisms have six carbon atoms and are called hexose sugars. The formula for a hexose sugar is $C_6H_{12}O_6$. Glucose, fructose and galactose are all examples of hexose sugars.

These three molecules all have the same formula ($C_6H_{12}O_6$) but have different names because they have different shapes and behave differently.

Glucose is an example of a hexose monosaccharide.

A pentose (5 carbon) sugar has the formula $C_5H_{10}O_5$. Deoxyribose and ribose are pentose sugars. They are vital components of nucleic acids.

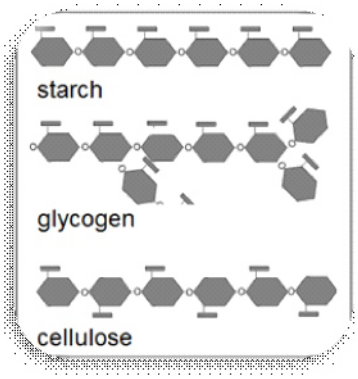
Disaccharides are called double sugars because they are made by joining together two monosaccharides. They are sweet to taste but do not dissolve in cold water as easily as monosaccharides do because they are larger molecules. Disaccharides dissolve easily in hot water. The formula for a disaccharide is $C_{12}H_{22}O_{11}$.

There are three common disaccharides:

You do not need to be able to draw the structural diagrams shown in this section. These diagrams are to help you understand the structure only.

- maltose = glucose + glucose
- sucrose (table sugar which comes from sugar cane) = glucose + fructose
- lactose (milk sugar) = glucose + galactose

Polysaccharides are formed when many monosaccharide molecules join together in a long chain to make one very large molecule. Polysaccharides do not dissolve in water and they do not taste sweet.



There are four common polysaccharides:

- starch is found in plants and may have more than 200 000 glucose molecules in each molecule; starch is an energy storage molecule for plants and an important source of food for animals
- glycogen has fewer glucose molecules than starch and forms branching chains; glycogen is an energy storage molecule in animals and fungi

- cellulose forms long, chain-like molecules that are very strong; cellulose forms cell walls in plants; many animals are unable to digest cellulose (break down the polymer into monomers)

- chitin is similar in structure to cellulose, but each monomer has one nitrogen atom added to one of the carbons in the ring structure; chitin is part of fungal cell walls and arthropod exoskeletons

ACTIVITY 3

1. Carbohydrates are very important molecules in living organisms. In each case, name the carbohydrate which is:

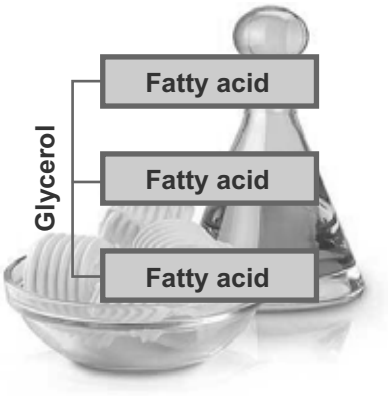
    a. the most important immediate energy source for an organism
    b. an energy storage molecule in plants
    c. a structural component of DNA
    d. a structural component of insect exoskeletons
    e. an energy storage molecule in animals
    f. an energy storage molecule in fungi
    g. a structural component of plant cell walls

2. Use the examples of carbohydrates outlined in 'What are carbohydrates' to draw a simple mind-map to illustrate the various groups of carbohydrates that have biological importance.

ANSWERS ON PAGE 116

What are lipids?

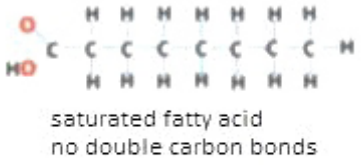
Lipids are also known as fats and oils. Lipid molecules are made up of atoms of carbon, hydrogen and oxygen but the ratio of hydrogen to oxygen is not 2:1 as it is in carbohydrates. Lipid molecules have many hydrogen atoms and fewer oxygen atoms, therefore the ratio of H : O is > 2:1.



Lipids are insoluble in water but they are soluble in organic solvents such as alcohol, benzene, chloroform and ether. They can be emulsified or broken down by alkalis such as soap. Each lipid molecule has one glycerol molecule bonded to three fatty acid molecules.

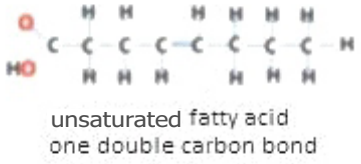
Cell membranes are built out of **phospholipids**. In a phospholipid one fatty acid is replaced with a phosphate.

There are three main types of fatty acid:



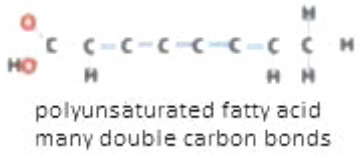
saturated fatty acid
no double carbon bonds

- saturated fatty acids have **no double** carbon bonds and therefore a full complement of hydrogen atoms; they are found in lipids of animals; they are solid at room temperature and are commonly called fats;



unsaturated fatty acid
one double carbon bond

- unsaturated fatty acids have **one double** carbon bond along the chain and therefore fewer hydrogen atoms in each molecule;



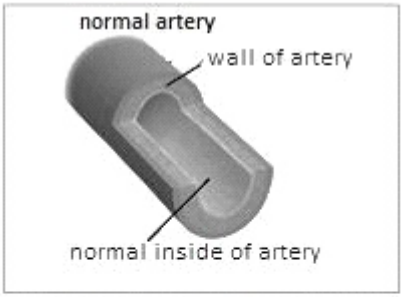
polyunsaturated fatty acid
many double carbon bonds

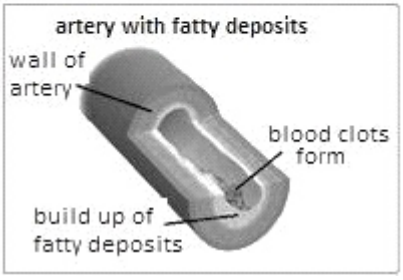
- polyunsaturated fatty acids have **several double** carbon bonds and therefore fewer hydrogen atoms.

Unsaturated fatty acids and polyunsaturated fatty acids are found in the lipids of plants. They are usually liquid at room temperature and are commonly called oils.

Saturated fatty acids in food can cause an increase in a fatty substance called **cholesterol** in the blood. Food with animal fats such as red meat and butter contain saturated fats and therefore should be eaten in moderation. Our bodies do need cholesterol but too much cholesterol in the blood forms plaque which sticks to the walls of the blood vessels and causes them to become narrow. This condition is called **atherosclerosis**.

Narrow blood vessels can cause blood pressure to increase making it more difficult for the heart to pump blood. This increases the risk of a heart attack. If a lump of cholesterol falls off the wall of a blood vessel, it may block narrower vessels in the heart and cause a heart attack. If this happens in a blood vessel in the brain, it causes a stroke.





Importance of lipids

- Lipids are important energy sources which contain double the amount of energy of carbohydrates. They are important forms of energy storage.
- Phospholipids are a part of all membranes in cells.
- The waxy lipid cuticle around plants protects the internal cells. Fat surrounds body organs such as the heart and kidneys to protect them from damage. The wax in your ears is a lipid that protects inner delicate parts of the ear and the oil on your skin keeps your skin supple and protects it from drying out.
- Lipids are good insulators against cold. They are found below the skin of many animals, especially those that live in cold places.
- Some vitamins only dissolve in fat, so we need lipids in our diet to absorb these vitamins.

ACTIVITY 4

This question requires you to interpret and analyse data (information) from a table. You will also need to do some research. You can use books or the internet to help you find information.

Everyone aged 20 and older should have their cholesterol measured at least once every 5 years. A blood test is done which gives information about your:

- Total cholesterol
- LDL cholesterol which is the main source of cholesterol build-up and blockage in the arteries
- HDL cholesterol which helps keep cholesterol from building up in the arteries and protects against heart disease
- Triglycerides, another form of fat in your blood, that can also raise heart disease risk

This table summarises the levels of total and LDL cholesterol and what they mean in terms of risk.

Total Cholesterol Level		**LDL Cholesterol Level**	
Less than 200 mg/dL	Desirable	Less than 100 mg/dL	Optimal
200-239 mg/Dl	Borderline high	100-129 mg/dL	Near optimal/above optimal
240 mg/dL and above	High	130-159 mg/dL	Borderline high
		160-189 mg/dL	High
		190 mg/dL and above	Very high

**Cholesterol levels are measured in milligrams (mg) of cholesterol per decilitre (dL) of blood.*

HDL (good) cholesterol protects against heart disease, so for HDL, higher numbers are better. A level less than 40 mg/dL is low and is considered a major risk factor because it increases your risk for developing heart disease. HDL levels of 60 mg/dL or more help to lower your risk for heart disease.

Triglycerides can also raise heart disease risk. Levels that are borderline high (150-199 mg/dL) or high (200 mg/dL or more) may need treatment in some people.

A person has a cholesterol blood test and receives these results:

Total cholesterol –	230 mg/dL
LDL cholesterol –	172 mg/dL
HDL cholesterol –	35 mg/dL
Triglycerides –	210 mg/dL

1. Analyse the results against the data table in order to determine this person's overall risk for developing heart disease.

2. Do some research on the internet or ask your pharmacist for some pamphlets on heart disease and cholesterol. Write down some recommendations you would make to this person regarding:

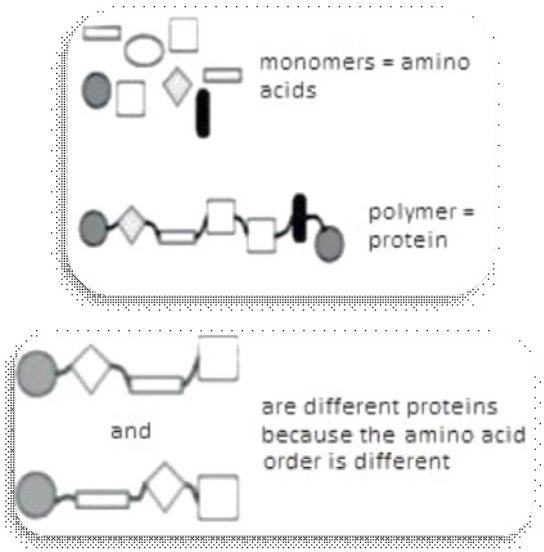
   a. diet
   b. body mass
   c. physical activity
   d. habits and addictions such as smoking.

3. There are some things relating to cholesterol levels that people cannot change, even if they are at risk for developing heart diseases. What are some of these things?

ANSWERS ON PAGE 116

What are proteins?

Protein molecules always contain the elements carbon, hydrogen, oxygen and nitrogen. Some proteins also contain atoms of sulphur and phosphorus.



The building blocks of proteins are amino acids. There are 20 different kinds of amino acids that can link together into many different patterns.

In the same way as thousands of different words are made up from the same 26 letters of the alphabet, so different proteins are formed by the different combinations of amino acids. They are joined by a peptide bond which is dehydration synthesis.

A molecule of water is formed when two amino acids are bonded together. Amino acids join together to make very long chains called polypeptides or proteins.

Large protein molecules often fold up into a coiled shape called a **helix**.

Proteins are heat and **pH** sensitive. Changes in acidity and high temperatures **denature** protein molecules. When proteins are denatured, they change shape and can no longer function. For example, when you cook an egg, the heat denatures the protein of the clear egg liquid called albumin. You can see this happening when the clear protein changes into a white solid.

helix:
a twisted spiral shape
pH:
a measure of how acidic or alkali a solution or substance is
denature:
to change the structure of a molecule so that it no longer functions

Importance of proteins

Proteins form an important part of cell membranes and protoplasm. They are needed for growth and repair of cells.

Enzymes, which control all the reactions in cell metabolism, are all proteins. Proteins are part of body structures, for example, gelatine in cartilage, keratin in hair. They are used for transport, for example, the red pigment, haemoglobin in blood, carries oxygen. Proteins protect the body, for example, antibodies protect the body from disease.

Some hormones, which are messenger molecules in the blood, are proteins.

Technically, haemoglobin is called a metalloprotein. This means that the protein is formed by amino acids and a metal ion. In the case of haemoglobin, the metal is iron. Other metals that are found in metalloproteins are copper, nickel and zinc.

ACTIVITY 5

1. Decide whether these statements are true or false. If they are false, or only partially correct, change the statements to make them true.

    a. A small portion of the protoplasm is protein.
    b. Haemoglobin in the blood is a protein.
    c. All amino acids are made of carbon, hydrogen, oxygen and sulphur.
    d. Proteins are the most important source of energy in the diet.
    e. Some hormones are proteins; while all enzymes are proteins.
    f. A protein that is subjected to low pHs may denature and not be able to work properly.
    g. The polymer of proteins is the amino acid.

h. Proteins are examples of organic compounds.
i. Proteins tend to be large molecules which may be folded or arranged in a helical manner.
j. The protein we eat in our food is vital for building new tissues and helping us to grow.

ANSWERS ON PAGE 117

COMMENT

Carbohydrates, lipids and proteins are three of the most important groups of organic compounds in living organisms. You will learn more about nucleic acids, another group of organic molecules in Lesson 5.

CHECKLIST

Are you able to:

- ❒ name the molecules that make up living organisms
- ❒ distinguish between inorganic and organic compounds
- ❒ name some of the different inorganic and organic compounds important to living organisms
- ❒ name the different groups of organic compounds found in living organisms
- ❒ identify the monomers and polymers of the different groups of organic molecules
- ❒ list the characteristics of carbohydrates, lipids and proteins
- ❒ say why carbohydrates, lipids and proteins are so important to living organisms?

LESSON 2

Cells, Bacteria and Viruses

About this lesson

In Lesson 1 you learnt that all living organisms are made up of molecules. Some of the molecules are organic such as carbohydrates, proteins, lipids, nucleic acids and vitamins. Other molecules making up living organisms are inorganic, such as water and minerals. These organic and inorganic molecules are used to build cells which are the basic units of life.

You will learn that there is a distinct structure or pattern that cells have, whether they are eukaryotic or prokaryotic.

You will also learn that viruses have a unique structure and will study the HI Virus and Influenza Virus. You will also study tuberculosis, or TB, a chronic infectious disease caused by a bacterium called Mycobacterium tuberculosis.

In this lesson you will:

- learn about the structure of cells
- learn how viruses were discovered
- examine the structure of a range of viruses
- use diagrams to explain how viruses reproduce
- compare the structure of a virus with the structure of prokaryotic and eukaryotic cells
- question whether viruses are living organisms
- learn about the HI Virus, Influenza Virus and TB.

Cells

The word 'cell' comes from the Latin word ‘cella’ which means small inner room, just like the rooms nuns or priests lived in, in ancient convents and monasteries. Cells are, in fact, just that – small compartments of living matter, completely enclosed to make self-contained units.

What do we mean by 'the basic unit of life'?

Look at this bead necklace. It is a complete necklace. However, it is made up of individual beads. Each bead is a unit in the complete necklace. If you broke the bead down by cutting it or smashing it, you could not build a necklace. In the same way, the walls which make up a building are complete, whole structures, but the wall is made up of individual units called bricks. You could break the bricks down into smaller pieces – the bricks are made of sand or clay, concrete, water and straw – but you cannot use these smaller parts to build the wall. The brick is the smallest complete unit needed to build a wall. The bead is the smallest complete unit needed to make a necklace.

Can you think of other part-whole examples which show that you understand the concept explained here?

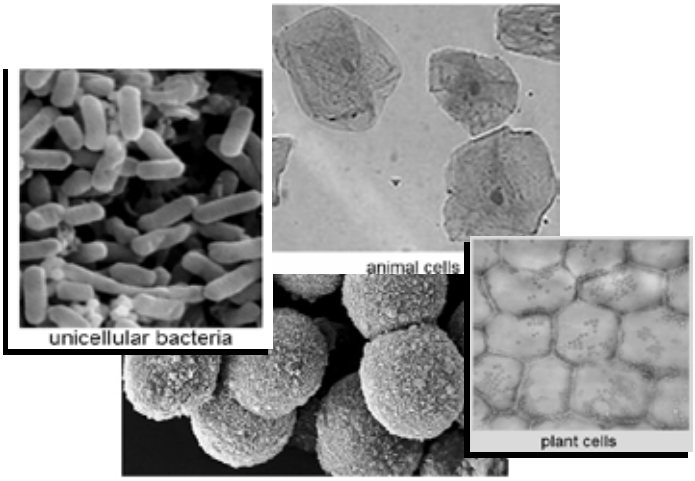
The bodies of living organisms are exactly the same. Your body works as a complete structure, but it is made up of extremely tiny units called cells. A cell is the smallest complete unit that can make up an organism's body. You can break cells down to smaller parts, but these parts cannot work by themselves and keep your body functioning. The smallest unit that can keep your body functioning is a cell.

A microscope is an instrument that is used to magnify objects that cannot be seen with the naked eye.

Some organisms are only made up of one cell and are called unicellular organisms. These are very simple organisms such as bacteria, certain algae and other protozoans. Unicellular organisms are so small they can only be seen under a microscope. You will learn more about the different kinds of organisms that live on Earth in Unit 7.

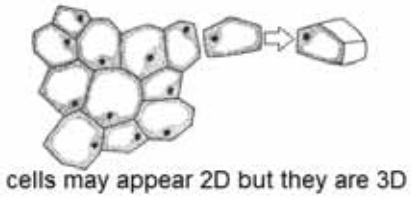
Organisms, like you, which are made up of many cells, are known as multicellular organisms.

These are photographs of cells taken down a microscope.



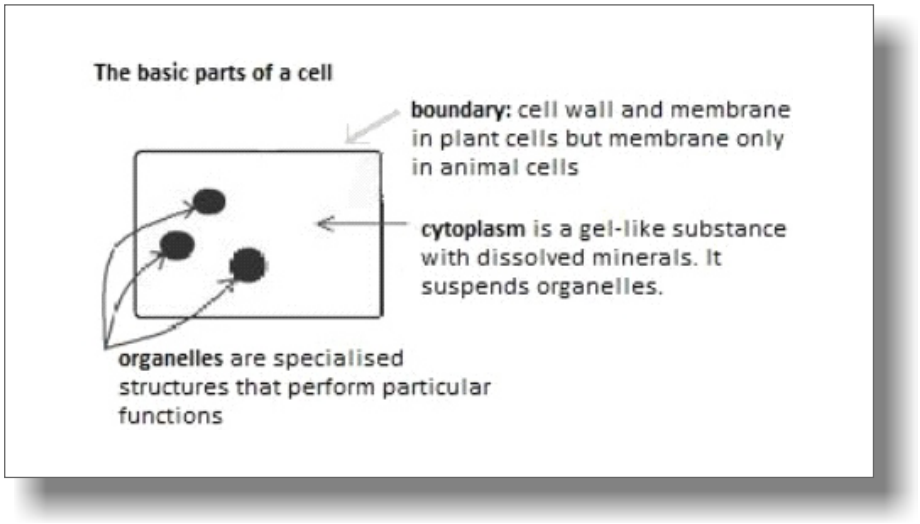
cells are three dimensional structures.

When you look at pictures of cells, you need to remember the concepts of two dimensions and three dimensions. Remember that cells are 3D objects. The pictures we see of the cells, however, are 2D representations of these 3D objects. We see only the dimensions of width and length. We cannot see depth. Remember that because the cell is a 3D object, we may not see all there is to see if we take a section through a cell.


cells may appear 2D but they are 3D

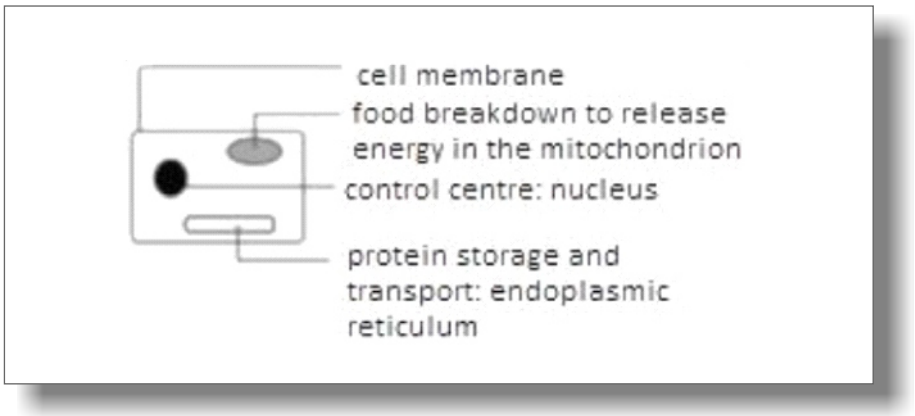
What are the basic parts of a cell?

Cells have a boundary of a plasma membrane, or cell membrane. Internally, cells contain membrane-bound organelles.

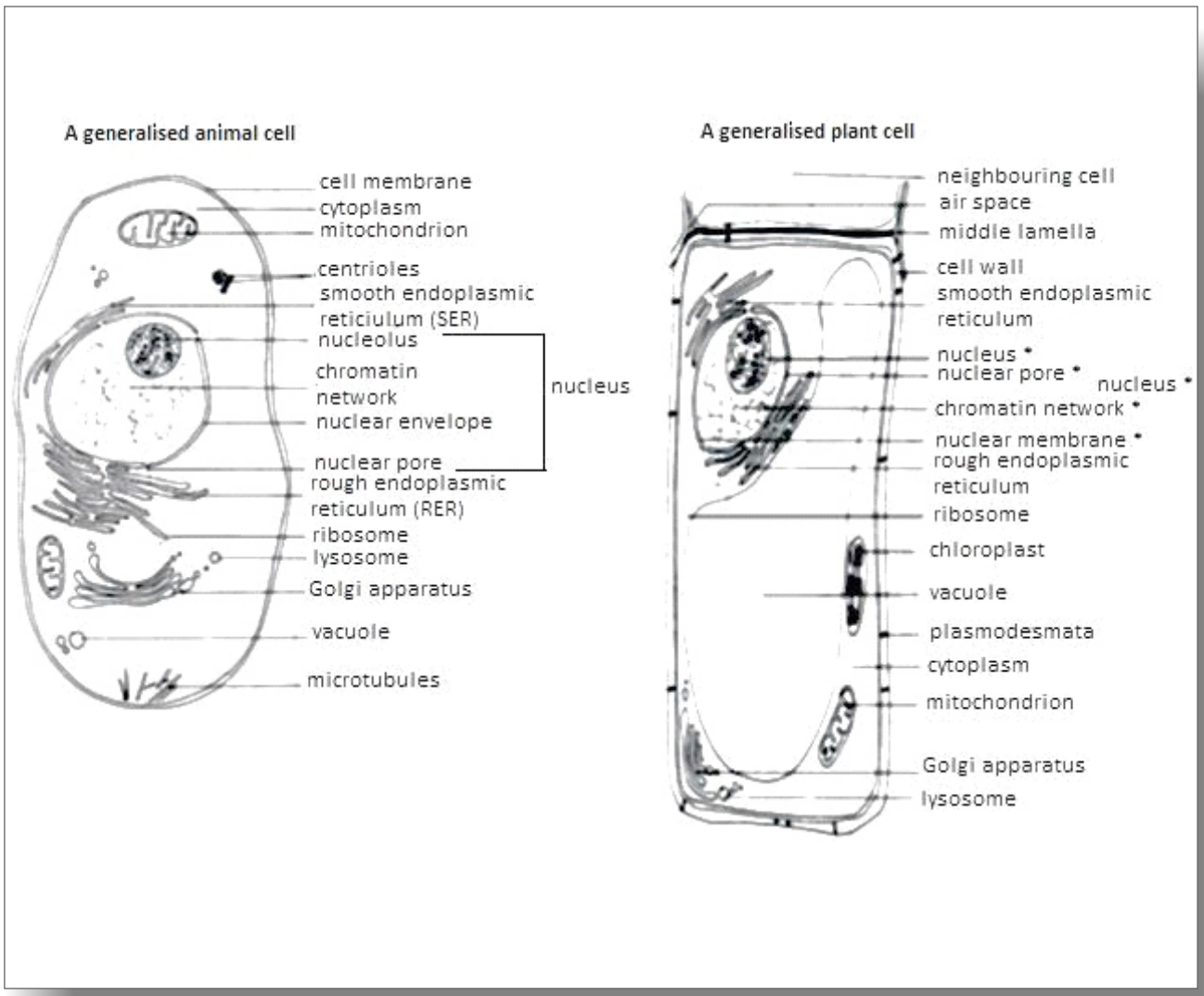


In this way, the cell is compartmentalised, much like the divisions inside a tool box. This means that certain functions can be carried out in isolation from others. It means that certain substances which may harm or affect the functioning of another part of the cell can be kept isolated or separated.

For example:



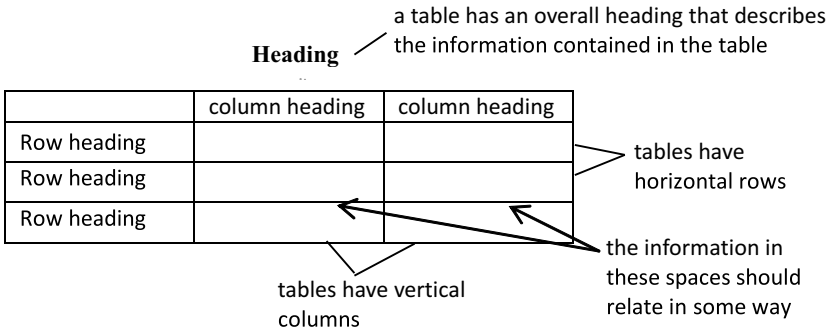
In Grade 10, you learnt about the structure of a general animal and plant cell. Make sure that you carefully revise the structure and functioning of the different organelles associated with both an animal and plant cell.



ACTIVITY 1

Tables are important tools that can be used to compare things and to organise data. You should draw them in pencil and write the information in pen.

1. Draw a table where you list the following organelles and describe their structures and their functions in a generalised cell: nucleus, mitochondrion, endoplasmic reticulum, chloroplast, Golgi apparatus, cell sap vacuole, ribosome and lysosome.



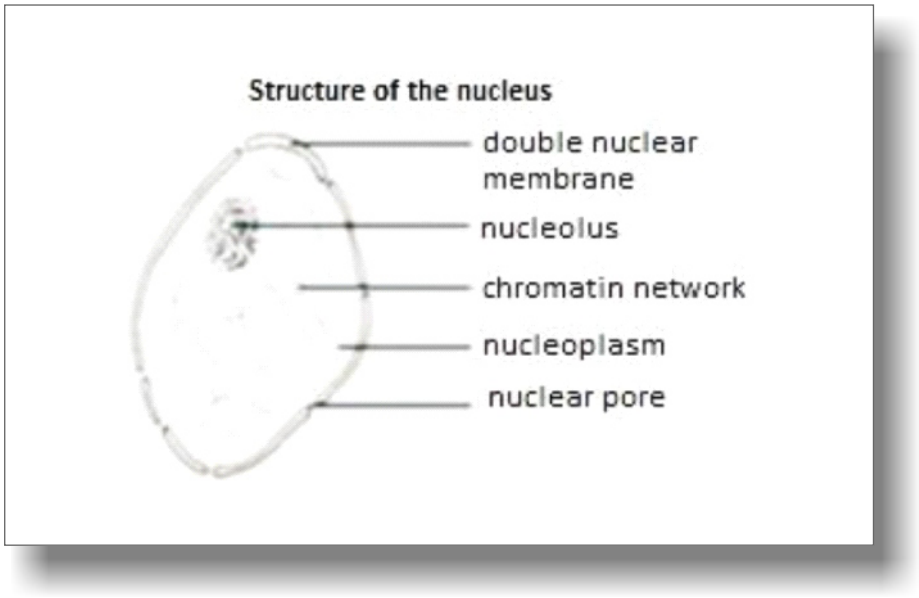
2. Draw a table which compares the plant and animal cell.

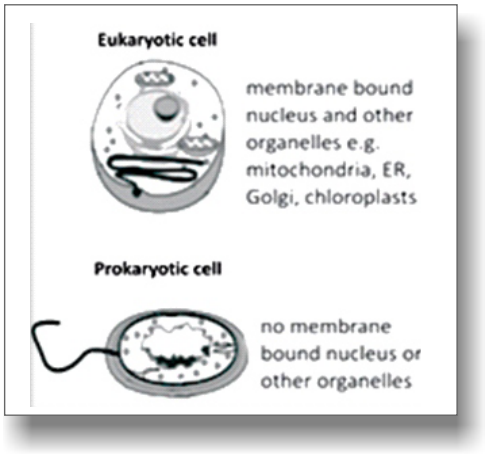
ANSWERS ON PAGE 118

Eukaryotic and prokaryotic cells

The cells that have been described previously are called **eukaryotic cells**. What does this mean?

Eukaryotes take their name from the Greek *eu – with* and *karyon – nucleus/core*. Eukaryotic cells have a 'true nucleus'. This means that the DNA is organised into a number of linear (or threadlike) chromosomes which float inside a double membrane. The nucleus is compartmentalised. The DNA is kept separate from the rest of the contents of the cell.



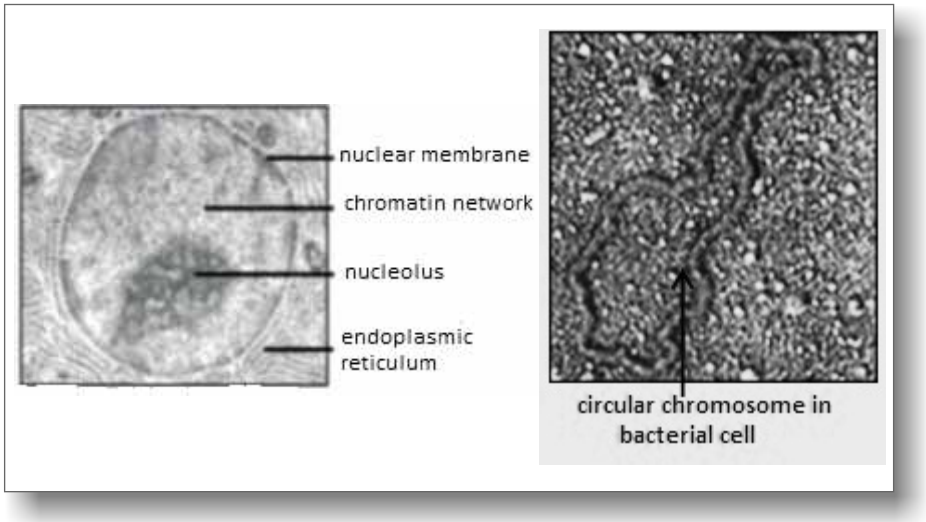


Another feature of eukaryotic cells is that there are membrane-bound organelles. Mitochondria, endoplasmic reticulum, chloroplasts, Golgi apparatus – all these organelles are surrounded by membranes which compartmentalise them.

Eukaryotic cells may combine together to make multicellular organisms. These organisms are called eukaryotes due to their cell structure. Some unicellular organisms, such as protistans, are eukaryotes. You will learn more about protistans in Unit 7.

Bacteria and cyanobacteria are known as **prokaryotes**. In prokaryotic cells, there is no 'true nucleus'. There is usually a single, circular chromosome. There is no membrane around this chromosome and it floats freely in the cytoplasm.

There are also no membrane-bound organelles such as mitochondria and endoplasmic reticulum. The cell membrane contains slight and irregular infoldings that perform the functions of cellular respiration and in some prokaryotes, photosynthesis. These infoldings are called mesosomes, but they are not true organelles. The only organelles in the cytoplasm that are similar to what is found in eukaryotic cells, are ribosomes. However, prokaryotic ribosomes are much smaller than eukaryotic ribosomes. Prokaryotic cells are thus far simpler than eukaryotic cells and as a result, they are much smaller too. You will learn more about bacteria in Unit 7.



ACTIVITY 2

Draw a table in which you use the information given in this lesson and compare prokaryotic and eukaryotic cells.

ANSWERS ON PAGE 119

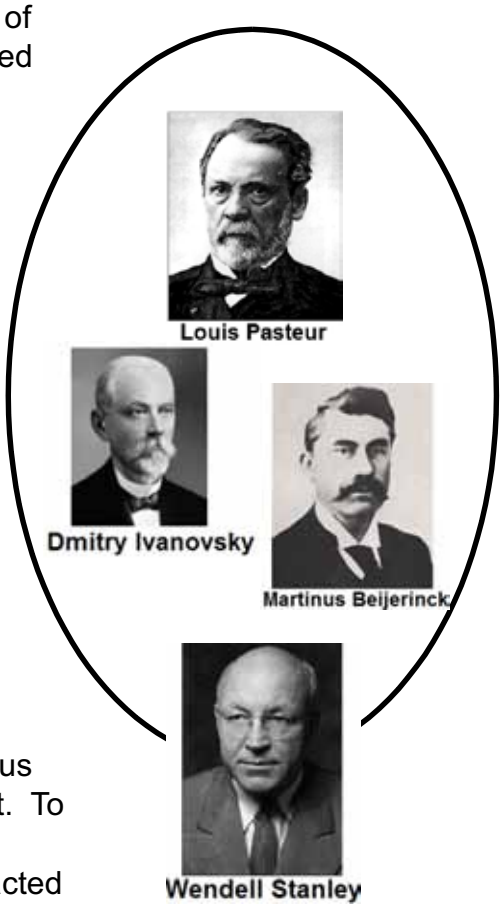
COMMENT

You have only looked at what we call a 'generalised' cell. Cells are usually highly specialised to perform specific functions. In order to perform these particular functions, the structure of the cell and the contents of the cell may be highly modified. You will learn more about specialised cells in Lesson 3.

Viruses

How were viruses discovered?

Late in the nineteenth century, European scientists, including Louis Pasteur, began to suggest that there was some kind of organism which was smaller than a bacterium, which caused diseases such as foot and mouth disease and rabies.



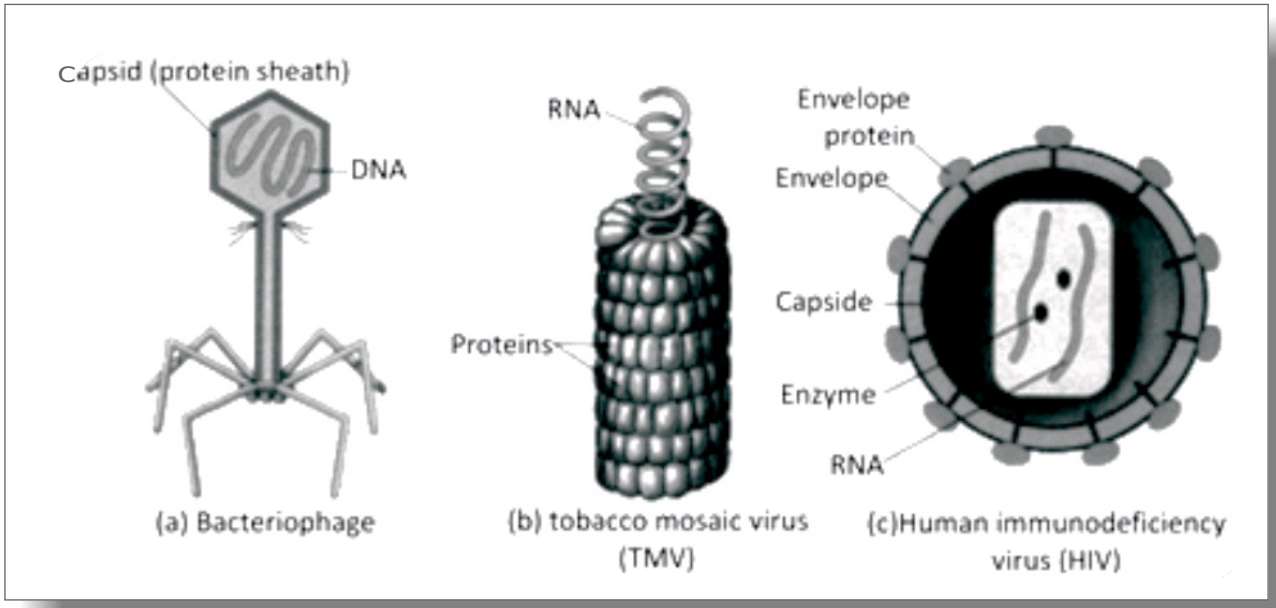
In 1882, Pasteur wrote, 'Rabies must be caused by a disease agent that is so small it cannot be seen under the microscope.' In 1892, Dmitry Ivanovsky wrote, 'I filtered the sap of a diseased tobacco plant to remove the bacteria. When I put the filtered sap on the leaves of healthy plants, they were immediately infected with this tobacco mosaic disease. An organism must have passed through the filter that is smaller than a bacterium.' Later, in 1895, Martinus Beijerink wrote, 'I found that the disease agent in tobacco plants was able to reproduce.' Pasteur called these disease-causing substances **viruses** after the Latin word *virus* which means 'poison'. Later, many diseases in both plants and animals were ascribed to viruses.

In 1933, Wendell Stanley prepared an extract of a plant virus called *tobacco mosaic virus* (TMV) in an attempt to purify it. To his surprise, the extract crystallised. This was unusual, because only chemical substances crystallise. The virus acted more like a chemical than a living organism. And so the great living/non-living debate around viruses began.

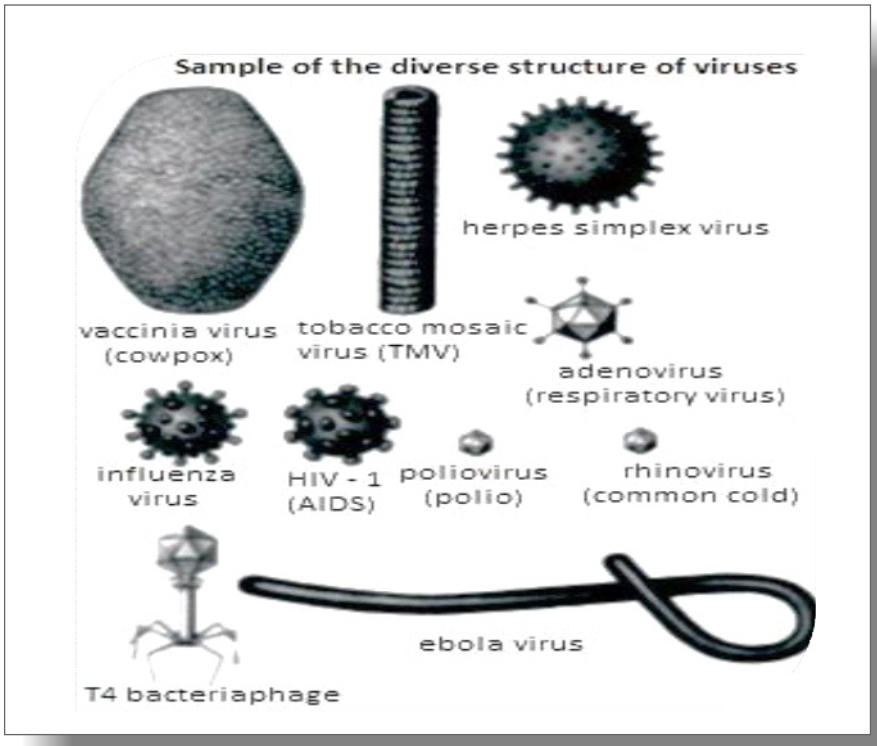
What do viruses look like?

Viruses are very small, about 20 nm to 450 nm and can only be seen with an electron microscope at a magnification of about 30 000 times.

1 nanometre (nm) = 10^{-9} m



Each virus consists of a core of nucleic acid, which may be deoxyribose nucleic acid (DNA) or ribose nucleic acid (RNA). A protein coat called a capsid surrounds the strand of nucleic acid. Enzymes may also be found inside the capsid. No other organelles, cytoplasm or membranes are found inside the capsid. Some viruses may have a membrane called the envelope around the outside of the capsid. There may be proteins on the outside of the envelope.



How do viruses reproduce?

Attachment/Adsorption Phase:
The virus attaches itself to the outside of a cell.

Penetration/Invasion Phase:
The virus penetrates through the cell wall (if present) and membrane and injects its nucleic acid (DNA or RNA) into the host cell. Some viral enzymes also enter the host. The empty capsule remains on the outside of the cell and is not used again.

Latent Phase:
The viral nucleic acid and enzymes take control of the host cell. The host cell DNA is broken down and used to **synthesise** many copies of the viral nucleic acid and new viral parts. The host enzymes are controlled and made to assemble new viruses.

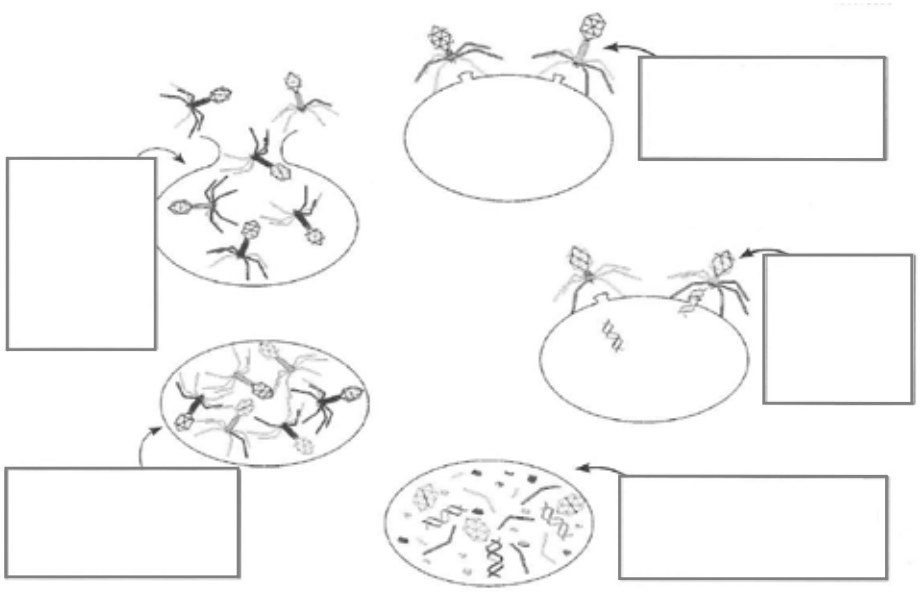
synthesise:
make

Lysis:
The new viruses cause the host cell to lyse or burst, killing the cell and releasing many viruses, which immediately invade neighbouring cells or get transmitted to other hosts.

ACTIVITY 3

This diagram shows how a virus called a bacteriophage infects a bacterial cell. The process of infection and reproduction is the same for all forms of viruses.

Annotate the diagram by writing down the descriptions of the stages of viral reproduction in the boxes.



ANSWERS ON PAGE 119

*What do **you** think?*

Why are viruses such a puzzle to biologists?

Are viruses similar in structure to eukaryotic and prokaryotic cells?

Are viruses definitely living organisms?

Viruses do not have the same basic cellular structure as eukaryotic cells: a boundary membrane, cytoplasm and organelles. Neither do they have the same characteristics as prokaryotic cells.

The table shows the characteristics of living organisms. In the column headed **Viruses**, write **yes** or **no** next to each characteristic, depending on whether viruses show this particular characteristic or not.

All living organisms, whether unicellular or multicellular, show the following characteristics:

Characteristic	Description of characteristic	Viruses
food	A fuel/food source is needed. Some organisms make the food themselves (photosynthesis), others consume another source of food.	
cellular respiration	The breaking down of food to obtain energy. This usually requires O_2.	
excretion	Respiration and food metabolism produce waste products which need to be removed from the body of the organism.	
growth	Unicellular organisms increase in size; multicellular organisms increase in cell number and in body complexity.	
sensitivity	Responsiveness to stimuli from the environment.	
movement	Either parts of the organism's body or the whole body can move to a greater or lesser degree.	

reproduction	Organisms are able to make a replica of themselves.	
cell structure	All organisms possess at least one cell, which will be bounded by a wall or membrane, have DNA and other organelles or membrane-like structures which will function in the cell's metabolism.	
metabolism	Substances are broken down to release energy and chemical building blocks (catabolism) + the building up of new substances needed by the cells (anabolism). Do viruses undergo any form of metabolism?	

HIV and influenza – viral diseases

Is a virus which causes a disease in humans and ultimately kills them, a **bad** organism?

Remember that when we characterise an organism as **beneficial** or **detrimental**, we are making a **value judgement**. HIV which gives one AIDS is considered detrimental to humans. It is negative only with respect to the damage it causes humans. It is not an evil, bad virus! It is only living in the ecosystem it is adapted to, namely the cells of the human immune system. The terms 'beneficial' and 'detrimental' when used to describe the effect organisms have on humans, are therefore **anthropocentric**. This means we are evaluating or judging something from a particular viewpoint or perspective.

infection:
a micro-organism that enters the cells of your body and multiplies
infectious disease:
illness caused by an infection
pathogen:
a micro-organism that causes the disease

The Human Immunodeficiency Virus

HIV is a retrovirus. It is more or less spherical with a diameter of about 120 nm. It has a protein capsid, surrounded by a viral envelope. The structure of the envelope enables the virus to attach to and enter target cells to begin the infectious cycle. HIV has two copies of single-stranded RNA that code for the virus's nine genes. The enzymes needed for the reproduction of the virus, are found inside the capsid. See the diagram of HIV in Lesson 4.

On entry into the target cell, the viral RNA is converted into double-stranded DNA by one of the virus's own enzymes, reverse transcriptase that is delivered, along with the viral RNA in the virus particle. The resulting viral DNA is then introduced into the cell nucleus and integrated into the cellular DNA by another one of the virus's enzymes. Once integrated, the virus may become latent, allowing the virus to avoid detection by the host immune system. However, the virus may be copied, making new virus RNA and viral proteins that are packaged and released from the cell as new virus particles that begin the replication cycle again.

The reason the human body does not 'fight' the HIV invasion as it would fight other viral infections with the immune system, is that HIV targets the cells of the immune system, such as CD4+T cells, macrophages, and microglial cells.

AIDS (Acquired Immune Deficiency Syndrome) may occur only after a period of latency which can last from 2 weeks to 20 years after infection. The infected person may develop a range of disorders such as AIDS, cancers and tuberculosis. These diseases usually cause the patient's death because she cannot fight the diseases as her immune system is compromised by HIV.

If an enemy army were to attack and kill all the soldiers of a country it invaded, the country would not be able to defend itself, because its soldiers would be dead.

This is why it is so difficult for the infected person to fight the HI Virus. It attacks the 'soldier' cells of the immune system, the very cells that should be protecting the body against infection.

ACTIVITY 4

So many myths, wrong ideas and misunderstandings exist about HIV and AIDS. Decide which of the statements are true and which are false. If a statement is false, explain why it is false.

1. You can become infected with HIV by having unprotected sex with someone infected with HIV even if the person does not show symptoms of AIDS.

2. Injecting drugs will give you HIV.

3. You can get HIV from toilet seats.

4. If you are fit and healthy you won't become infected with HIV.

5. Married people don't become infected with HIV.

6. If you stick with one partner you won't become infected with HIV.

7. Women are safe from HIV as long as they use a contraceptive.

8. You can become infected with HIV from sharing toothbrushes.

9. If you have sex with people who look healthy, you won't become infected with HIV.

10. If you only have sex with people you know, you won't become infected with HIV.

11. Anal sex between two men is more risky than anal sex between a man and a woman.

12. You can become infected with HIV from kissing.

13. A man can become infected with HIV if he has oral sex with a woman.

14. A woman can become infected with HIV if she has oral sex with a man.

15. Condoms can stop you becoming infected with HIV.

ANSWERS ON PAGE 119

The Influenza Virus

The most famous and lethal outbreak of flu was the 1918 Spanish flu pandemic. It is estimated that up to 100 million people may have been killed. This huge death toll was caused by an extremely high infection rate and the severity of the symptoms. It killed about 20% of those infected, as opposed to the more usual flu epidemic mortality rate of 0.1% It is believed that 5% of the world's population was killed. As many as 25 million may have been killed in the first 25 weeks. In contrast, HIV has killed 25 million in its first 25 years. Later flu pandemics such as the 1957 Asian flu and the 1968 Hong Kong flu were not as devastating. But even these smaller outbreaks killed millions of people. In these outbreaks, antibiotics were available to control secondary infections and this may have helped reduce mortality compared to the Spanish Flu of 1918.

Flu, as influenza is commonly called, is a more complicated and serious condition than a 'common cold'. Influenza causes up to half a million deaths a year worldwide. Influenza is transmitted through the air by coughs or sneezes. Influenza can also be transmitted by direct contact with bird droppings or nasal secretions, or through contact with contaminated surfaces. Influenza viruses can be inactivated by sunlight. As the virus also can be inactivated by detergents, disinfectants and soap, frequent hand washing reduces the risk of infection.

Influenza is caused by a group of RNA viruses that affects birds and mammals such as humans and pigs. The different influenza viruses are very similar in overall structure.
The virus particles are 80120 nm in diameter and usually roughly spherical. They have a viral envelope wrapped around a central core. The central core contains the viral RNA and other viral proteins that package and protect this RNA. Unusually for a virus, it does not have a single piece of RNA. Instead, it contains seven or eight pieces of RNA, each piece of RNA containing either one or two genes. Influenza viruses target the surfaces of epithelial cells, typically in the nose, throat, and lungs of mammals, and intestines of birds. You can find a diagram of the flu virus in Lesson 4.

ACTIVITY 5

Find out about the causes and treatment of influenza. Write a magazine article in which you describe ways to avoid catching flu, how flu should be treated and who is most at risk.

Brainstorm your article before you write it. Brainstorming will help you to collect and put in one place all the facts and ideas you want to write about. Now, organise your ideas by putting all the ideas which are similar, together. Next, organise your ideas into separate paragraphs. Make sure that each paragraph has one main idea.

Finally, write your introduction and conclusion. Your introduction should be clear and focused and have information about the text in it. Your conclusion should provide a summary of all your main ideas.

ANSWERS ON PAGE 120

Your article should be between 150 and 250 words.

COMMENT

Viral infections are hard to treat because viruses live inside your body's cells. They are 'protected' from medicines, which usually move through your bloodstream. Antibiotics do not work for viral infections because the virus has a completely different structure to the structure of prokaryotic (or eukaryotic) cells.

Tuberculosis – a bacterial disease

Throughout recorded history, humans have been plagued by disease. They believed that diseases were caused by miasma, a mysterious toxic vapour that arose from stagnant water, slums and faeces. It was not until the end of the 19th century that Louis Pasteur and Robert Koch grew some bacteria in their laboratory and made some observations on the biology of bacteria. Today, between 4 000 and 5 000 species of bacteria are known to exist. They are the most primitive (fossilised in rocks 3.8 billion years old) and the most plentiful organisms on earth. Each person has 10 times as many bacterial cells as their own cells!

How do pathogenic bacteria cause disease?

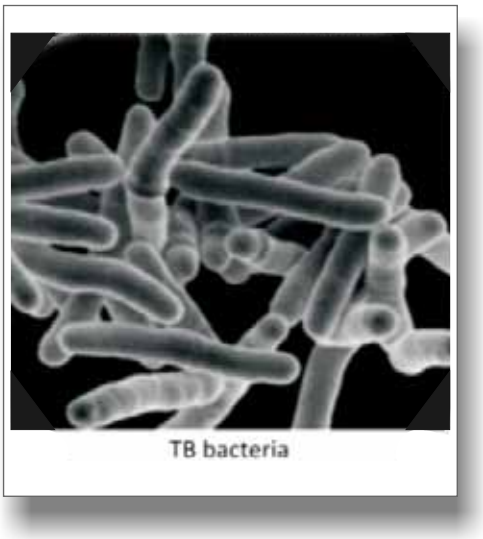
Pathogenic bacteria affect humans in the following ways:

1. As bacteria divide and multiply they secrete toxins that interfere with human bodily functions. For example they may paralyse our nerves, or block an epithelial tissue's ability to absorb. Cholera prevents water being absorbed from undigested food. Cholera victims therefore get diarrhoea and they dehydrate. Toxins can also cause fever, headache, tiredness and weakness.

2. As the bacteria invade tissue and multiply rapidly, they begin to interfere with the functioning of organs. For example Pneumococci invade the lungs causing them to fill with liquid. This decreases the available surface area for gaseous exchange. High fever and chest pains are typical symptoms of pneumonia.

3. When the human immune system fights the invading bacteria, surrounding human tissue may get damaged. This causes tissue destruction, pus formation, abscesses and scarring.

What is tuberculosis?


TB bacteria

The bacterium that causes tuberculosis can infect almost any human organ, although the lungs are most commonly infected. Infection usually occurs by inhalation of droplets exhaled during coughing by an infected person. In a healthy person with a strong immune system, the bacteria are usually rapidly destroyed. Transmission usually occurs in damp, overcrowded conditions, where people are not completely healthy or are malnourished or do not have strong immune systems. A person whose immune system is already compromised by HIV/AIDS tends to get TB easily. Also, patients with other lung diseases such as emphysema stand a greater risk of getting TB if they live in an area where TB is common.

The initial infection is called primary TB and often there are no symptoms. Some bacteria may, however, remain dormant for up to thirty years in the lungs or other tissue and then re-emerge as post-primary TB in the lungs or elsewhere. Symptoms are fever, weight loss and severe coughing with thick sputum which is infected and may become blood tinged. Without treatment, the bacteria destroy the lung tissue and cause accumulation of fluid in the pleural cavity between the lung and the chest wall.

Treatment involves the use of a range of various TB antibiotics to cover a wide range of strains of the TB bacterium for a period of 6 months or longer to ensure complete eradication. Prevention of TB by vaccination is most successful, although it is not effective in someone who already has TB. It has been estimated that the TB bacterium resides inactive in about 2 billion people worldwide. This is about one third of all humans. Ten percent of the people infected will develop active TB symptoms over their lifetimes. The majority of patients will die if they do not receive treatment, especially if they have HIV, severe malnourishment, or another underlying illness.

TB is a major public health problem in South Africa. South Africa ranked fifth on the list of 22 TB countries in the world. According to the World Health Organisation's Global TB Report 2009, South Africa had nearly 460,000 new TB cases in 2007, with an incidence rate of an estimated 948 cases per 100,000 population – a major increase from 338 cases per 100,000 population in 1998. There were an estimated 1.1 million HIV positive new TB cases globally in 2010.

The TB-HIV/AIDS co-infection rate is high, with an estimated 73 percent of new TB patients co-infected with HIV.

TB is the leading cause of death among people with AIDS. Almost one in four deaths among people with HIV is due to TB. In 2010 350,000 people died of HIV-associated TB.

Worldwide, about 5 000 people die every day from TB. Most of those deaths occur in Africa, where extreme poverty, lack of adequate health facilities and rampant HIV infection rates are exacerbating an already alarming TB crisis. Multidrug-resistant (MDR) TB, largely caused by patients not taking their medicine correctly or for the full period of time they are supposed to take it, is further worsening the epidemic.

ACTIVITY 6

After reading the above information on TB carefully, answer the following questions:

1. What is tuberculosis (TB)?

2. What is multidrug-resistant tuberculosis (MDR-TB)?

3. How is TB spread?

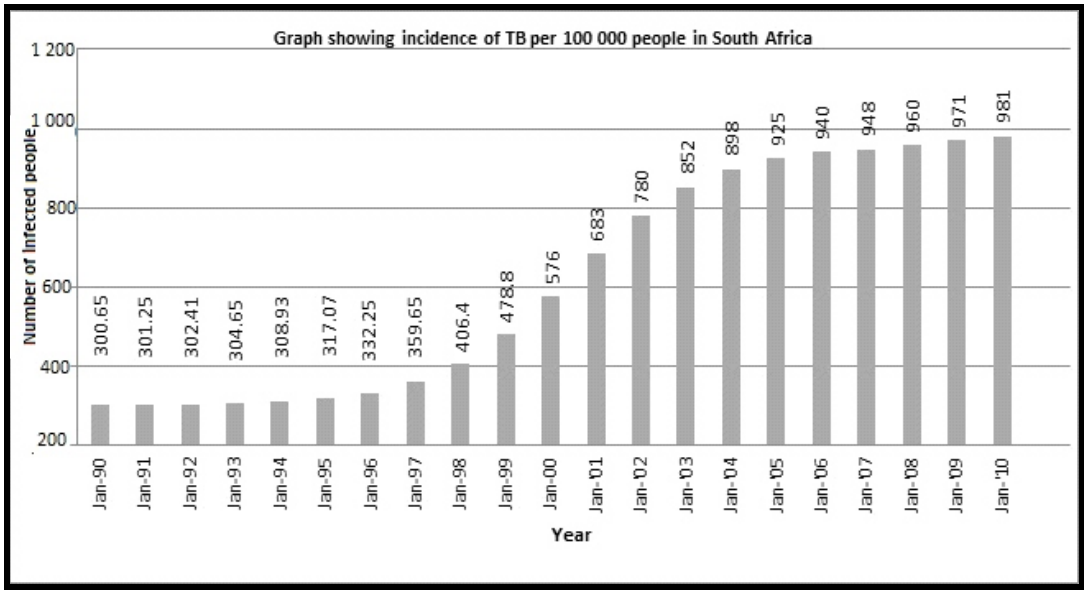
4. How does drug resistance happen?

5. Is there a vaccine to prevent TB?

6. What are the symptoms of TB?

7. Why is there such a high correlation (relationship) between the incidences of TB in people with HIV?

8. Study the graph and then answer the questions.



a. What kind of graph is this?

b. How many people in every 100 000 had TB in January 2009?

c. What is the overall trend for the incidence of TB in South Africa since 1992?

ANSWERS ON PAGE 121

COMMENT

Education is one of the greatest weapons in fighting any disease. HIV and TB are not exceptions. When ordinary people learn that they can prevent infection, they are empowered to protect themselves and their children. Who will you share your knowledge with about HIV and TB?

CHECKLIST

Are you able to:

- ❒ explain what is meant by 'the cell is the smallest basic unit of life'
- ❒ recognise the differences between the terms 'unicellular' and 'multicellular'
- ❒ describe the structure and functioning of the organelles in plant and animal cells
- ❒ compare and contrast plant and animal cells
- ❒ distinguish between eukaryotic and prokaryotic cells
- ❒ explain how viruses were discovered
- ❒ describe the structure of viruses and how viruses reproduce
- ❒ compare the structure of a virus with the structure of cells
- ❒ give reasons for and against describing viruses as living organisms
- ❒ describe infection, symptoms and effects of HIV and influenza and suggest ways of avoiding infection by these two viruses
- ❒ describe how pathogenic bacteria cause disease
- ❒ explain how a person becomes infected with TB, describe its symptoms and its treatment
- ❒ acknowledge the significance of TB in South Africa?

LESSON 3

Cells, tissues, organs and systems

About this lesson

In Lesson 2 you learnt that all living organisms are built from basic units called cells and that the simplest unicellular organisms are able to carry out all the life processes inside a single cell. The human body has different types of cells with each type carrying out a different function. You will look at some of these cells and how they are organised in the human body as well as how tissues in the body perform a variety of functions.

Different tissues are organised into organs which can be thought of as 'body parts' as they are able to perform specific tasks in the body. Your stomach, your eye, tongue, brain, liver, heart and lungs are all organs. Groups of organs may work together to form an organ system. An organism has many systems. For example, the human body has a digestive system which includes organs such as the mouth, stomach and small intestine.

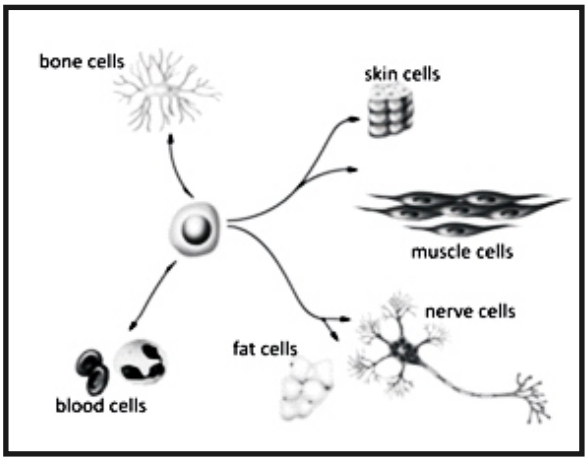
In this lesson you will:

- identify the relationship between structure and function in cells
- recognise that similar cells group together in tissues
- identify and examine different kinds of epithelial cells
- see how the body is organised from simple to more complex components or parts
- define cells, tissues, systems, organs and organisms
- describe the structure and function of connective tissue, muscle tissue and nerve tissue
- define what is meant by an organ and a system
- recognise a number of the different systems in the body together with their associated organs
- describe the basic functions of the major organ systems in the body
- show how the systems are reliant on each other for efficient functioning

Cells in the human body

The billions of cells that make up the human body all come from a single fertilised egg cell. As this cell divides repeatedly to make the human body, so groups of cells differentiate and specialise to become tissues. If all your body cells operated independently, it would be impossible to organise and operate your body.

What different kinds of cells are there in the human body?



In Lesson 2 you learnt the structure of the 'generalised animal cell'. In multicellular organisms such as humans, cells differentiate in structure and become specialised in function. This diagram, which is not drawn to scale, shows only some of the many specialised cells that can be found in the human body. All the cells, although differing in structure and function, have the same basic composition: a cell membrane which forms the boundary around the cell; cytoplasm and organelles suspended in the cytoplasm.

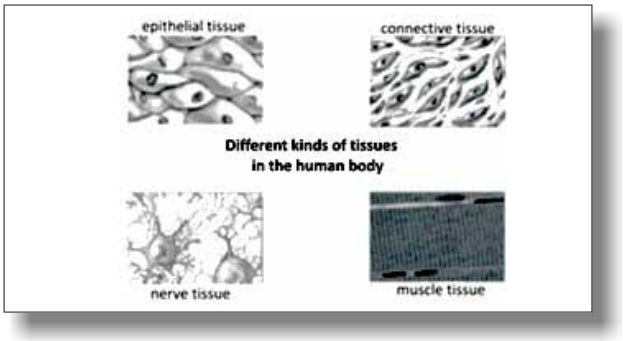
tissue:
derived from the Latin for 'woven'. Just as cotton threads are woven together to make cloth, so similar cells work together to make a functioning tissue.

Cells are not found in isolation. Similar kinds of cells are usually found grouped together. Groups of cells, which are similar in structure because they are specialised for a particular function, are called tissues.

Animals, including humans, have four main groups of tissues:

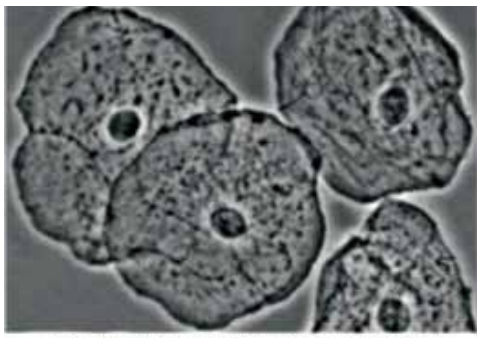
- **epithelial tissue** to cover and protect the outside and inside of the body;
- **connective tissue** to support and join the parts of the body;
- **nerve tissue** to carry signals from one part of the body to another.

You will learn more about connective, muscle and nerve tissue later in this lesson.



Epithelial cells

Epithelial tissue is made up of tightly connected cells arranged in one or more layers. Epithelial tissue covers the whole surface of the body (it's your skin!) as well as lining all cavities and forming glands. Epithelium can be specialised for many functions which include protection, secretion, absorption and filtration.

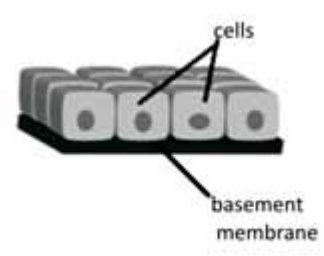


epithelial cells scraped from the inside of a human cheek

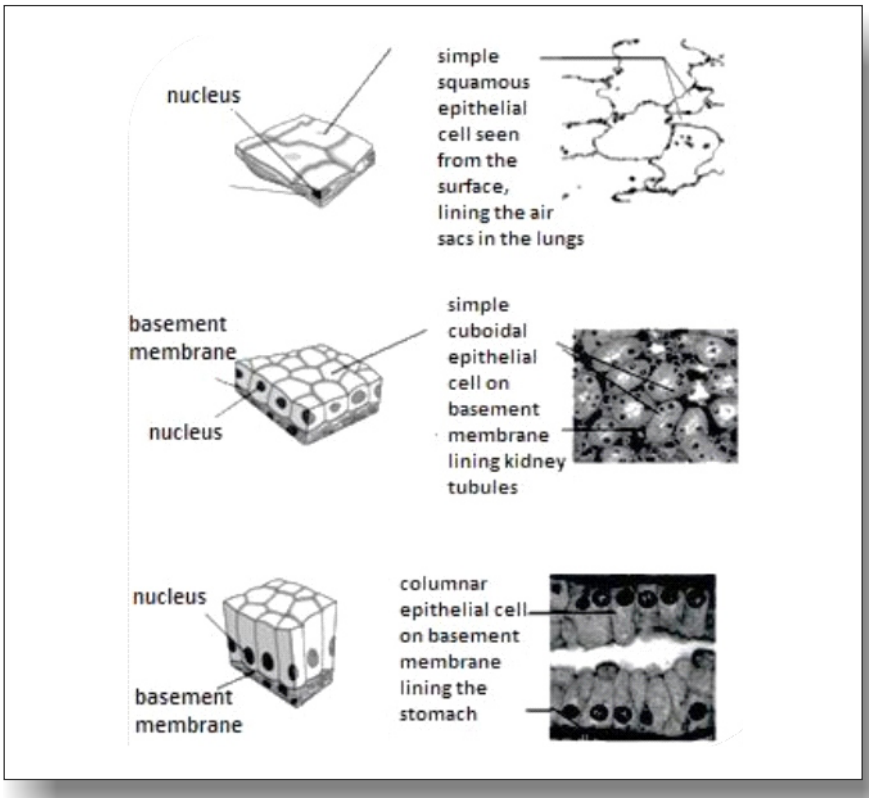
There are two main types of epithelium:

- **simple epithelium** which has one layer of cells; and
- **stratified epithelium** which has several layers of cells.

Epithelial cells always lie on a basement membrane. The basement membrane is a thin sheet of connective tissue and it provides structure and support for the epithelium and binds it to underlying structures. The basement membrane strengthens the epithelium so that it does not stretch or tear.



The cells fit closely together to form continuous sheets to protect the parts that they cover. The cells have one free surface. In the skin this surface is exposed to the outside environment. In the internal organs the free surface is exposed to the cavity of the organ.

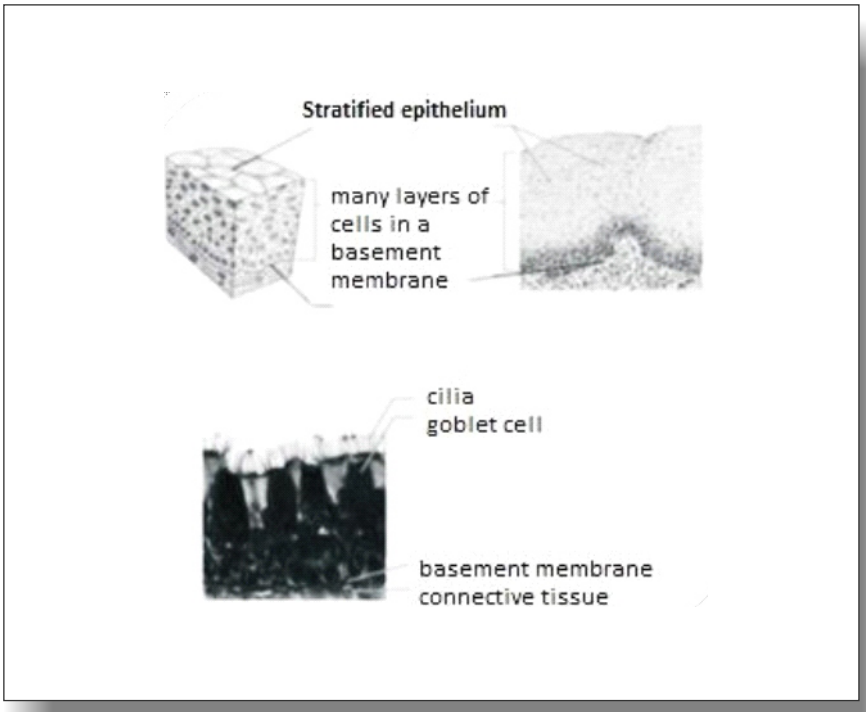


Different kinds of epithelium have different shapes that depend on the different functions that they have. Epithelial tissues are named after the shape of the cells and the extra parts that they may have on them.

- The cells in simple squamous epithelium are thin and permeable so that substances such as food and gases can pass easily through them.
- The cells in cuboidal epithelium are slightly thicker and line tubules that carry liquids from one part of the body to another.
- Columnar epithelium contains goblet cells that produce mucous to protect the gut from acidic digestive juices.
- Stratified squamous epithelium makes up human skin and has several layers of cells. The outermost cells are dead and are constantly being rubbed away. These cells are continually replaced by cells on the basement membrane that divide by mitosis.

The free surfaces in some organs have structures with special functions:

- the movement of cilia in columnar ciliated epithelium carries dust particles and bacteria out of the windpipe or trachea in the lungs;
- goblet cells produce mucus or other substances which are secreted onto the surface of the epithelium of the inner surface of the nose for example.



ACTIVITY 1

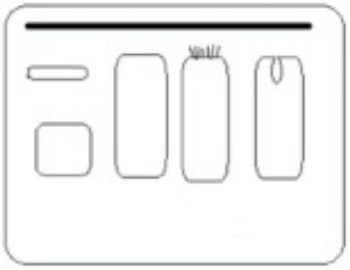
The table below lists names and descriptions of the different epithelial types. Redraw the table in your workbook, and match the correct description to each name.

ANSWERS ON PAGE 122

Name of tissue	Description of tissue
Simple squamous	A single layer of tall cells that are found in places like the lining of the intestine and gallbladder.
Simple cuboidal	The free surface of the cells have small hair-like structures that can move and sweep particles along the surface.
Simple columnar	Many layers of cells, the topmost layer is made up of tall cells; found in the mammary ducts and epididymus of the testes.
Stratified squamous	One layer of cells that are roughly square or cube-like in shape; found in glands, duct and portions of the kidney tubules.
Stratified columnar	A single layer of cells that are thin and flat; they form the lining of cavities such as the mouth, blood vessels and lungs.
Glandular	Many layers of cells are present; this is the type of epithelium that makes up the skin surface and lining of the mouth and throat.
Ciliated	Columnar and cuboidal cells often become capable of secreting substances such as enzymes, hormones, mucus, sweat and saliva.

ACTIVITY 2

Can you build your own diagrams of different epithelial tissues? Select from the shapes in the box to build:



1. simple squamous epithelium
2. stratified epithelium
3. simple cuboidal epithelium
4. simple columnar ciliated epithelium
5. simple columnar epithelium with goblet cells

ANSWERS ON PAGE 123

COMMENT

Epithelial cells are just one kind of many different cells found in the body. You have seen how a structurally generalised cell can be modified to perform specialised functions.

ACTIVITY 3

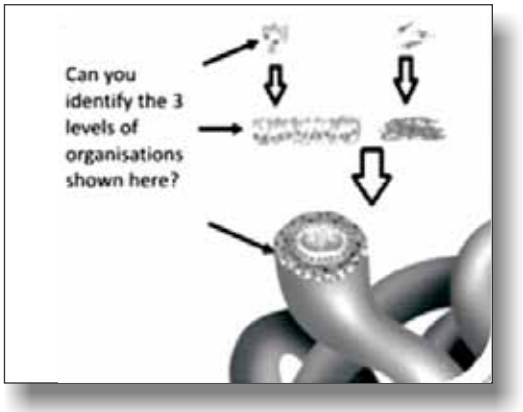
The sketch shows a man playing soccer. His body has tissues that perform all kinds of functions. Use what you have learnt to answer these questions:

1. What is the tissue that forms the man's skin?
2. What tissue fills the spaces between the other tissues and parts of the body?
3. What tissue moves the body when the man runs and kicks the ball?
4. What tissue sends messages from his eyes to his brain so that he can see the ball?
5. What tissue sends messages to his legs from his brain to allow him to kick the ball?

ANSWERS ON PAGE 123

How is the body organised?

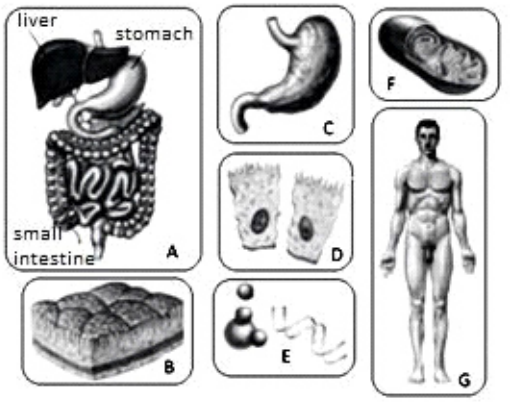
We can see that the human body is organised from simple to complex units. Smaller, simple units make up larger, more complex units that contribute to still larger units. The level of complexity increases as you move from step to step.



Level of organisation	Description	Example
 Level of the atom	Atoms are defined as the smallest unit of an element that still maintains the property of that element.	carbon, hydrogen, oxygen
 Level of the molecule	Atoms combine to form molecules.	water, DNA, carbohydrates
 Level of the cell	Cells are the smallest unit of life and are enclosed by a membrane.	muscle cell, skin cell, neuron
 Tissue level	Tissues are groups of cells with similar functions.	muscle, epithelial, connective
 Organ level	Organs are two or more types of tissues that work together to complete a specific task.	heart, liver, stomach
 System level	A system is a group of organs that carries out more generalised set of functions.	digestive system, circulatory system
 Organism level	An organism has several organ systems that function together.	human

ACTIVITY 4

Match the terms with the pictures. Then, rewrite the terms in your notebooks. Next to the terms, number the pictures so that they are organised from simplest to most complex.



organism
organ
tissue
system
organelle
atoms, molecules
cell

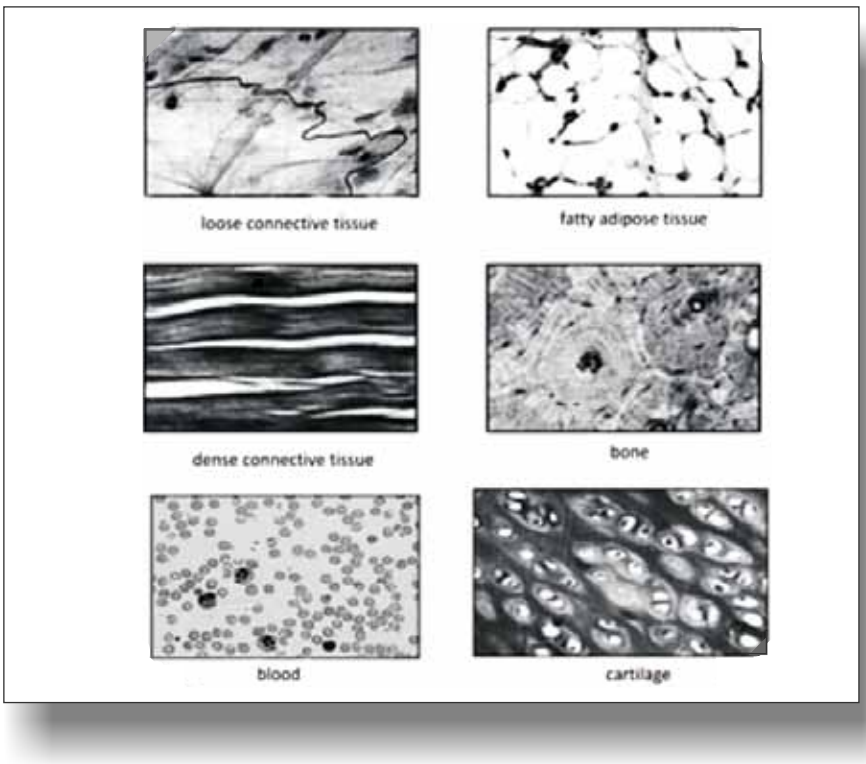
ANSWERS ON PAGE 123

Connective, muscle and nerve tissue

You have learnt about epithelial tissue. However, what about other tissues?

Connective tissue

Fat, tendons, ligaments, cartilage, bone and blood are all examples of connective tissue.

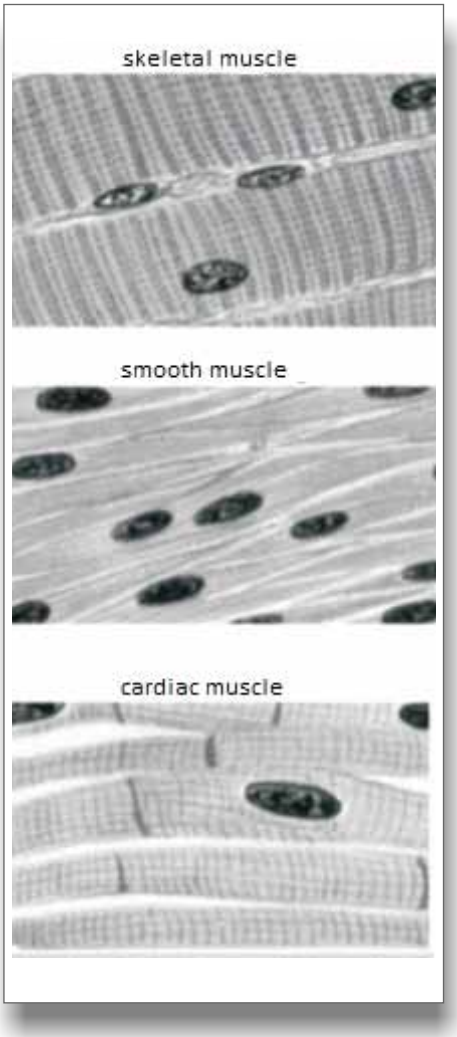


Connective tissue holds cells together and supports the body. Connective tissue is made up of cells suspended in a non-cellular matrix. The matrix (also known as ground substance) is secreted by the connective tissue cells and determines the characteristics of the connective tissue. It is the consistency of the matrix that establishes the function of the connective tissue. The matrix can be liquid, as in blood, gel-like, as in cartilage or fat or solid, as in bone.

Fibroblast cells are responsible for making protein fibres for the matrix. Collagen fibres are strong, elastic fibres are flexible and reticular fibres form a supportive framework for organs and basement membranes.

Muscle tissue

Muscle tissue is characterised by the ability to contract. When muscle cells contract, they get shorter, allowing movement.



There are three different types of muscle tissue:

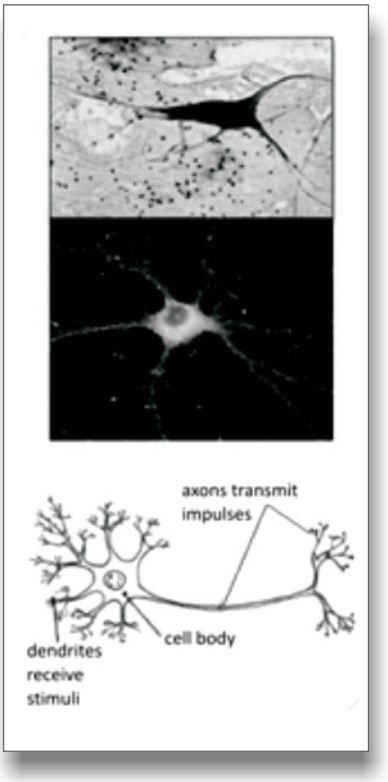
Skeletal muscle
Skeletal muscle tissue is composed of long cells with many nuclei and visible striations or stripes. It allows movement as it is attached to bones in the body. Skeletal muscle is consciously controlled and is also known as voluntary muscle.

Smooth muscle
Smooth muscle is composed of short, cylindrical cells that taper at the ends. These muscles are usually involved in involuntary actions and occur in parts of the body like the digestive tract and in the walls of blood vessels.

Cardiac (heart) muscle
Cardiac muscle tissue contains short, branched, striated cells, with one nucleus at the centre of each cell. The branches allow communication between cells to help the heart beat. Cardiac muscles are also involuntary muscles.

Nerve tissue

Nerve tissue responds to changes in the environment. Special organs sense changes in the environment and send messages called impulses to various organs in the body to respond to these changes. Nerve tissue is found in the brain, spinal cord and peripheral nerves that branch throughout the body.



Neurons are the cells that carry electrical impulses. There are three main types of neurons, which are classified by their function. Sensory neurons conduct impulses from the sensory organs such as the eyes, nose and ears, to the central nervous system, the brain and spinal cord. Motor neurons are responsible for conducting impulses from the central nervous system to the effector organs which are the muscles and glands. Finally, interneurons are those neurons that connect sensory neurons to motor neurons.

ACTIVITY 5

Decide which of the following words best suits each of the statements below:

A. Connective
B. Epithelium
C. Muscle
D. Nervous

1. _____ forms basement membranes
2. _____ allows movement of limbs and for organ movements within the body
3. _____ function is to support cells
4. _____ function is to communicate
5. _____ function is to protect and line
6. _____ uses signals called impulses to carry out its functions
7. _____ supports and reinforces the body organs
8. _____ cells of this tissue may absorb and/or secrete substances.
9. _____ basis of the major controlling system of the body
10. _____ its cells shorten to exert force
11. _____ forms endocrine and exocrine glands
12. _____ surrounds and cushions body organs
13. _____ function is to contract and move body
14. _____ characterised by having large amounts of extracellular material
15. _____ allows you to smile, grasp, swim, ski, and throw a ball
16. _____ widely distributed; found in bones, cartilages, and fat deposits
17. _____forms the brain and spinal cord
18. _____ diverse forms that can be liquid, gel-like or solid
19. _____ your skin
20. _____ allows you to see

ANSWERS ON PAGE 123

COMMENT

Cells which have similar structures and functions are organised into tissues. Tissues perform basic functions in our bodies.

Systems in the human body

Some systems in the human body

The body has many different functioning organ systems, such as the digestive system, the reproductive system, which will be discussed in Lesson 4, and the nervous system. It is important to keep in mind that these systems don't exist as individual units. The final product of these co-operating systems is one unit called the body. Each system depends on the others, either directly or indirectly, to keep the body functioning normally.

The skeletal system

The skeletal system is the framework of the body and is made up of 206 bones. The skeleton gives the body its basic shape, and protects the fragile internal organs. Because the skeleton is made of bone, it also stores calcium in case there is an inadequate amount provided in your diet. A vital role of this system is the production of red blood cells.

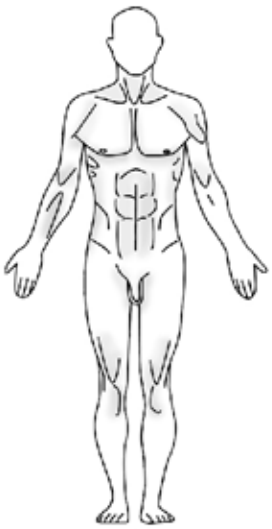

Muscular and skeletal system

The skeleton can be divided into two parts: the axial skeleton and the appendicular skeleton. The axial skeleton comprises the bones of the head and body while the appendicular skeleton is made up of the limbs. Joints exist between bones to allow for movement. The ends of bones are covered with cartilage to protect them and in some cases, where movement occurs at the joint, to facilitate easy movement. Ligaments hold bones together at moveable joints.

The muscular system

Muscles are the organs that make up this system. You have learnt that there are three types of muscle tissue: skeletal, cardiac and smooth. Skeletal muscles are voluntary muscles that work with the connective tissues such as bones, cartilage, ligaments and tendons to allow the body to move.

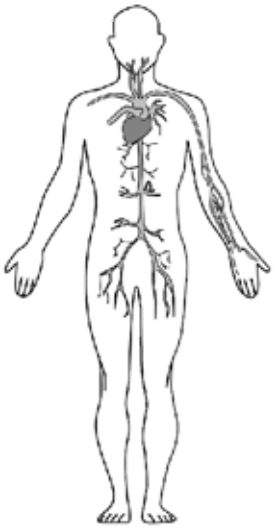
Cardiac muscles, that make the heart beat, make up the walls of the heart. They are involuntary muscles, which means you cannot voluntarily control the action of these muscles. Smooth muscles are also involuntary. They help move food along in the digestive tract, move blood through veins and arteries, dilate and contract the pupils of your eyes, focus the lens in your eyes and perform many vital functions within your body of which you are not aware. As your muscles work, they generate heat which helps you to maintain a constant body temperature so chemicals such as enzymes can work optimally in your body.



Integumentary system

The integumentary system

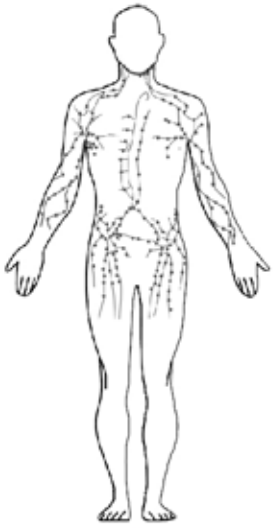
The skin, nails, hair and sweat glands are the organs which make up this system. It protects the internal structures of the body from damage, prevents dehydration and invasion by toxins or pathogenic organisms, stores fat and produces vitamins and hormones. The skin is also responsible for regulating body temperature. Your skin contains many sensory cells such as temperature, pressure and pain receptors. The information that is collected by these sensory cells in the skin is relayed to the brain and/or spinal cord.



Circulatory system

The circulatory system

The heart and blood vessels are the organs associated with this system. The circulatory system is a closed system whose main function is to carry blood to all parts of the body. The blood transports nutrients and gases to cells and tissues throughout body, and collects wastes from the cells. The heart acts as a pump to drive the blood through the vessels. The human circulatory system is a double circulatory system. This means that deoxygenated blood from the body enters the heart and is pumped directly to the lungs. Here carbon dioxide moves into the lungs while oxygen moves into the blood. This oxygenated blood is returned to the heart and then it is pumped to the body.

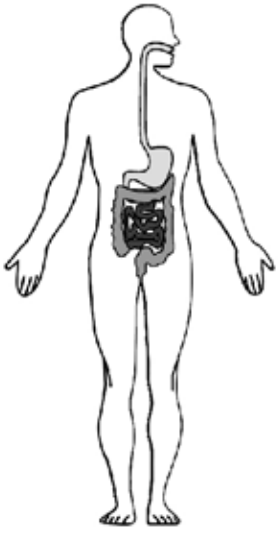


Lymphatic system

The lymphatic system

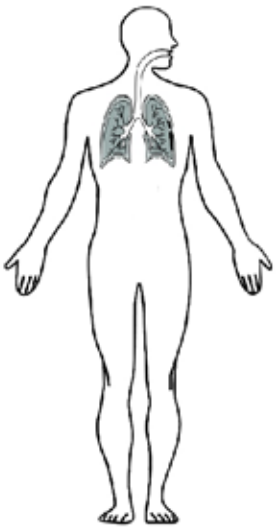
This one-way transport system is closely linked to the circulatory, immune and digestive systems. The main organs are lymph nodes and vessels, the thymus and spleen. Blood plasma leaks from capillaries into spaces in the tissues and becomes tissue fluid where it bathes the cells. Tissue fluid is collected into lymph vessels, passes through lymph nodes where it is filtered for pathogens, and then returned into the circulatory system. This ensures that the blood volume remains constant.

Contracting skeletal muscles surrounding the lymph vessels help push lymph along the vessels, assisted by valves which prevent backflow. The white blood cells called lymphocytes and macrophages in the lymphatic system assist with immunity of the body against disease. In the small intestine, special lymph vessels called lacteals are involved with the absorption of lipids.


Digestive system

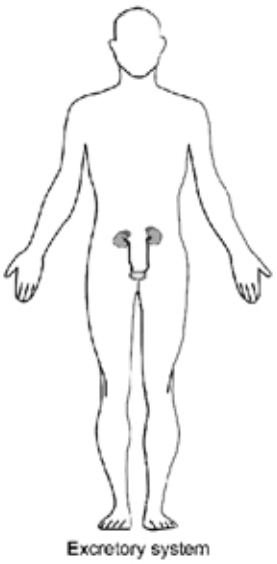
The digestive system

This system breaks down large food molecules into smaller molecules. These molecules are absorbed into the circulatory system and transported throughout the body to provide energy for all cells. Digestion is both mechanical and chemical. Food contains a mixture of nutrients, carbohydrates, proteins and fats, and the digestive system deals with each nutrient in a different way. Once the food substances have been broken down and the nutrients absorbed, the wastes are expelled from the body. The primary organs in this system are the mouth, stomach and intestines. The accessory or additional organs are teeth, tongue, salivary glands, liver, gallbladder, pancreas and spleen. The food substances are moved along the length of the digestive system due to the continual contraction and relaxation of sets of circular and longitudinal smooth muscles.


Respiratory system

The respiratory system

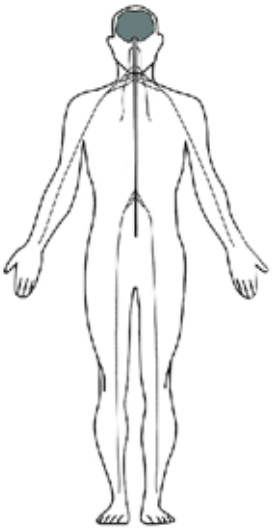
Trachea and bronchi. This system provides the body with oxygen via gas exchange between air from the outside environment and gases in the blood. It is in the lungs that oxygen from the outside meets the blood by way of the thin tissues in the lungs. Muscles cause the rib cavity to expand and contract; this is vital in causing changes to the size of the thoracic cavity to allow inhalation and exhalation of air.


Excretory system

The excretory (urinary) system

The excretory or urinary system is mainly comprised of the kidneys, the ureters, the bladder and the urethra. It is the urinary system that filters out toxins and certain waste products that the blood has taken from the cells. The blood passes through the kidneys in order to be filtered. Along with removing wastes, the urinary system maintains water and salt balance in the body.

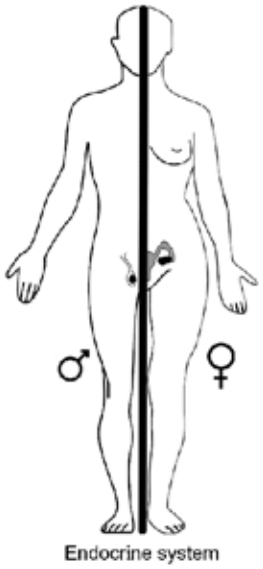
The nervous system


Nervous system

This system is made up of the brain, spinal cord and nerves. It monitors and co-ordinates internal organ function and responds to changes in the external environment. It is a very complex system. The nervous system can be subdivided into the central and peripheral nervous systems. The central nervous system is made up of the brain and spinal cord. The peripheral nervous system is made up of cranial and spinal nerves. The spinal nerves are those that carry messages to and from the spinal cord. The nervous system also includes special sense organs such as the eyes, ears and taste buds.

Specialised nerve cells in these organs detect specific stimuli. The rods and cones of the retina in the eye detect light; the fine hair-like cells in the organ of Corti in the ear detect sound; the chemoreceptors in the tongue and nose detect chemicals and pain receptors in the skin detect pressure. The stimuli that are detected by these specialised cells are passed to the central nervous system for processing. This means that your brain or spinal cord will cause your body to react appropriately, depending on the message received, for example, blinking your eye, eating the food in front of you, or removing a pin from your finger. Messages can then be sent back to the muscular system for the body to react to the stimuli.

The endocrine system



Endocrine system

This system is made up of various endocrine glands such as the pituitary gland, pineal gland, hypothalamus, ovaries, testes, thyroid gland and adrenal glands. These glands produce hormones. Hormones are chemical substances that are produced by the endocrine glands and released into the blood. They circulate throughout the body, but have specific effects in certain target organs or cells.

For example, insulin is released by the pancreas and has effects in the liver and in all cells that need to take up glucose from the blood. The hormones circulate in the blood and help to regulate growth and maintain homeostasis within the body. This means that the body is controlled to be at a steady balanced internal state in terms of temperature, water and carbon dioxide balance, and pH. Other substances such as glucose levels in the blood are also controlled by hormones.

ACTIVITY 6

1. Read the information about the different organ systems and then organise the information into a summary table with the following headings:

    a. System
    b. Major Organs in the System
    c. Functions of the System.

2. In what way/s are the following systems dependent on other systems, either directly or indirectly, for their efficient functioning?

    a. Lymphatic
    b. Digestive system
    c. Describe how another two systems of your choice are dependent on other systems for their efficient functioning.

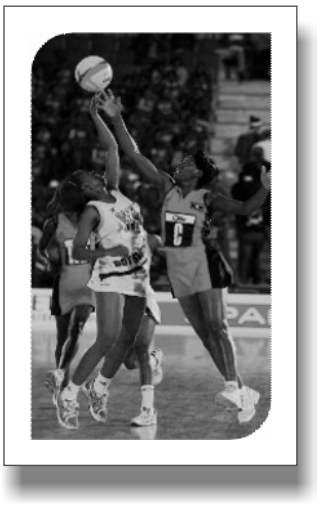
ANSWERS ON PAGE 124

ACTIVITY 7

Now that you have worked through this lesson, answer these questions.

1. In this discovery activity we want you to think how the skeletal, muscular, nervous, circulatory, respiratory and other systems work together.

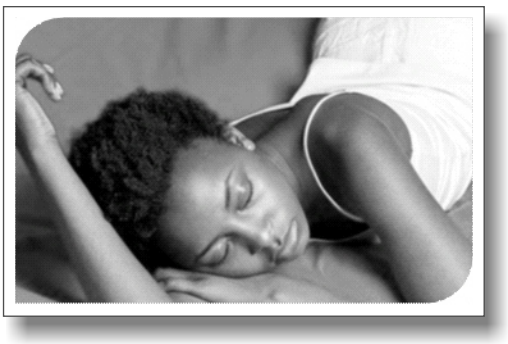
    a. What happens in your body when your friend throws a ball to you during a netball game and you throw it up into the net to score a goal? How many body systems are involved?



b. What happens in your body when you come home, smell food cooking and go to the kitchen? You eat some food and drink a glass of milk. How many body systems are involved? What role does each play?

c. What happens in your body when you're studying for a test? You are reading the problems, writing the answers, getting up to have a break, and talking to a friend on the phone. How are the body systems working together to complete these tasks?

d. What happens in your body when you're sleeping? Which systems are working?



ANSWERS ON PAGE 124

COMMENT

Each of our body systems is interconnected and dependent on other systems. Our heart, which is part of our circulatory system, does not beat unless our brain, which is part of our nervous system, tells it to. Our skeletal system is dependent on our digestive system for increase in size and strength. Our muscular system needs our respiratory and circulatory systems to supply energy in the form of oxygen and nutrients. It takes all the systems to work together efficiently for human growth and development.

CHECKLIST

Are you able to:

- ❒ identify the relationship between structure and function in cells
- ❒ recognise that similar cells group together in tissues
- ❒ identify and examine different kinds of epithelial cells
- ❒ see how the body is organised from simple to more complex components or parts
- ❒ define cells, tissues, systems, organs and organisms
- ❒ describe the structure and function of connective tissue, muscle tissue and nerve tissue
- ❒ define what is meant by an organ and a system
- ❒ recognise a number of the different systems in the body together with their associated organs
- ❒ describe the basic functions of the major organ systems in the body
- ❒ show how the systems are reliant on each other for efficient functioning

NOTES

LESSON 4

Sexual reproduction in humans

About this lesson

Humans belong to the group of animals known as mammals. Like all mammals, humans undergo internal sexual reproduction; the female goes through a period of pregnancy and then bears live young. The young are fed milk from the female's mammary glands. There is extended parental care of the offspring as they in turn develop to sexual maturity. In Lesson 3 you learnt that the human body is made up of different systems which perform specialised functions. The function of the reproductive system in humans is to bring about sexual reproduction. The human female reproductive system is controlled by a complex interplay of a variety of different hormones.

You will also learn about contraception as a means to prevent contraception.

Finally, you will learn about sexually transmitted diseases.

In this lesson you will:

- identify the male reproductive organs and their functions
- identify the female reproductive organs and their functions
- investigate the stages of the ovarian and menstrual cycles and recognise the hormones that control these cycles
- describe fertilisation and explain the steps following fertilisation leading to pregnancy
- describe the changes in the female body during pregnancy
- explain the stages of birth
- describe the different forms of contraception and evaluate the success of different contraceptives
- discuss ways STDs are transmitted and categorise sexual behaviour which may result in the transmission of STDs

Male and female reproductive organs

Sexual reproduction and gametogenesis

gamete: *specialised sex cell that is produced by the process of meiosis*
meiosis: *cell division that reduces the chromosome number by half*
gametogenesis: *the process of producing gametes by meiosis*
spermatogenesis: *gametogenesis to produce sperm*
oögenesis: *gametogenesis to produce ova (singular: ovum)*
testes: *singular testis*

Sexual reproduction involves the joining together of two cells from two different organisms. Each organism produces specialised cells by the process of **meiosis** which reduces the number of chromosomes in the cell by half. You will learn more about this process in Lesson 5.

These specialised cells are called **gametes**. One of these gametes fuses with a gamete from another organism. The resulting cell undergoes mitosis and grows into a new organism. Apart from reducing the number of chromosomes in the cell, meiosis also brings about genetic variation. Genetic variation enables individuals to produce physically and genetically unique offspring.

A common error that many people make is to say that meiosis happens **in** sex cells or gametes. This is incorrect. Meiosis happens **in** the sex organs **to produce** sex cells or gametes.

Spermatogenesis takes place in the testes of the male organism. Specialised cells undergo meiosis to produce the haploid sperm cells. This process happens continually after puberty has begun and is controlled by hormones in the male body. Oögenesis takes place in the ovaries of the female organism. Specialised cells undergo meiosis to produce the haploid egg cells. Hormones in the female body regulate this process.

The male reproductive system

The male reproductive system consists of:

- 1 pair of testes which are the sex organs that produce the male gametes or sperm cells
- a number of tubes for the delivery of sperm
- accessory sex glands which contribute substances to the sperm
- a penis which is used for copulation and delivery of the sperm into the female body

The testes have two main functions. Firstly, they are glandular organs that produce the sperm cells by **spermatogenesis**.

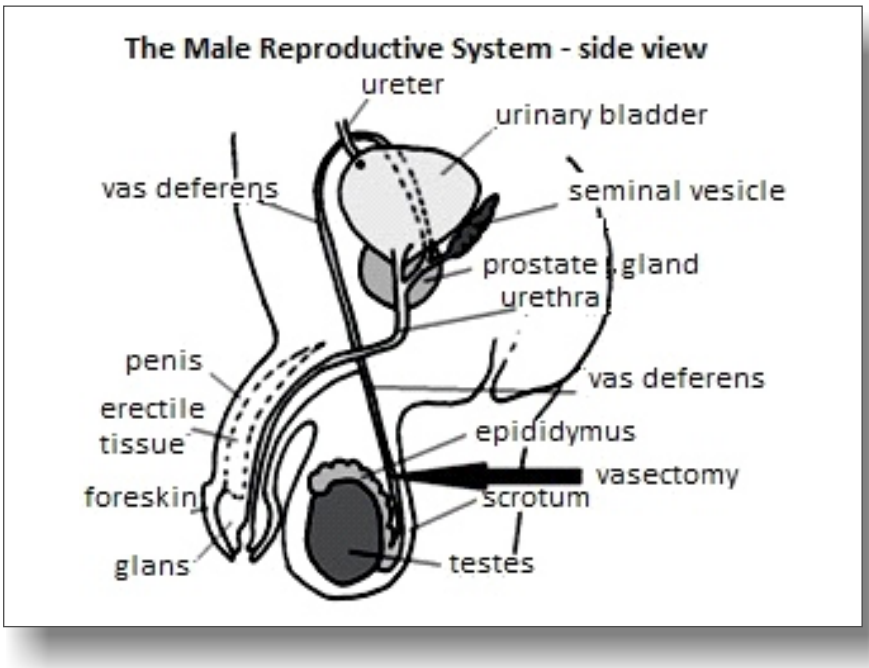
Each testis is made up of hundreds of metres of tightly coiled tubes called the **seminiferous tubules** where sperm is produced. Secondly, they produce the male sex hormones **androgens**, of which the main one is **testosterone**. Testosterone stimulates sperm production and also controls the development of secondary male characteristics such as a deep voice, facial hair, penis development and increased muscle development.

Each testis is enclosed in a sac of skin called the **scrotum**. Together, the scrotum and the testis make up the **testicle**. The testicles hang outside the body where the temperature is slightly lower than body temperature. This is for optimal sperm production.

The seminiferous tubules leave the testis and form the **epididymus**. The epididymus is a highly convoluted tubule about 5 cm long, but wider than the seminiferous tubules. There is an epididymus situated on top of each testis. After the mature sperm cells are produced, they are stored in the epididymus.

The tube that leaves the epididymus is called the **vas deferens**. The vas deferens leaves the scrotal sac and runs in the male body, up and around the urinary bladder. When the male ejaculates sperm, the sperm moves from the epididymus along the vas deferens.

The vas deferens passes a number of **accessory glands** which add substances to the sperm. The **seminal vesicles** secrete a yellowish liquid into the vas deferens. The liquid contains a food source for the sperm.

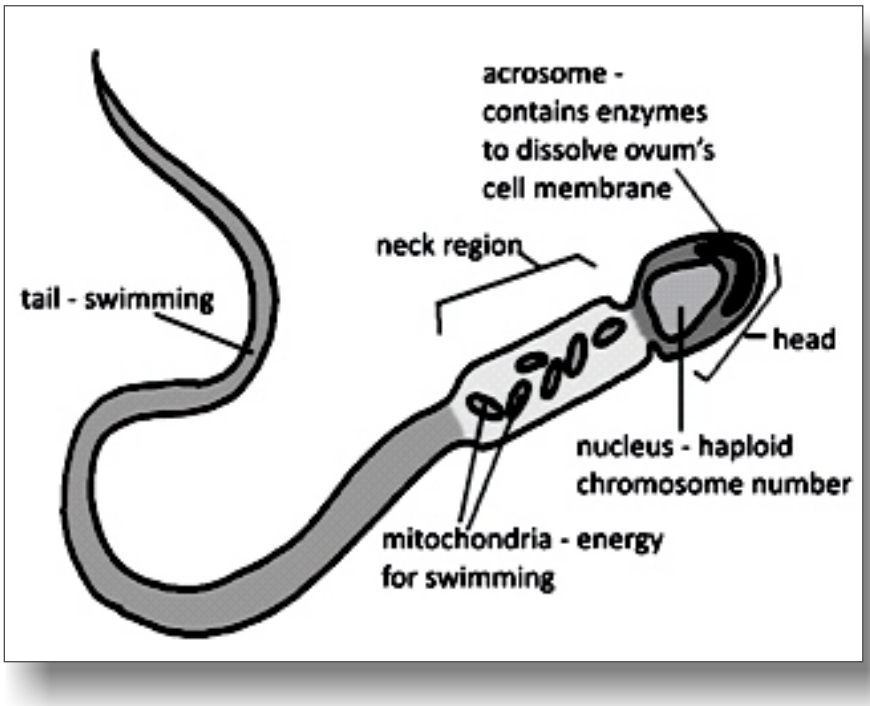


The **prostate gland** secretes a milky, alkaline fluid into the vas deferens. This fluid assists with motility of the sperm and counteracts acids in the urethra and vagina. **Cowper's gland** adds a substance to the vas deferens which assists with sperm motility. This substance also assists with lubrication of the penis in the vagina by producing a slippery fluid which escapes from the tip of the penis prior to ejaculation. Once the vas deferens passes the accessory glands and has all the additives contributed to the sperm, the substance in the tube is now called **semen**.

The vas deferens passes under the urinary bladder and joins the **urethra** which leaves the bladder. The urethra therefore carries urine and semen, but at different times. It is impossible to urinate and ejaculate semen simultaneously. The urethra lies inside the penis and opens to the outside of the body at the tip of the penis.

The **penis** is the external male sex organ responsible for transferring sperm from the male to the female. In order for this transfer to take place, the **erectile tissue** of the penis becomes filled with blood and the penis becomes stiff and hard. This is an **erection**. The angle of the penis and the stiffness facilitate entry into the female's vagina during intercourse. The tip of the penis is very sensitive and is called the **glans**. The glans is covered by retractable protective skin called the **foreskin**.

Examine the diagram of a sperm cell. It is made up of a head, a neck region and a tail. The tail is whipped about and is used to propel the sperm forward. The neck region is rich with mitochondria.



Can you think why the sperm cell would need so many mitochondria? Mitochondria make ATP (energy) which the tail needs in order to move. The nucleus, containing the haploid chromosome number, is found in the head. Another organelle, the acrosome is also found in the head. The acrosome contains enzymes that will be used to dissolve the cell membrane of the ovum, if the sperm comes in contact with an unfertilised ovum.

ACTIVITY 1

Records of human fertility for the period 1941 1990 show changes in the sperm counts of normal men. The table below summarises the changing percentages of men with high or low sperm counts over a period of 50 years.

Time period	Men with high sperm counts (%)	Men with low sperm counts (%)
1941 – 1950	50	4
1951 – 1960	45	5
1961 – 1970	28	11
1971 – 1980	21	14
1981 – 1990	15	18

1. By how much did the percentage of men with high sperm counts decrease in the period 1951 to 1970?

2. On the same system of axes, draw two sets of bar graphs to compare the percentages of men with a high sperm count and a low sperm count from 1941 to 1990.

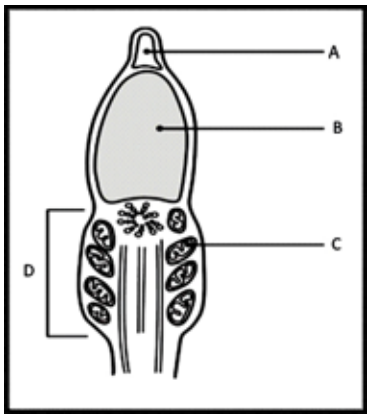
3. Describe the trend for men with low sperm counts and compare it with those with high sperm counts over the 50-year period.

4. Give one reason why it is necessary for a large number of sperm to be produced when only one sperm is required to bring about fertilisation.

ANSWERS ON PAGE 125

ACTIVITY 2

1. Look at the diagram. Provide labels for structures A, B, C and D.



   a. Explain the function of label C in a sperm cell.

   b. Semen has a pH of 7,5. Sperm cells have high mortality rates in acidic conditions. How does the male body ensure that sperm cells are not killed by acidic urine as they travel through the urethra?

   c. A vital factor in the survival of the sperm is the temperature at which they are stored in the scrotum. What temperature is most favourable for sperm longevity and explain how this temperature is maintained in the scrotum.

ANSWERS ON PAGE 125

The female reproductive system

The female reproductive system consists of:

- 1 pair of ovaries which are the sex organs that produce the female gametes called the eggs or ova
- 1 pair of oviducts or Fallopian tubes which deliver the ovum to the uterus; the oviducts are the place where fertilisation happens
- a uterus which is the structure where the fertilised egg develops into a foetus
- a vagina which is for copulation and the birth of baby

In the female reproductive system there are two ovaries which have two main functions. The first is to produce the female gametes by the process of oogenesis. The second is to produce a group of female hormones that control the female reproductive cycle as well as maintain the uterus in the case of pregnancy.

The **ovaries** are small oval shaped organs about 1.5 cm long. They are situated in the abdominal cavity on either side of the uterus and are held in place by ligaments.

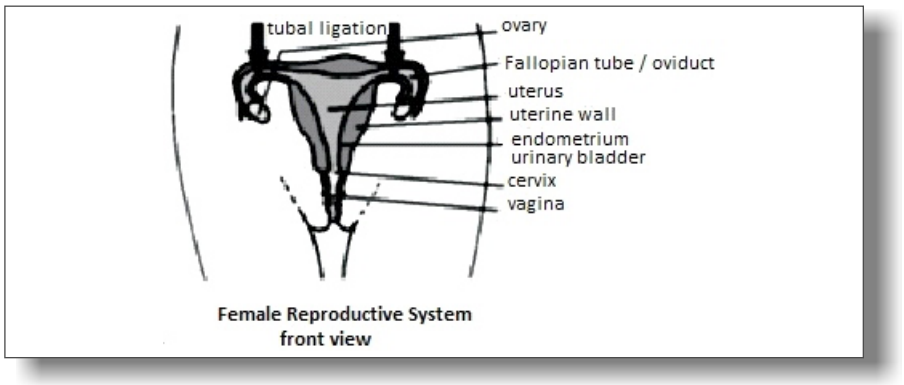
The **oviducts**, or **Fallopian tubes**, are two tubes that deliver the ovum to the **uterus**. Once the ovum is released from the ovary, it moves down the oviducts. Movement is facilitated by smooth muscle contractions and ciliated epithelial cells sweeping the cell along.

If sperm is present in the oviduct, **fertilisation** takes place here. If the ovum is fertilised, the first mitotic divisions of the zygote take place in the oviduct as the zygote passes on towards the uterus. You will learn more about cell division in Lesson 5.

The uterus is a hollow organ, roughly the shape of an upside down pyramid, 2 – 3 cm long and the walls of the uterus are very muscular. The inner lining of the uterus is called the **endometrium**, a mucous membrane that is highly **vascular**. The endometrium changes in thickness throughout the cycle and a **zygote** may implant into it. The uterus is responsible for the care of the **embryo** from implantation to birth. If no zygote is implanted in the uterus, the endometrium sheds off as menstrual bleeding. The uterus narrows down to the **cervix**.

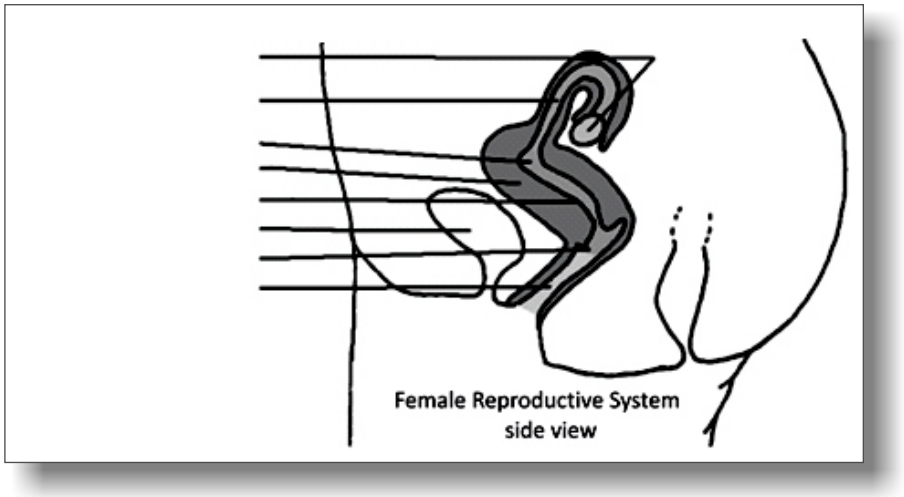
vascular:
many blood vessels in the mucous membrane

The cervix opens into the vagina which is a tube roughly 8 cm long stretching from cervix to exterior. The vagina receives the penis during copulation and acts as the birth canal.



ACTIVITY 3

Study the diagram that was provided earlier of the front view of the female reproductive system. This is a diagram of the side view of the female reproductive system. Provide a label for each label line.



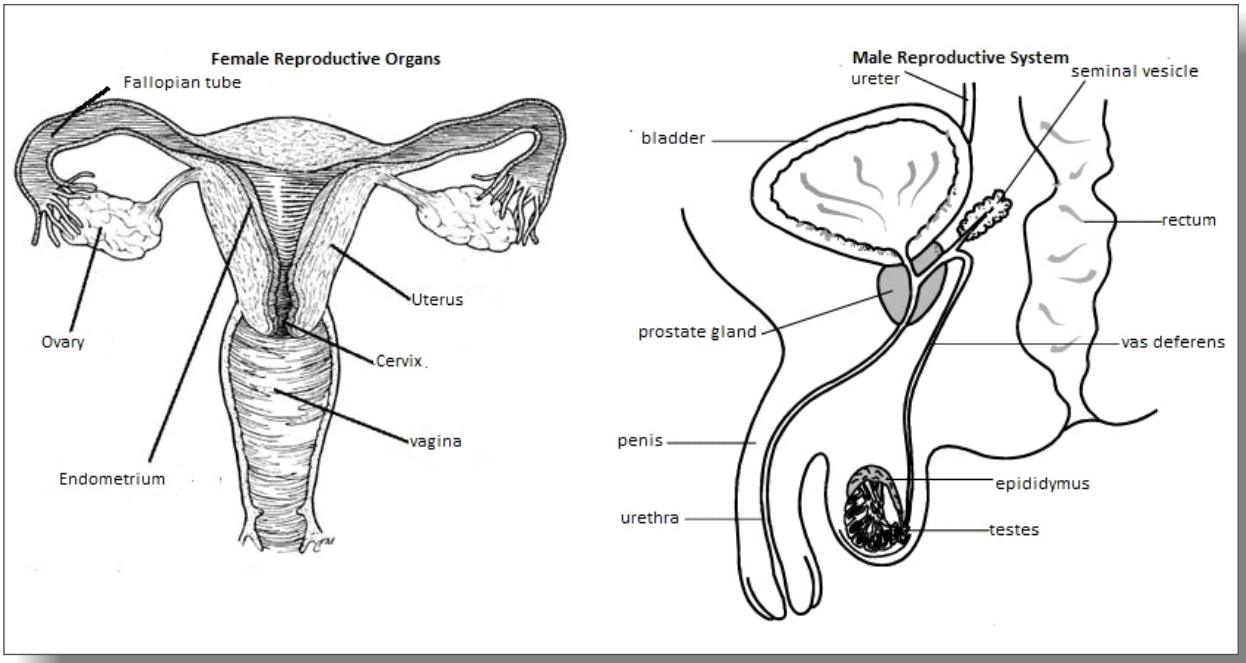
ANSWERS ON PAGE 126

COMMENT

The structures of the organs in the male and female reproductive system are specially designed to bring about fertilisation and pregnancy, as well as birth of the baby. The endocrine system ensures that these organs mature during puberty and begin to function efficiently throughout the period of fertile adult life.

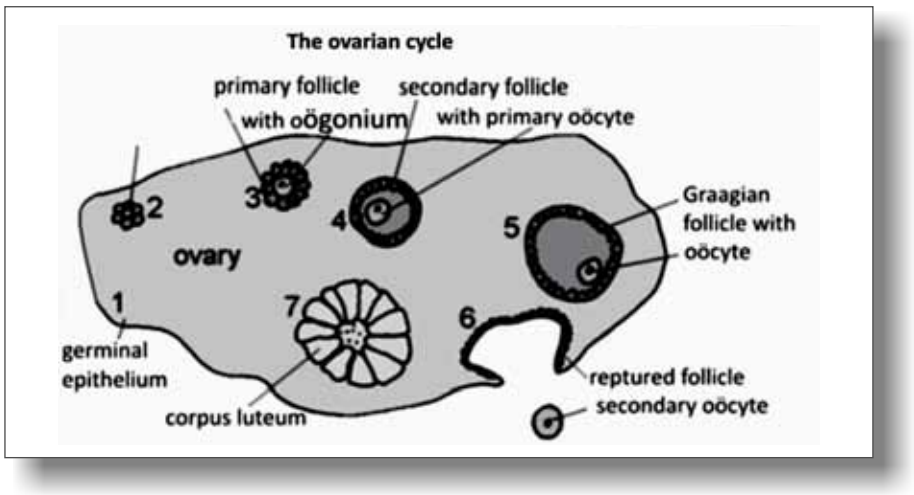
Female reproductive cycles

The human female reproductive system is controlled by a complex interplay of a variety of different hormones.



The ovarian cycle

The **ovarian cycle** occurs once a month after puberty. Normally, only one egg is produced and released from one of the two ovaries each month. The diagram on the next page shows a plan of what the surface of one ovary looks like over the course of one month, as the ovarian cycle takes place.



Follow the process of the ovarian cycle as described below.

a. The **germinal epithelium** produces **oögonia**. (see 1)

b. The oögonia are present in the ovary of the female when she is born. However, they are immature and wait many years before maturing. (see 2)

c. The oögonia develop inside **primary follicles**. (see 3)

d. **Follicle Stimulating Hormone** (or FSH) stimulates the primary follicles to develop into **secondary follicles**. **Meiosis** will begin and the oögonium (2n) becomes the **primary oöcyte** (n). You will learn more about meiosis in Lesson 5. (see 4)

e. The primary oöcyte is located inside the mature **Graafian follicle**. The Graafian follicle secretes **oestrogen**, a hormone which stimulates the endometrium to thicken in preparation for pregnancy. Fluid builds up inside the Graafian follicle and thent moves to the surface of the ovary. (see 5)

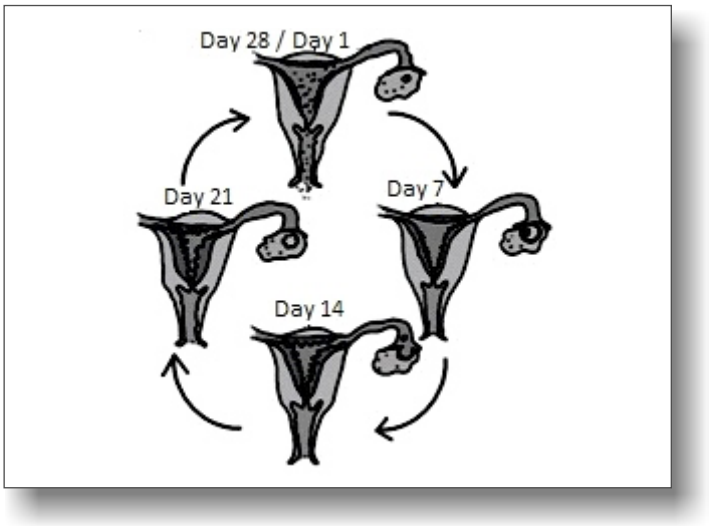
f. The Graafian follicle bursts, releasing the secondary oöcyte. This is called **ovulation**. Ovulation is stimulated by **Luteinising Hormone** (LH) which is secreted by the hypophysis of the brain. (see 6)

g. Under the influence of LH, the Graafian follicle now becomes the **corpus luteum**, which secretes the hormone **progesterone** that will maintain the endometrium for a pregnancy. If the secondary oöcyte is not fertilised, the corpus luteum degenerates. (see 7)

The menstrual cycle

Another significant hormonal controlled cycle is the **menstrual cycle**. The menstrual cycle is also sometimes called the **uterine cycle** as it describes events that take place in the uterus over the course of one month. The ovarian cycle and the menstrual/uterine cycle occur simultaneously.

Day 28/day 1: Beginning of the menstrual cycle and first discharge of blood as the endometrium is shed from the previous month's cycle. The shedding of blood is called **menstruation**, which lasts between 4 and 6 days.



Day 7: Inside the ovary, the Graafian follicle is developing and secreting oestrogen which stimulates the endometrium to thicken again.

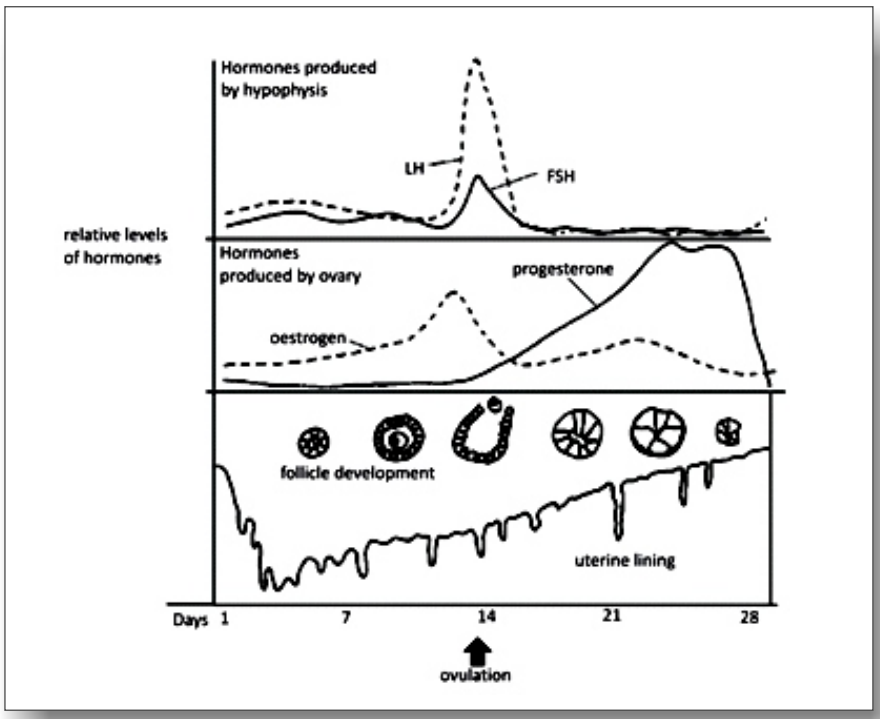
Day 14: **Ovulation** takes place and the secondary oöcyte begins to move down the oviduct. The endometrium is very thick. Fertilisation could take place while the oöcyte is in the oviduct. The Graafian follicle will become the corpus luteum.

Although the cycle is always shown as a 28 day cycle, this is an average. Most women have cycles slightly shorter or longer than the 28 day cycle. It is also very common for young girls to have very irregular cycles.

Day 21: The corpus luteum continues to stimulate the endometrium which is now at its thickest. If fertilised, the zygote will implant in the endometrium.

Day 28: If implantation has occurred, the corpus luteum will sustain the endometrium. If no fertilisation took place, the oöcyte will not implant and menstruation will take place.

The graph on the next page places the menstrual cycle on a two dimensional x and y-axis. The levels of the different hormones are depicted on the graph. Follow the line for each hormone on the graph.

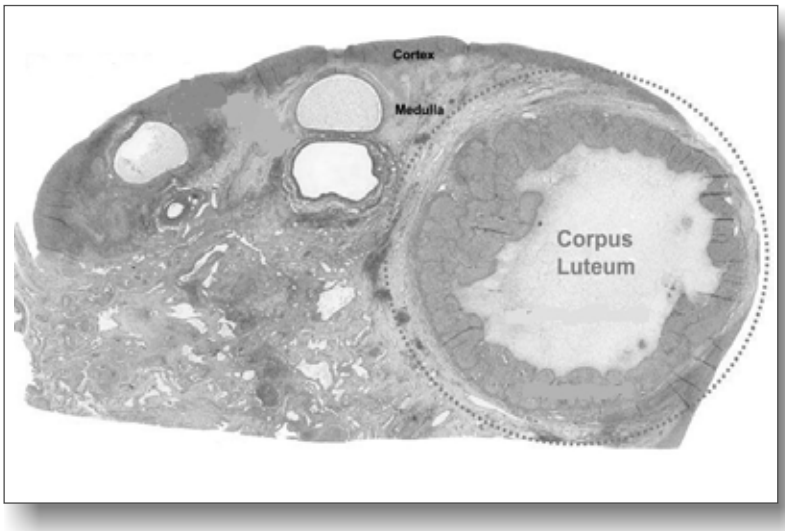


Follicle Stimulating Hormone (FSH) is produced by the hypophysis which is situated in the brain. It stimulates the development of primary follicles to Graafian follicles. Notice how FSH peaks on the graph at ovulation.

Oestrogen is produced by the developing follicle. It inhibits production of FSH so that only one follicle matures at a time. It also stimulates the endometrium tissue to thicken and the hypophysis to produce LH. Oestrogen peaks just before ovulation.

Luteinising Hormone (LH) is produced by the hypophysis and stimulates ovulation on Day 14. It converts the Graafian follicle into the corpus luteum. LH peaks at ovulation.

Progesterone is produced by the corpus luteum. It helps to prepare the endometrium for possible pregnancy. It inhibits FSH and LH, so no further follicle development or ovulation takes place. If fertilisation does not occur, the corpus luteum breaks down. Production of progesterone stops. Therefore FSH
Is no longer inhibited and a new cycle begins.



ACTIVITY 4

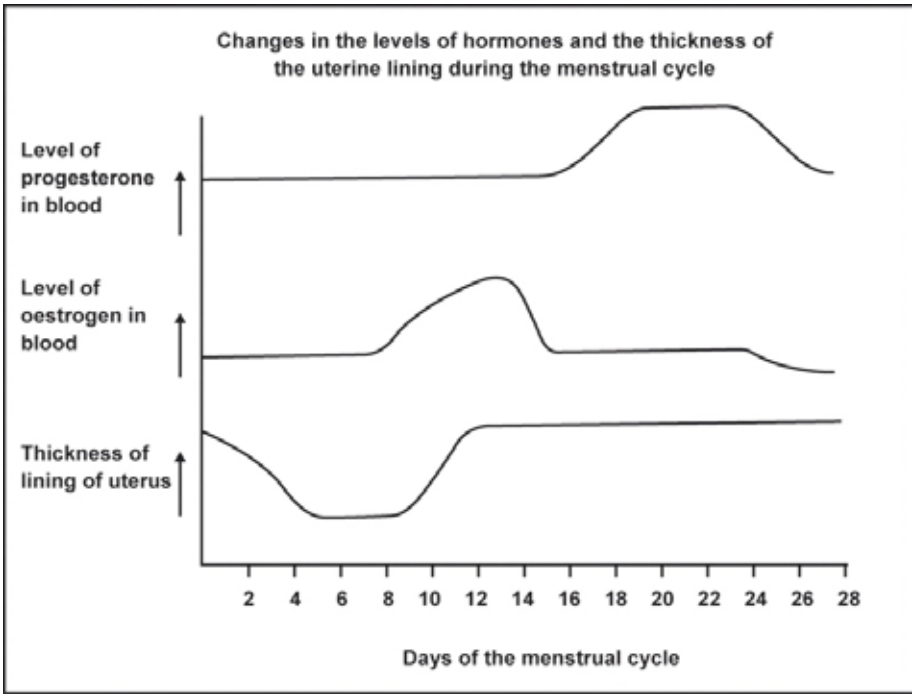
Before you forget what these hormones control, let's build up a table to help you study this work. Remember that tables are excellent ways of summarising information for study purposes. Complete the table.

Name of hormone	Where it is produced	Functions
Follicle Stimulating Hormone or FSH		
	Graafian follicle	
	hypophysis of brain	
		maintains endometrium and uterus through pregnancy

ANSWERS ON PAGE 126

ACTIVITY 5

Study the graph and answer the questions that follow.



1. What is menstruation?

2. Select the days on which menstruation occurs from those given below:

   Days 0 – 5
   Days 5 – 12
   Days 9 – 16
   Days 24 – 28

3. Use the graph to describe the changes in the hormone levels that took place before the breakdown of the uterine lining.

4. What is the effect on the uterine lining when the level of oestrogen increases?

5. Why is it important that a high level of progesterone is maintained during pregnancy?

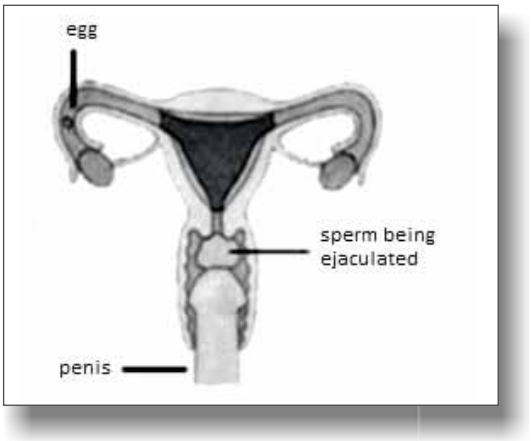
ANSWERS ON PAGE 126

COMMENT

The female reproductive system is finely controlled by a complex interaction of a range of hormones. Menopause is the permanent stopping of ovarian function. This means that the woman is no longer fertile because her ovaries are no longer producing ova and she no longer menstruates. She therefore can no longer fall pregnant. Generally a woman will experience some irregularity with her cycle and then her periods will stop altogether. The average age of natural menopause is 51 years, although this varies between individuals.

Fertilisation, pregnancy and birth

Fertilisation

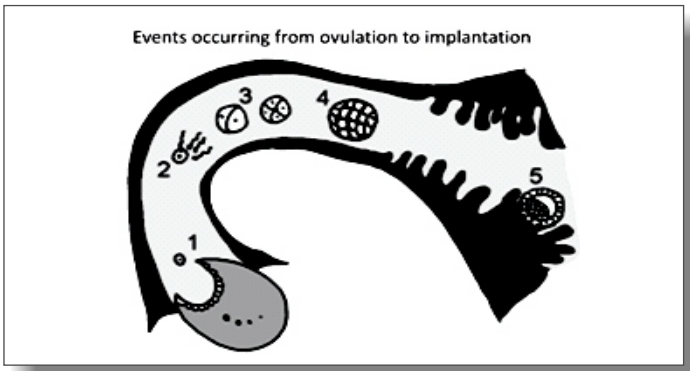


Intercourse occurs when the erect penis is inserted into the vagina. The penis moves in the vagina. Movement is facilitated by vaginal fluid and seminal fluid lubrication. The male ejaculates semen into the vagina. About 5 ml of semen is released containing ± 500 million sperm cells. The sperm immediately begin to swim up through the cervix, into the uterus and along the oviducts.

If there is an oöcyte in one of the oviducts, **fertilisation** will take place. Sperm die after a few days and become part of the normal vaginal discharge.

Let's take a closer look at the processes that take place from ovulation to implantation. Refer to the diagram.

Once an oöcyte is released it begins to move down the oviduct towards the uterus (1). If sperm are present in the oviduct where the oöcyte is moving, **fertilisation** will take place (2). The acrosome in the head of the sperm cell releases enzymes which eat away at the membrane around the oöcyte. The nucleus will then penetrate into the female gamete. Once one sperm cell has penetrated the egg, the membrane of the egg will repel any other sperm cells. The nuclei of the two gametes fuse and the result is a 2n **zygote**. The zygote will continue to move down the oviduct towards the uterus.



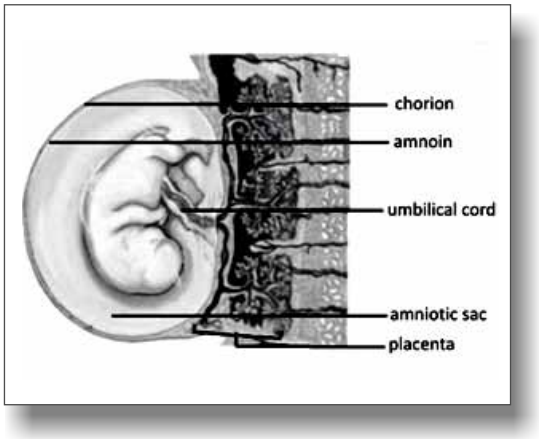
morula:
Latin for mulberry which is what the cells look like

As it moves, it begins to divide by mitosis (3). The round mass of cells that reaches the uterus is called a **morula**. The morula (4) continues to divide and develops into a ball of cells arranged around a hollow fluid-filled sac. It is now called a **blastocyst**. The blastocyst will **implant** in the endometrium (5). The external wall of the blastocyst extends finger-like projections called **villi**, which make attachment to the endometrium secure. These projections will develop into the **placenta** as the embryo develops.

The nutrients from the placenta, diffuse from mother to offspring and metabolic wastes diffuse from offspring to mother. Oxygen and carbon dioxide are exchanged between mother and offspring. The placenta acts as a filter to many chemicals and micro-organisms that might be pathogenic, however, a number of life threatening pathogens, such as the German measles virus and the HIV, can pass through the placental filter from mother to offspring. From about the 12th week of pregnancy, the placenta takes over the function of the corpus luteum and produces progesterone and oestrogen that help to maintain the pregnant state of the uterus.

Pregnancy

Pregnancy is also known as the **gestation period** and lasts ± 40 weeks. After implantation, the blastocyst develops further. For the first 8 weeks of development, the offspring is called an **embryo**. The embryo establishes a firm connection with the mother's body via the placenta. The organs begin to differentiate and develop.



From the 9th week until birth, the offspring is known as the **foetus**. Further development and growth take place until birth.

A number of membranes surround the developing baby and it is important that you know the names of the membranes, can identify them on a diagram and understand their functions.

The chorion is the outermost membrane around the embryo and other membranes. The chorion developed from the villi which originally attached the blastocyst at implantation. The chorion plays a major role in the development of the placenta.

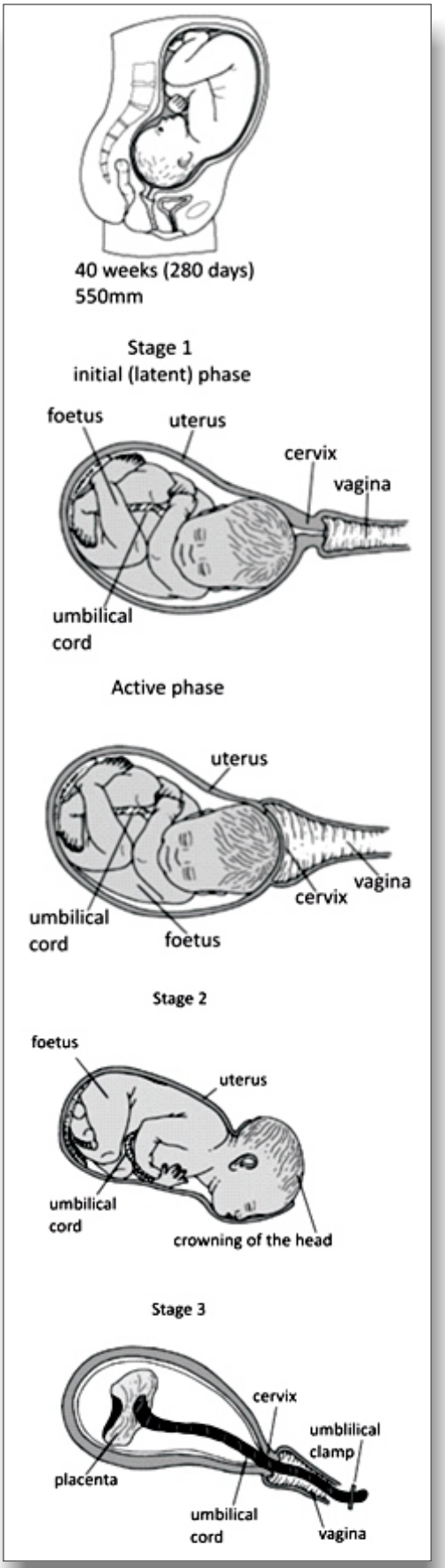
The amnion is the tough membrane found just inside the chorion, closest to the embryo. It holds the amniotic fluid in which the embryo is bathed. Amniotic fluid consists of water, foetal cells and waste products. The amniotic fluid acts as a shock absorber and prevents the embryo from drying out. The embryo is able to move freely in the watery medium which helps to maintain a stable temperature in the uterus.

The endometrium is a spongy, vascular tissue. The finger-like projections of the blastocyst, the chorionic villi, grow into the spongy spaces of the mother's tissue. The tissue that subsequently develops, made up of both mother and embryonic tissue, is called the placenta. The blood of the mother and embryo are close, but never mix. A transfer of substances takes place by diffusion, through the thin walls of the capillaries of mother and embryo/foetus.

The umbilical cord is made of tissue that joins the foetus to the placenta. It carries large veins and arteries from both the baby and the mother.

Today, technology such as ultrasound, exists to allow **gynaecologists** to see what is happening inside the uterus during the pregnancy.

gynaecologists: *specialist doctors who deal with female reproductive system tissues and pregnancy*



Birth

A normal pregnancy lasts an average of 40 weeks. At 40 weeks, the foetus is able to survive independently outside the mother's body. At about 40 weeks, the baby is in a head-down position, the placenta begins to break down and the hypophysis begins to produce a hormone called **oxytocin**. Oxytocin stimulates the muscles in the uterine wall. The contraction of these muscles is painful and the mother is aware that birth is about to begin.

The process of giving birth is divided into **3 stages**.

Stage 1:

Uterine contractions cause the cervix to dilate or open about 10 cm. The baby's head is wedged tightly into the cervix. The contractions intensify and arrive closer and closer together. The chorion and amnion break and the amniotic fluid flows out of the body. This is often called the 'breaking of the waters'.

Stage 2:

Powerful muscle contractions push the baby, headfirst, through the cervix and vagina to the outside.

Stage 3:

The umbilical cord must be clamped and cut. Usually the baby is put to its mother's breast to suck immediately. This is comforting for the baby and it stimulates a second series of contractions which are slightly less severe than the contractions in stage 2. A few minutes after the baby is born, the placenta, umbilical cord and membranes, also called the afterbirth, are pushed out of the body. It is important that all the tissue is expelled. Any tissue left in the body can become infected with bacteria and cause **sepsis**.

sepsis:
blood poisoning and inflammation triggered by bacterial infection which can cause death

ACTIVITY 6

Answer the following multiple choice questions:

1. The function of the amnion is to _____

    a. serve as a reserve food supply.
    b. give rise to the placenta.
    c. prevent the developing foetus from moving about.
    d. enclose the fluid that protects the embryo against injury.

2. Which statement is false?

    a. The endometrium receives the blastocyst if fertilisation took place.
    b. Fertilisation will normally take place in the oviduct between 1 to 5 days after ovulation.
    c. The mother's blood and the baby's blood mixes together in the umbilical cord.
    d. The placenta is made up of mother's tissue and baby's tissue.

3. The haploid nucleus of the male gamete, which is called the sperm, joins with the haploid nucleus of the female gamete called the oöcyte, to produce a diploid zygote. This process is called _____

    a. implantation
    b. fertilisation
    c. ovulation
    d. gestation

4. Arrange the following stages of childbirth in the correct order in which they occur.

    a. s t w u v x
    b. w t u s x v
    c. t s u v w x
    d. w u t x s v

    s. The cervix dilates.
    t. Gentle contractions of the uterus begin.
    u. 'Breaking of the waters'.
    v. The umbilical cord is clamped and cut.
    w. The baby moves its position and faces backwards with its head near the cervix.
    x. The baby's head emerges from the vagina.

5. Which statement is false?

   a. When the chorion and amnion break and the amniotic fluid flows out of the body, this is often called the 'breaking of the waters' and it signals that birth is close.

   b. Progesterone stimulates the muscles in the uterine wall to begin rhythmical contractions. The contraction of these muscles is painful and the mother is aware that birth is about to begin.

   c. Stage 2 of the birth process occurs when powerful muscle contractions push the baby, headfirst, through the cervix and vagina to the outside.

   d. A few minutes after the baby has been born, the placenta, umbilical cord and membranes, also called the afterbirth, are pushed out of the body.

6. Which statement is false concerning the health of the unborn child?

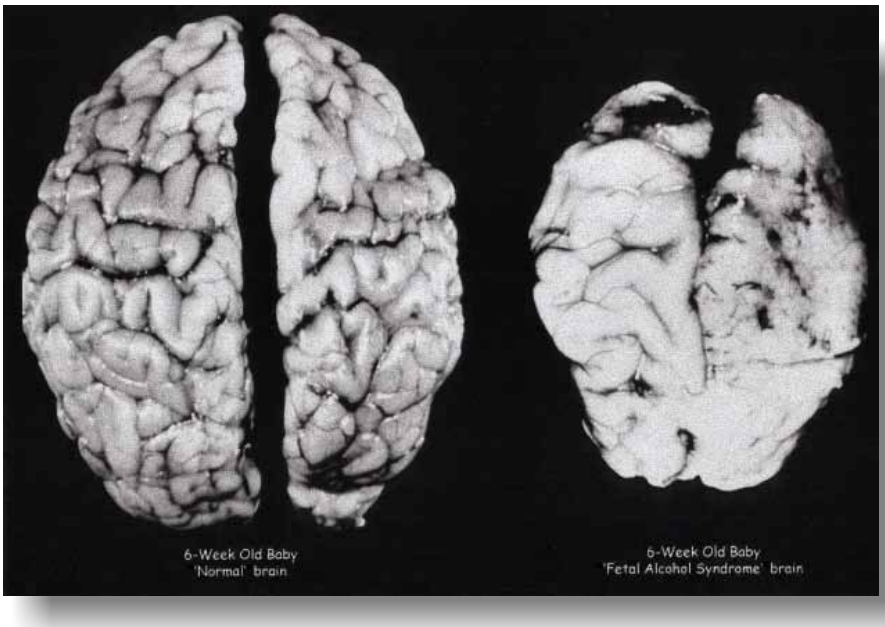
   a. Alcohol, smoking and drugs can permanently damage a foetus.

   b. Foetal Alcohol Syndrome is a condition where the baby suffers mental retardation and will have learning problems and delayed physical development.

   c. Most drugs and alcohol cannot cross the placental barrier from mother to foetus.

   d. A mother should do all she can to ensure the health of her unborn child and therefore she should completely avoid alcohol and drugs.

ANSWERS ON PAGE 127



COMMENT

At birth, the progesterone levels decrease rapidly as the placenta is no longer functional. The hypophysis secretes the hormone prolactin, which stimulates the milk glands to produce milk.

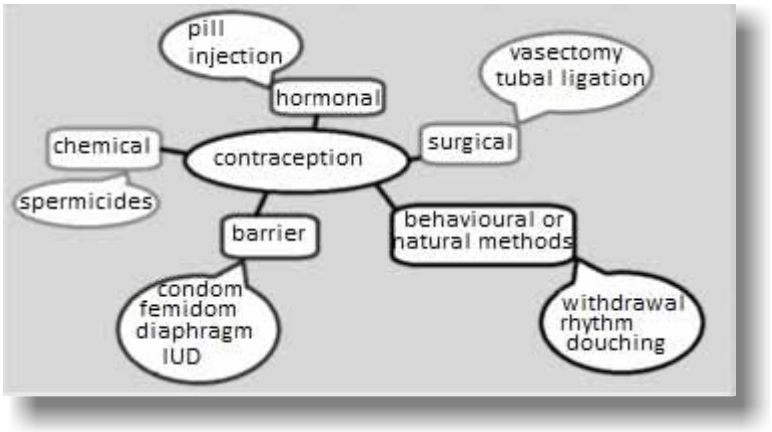
As the baby sucks on the nipple, the sucking action stimulates more prolactin and the breast makes more milk. It generally takes a day or two after birth for the milk to flow freely. The milk that is produced immediately after birth is very rich in fats, essential nutrients and, very importantly, immunoglobulins.

A baby's immune system is very immature at birth and many of the important immunoglobulins are passed from mother to child, until the baby's immune system matures. The baby drinks milk from its mother until it is able to start eating solid foods, at around 6 months of age. The baby can continue to breastfeed, even when it is on solid food.

A breastfeeding mother must avoid alcohol, tobacco or drugs, as these can pass to the baby via the milk. A very important function of breastfeeding is that it creates a strong bond of love and nurturing between the mother and the baby. Mothers who do not wish to breastfeed can bottle feed their baby with commercially produced milk formula.

Contraceptives

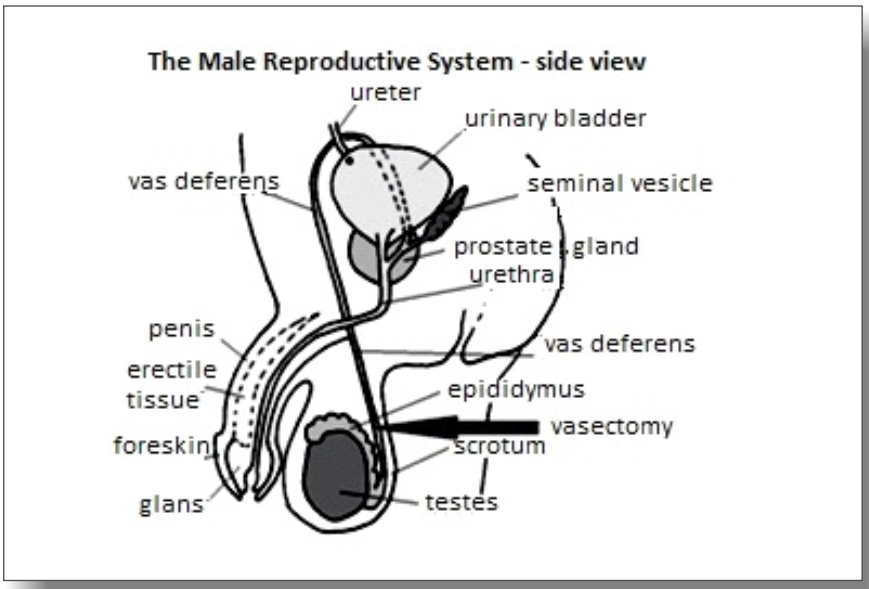
People do not always have sexual intercourse for the purpose of having a baby. Very often, partners want to share love and intimacy and wish to avoid a pregnancy. They therefore use contraception, which prevents conception or fertilisation.



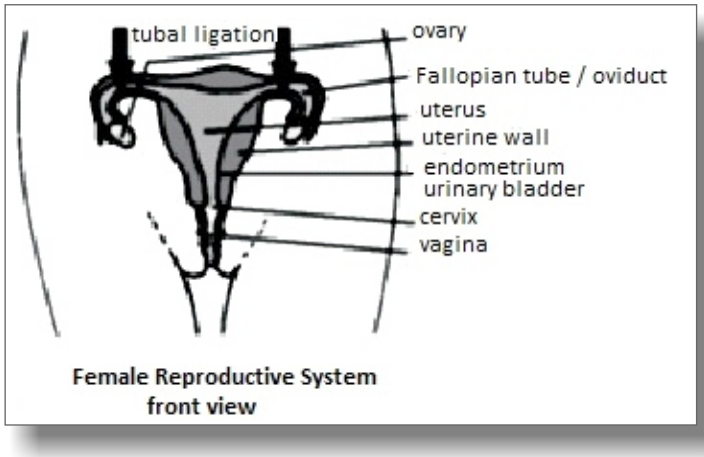
Different types of contraception

Surgical contraception:

In males, vasectomy is a small incision is made at the back of each testis and the vas deferens is cut. The procedure takes place under local anaesthetic. Although sperm cells are still produced in the testes, they are not able to pass along the vas deferens and into the female body. Sperm is stored in the epididymus and then reabsorbed into the body when it is not used. The male is still able to have sex as the accessory glands produce semen and he is able to ejaculate. There is just no sperm in the ejaculate. The testes still produce testosterone, which is absorbed directly into the blood, not secreted into the vas deferens. The man will still have all his male characteristics.



In females, tubal ligation involves the cutting and blocking off of the oviducts. The eggs that are released from the ovary can no longer be reached by sperm so no fertilisation can take place. The female hormones are still produced and secreted into the blood, so the ovarian and menstrual cycles still continue.



This procedure is more complicated than a vasectomy, and is done under general anaesthetic. About 5 days recovery is needed after the procedure. Surgical contraception is permanent. It is only recommended for people who have had all the children they want to have. Surgical contraception is 100% effective as a contraceptive measure but provides no protection against AIDS or other STDs.

Behavioural or so-called 'natural' methods

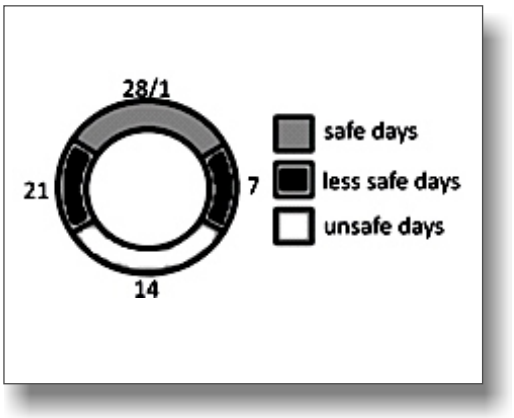
Withdrawal or coitus interruptus

Just before ejaculation takes place, the penis is **withdrawn** from the vagina. This is highly unreliable as a small amount of semen, with sperm, is released before ejaculation, as a lubrication fluid and ejaculation is not so easily controlled.

withdrawn:
removed

Rhythm Method

Sex is limited to times during the female's menstrual cycle when fertilisation either cannot take place or is less likely to take place. The female needs to keep careful records of when she ovulates. With a 28 day cycle, ovulation should be 14 days after the start of menstruation. The female's body temperature also increases slightly (±0.5°C) and the vaginal discharge is clear and jelly-like. This method is not very reliable as very few women have regular cycles. Sex becomes less spontaneous as it is controlled by the calendar. This method is approved by certain religious groups that do not approve of other contraceptive measures. The rhythm method offers no protection against disease.



Douching

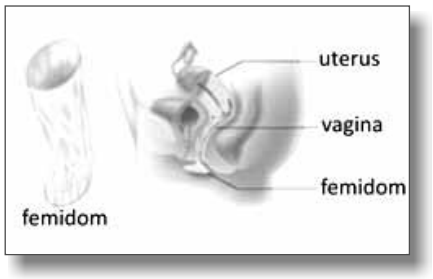
Douching involves washing out the vagina after sex. This is a highly unreliable method of contraception as sperm may have already entered the uterus, and washing the vagina is ineffective. This method offers no protection against disease.

Barrier methods

Barrier methods place a barrier or obstruction in the way of the sperm so it cannot get to the egg.

Condoms

A condom is a thin rubber sheath that fits over the erect penis and collects the semen. Sperm does not enter the female's body, so fertilisation will not take place. If used correctly, the condom is reliable. Its reliability can be increased by using a spermicide with the condom. The condom will assist in preventing the spread of disease.



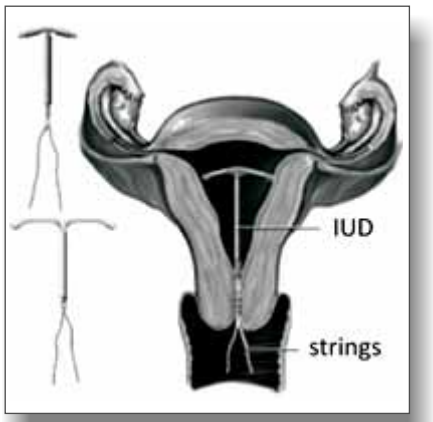
Femidoms

Like the male condom, the femidom is a thin rubber sheath, but it fits inside the vagina and is closed at the top end to prevent sperm from entering the cervix. It is also reliable in preventing spread of disease.

Diaphragms

The diaphragm is a hemisphere made of a flexible rubber with a more rigid rim. It looks like a rubber ball cut in half. It is inserted into the vagina and fits tightly around the cervix. It must be inserted before sex. It blocks the cervix, preventing sperm from entering the uterus. It is very reliable, especially if used together with a spermicide. It is not effective in preventing disease.

Intra-uterine Device



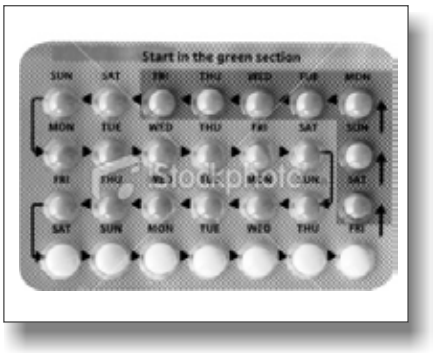
An Intra-uterine Device (IUD) is a small metal or plastic device in the shape of a loop, a T, or a spiral. It is placed in the uterus. The physical presence in the uterus prevents the implantation of a blastocyst in the endometrium. It must be inserted by a doctor or health care worker. It should be regularly checked and can be left in place for between 3 and 5 years. It is a very reliable form of contraception but cannot prevent disease. The IUD prevents implantation, not fertilisation. Some people object to the use of an IUD on the grounds that it aborts a fertilised blastocyst.

Chemical contraceptive methods

Spermicides are chemicals that kill the sperm cells, but cannot kill micor-organisms that cause disease, and come in the form of creams, gels and foams. They are squirted into a special applicator and are inserted high into the vagina around the cervix. Some spermicides come in the form of a tablet or pessary which is inserted into the vagina and which dissolves with body heat.

C-film ® is a special paper which is saturated with spermicide and inserted into the vagina and dissolves with body heat. Spermicides are not very reliable when used alone, but together with a condom or diaphragm, they are highly effective.

Hormonal contraceptive methods



The Pill contains the female hormone progesterone or a combination of progesterone and oestrogen.

The hormones cause the body to sense that it is already pregnant, so no follicles mature and ovulation stops. One Pill needs to be taken at the same time every day. The Pill comes in a 28 day pack. Twenty one of the pills contain active hormones and 7 are placebos or inactive pills. Taking the placebos drops the hormonal level so the woman menstruates.

A disadvantage of the Pill is that if it is forgotten, hormone levels can drop and ovulation can take place. If a woman vomits or has diarrhoea, her illness can affect the effectiveness of the Pill. Certain drugs such as antibiotics can also affect the reliability of the Pill.

The Pill can be obtained free of charge from family planning clinics.

The Pill:
name given to the group of contraceptives that are taken in oral tablet form.

ACTIVITY 7

Write a mini-essay explaining how any three contraceptive methods affect human reproduction. You should also explain one way in which contraception can influence the quality of human life.

ANSWERS ON PAGE 127

COMMENT

Many different methods of contraception exist. They vary in their efficiency in preventing pregnancy. Many people believe that contraceptives will also keep them safe from sexually transmitted diseases. With the exception of the condom, contraception does not prevent disease.

Sexually Transmitted Diseases

Sexually Transmitted Diseases (STDs) are not new and have been in existence for centuries. In today's society, we are very aware of these diseases and we are able to control and prevent many of them.

STDs are **infectious diseases** which are transmitted from one person to another during **sexual contact**. The diseases are normally caused by **pathogens** or disease carrying organisms, such as a bacteria, viruses or fungi. STDs affect men and women regardless of age, colour or social position. Very alarmingly, STDs have become common amongst teenagers.

It is important to know how to protect yourself against STDs as they can become a very serious health problem if left untreated. Some STDs can, if left untreated, cause permanent damage to one's health, such as infertility or even death, as in the case of AIDS, which is the result of infection by HIV.

Ways of getting and transmitting STDs

It is a common misconception, or incorrect idea, that one must have sexual intercourse in order to become infected with STDs like herpes or genital warts.

Although these diseases are definitely transmitted through sexual contact, you will get these infections through simple contact with the infected area on someone's skin, who suffers from the disease. Some people say is that you cannot be infected through anal or oral sex. This is not true. The bacteria or viruses that cause these infections can enter one's body through tiny cuts or tears in the skin. In the case of HIV, the virus can enter through the soft linings of the mouth, vagina or anus.

Many people carry these infections without being aware of the fact themselves. This is dangerous because they are infectious to others people with whom they may have intimate contact.

Some behaviours can increase your chances of getting sexually transmitted infections:

- becoming sexually active at a young age increases the chances of becoming infected.
- having multiple sexual partners places you more at risk of infection than someone who has only one partner.

- having sex without proper protection. Condoms are the only form of protection that reduce the risk of acquiring an STD. Spermicides and birth control mechanisms may reduce the risk of pregnancy but they will not prevent STDs.

The saying 'prevention is better than cure' is very true of STD infection. The only sure way of preventing infection is sexual abstinence and avoiding sexual or intimate contact altogether. The most effective protection during sex, however, is still the use of a condom.

Responsible sexual behaviour is very important in limiting the spread of STDs. Monogamy , or having one faithful long-term sex partner, will decrease the incidence of STDs. If you allow someone else's blood to come into contact with your blood,as in the instances of shared needles, disreputable tattoo artists, accident scenes, rituals like circumcision and blood-brother rituals, you increase your chances of catching AIDS. These practices should therefore be avoided.

Perhaps the most significant of these measures is monogamy. Many people are prone to multiple sexual partners, which increases the chance of spreading these diseases. If one is going to adopt a lifestyle which does not embrace monogamy, then one has to behave responsibly and use condoms. Many people say 'It will never happen to me'. This is not a responsible or realistic way to approach a serious problem such as STDs.

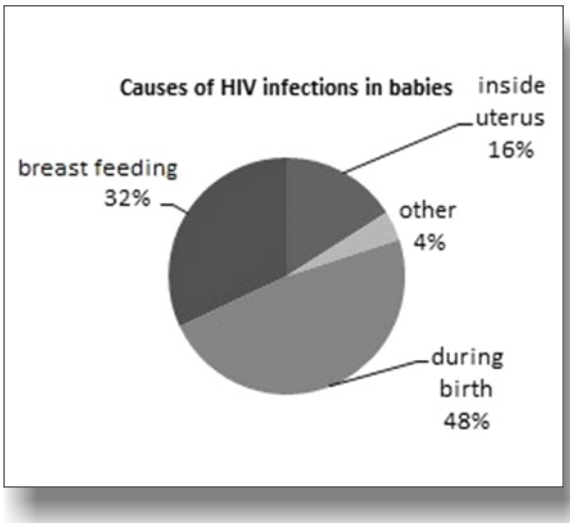
ACTIVITY 8

1. Examine the pie graph and answer the questions that follow from the graph and from your knowledge.

   a. Explain why babies are more likely to contract HIV during natural birth than when inside the uterus.

   b. The smallest slice on the pie chart is marked 'other 4%'. Explain what this means and give an example.

   c. If this graph shows causes of HIV infections in babies as a result of natural birth only, how do you think the pie graph would differ if it showed caesarean births only? Justify your answer.



2. Some sexually transmitted diseases are increasing worldwide.

   The table indicates the number of people infected with two common bacterial STDs.

Year	Number (per 100 000 people) infected with syphilis	Number (per 100 000 people) infected with gonorrhoea
1986	50	150
1990	150	280
1994	200	150
1998	220	100

   a. On the same system of axes, draw two line graphs to compare the number of people infected with syphilis and gonorrhoea from 1986 to 1998.

   b. Describe the trends shown in both graphs for **each** of the two diseases.

ANSWERS ON PAGE 129

CHECKLIST

Are you able to:

- ❒ identify the male and female reproductive organs and their functions
- ❒ describe the stages of the ovarian and menstrual cycles
- ❒ recognise and describe the actions of the hormones that control these cycles
- ❒ describe how fertilisation happens and explain the steps following fertilisation and leading to pregnancy
- ❒ describe the changes in the female body during pregnancy
- ❒ explain the stages of birth
- ❒ discuss ways STDs are transmitted

LESSON 5

Genetics and Inheritance

About this lesson

In this lesson we will deal with cells, their cell cycle, cell division, mitosis and meiosis and we will compare the two. We will also learn about the structure of DNA, **chromosomes** and **nucleic acids**. You will also learn about a process that is called **protein synthesis** which is strictly controlled by your DNA.

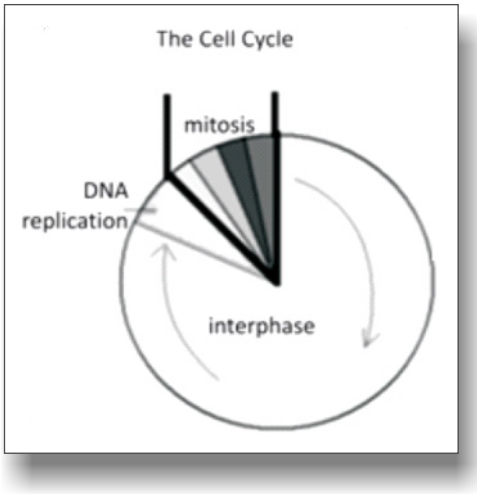
Further, you will be introduced to genetics and inheritance and genetic disorders.

In this lesson you will:

- identify the different stages of mitosis and recognise the need for mitosis
- identify the stages of meiosis and recognise the need for meiosis
- compare mitosis and meiosis
- investigate the structure of DNA
- describe the process by which a DNA molecule replicates
- describe the relationship between DNA, RNA and proteins
- explain the processes of transcription and translation
- define terminology associated with genetics and inheritance and find out how the basic principles of inheritance were discovered
- solve genetics problems involving simple inheritance of a single trait
- read about some genetic disorders that are the result of mutations and chromosomal abnormalities

Cell division

Cells do not live forever. They go through a 'life cycle' called the **cell cycle**. Cells spend 90% of their life span growing and performing their normal metabolic functions.

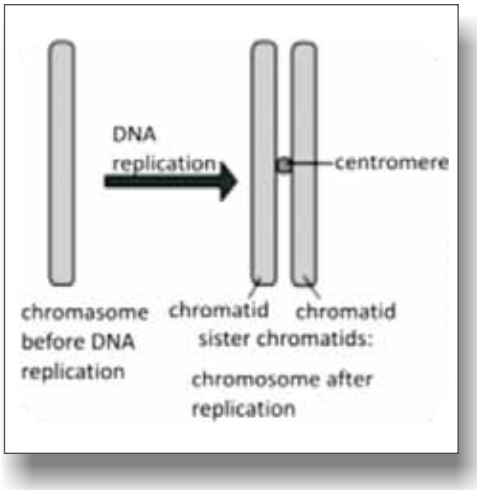


DNA replication takes place during interphase

The DNA in cells is decoded to make proteins. The proteins do what they are meant to do it's business as usual in cells for most of their life span. This is called the interphase part of the cell cycle. The cell's life cycle is divided into two main phases, the interphase and cell division or mitosis. Mitosis, or normal cell division, will only take up 10% of the cell cycle.

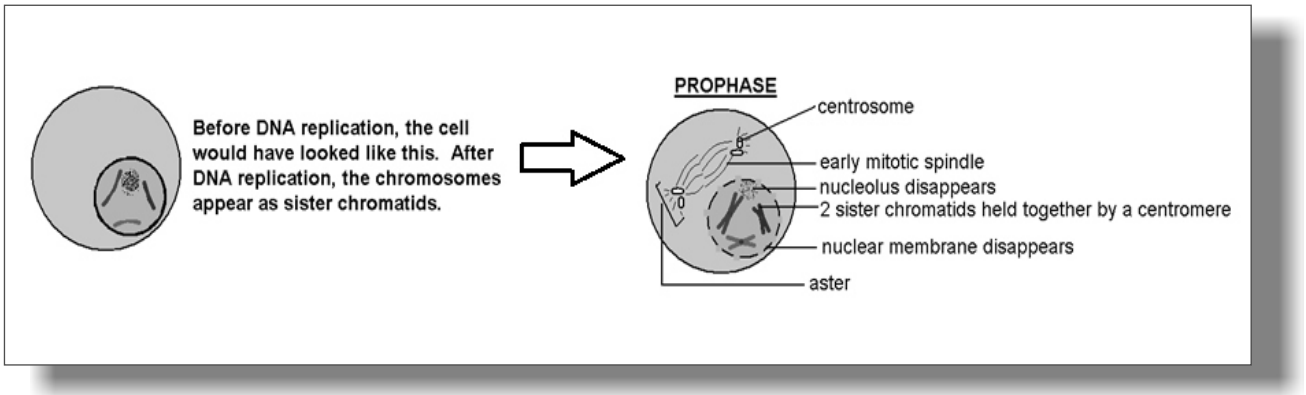
Our bodies produce billions of new cells all the time. Some very specialised cells, such as nerve cells, never divide. They remain in interphase. Other cells will divide. Only somatic cells or normal body cells undergo meiosis. Meiosis is also known as reduction division. It is a specialised form of cell division that produces gametes or sex cells.

Mitosis

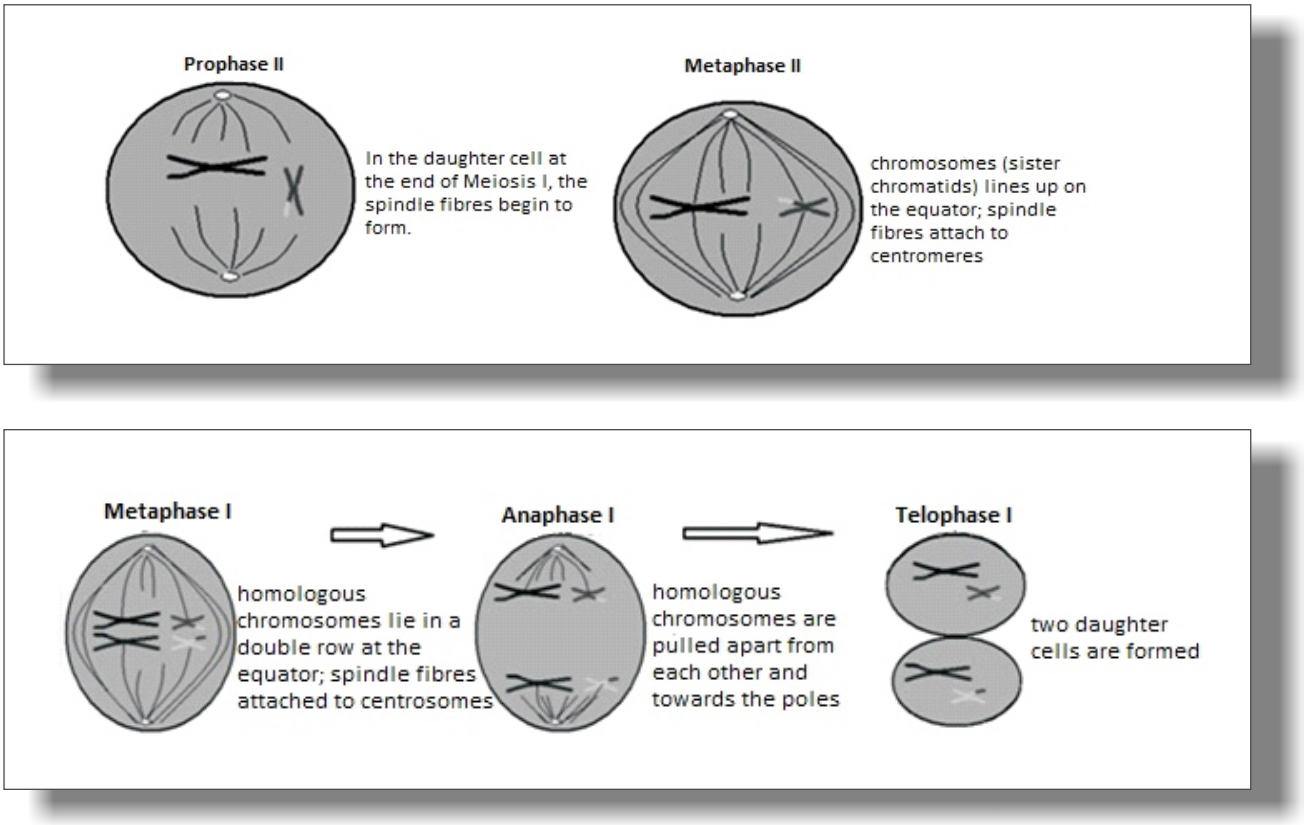


Mitosis is cell division of somatic or body cells. Why does mitosis or cell division need to take place? Mitosis occurs so that **growth** and **replacement** of damaged or old cells can take place.

At the end of mitosis, **two identical daughter cells** are produced. The cells are identical to each other and are also identical to the original parent cell. If these new cells are going to be identical to the original cell, then they need a copy of everything that was in the original cell. That means they need a copy of the complete complement of DNA. The DNA needs to copy itself before the cell divides by mitosis. You will learn about this process called **DNA replication** later in this lesson.



The following set of diagrams summarises the process of mitosis.



Sister chromatids, although they appear as two strands, are still one chromosome.

ACTIVITY 1

1. A cell from the body of an animal has 28 chromosomes. If the cell divides by mitosis:

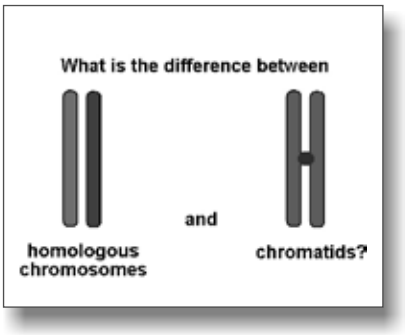
   a. How many new cells will be produced?

   b. How many chromatids would be found in the cell just as it starts to divide?

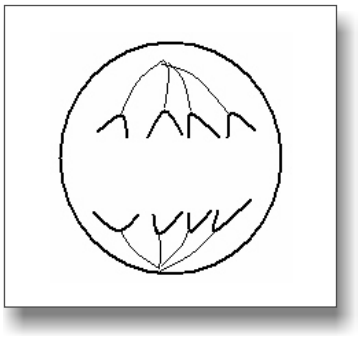
   c. How many chromosomes will be in each daughter cell?

   d. Will the daughter cells be the same or different to the original cell?

   e. Will the daughter cells be the same or different to each other?



2. The diagram alongside shows a cell undergoing mitosis.



a. How many chromosomes are shown in the diagram?

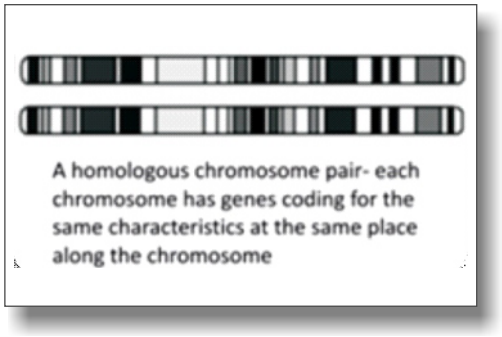
b. How many chromosomes would be found in the daughter cells at the end of mitosis of the cell?

c. Describe the appearance/characteristics of the daughter cells formed at the end of mitosis of the cell.

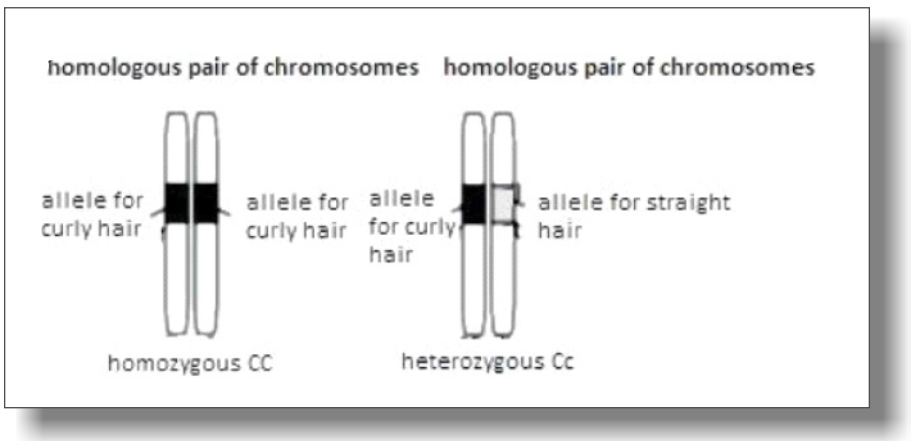
d. Explain **two** ways in which mitosis is biologically significant.

ANSWERS ON PAGE 129

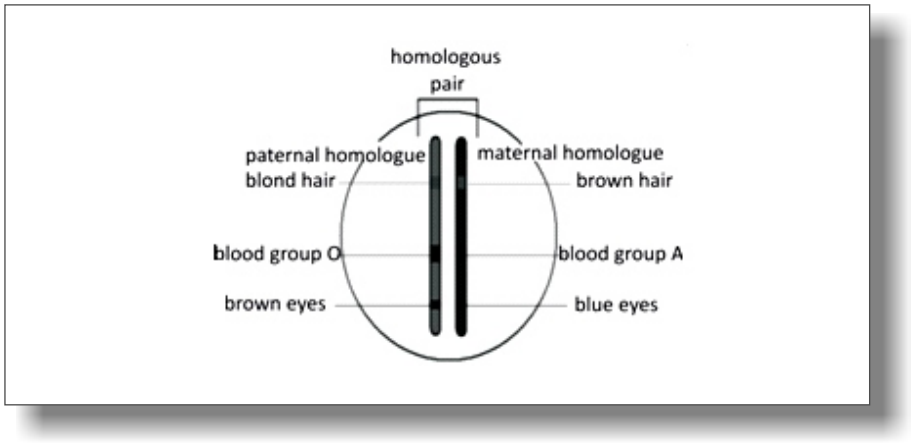
Meiosis



Meiosis is also called **reduction division**. The number of chromosomes in somatic cells is known as the **diploid** chromosome number (**2n**). This is because there are **two sets** of chromosomes in each somatic cell. In humans, there are **23 pairs of chromosomes**. A pair of chromosomes in a set will have genes coding for the same characteristics on them. Therefore, these chromosomes are called **homologous chromosomes**. One of the homologous chromosomes in the pair originally came from the father of the individual and is called the paternal homologue and the other homologous chromosome came from the mother of the individual and is called the maternal homologue. An individual therefore possesses characteristics inherited from both parents.



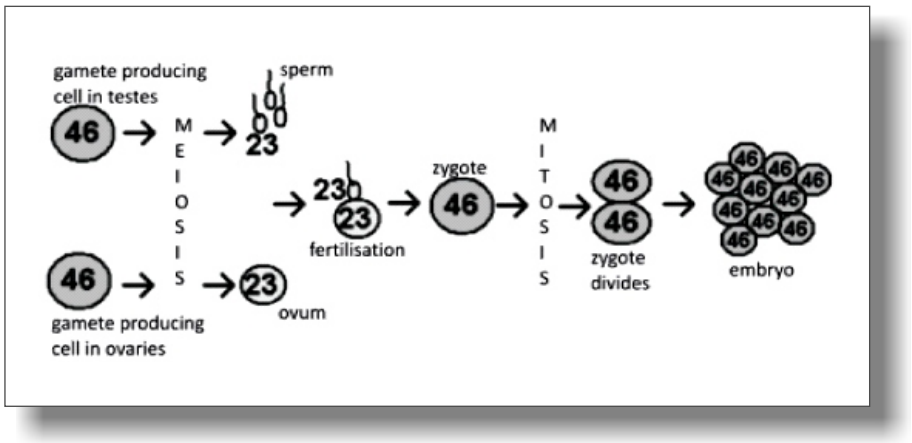
In the reproductive organs, specific tissues undergo a very special form of cell division called **meiosis** which halves the chromosome number. The resulting **gametes** or sex cells end up with only one set of chromosomes, not a homologous pair. A gamete is therefore not diploid (2n) but **haploid (n)**.



Meiosis is the cell division process that reduces the number of chromosomes from their diploid number to their haploid number. The gametes that are produced are haploid, which means they are non-identical to each other or the parent cell.

This means that there are two **purposes** or aims of meiosis: to **reduce the number of chromosomes** from 2n to n and to introduce **genetic variation**, so that the offspring will have inherited parental characteristics, but **not** be clones or exact copies of the parent.

Why must gametes be haploid? Think of what you learnt about reproduction in Lesson 4.

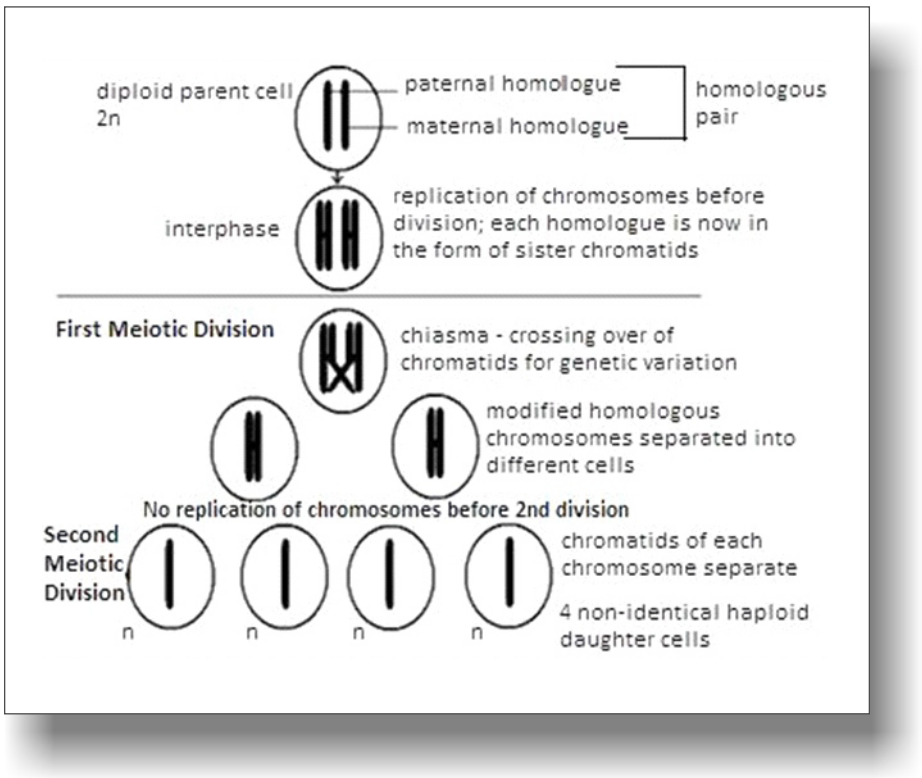


Haploid gametes are necessary so that when the two gametes, the egg and sperm, join together at fertilisation, the resulting cell called a **zygote** will be diploid again, with two sets of chromosomes, one from the egg, the mother's chromosomes, and one from the sperm, the father's chromosomes. The zygote will therefore have homologous chromosomes.

Remember that although we are referring here to sperm and eggs, meiosis occurs in **all** organisms that undergo sexual reproduction, including plants.

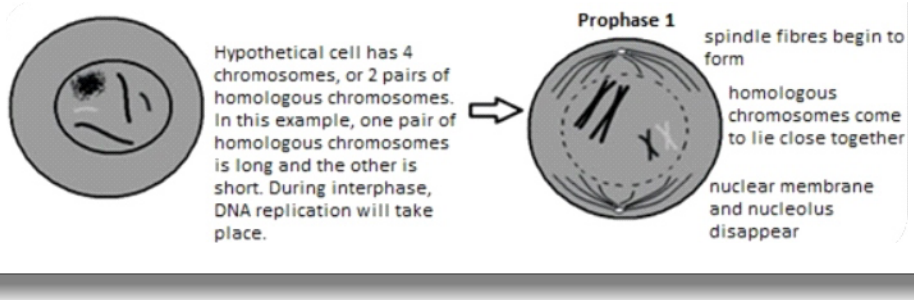
The scheme shown below summarises the two main purposes of meiosis and how they take place.

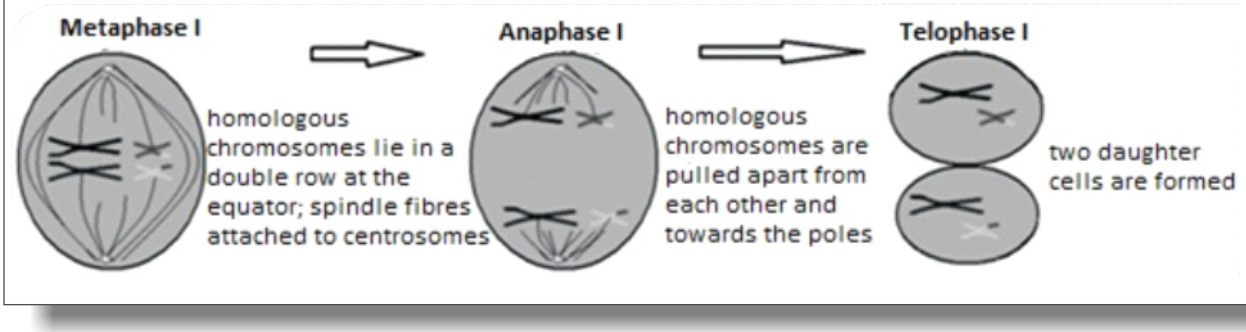
Although the drawing presents a hypothetical cell which only has two chromosomes, the principle is the same in a human cell that starts off meiosis with 46 chromosomes.

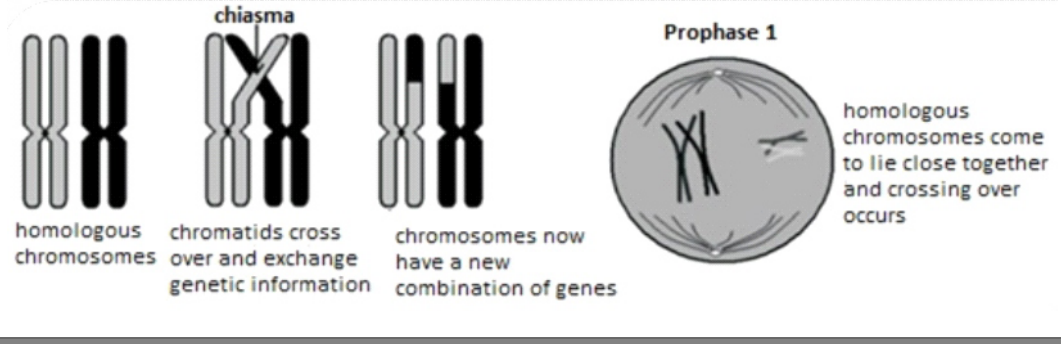


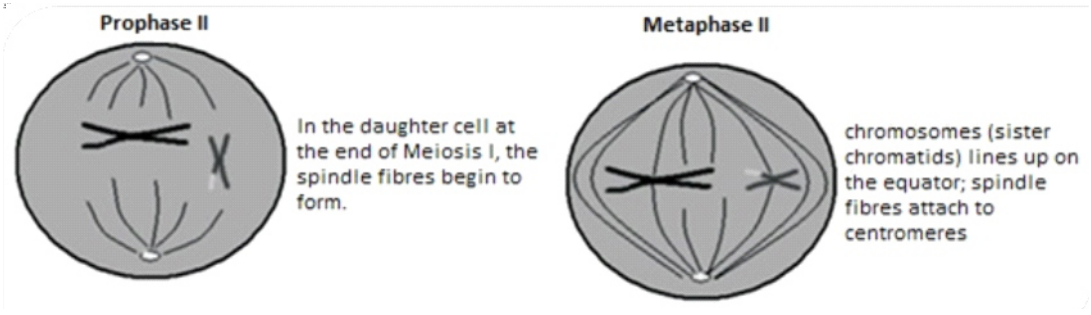
Starting with a diploid, or 2n, parent cell with homologous chromosomes, the cell undergoes DNA replication, as it would have just before mitosis. Each homologous chromosome is then in the form of two sister chromatids.

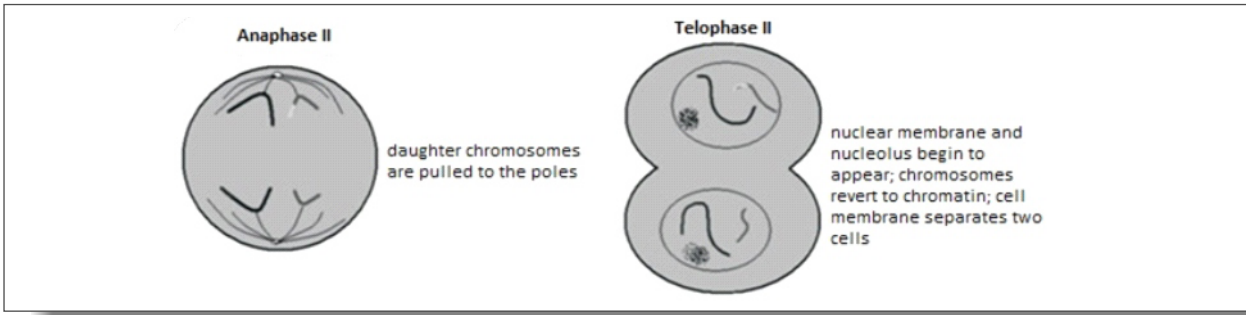
You will see from this scheme that meiosis has two divisions, not one as in mitosis. You can see that there is a process which takes place during the first meiotic division that **recombines** the genetic material on the homologous chromosomes. This is a vitally important process for introducing genetic variation. You will also see from the summary diagram that there is no DNA replication before the second meiotic division. By the end of the second meiotic division, each daughter cell has half the number of chromosomes that the original parent cell had. We say that each cell is haploid. It is a gamete, ready for fertilisation during sexual reproduction. Also, the DNA in the daughter cells is non-identical.

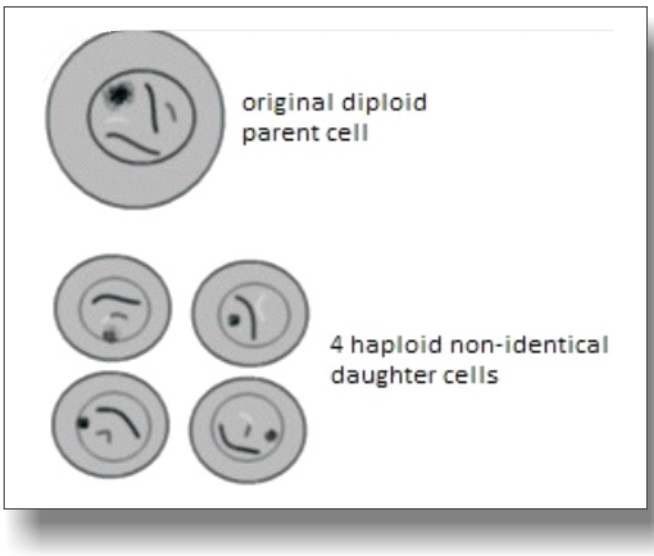

Hypothetical cell has 4 chromosomes, or 2 pairs of homologous chromosomes. In this example, one pair of homologous chromosomes is long and the other is short. During interphase, DNA replication will take place.
Prophase 1
spindle fibres begin to form
homologous chromosomes come to lie close together
nuclear membrane and nucleolus disappear


Metaphase I
homologous chromosomes lie in a double row at the equator; spindle fibres attached to centrosomes
Anaphase I
homologous chromosomes are pulled apart from each other and towards the poles
Telophase I
two daughter cells are formed


chiasma
homologous chromosomes
chromatids cross over and exchange genetic information
chromosomes now have a new combination of genes
Prophase 1
homologous chromosomes come to lie close together and crossing over occurs


Prophase II
In the daughter cell at the end of Meiosis I, the spindle fibres begin to form.
Metaphase II
chromosomes (sister chromatids) lines up on the equator; spindle fibres attach to centromeres


Anaphase II
daughter chromosomes are pulled to the poles
Telophase II
nuclear membrane and nucleolus begin to appear; chromosomes revert to chromatin; cell membrane separates two cells



What did we start off with and what are we ending with?

We began with a diploid parent cell. In our hypothetical example, the diploid parent cell had 4 chromosomes. At the end of meiosis, there are four daughter cells. Each cell is haploid – it has only two chromosomes, half the number in the original cell. Also, very importantly, the chromosomes no longer resemble the chromosomes in the parent cell. This is because variation has been achieved through crossing over.

Comparing meiosis I and meiosis II

Meiosis I	Meiosis II
DNA replication takes place before division.	No replication of DNA before division
Prophase is complete.	Prophase is very short or not at all.
Chromosomes in homologous pairs.	No homologous pairs.
Crossing over of chromatids.	No crossing over of chromatids.
In the metaphase, homologous chromosomes in a double row on either side of the equator	In metaphase, single row of chromosomes along the equator
In anaphase, homologous pairs separate; centromeres.	In anaphase, centromeres divide separating chromatids.
Random assortment of homologues moving to poles.	No random assortment.
Two cells are the result.	Four cells are the result.

ACTIVITY 2

1. The diagram represents a process taking place during meiosis.

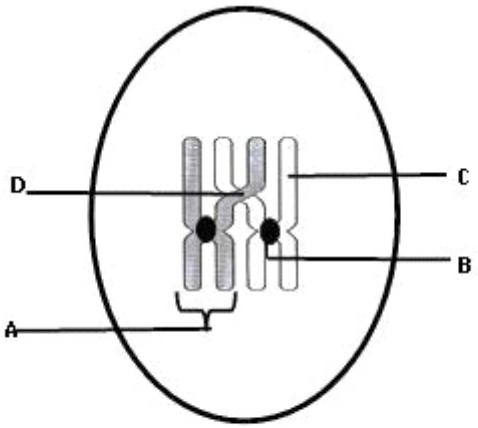


Diagram representing a process taking place during meiosis

a. Provide labels for parts A, B, C and D

b. Name the process in meiosis that is illustrated in the diagram.

c. State one importance of this process.

d. During which phase of meiosis does this process take place?

e. Draw a diagram of the structure labelled A as it would appear immediately after the process illustrated in the diagram.

ANSWERS ON PAGE 130

ACTIVITY 3

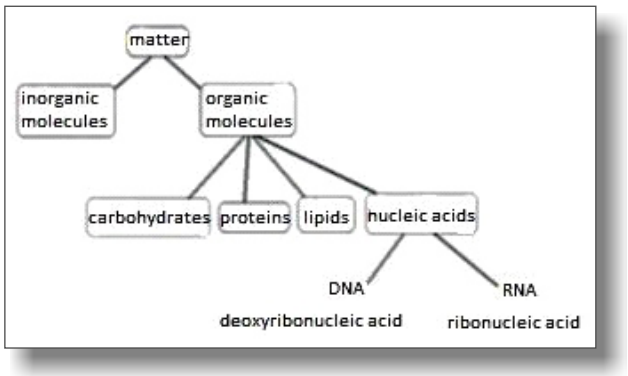
Draw up a table in which you compare mitosis and meiosis.

ANSWERS ON PAGE 131

COMMENT

Meiosis, a cell division process, is vital for growth and replacement of worn or damaged cells and is essential for the production of haploid gametes. Meiosis also brings about genetic variation in individuals.

DNA

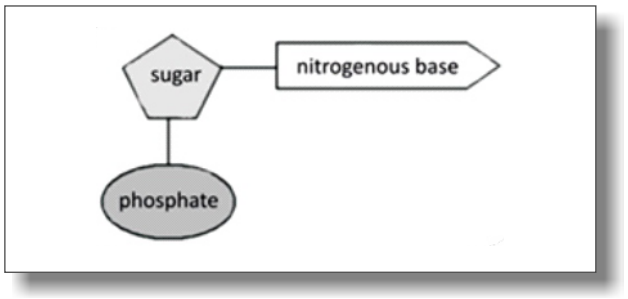


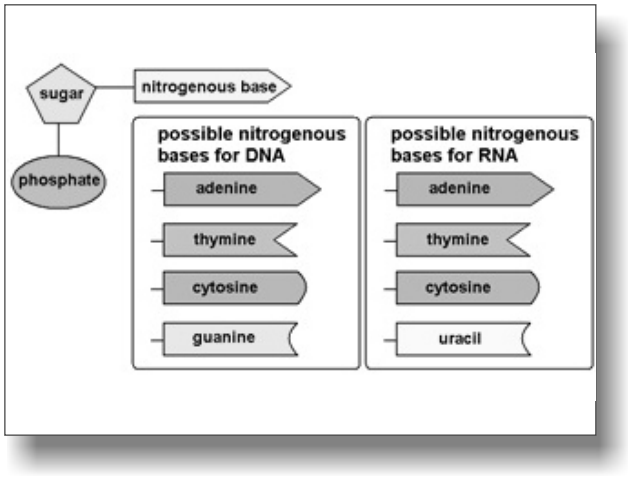
The DNA in the nucleus makes up the **chromosomes**. It not only controls all the metabolic functions in a cell, but also ensures that new cells and offspring inherit copies of this information. You have learnt about the different kinds of molecules that make up living organisms. **Nucleic acids** are organic molecules. DNA and RNA are examples of nucleic acids.

Think of the DNA as a reference book in a library. You cannot take the reference book out of the library as someone else might want to use it. If you needed certain parts of the book you could copy pages of it. The DNA, like the reference book can be copied but cannot be removed from the nucleus.

DNA is a nucleic acid

DNA is an organic molecule that is found in every living cell. It is a macromolecule – which means that it is an extremely large molecule made up of smaller building blocks. Most large organic molecules are called polymers and they are made up of smaller building blocks called monomers. Nucleic acids are no exception. In the case of nucleic acids, the monomer is called a **nucleotide**.

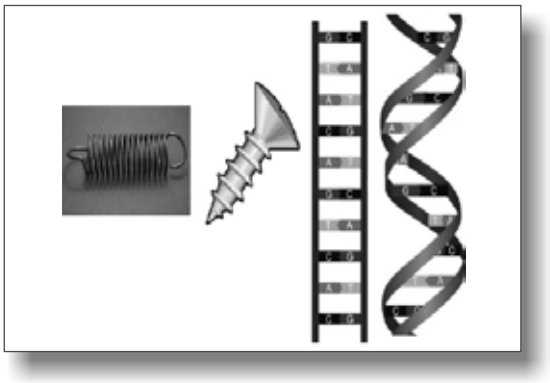




A nucleotide is a 'packet' of 3 molecules bonded or joined together in a very specific way: there is always a five-carbon, or pentose, **sugar** molecule. The sugar in DNA is **deoxyribose** (hence **deoxyribo**nucleic acid). The sugar is bonded to a **phosphate** molecule and is also bonded to a **nitrogenous base**. The nitrogenous **base** is so-called because it behaves as a chemical base and not as an acid.

In nucleotides forming DNA, the sugar (deoxyribose) and phosphate that make up the nucleic acid are the same. It is the nitrogenous bases that differ. There are four possible nitrogenous bases in DNA: adenine, guanine, cytosine and thymine. Therefore, there are four possible nucleotide monomers that could make up DNA molecules.

It is the order in which the individual nucleotides are bonded that make up the coded information on the DNA. Just like the order of letters in a word determines its meaning, so the order of the nucleotides along a chain of DNA makes up the coded message.

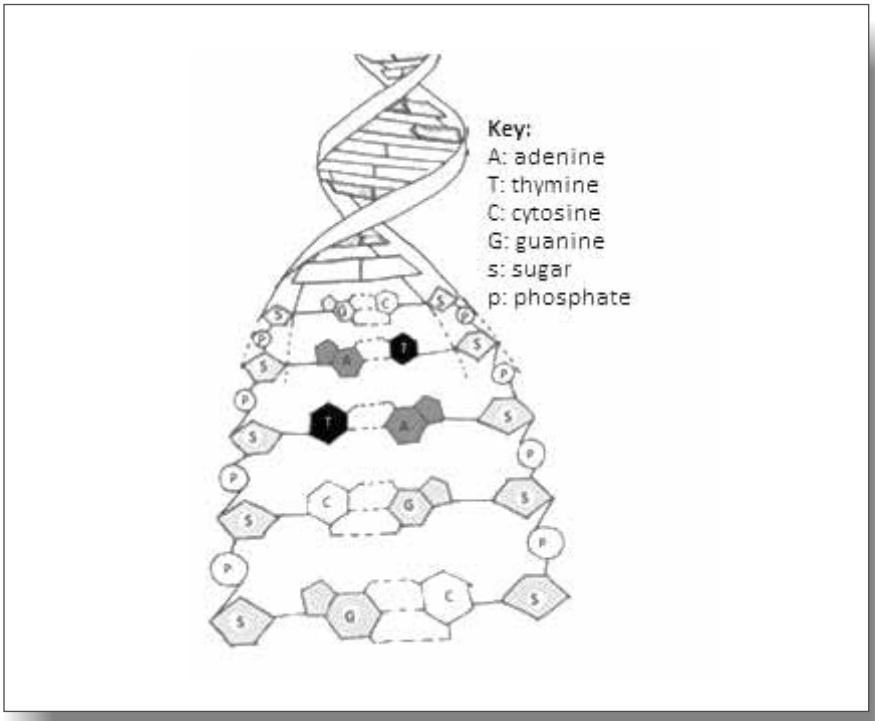


DNA is a double strand of bonded nucleotides. The two parallel strands of nucleotides form a ladder-like structure which is then twisted into a spiral shape to form what is called a **double helix**.

If you twisted a ladder, it would become a helix. A helix is a three dimensional, twisted structure. A spring and a screw-thread are helical structures.

You can see that the sugar-phosphate-sugar-phosphate chain runs up the edges of the molecule on what we call the double 'backbone' of the molecule. The nitrogenous bases from either backbone reach across like the rungs of a ladder. The nitrogenous bases of the nucleotides opposite each other are bonded together by weak hydrogen bonds. You can see these as dotted lines in the diagram. Can you spot a pattern with the nitrogenous bases that are bonded to each other?

Guanine is always bonded to cytosine. Adenine is always bonded to thymine. The nitrogenous bases said to bond in a **complementary** manner. We call the bonding as it appears in DNA 'complementary base pairing'.

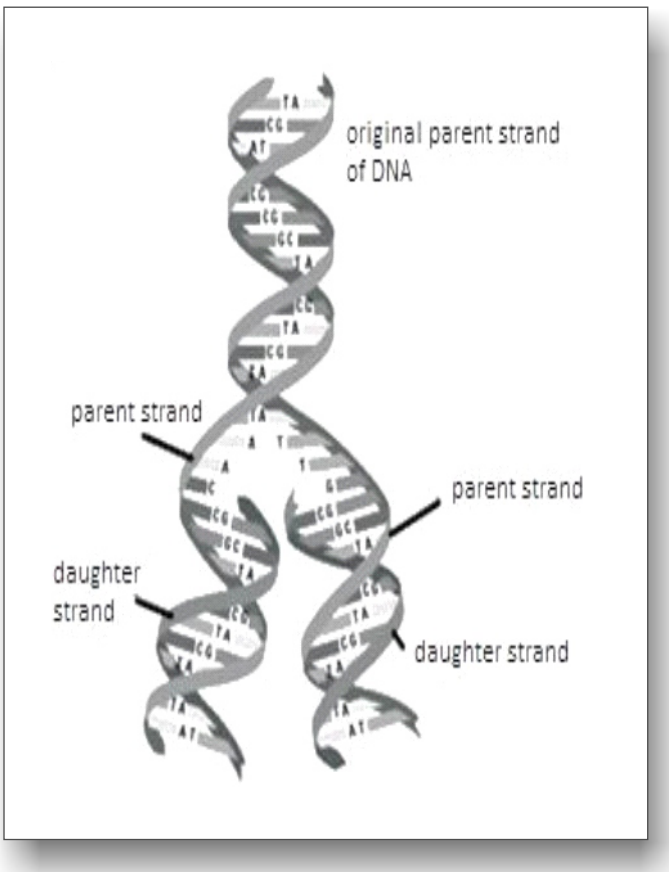


DNA replication

How long does the DNA replication process take? The process of DNA replication is incredibly fast. It is amazing that a chromosome of 250 million base pairs can be replicated in several hours. The speed of DNA replication for humans is about 50 nucleotides per second. The human genome, all the DNA in one cell, can be copied in a few hours.

You learnt that cells divide by a process called **mitosis**. Mitosis produces two cells which are identical to each other and to the original parent cell. If these new cells are going to be identical to the original cell, then they need a copy of everything that was in the original cell. That means they need a copy of the complete set of DNA. The DNA needs to copy itself before the cell divides by mitosis. When the DNA makes a copy of itself, the process is called **DNA replication**. The word 'replication' means that the copying process is strict and an identical replica or copy of the original is made.

The cell has to undergo DNA replication **before** it undergoes mitosis. DNA replication is not a part of mitosis. It happens during interphase, before mitosis begins. It is a very necessary process because before a cell divides, it must make a copy of all the DNA so that each daughter cell has a full set of DNA.



The first thing to happen in DNA replication is that an enzyme causes the DNA double helix to unwind. This enzyme is called gyrase. Gyrase starts at one end of the DNA double helix and starts to work up the strand. It does not unwind the entire strand, but simply unwinds the section of the strand ahead of the rest of the DNA replication process.

Once the DNA has been unwound, another enzyme called helicase breaks the weak hydrogen bonds holding the base pairs together. This action “unzips” the DNA double strand exposing the bases.

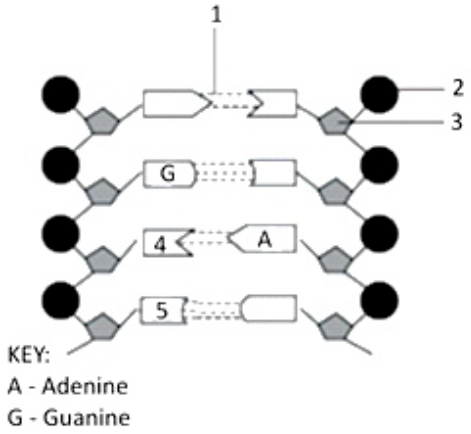
Each single strand of DNA now acts as a template or a precise guide to be copied.

Free nucleotides in the nucleus pair up with complementary exposed bases on the template. New hydrogen bonds are formed between the base pairs. A family of enzymes controls this stage of the process. These enzymes are called DNA polymerases. Because of the strict complementary base pairing rules, there is little chance for errors, although they sometimes do occur. One of the DNA polymerase enzymes runs up the newly formed chain checking for errors, like a proofreader, and correcting any that may have been made. In this way a precise copy of each strand of DNA is made. Any pieces of DNA that need to be joined together are joined by enzymes called ligases.

Finally, each new strand rewinds into a double helix. The two new strands are identical to each other and to the original strand. The original DNA has replicated. Each chromosome in the nucleus now has a copy of itself.

ACTIVITY 4

1. The diagram shown here represents part of a molecule.



   a. Identify the molecule

   b. Label the parts 1 – 5

   c. What is the collective name for parts 2, 3 and 4?

   d. What is the significance of this molecule in the cell?

   e. If one strand of a DNA molecule reads

      A T G T A C C T A G

      what will the complementary strand read?

f. Which statement about DNA is **false**?

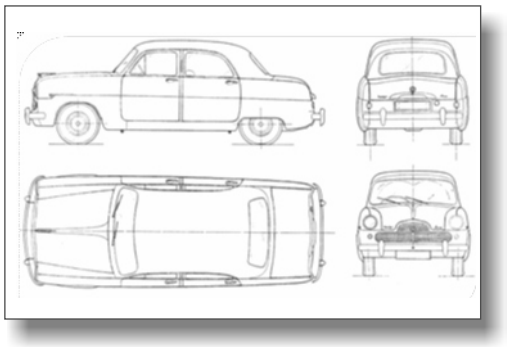
i. The DNA molecule is made up of two strands of nucleotides twisted into a double helix.

ii. The nucleotides in the double strand of DNA are bonded together by weak nitrogen bonds.

iii. Nitrogenous bases are complementary: adenine will always bond with thymine and cytosine with guanine.

iv. The DNA molecule has two sugar-phosphate backbones to which the nitrogenous bases are bonded.

ANSWERS ON PAGE 131

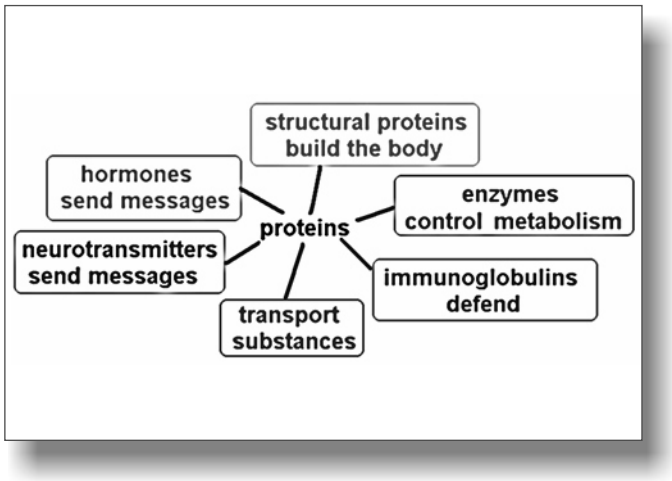


DNA is often described as the 'blueprint' molecule. This means that it contains all the information for the building and functioning of a living organism, just like blueprints are the designer's instructions for the building of a car.

COMMENT

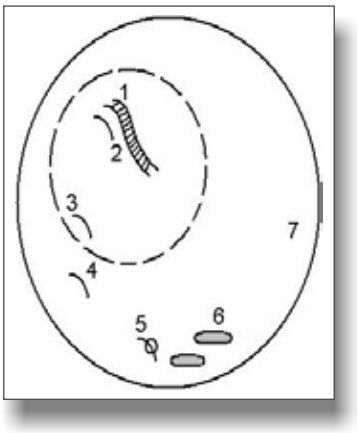
Genes are stretches of DNA that code for the making of proteins. In this way, the DNA is the blueprint for your body.

Protein synthesis



You learnt about proteins in Lesson 1. You have seen how they are important organic molecules with a range of vital functions. The protein contained in foods you eat is digested into its monomers, amino acids. The amino acids are absorbed into your blood and transported to your cells. In your cells, these amino acids are used to build up the various proteins your body needs. The process is called protein synthesis and it is strictly controlled by your DNA.

An overview of how DNA and RNA work together to make proteins



The diagram summarises how DNA and RNA function. At Point 1 you see the DNA which makes up the chromosome, which carries many genes. Each gene carries the information to make one protein. Let's say that one protein in particular is needed in the cell. At Point 2, you can see that the one gene which codes for that protein is copied by RNA. Points 3 and 4 show the copied gene, in the form of RNA, moving out of the nucleus and into the cytoplasm. Point 5 shows the RNA and a ribosome together making a protein. Point 6 shows the finished protein which can then be stored, or used by the cell immediately – Point 7.

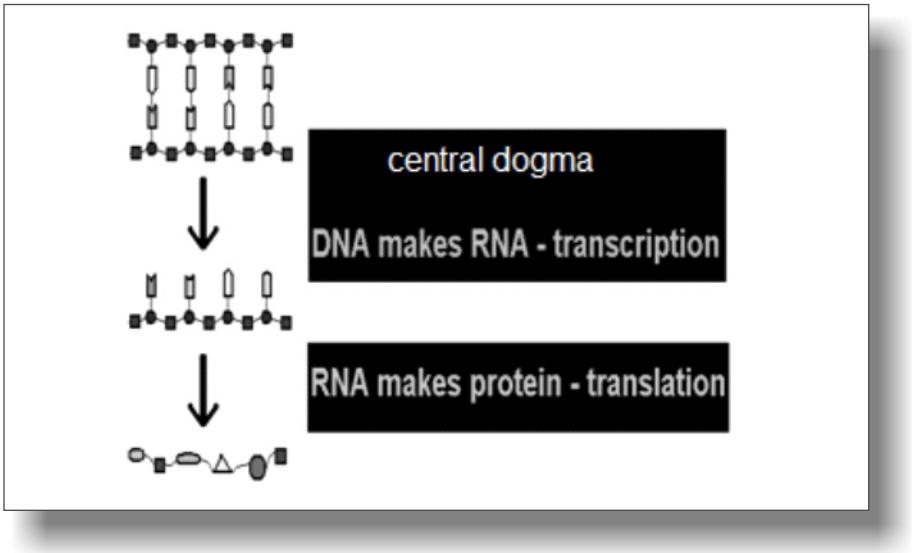
The Central Dogma

dogma:
a law or principles that are factual and true

In science, there exists a **dogma** that is central to all life on earth. This law is known as the **central dogma**. The central dogma states:

DNA makes RNA
and
RNA makes protein

When DNA makes mRNA, we call the process **transcription**. When the RNA makes protein, the process is called **translation**. You will learn about both of these processes.



Transcription

transcription:
to 'write over' or to copy something.

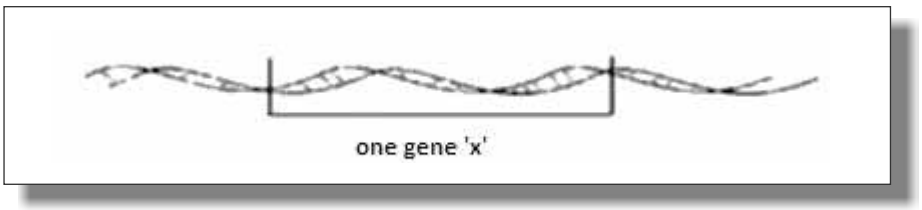
In mediaeval times, a **scribe** used to copy important documents. It was essential that the scribe copied the original precisely and did not make mistakes.

Transcription implies an exact and accurate process which produces a copy of the original. In protein synthesis, the code for the making of the protein must be copied precisely and accurately. Can you think why this must be so?

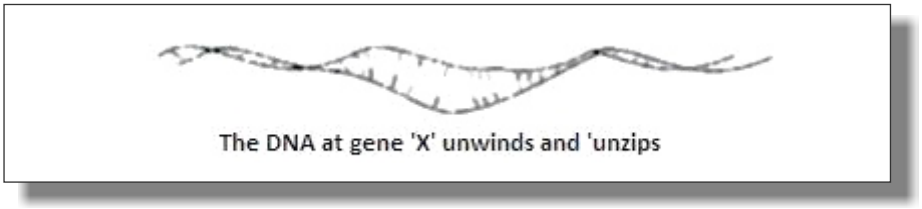
The transcription process involves copying the nucleic acid code, that is the order of nucleotides making up the gene. The copy is made in the form of RNA. As you will soon see, there are different types of RNA. The RNA which copies the nucleic acid code from the DNA is called **messenger RNA** or **mRNA**. It is called this because mRNA carries the encoded message from the DNA, out of the nucleus, to the ribosomes in the cytoplasm, where the next stage of protein synthesis, translation, takes place.

A gene is a specified length of DNA which occupies a specific place on a specific chromosome.

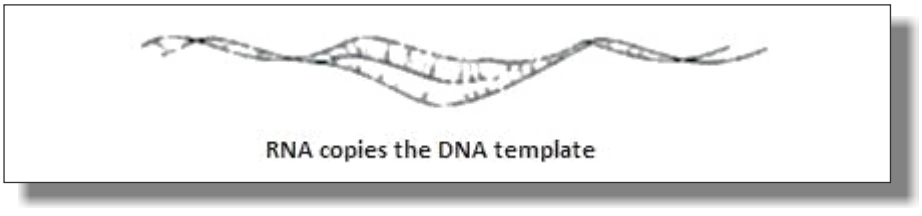
Transcription takes place in the nucleus. Each chromosome has many genes on it. Each gene codes for one protein. RNA copies just the section of DNA coding for one protein. Let's imagine that on a long chromosome, gene X needs to be copied.



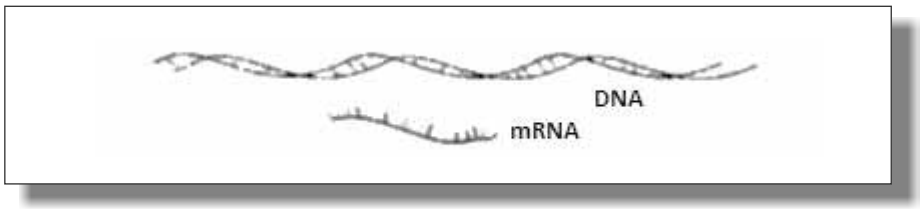
The small piece of DNA, which is one gene, unwinds and 'unzips' and enzymes break the hydrogen bonds between nucleotides. This means that a short portion of the chromosome has exposed nitrogenous bases.



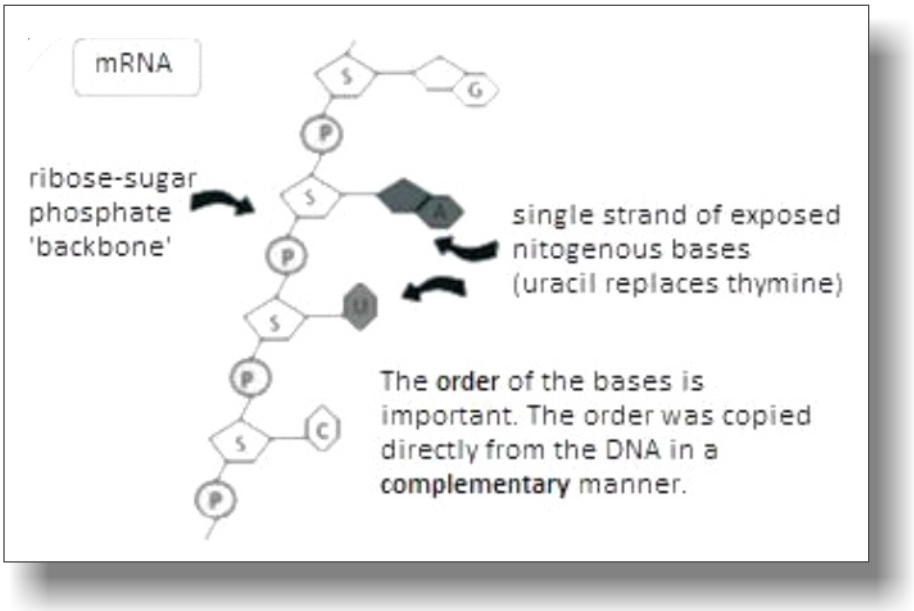
RNA nucleotides use the exposed bases as a template to copy the strand of DNA in a complementary manner.



Once the gene has been copied, the RNA breaks away from the DNA. This is accomplished by enzymes breaking the temporary hydrogen bonds that were made between DNA and RNA nitrogenous bases. The RNA will move away and the DNA structure is re-established. Hydrogen bonds are remade to form a DNA double strand and the double helix winds up. The RNA that has been formed is a copy of the gene. It is called **messenger RNA** or **mRNA**.



Let's have a closer look at the mRNA molecule. mRNA has a sugar-phosphate 'backbone', to which the nitrogenous bases are bonded. In RNA, the nitrogenous base uracil replaces thymine. The order of the bases along the single strand of RNA is important. The order of the bases will determine the order of amino acids in the final protein. The order was copied directly from the DNA molecule in a complementary manner.



ACTIVITY 5

How much have you remembered about this process?

1. During transcription, does the whole DNA molecule unwind?

2. Why must the hydrogen bonds between complementary nucleotides on the DNA be broken?

3. What controls each step in transcription?

4. Why is the RNA called 'messenger RNA'?

5. What happens to the DNA after transcription?

ANSWERS ON PAGE 131

6. Why is this process called 'transcription'?

Translation

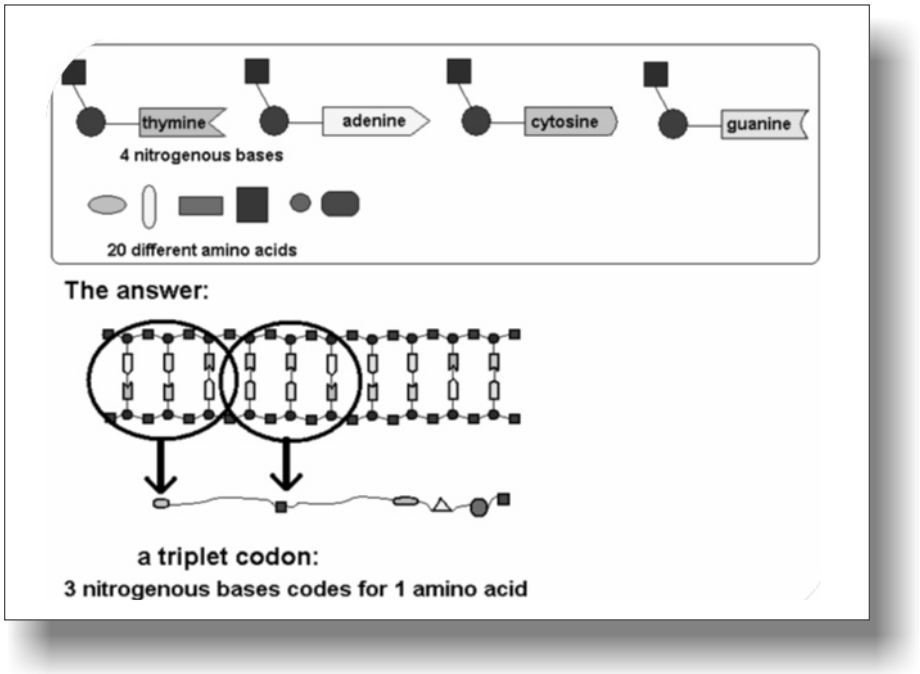
translation:
to change something from one form to another

You are probably familiar with translation as we use it in languages. The translation of 'Where do you live?' from English into isiZulu is 'Uhlalaphi'. When translating you change the form of the language from English to isiZulu.

In protein synthesis, translation refers to the changing of the **nucleic acid code** into **protein code**. Remember that in transcription, the nucleic acid code was copied from the DNA to the mRNA. Now the nucleic acid code must be converted into the protein code, which is a chain of amino acids in a particular order.

You have already learned that one gene codes for the making of one protein. You also know that the order or sequence of nucleotides along the DNA is very important. Basically, you have different combinations of the four possible nucleotides which have to be translated into the string of amino acids. But here is a problem. There are 20 possible amino acids. Clearly one nucleotide cannot code for one amino acid as there are only 4 different nucleotides. So how does the code work?

After experimentation, scientists showed that a sequence of three nitrogenous bases codes for one amino acid. Each set of three nitrogenous bases on the DNA that represents an amino acid is called a codon. This genetic code is universal – the codons represent the same amino acids in all organisms.

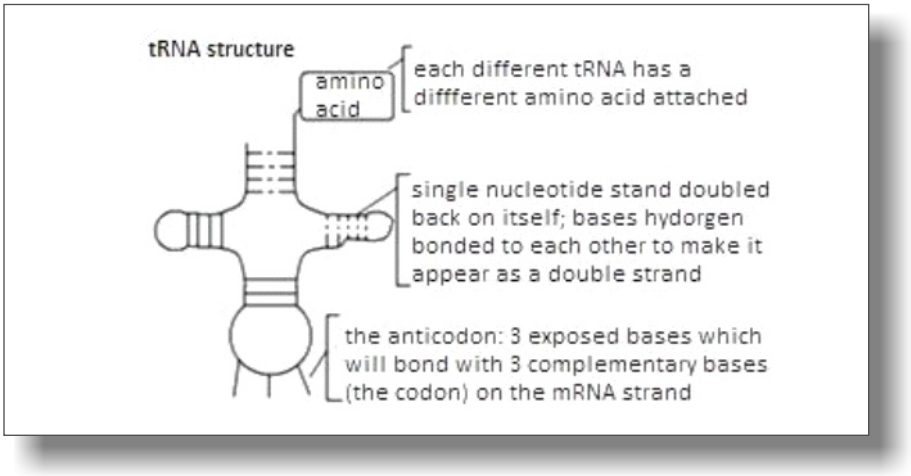


Not only are there triplet codons to represent all 20 amino acids, but there are also instructional codons that tell the RNA to start reading a gene and to stop at the end of the gene!

So, for example, a triplet codon on the DNA of TCA, or, thymine, cytosine, alanine, will code for the amino acid serine. The DNA triplet codon CAG, or, cytosine, alanine, guanine, will code for the amino acid glutamine. And so on. The start codon on DNA reads ATG while one of the stop codons is TAA.

Translation takes place in the cytoplasm and involves the **mRNA, ribosomes and tRNA**.

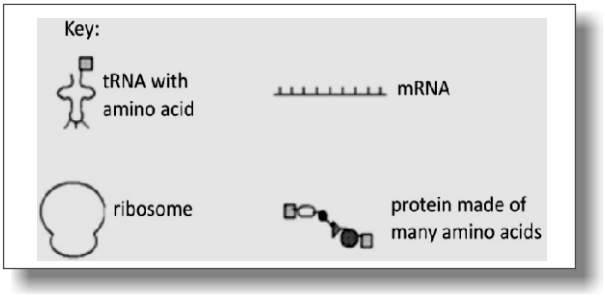
Ribosomes are extremely small organelles which, unlike other organelles in the cell, do not have membranes around them. They are made up of two little subunits that fit together.

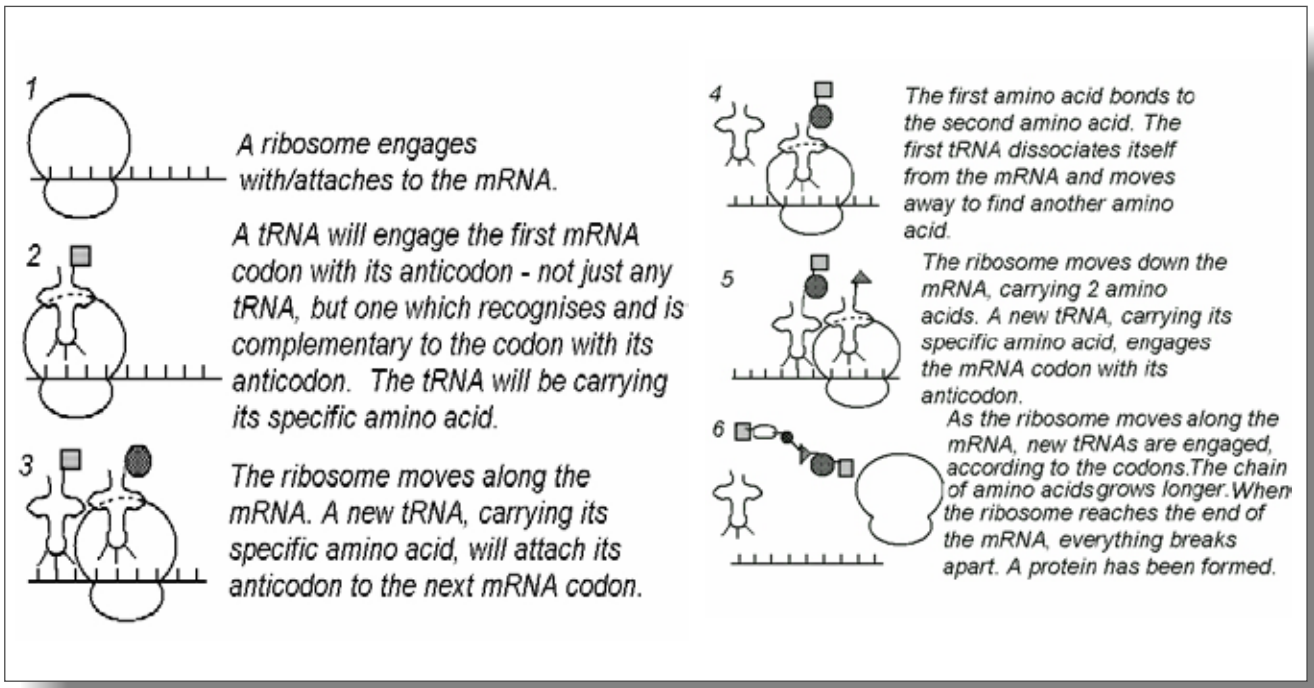


Transfer RNA is also a single nucleotide strand, but it is doubled back on itself so it appears to be a double strand in a clover leaf shape. The bases are hydrogen bonded to each other to make it appear as a double strand in places.

Each different tRNA has a specific **amino acid** attached to it. Each tRNA has three exposed or unbonded bases, called the **anticodon**. The anticodon will bond with three complementary bases, or the **codon**, on the mRNA strand. The anticodon of the tRNA will dictate which amino acid is attached to it.

The set of diagrams on the next page explains the process of translation, with annotations. A key here shows what the different parts of the diagrams mean.





A ribosome will attach itself to the start of the strand of mRNA. The ribosome will engage over a three base codon on the mRNA. A tRNA, which is present in the cytoplasm, will engage the first mRNA codon with its anticodon. It won't be just any tRNA – it will be a tRNA that is complementary to the mRNA codon with its anticodon. If the mRNA codon reads CUA, then the anticodon of the tRNA must read GAU. And of course, the tRNA with the GAU anticodon will be carrying its own very specific amino acid. GAU happens to code for the amino acid leucine. After the first tRNA has engaged with the mRNA, the ribosome will slide along the mRNA. A new codon will be exposed. A tRNA with an anticodon that is specific to the exposed mRNA codon, will engage with the mRNA. This new tRNA will be carrying its own specific amino acid.

At this point, the amino acid from the first tRNA detaches itself from its tRNA and attaches itself to the amino acid on the next tRNA. The first tRNA will dissociate itself from the mRNA and float off into the cytoplasm to find another amino acid.

In the meantime, the ribosome moves down the mRNA once again. A new codon on the mRNA is exposed and a new tRNA which is carrying its specific amino acid, will engage its anticodon with the mRNA codon. The two amino acids from the previous tRNA will attach themselves to the new amino acid, creating a chain of three amino acids.

You can see how this process will continue along the whole length of the mRNA. New tRNAs are engaged according to the codons. The chain of amino acids will grow as the ribosome decodes the whole length of the mRNA.

When the ribosome finally reaches the end of the mRNA, it will detach itself. The chain of amino acids will also detach itself from the final tRNA. A protein has been formed! The order of the amino acids determines the type of protein. And remember that the order of the amino acids was determined by the order of codons.

What happens at the end of this process?

- The protein will move off into the cytoplasm to be used or it will be stored in the endoplasmic reticulum.
- The tRNAs will pick up new amino acids and carry them to other ribosomes that are busy decoding mRNA.
- The ribosomes will decode thousands of stretches of mRNA in their lifetime before they are worn out.
- The mRNA can be read many times to produce many copies of the same protein, before it too is worn out.

ACTIVITY 6

1. Describe each of the following:

   a. Transcription
   b. Translation

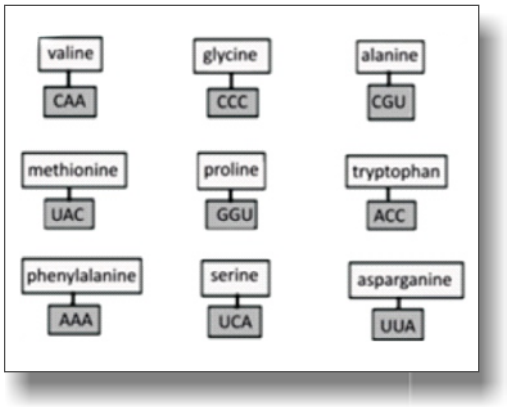
2. The information below shows the sequence of nitrogenous bases of a strand of DNA which codes for part of a protein molecule.

   GTT – ARD – TGG

   Write down the mRNA codon sequence that reads from left to right from the DNA sequence above.

3. The diagram shows the anticodons of nine different tRNA (transfer RNA) molecules, each carrying a particular amino acid. Select and write down from the diagram the amino acids, in the correct sequence, that would be required for the base sequence of mRNA

   UUU – GUU – AUG



ANSWERS ON PAGE 132

COMMENT

DNA is the blueprint for making proteins. Proteins are vital to the structure and functioning of our body. RNA helps to take the code from DNA and change it into protein. You could say that RNA is the baker that reads a recipe (DNA) and makes a cake (protein) based on the instructions in the recipe!

Genes and inheritance

Each individual **inherits** a variety of characteristics from his or her mother and father. In humans, examples of these characteristics are hair colour, eye colour, nose shape and build. Often in a family you can see that the children are siblings and that the children resemble their parents. In plants, examples of characteristics that are inherited are flower colour, height of plant and shape of seed.

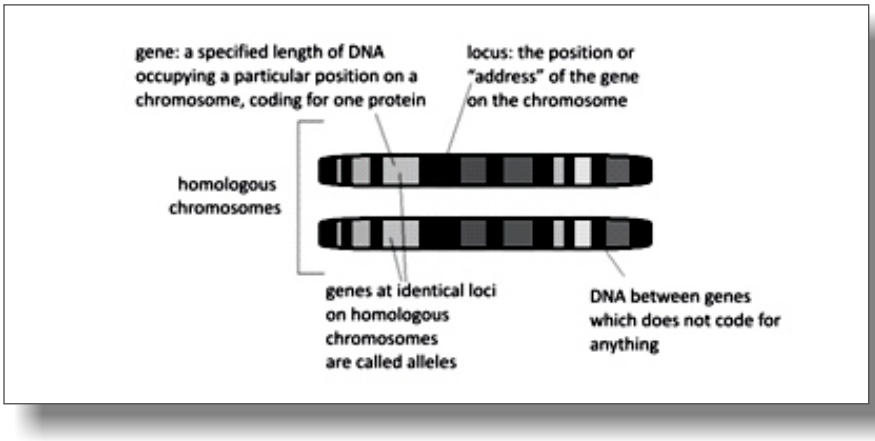
Although individuals of one species share many characteristics, there is still **variation** within the species, so that not all individuals are completely alike. **The study of the mechanisms involved in inheritance and variation is called genetics.** Although characteristics are transmitted from parent to offspring, there is still **variation** between parent and offspring and among offspring. This variation is the result of crossing over and random assortment of homologous chromosomes in meiosis, as well as random fusing of gametes in sexual reproduction.

What characteristics do you have that are clearly inherited from your parents? Do you have the same shaped nose as your mother? Or do your ears look like your father's ears? Do you and your brothers and sisters look alike?

Getting to grips with terminology

Chromosomes are long molecules of DNA. Humans have 46 chromosomes which can be arranged into two sets of 23. The pair of chromosomes is called a **homologous pair**. One chromosome came from the mother and the other from the father. The **genes** are located along the chromosome. A gene is a specified length of DNA which occupies a specific place on a specific chromosome. **Each gene codes for one protein.**

This protein can form a small part of a rather long and complex procedure or contribute a small part to a physical characteristic.



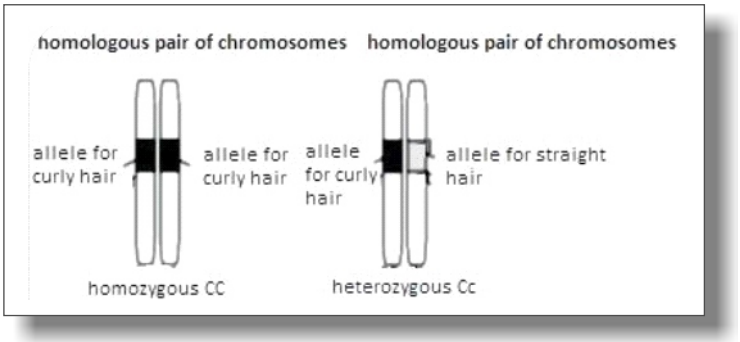
We know that there are many genes on one chromosome. The sketch shown here is a great simplification. Geneticists think there are between 20 000 to 30 000 genes in total on the 46 chromosomes in each human cell.

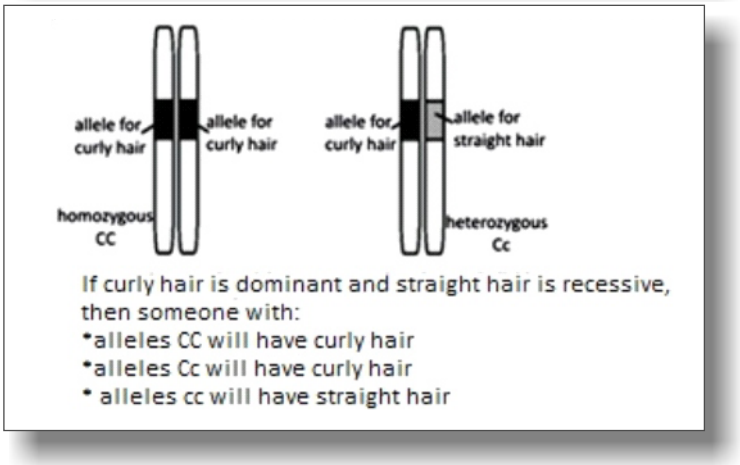
For example, your vision, such as long-sightedness and short-sightedness, is controlled by about ten genes or the gene can be evidenced by one physical characteristic such as attached or free ear lobes – this is the work of one gene. Every physical characteristic as well as every function in your body is controlled by genes.

The gene coding for one specific protein will therefore always be found in that place in every individual of that species. The specified place or position of the gene on the chromosome is called the **locus**. The locus is like the address of the gene. Genes at identical loci on homologous chromosomes are called **alleles**.

locus:
plural is loci

Now, although alleles code for an identical characteristic, they can differ in some situations. The two alleles coding for the production of insulin will be identical, but the alleles coding for hair structure could be slightly different: one could code for straight hair and the other for curly hair. If the two alleles are identical for a characteristic, for example, both alleles code for curly hair, then the individual is said to be **homozygous** for that characteristic. A homozygous individual is said to be **pure-bred** for that characteristic. In genetic 'shorthand' we write 'homozygous curly hair' as CC when both alleles are the same.





If the alleles are non-identical for a characteristic, say one allele codes for curly hair and one for straight hair, then the individual is said to be **heterozygous** for that characteristic. A heterozygous individual is said to be a **hybrid** for that characteristic. In genetic shorthand we write 'eterozygous curly and straight hair' as Cc.

In heterozygous individuals, one allele of the pair is **dominant** over the other. The dominant allele suppresses the action of the **recessive** allele. Although both alleles are present, only the dominant allele will be physically expressed. So in a person with Cc, the person would have curly hair and not straight hair.

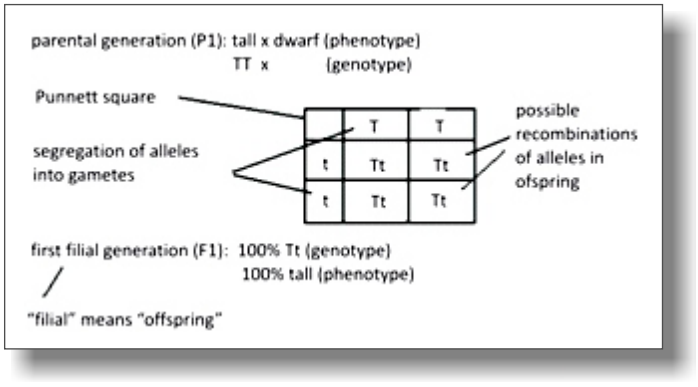
The genotype of a plant with flowers that are red could be RR (both alleles dominant red colour, i.e. homozygous for red colour) OR Rr (one allele for red, one for white, i.e. heterozygous). A plant with genotype rr would be phenotypically white flowered.

When we talk about the genes that an organism possesses for a certain characteristic, then we are describing the two alleles that are present on the homologous chromosomes. The genetic make-up of an organism is known as the **genotype** while the physical appearance of the organism due to the genetic expression of the genotype is called the **phenotype**.

Mendel and genetic crosses

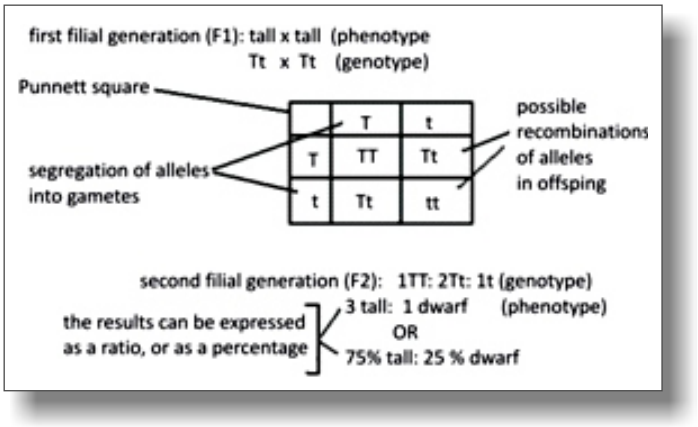
Gregor Mendel (1822 – 1884) was a Czech monk who from the age of 21 lived and studied in Austria. He studied natural sciences and mathematics and became interested in the hybridisation or cross breeding of plants. When he joined a monastery in 1853, he worked in the monastery vegetable garden. His observations of the variations in the pea plants in the garden led him to perform many experiments related to the breeding of these plants.

Mendel studied seven different characteristics of pea plants, such as wrinkled or smooth seed coats, tall or dwarf plants, or green or yellow seed coats. Mendel observed the scientific method patiently and strictly, and performed thousands of experiments crossing plants with similar and different characteristics.



The simplest crosses that Mendel performed with his pea plants were **monohybrid crosses**. A monohybrid cross is where only one heredity trait/characteristic is investigated at a time. Genetic diagrams called **Punnett squares** make it easier to understand how monohybrid crosses work.

For example, a pure-breeding (homozygous) tall plant is crossed with a pure-breeding dwarf plant. Tall is dominant over dwarf. All the offspring in this cross will be phenotypically tall, but will be genotypically hybrid or heterozygous.



Mendel took the first filial generation and crossed these plants with each other. A hybrid (heterozygous) tall plant is self-crossed. He discovered that he got tall and short plants in the ratio of 3:1. Genotypically, the ratio was 1TT:2Tt:1tt.

Mendel observed that the behaviour of the alleles controlling different traits revealed **patterns** in the way they are inherited.

ACTIVITY 7

In humans, the allele for blue (b) eyes is recessive to the allele for brown (B) eyes. A man, heterozygous for brown eyes, marries a woman with blue eyes. Show how the possible genotypes, phenotypes and ratio of individuals with brown and blue eyes in the F_1-generation, may be obtained.

ANSWERS ON PAGE 132

COMMENT

When Mendel worked out his ideas about inheritance, he did not know about genes and meiosis! It is amazing that he was able to make the conclusions he did with such little existing scientific knowledge in his field of study, and that these conclusions are still valid today.

Genetic disorders

DNA carries the instructions to make all the structural and functional proteins in the body. Every time a cell divides, the DNA must replicate. What happens if the DNA is not copied correctly? What happens if the DNA is damaged? Changes to the DNA are known as mutations. What are the consequences of mutations?

Mutations

Mutations occur spontaneously in all living cells. Mutations occur when an individual has been exposed to an environmental toxin or nuclear or x-radiation. The individual's DNA will be irreparably damaged.

Mutations occur when the structure of usually a dominant allele changes. The change to the genetic code brings about a change in the protein produced. If the mutation happens in a body cell, the mutation will die out with the cell. If the mutation spreads to other body cells, as in a cancer, then the mutation will die when the organism dies. The only way mutations are inherited is if the mutation occurred during gametogenesis.

Genetic diseases or disorders cannot be 'caught' from someone else! They are not infectious. A person can only inherit a genetic disorder or disease from his or her parents.

If the DNA of the cells undergoing gametogenesis is damaged, then the mutation can be passed on to the offspring, if the parent is fertile. A number of mutations occur during gametogenesis which can cause the resulting offspring to suffer from some kind of genetic disorder. Genetic disorders can then be further inherited by succeeding generations.

Two main types of mutations exist:

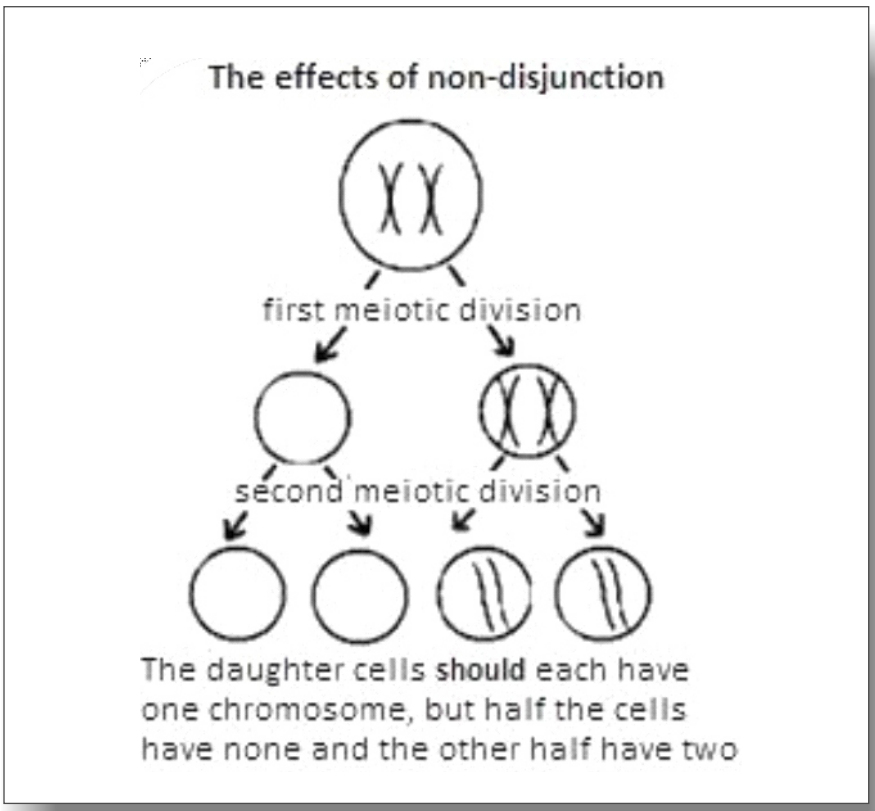
- **gene mutations** (also known as 'point mutations')
- **chromosome mutations**

Gene mutations:
Gene mutations involve the changing of single base pairs. These occur when a copying error occurs during DNA replication. Base pairs could be substituted, added in or deleted.

translocated: *moved*

Chromosome mutations:
Chromosome mutations involve the changing of many genes on a chromosome. Pieces of a chromosome can be duplicated, deleted, inverted or even **translocated** from one chromosome to another. These mutations can be harmless or cause serious problems when genes are lost.

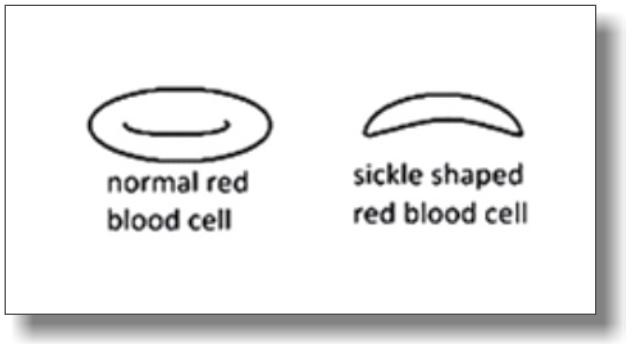
During meiosis, a mistake may occur where two homologous chromosomes, instead of separating, both go to the same pole and therefore into the same gamete. This is called a **non-disjunction** and is another form of a chromosomal mutation. As a result of non-disjunction, some gametes will have two copies of a chromosome and other gametes will lack a copy of the chromosome in question. The condition of a cell with too few chromosomes or too many chromosomes is called **aneuploidy**.



Down's syndrome or trisomy 21 is a genetic disorder, which happens when there is a non-disjunction involving chromosome 21. A person with trisomy 21 will have three copies of chromosome number 21. This person may have varying degrees of mental retardation, poor muscle tone, a tendency to heart conditions as well as a characteristic physical appearance. The person may have small almond-shaped eyes, ears that are situated lower than normal, a large flat forehead, flat nose bridge, large tongue and short stubby fingers and toes.

The risk for a woman to have a trisomy 21 child increases with her age. This suggests that meiosis may become faultier as an organism increases in age.

Sickle cell anaemia is caused by a gene mutation at the end of chromosome 11 causing the protein haemoglobin to be abnormally shaped. The normally globular (rounded) soft haemoglobin becomes a stiff rod shaped molecule. This causes the red blood cell, which holds the haemoglobin, to become hard and pointed like a sickle. The sickle shaped cells easily block capillaries.



This tool for cutting grass and vegetation is called a sickle. The decription of sickle cell anaemia comes from the shape of this blade.

Blockage causes pain, severe organ damage and can cause strokes. The sickle cells only live 10 – 20% as long as normal blood cells, so as they die before new cells can be made, the sufferer does not have sufficient haemoglobin to transport oxygen. The sufferer will be tired and weak. Life expectancy is about 50 years.

This mutation is widespread amongst African populations, particularly the populations descended from Central Africa.

ACTIVITY 8

1. A group of Grade 12 learners did a survey about the frequency of genetic disorders in a small human population. The results are shown in the table. The number of people in the population is 1 200.

Genetic disorders	Frequency in population (%)
Albinism	7
Down's syndrome	x
Sickle cell anaemia	10
Without any disorder	78

genetic counselling: *when patients or relatives, at risk of a genetic disorder, are advised of the consequences of the disorder, the probability of developing or transmitting it, and the options open to them in management and family planning*

a. According to the table, which disorder is most common in this community?

b. Calculate the number of people with Down's Syndrome.

c. Give one reason why **genetic counselling** would be important for parents who are expecting children that may be sufferers of a disorder such as Down's Syndrome.

ANSWERS ON PAGE 132

COMMENT

Having a child with a genetic disorder can place a great deal of strain on a family, both emotionally and financially. A family needs to be ready to look after the child , love the child and offer her all the benefits she needs to be a happy self- fulfilled individual, as far as possible. Sometimes, the genetic disorders are so severe that the child will not have any chance of leading a quality life.

Also, sometimes, parents decide, realistically, that they cannot take care of the child as she needs to be taken care of once she is born. In these cases, a couple may decide to legally abort the foetus. This is not an easy decision to make. Different people have very different views on the subject of abortion.

CHECKLIST

Are you able to:

- ❒ identify the different stages of mitosis and recognise the need for mitosis
- ❒ identify the stages of meiosis, recognise the need for meiosis and compare mitosis and meiosis
- ❒ explain the structure of DNA and label diagrams showing the structure of DNA?
- ❒ describe the process by which a DNA molecule replicates
- ❒ describe the relationship between DNA, RNA and proteins
- ❒ explain the processes of transcription and translation
- ❒ define terminology associated with genetics and inheritance and explain how the basic principles were discovered
- ❒ solve genetic problems involving inheritance of a single trait
- ❒ discuss some genetic disorders and think about the ethics of caring for someone with a genetic disorder.

NOTES

LESSON 6

Energy and the human body

About this lesson

There are characteristics that allow us to identify something as a living organism. The two characteristics we will explore in depth in this Lesson are that living organisms have some form of **nutrition**, and they undergo **cellular respiration**.

These two processes are linked and form the basis of all life on earth. In studying these two processes you will be looking at the core of what it means to be living, whether you are a human, an apple tree or a bacterium!

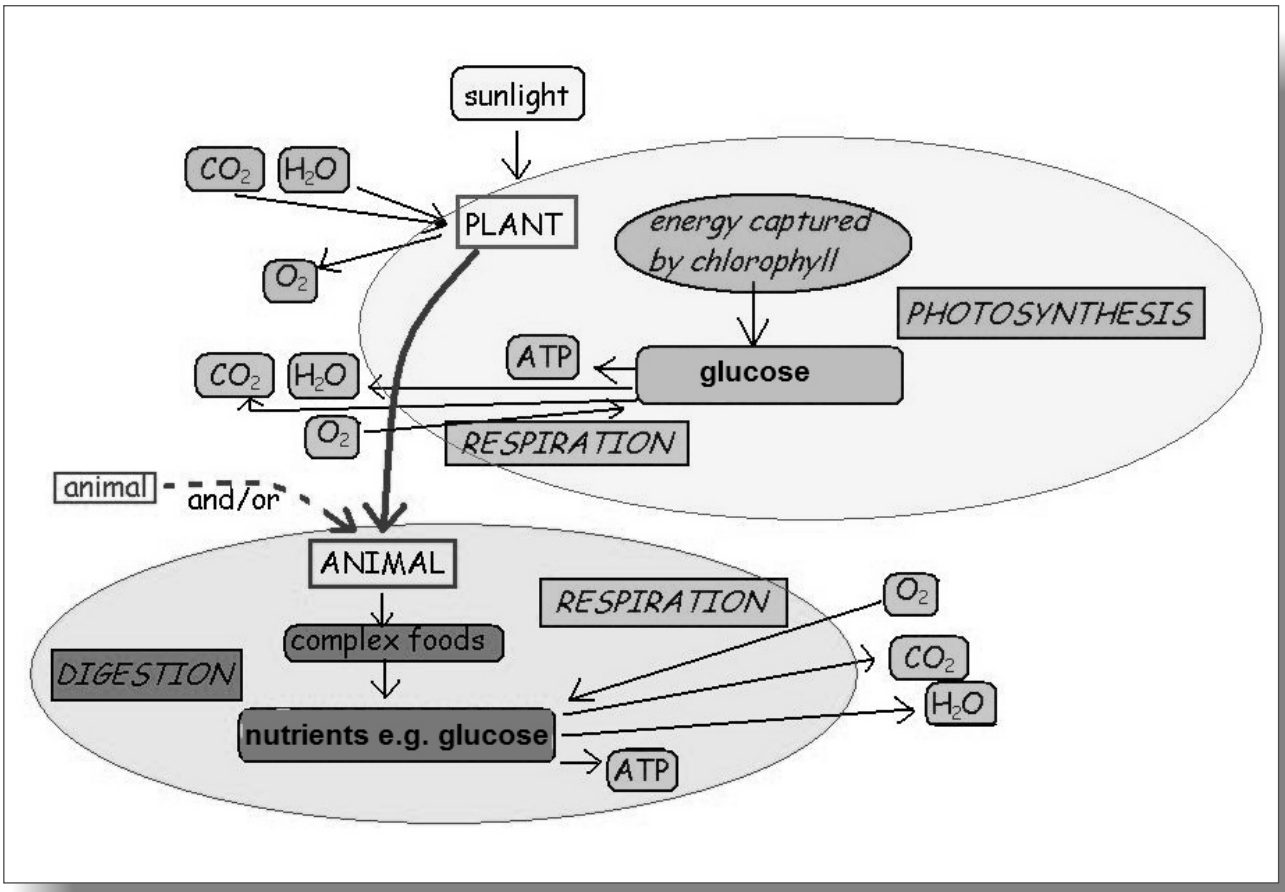
We will also discuss why digestion and absorption of the food we eat has to take place and the importance of cellular respiration.

In this lesson you will:

- explain the link between the sun, plants and human nutrition
- explain why food needs to be digested and absorbed
- define what digestion is and the two kinds of digestion that take place
- explain why glucose needs to be converted into ATP
- describe what ATP is
- investigate the chemical equation that represents the overall process of cellular respiration.

Energy from the sun

An overview of how energy flows from sun to plants to animals



Plants capture radiant energy from the sun

photosynthesis: *the process green organisms use to make their own food. This process is carried out in many kinds of bacteria, algae and in the green stems and leaves of plants.*

Every day, radiant energy from the sun equal to the energy of 1 million atomic bombs reaches the earth. **Photosynthesis** captures about 1% of this enormous energy supply. The source of chemical potential energy for plants and animals is carbohydrates produced during photosynthesis.

Every bit of food you and other heterotrophic organisms eat, either directly or indirectly, comes from plants and thus from photosynthesis. Life would be impossible without photosynthesis.

ACTIVITY 1

1. From the flow chart on the previous page, write down a sentence to describe what the 'ingredients' of photosynthesis are and what the 'results' are.

2. Now convert the sentence into a **chemical equation**. In chemistry, the 'ingredients' are called the **reactants** and the 'results' are called the **products**.

3. Describe where the reactants for photosynthesis come from, as well as the fate of the products.

4. In organisms, biological processes are known as **metabolic processes**. Those metabolic processes which build up products are called **anabolic processes**. Those which break down substances are known as **catabolic processes**.

   From the above equations, what kind of metabolic process is photosynthesis? Explain why?

5. From the flow chart, you can see that the process of **photosynthesis** supports all life on earth.

   Plants are the only organisms which are able to 'trap' and then convert sunlight energy into usable food energy (glucose). The plants use that glucose as their own source of food and convert it to ATP by cellular respiration.

   Animals which eat plants both directly or indirectly obtain their food from the plant and then process it by digestion, and convert energy into ATP by cellular respiration. Is cellular respiration an anabolic or catabolic process? Explain why?

6. What would happen if the sun stopped shining?

ATP:
the universal form of usable energy for all living cells. ATP stands for: Adenosine Triphosphate which is a small nucleic acid molecule.

ANSWERS ON PAGE 132

COMMENT

Humans are completely reliant on plants for their food and energy. Humans eat plants directly as well as animals that eat plants. Food obtained from plants has to be processed before we can use it.

Human nutrition

Most of the food we eat is of no use to our bodies in the form in which it is taken in as it is far too complex. This means that the molecules of food substances are too large to be absorbed through the wall of the intestine into the blood stream. Digestion, a process whereby the food is mechanically and chemically broken down and converted into small molecules that can be absorbed by the blood, has to take place.
The blood then transports these units to the cells where they are absorbed and then broken down further by cellular respiration to produce ATP, the form of energy the cells can use.

The absorbed products are then used by the cells in the process of cellular respiration.

Digestion and absorption of food

Our energy comes mainly from carbohydrates, but energy is also obtained from proteins and fats. We eat plant and animal matter and in this way, obtain our nutritional requirements.

We eat a range of food substances. But the food has to be digested. This means that the complex, insoluble foods that we eat have to be broken down into smaller, soluble units, so that these units can be absorbed into the blood.

Enzymes are biological catalysts. They make reactions happen faster in living organisms. Enzymes are extremely complex and usually rather large proteins. They do not change as a result of the reaction they catalyse, so they can be used over and over again, catalysing large amounts of material. In the digestive system, there are specific enzymes that digest and break down specific nutrients in specific places.

Digestion is the mechanical and chemical breaking down of complex food molecules into simple molecules. Mechanical digestion takes place when the food is physically torn apart and mashed into smaller pieces by organs such as the teeth and the churning movements of the stomach. Chemical digestion is more complex. Chemical digestion takes place as a result of the action of chemicals called **enzymes**. Chemical reactions take place in the digestive system. The process of digestion is catabolic, as large, complex molecules are broken down into smaller, simple molecules that are able to move from the digestive system into the blood stream.

Carbohydrates, for example, are digested in the mouth and small intestine. Polysaccharide molecules which are very large and complex must be broken down into simple monosaccharide molecules such as glucose.

After digestion, food needs to be absorbed from the digestive system into the blood stream where it is transported throughout the body to the cells. Absorption, as you have seen above, takes place mainly in the small intestine, although some substances are absorbed in the stomach and large intestine too. Glucose molecules are absorbed in the small intestine. Most nutrients, including glucose, are absorbed directly into the blood stream, but lipids are first absorbed into the lymphatic system which eventually empties into the blood system.

Once the food is absorbed, it is taken to the cells via the blood circulatory system. The nutrient molecules move from the blood vessels into the cells.

ACTIVITY 2

Many people have a wide range of choices when it comes to the foods they eat. Other people do not have these choices. Write an essay in which you discuss whether everyone eats the correct balance of nutrients to provide the required amounts of energy. Make sure that your essay is organised into logical paragraphs.

ANSWERS ON PAGE 133

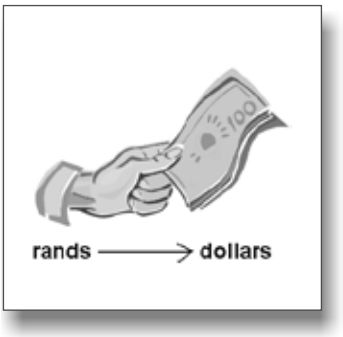
COMMENT

The food substances that we eat cannot be used as they are by our bodies. Food needs to be broken down into small molecules and transported to the cells that require energy and other building blocks. Some products of digestion are usable as they are in the cells. For example, proteins can be built out of the amino acids that have been absorbed. However, some nutrient molecules, such as glucose, are still in a form that is not directly usable to our cells and therefore, further change to the nutrient molecules is needed.

Cellular respiration

Simple nutrient molecules such as glucose are taken into body cells. However, the body is still not able to use the energy in the form of glucose, for example. A further chemical change is needed before the cell can use the energy from the food. This set of chemical reactions is called cellular respiration, which happens in plant and animal cells.

Changing glucose into ATP



Simply put, the purpose of cellular respiration is to convert the chemical energy of the food molecule into the chemical energy of the ATP molecule – a form of energy that the cell can use. The process of cellular respiration is identical in all living organisms. Evolutionary speaking, it is one of the oldest metabolic processes, having evolved in the most primitive organisms and being maintained almost unchanged today in the most complex organisms.

What is ATP?

If you go on holiday to America, you cannot buy a Big Mac Burger with Rands. You need to convert your Rands into Dollars.

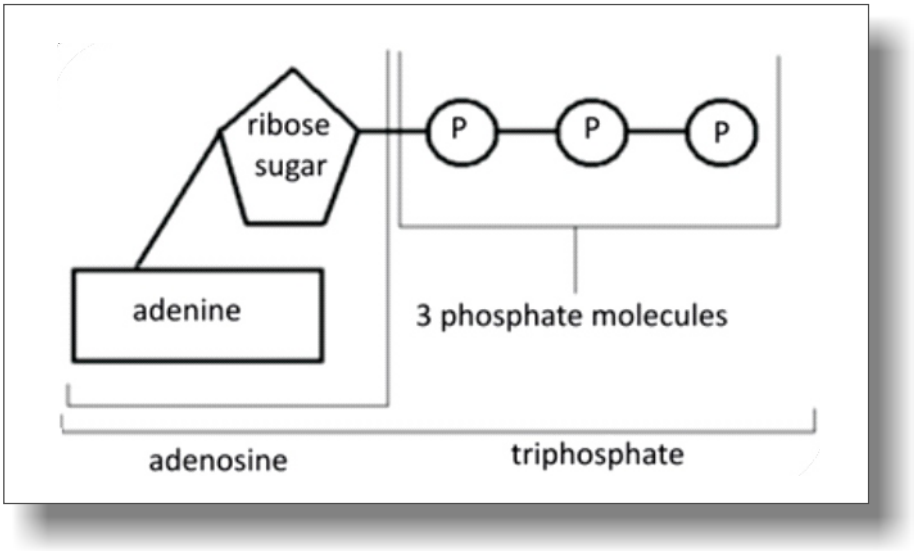
In your cells, you have glucose which is a form of energy. But the cells cannot use the energy in the form of glucose.

Just as you have to convert Rands to Dollars, your cells need to convert glucose to a usable form of energy. Cellular respiration converts glucose, which is a form of energy, into ATP, another form of energy. The cell can only use ATP, not glucose, to drive its functions.

ATP is the universal form of usable energy for all living cells. ATP stands for: Adenosine Triphosphate, which is a small nucleic acid molecule.

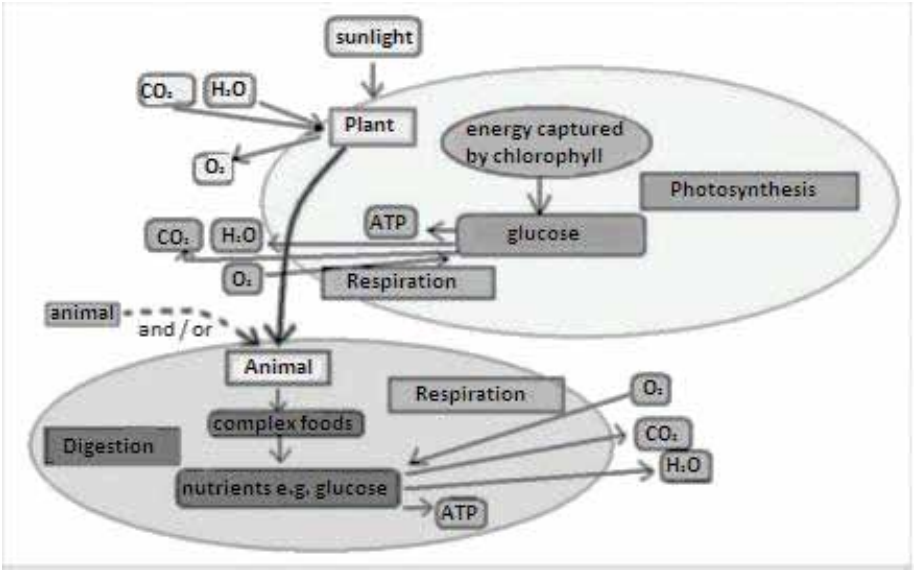
The bonds between each phosphate molecule are the energy-rich parts of ATP. As the bond between the third and second phosphate is broken, energy is released to drive functions in a cell. These functions range from protein synthesis to muscle cell contraction to active transport of substances into and out of the cell to movement of organelles and substances within the cell and many others.

Cellular respiration takes place in the mitochondria of the cell. A series of complex reactions begin with a glucose molecule and end up with ATP and waste products. Although many reactions are involved in cellular respiration, the whole process can be summarised in a chemical reaction.



ACTIVITY 3

1. Look again at the flow diagram. Now, write down the chemical equation for the process of cellular respiration.



2. What is the name and chemical formula of the food molecule?

3. What needs to happen to this molecule before the cell can use the energy possessed by the molecule?

4. What is the form of usable energy generated by cellular respiration?

5. What are the waste products generated by this process?

6. Is this reaction anabolic or catabolic? Give reasons for your answer.

7. Name at least four ways that energy produced by this process can be used by cells.

ANSWERS ON PAGE 133

COMMENT

The energy that runs your body, lets you move and grow and function, comes from the food you eat. The food you eat must be converted into a form of energy that is usable to your cells. The process of cellular respiration makes this conversion possible.

CHECKLIST

Are you able to:

- ❒ explain the link between the sun, plants and human nutrition
- ❒ explain why food needs to be digested and absorbed
- ❒ define what digestion is and the two kinds of digestion that take place
- ❒ explain why glucose needs to be converted into ATP
- ❒ describe what ATP is
- ❒ investigate the chemical equation that represents the overall process of cellular respiration

Answer section

Lesson 1

Activity 1

1. There are three different elements present in glucose: carbon, hydrogen and oxygen.

2. There are six carbon atoms, twelve hydrogen atoms and six oxygen atoms in each molecule of glucose.

3. Five of the six carbon atoms are arranged in a ring structure.

4. The carbon atoms are numbered in the diagram for you to locate them easily.

5. Hydrogen is the most common element.

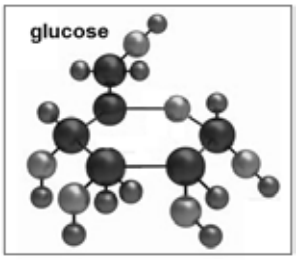
6. They refer to the number of atoms of each element in one molecule of glucose.

Activity 2

1. a. element; b. atom; c. molecule; d. compound; e. carbon

2 a. False – each piece would be called an atom.
b. True
c. True
d. False – an element contains only one kind of atom.
e. True
f. False – a molecule that has two or more different kinds of atoms bonded together is called a compound.
g. False – most molecules that make up living organisms are compounds.
h. False – molecules containing carbon and hydrogen are called organic substances.

models made from sweets and toothpicks



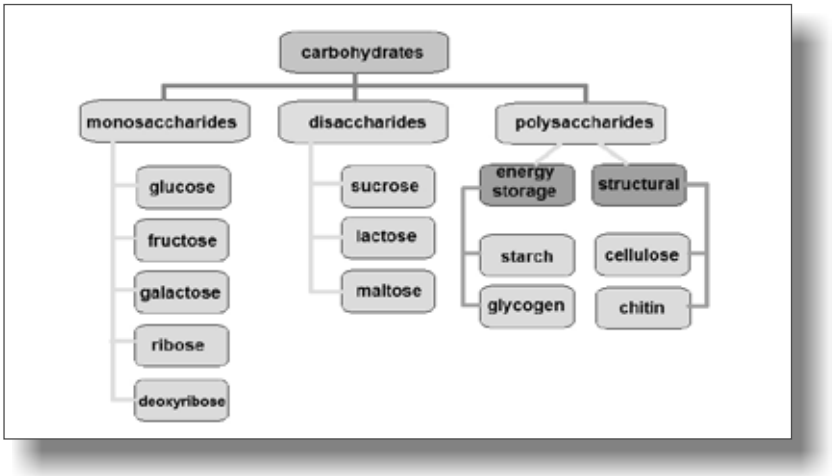
i. False - all of these molecules are examples of organic molecules.
j. True

Some ideas of what your models could look like, are shown on the left.

Activity 3

1 a. glucose
b. starch
c. deoxyribose
d. chitin
e. glycogen
f. glycogen
g. cellulose

2. The mind-map may be constructed in a variety of ways, depending on how you choose to organise the information. One possible answer is illustrated here:



Activity 4

1. This person is at risk for developing heart disease:
Total cholesterol – 230 mg/dL – borderline high risk
LDL cholesterol – 172 mg/dL – high risk
HDL cholesterol – 35 mg/dL – high risk
Triglycerides – 210 mg/dL – high risk

2. A variety of things can affect cholesterol levels. These are things someone can do something about in order to change:

a. Diet. Saturated fat and cholesterol in the food you eat make your blood cholesterol level go up. Saturated fat is the main culprit, but cholesterol in foods also matters. Reducing the amount of saturated fat and cholesterol in your diet helps lower your blood cholesterol level.

b. Body mass. Being overweight is a risk factor for heart disease. It also tends to increase your cholesterol. Losing weight can help lower your LDL and total cholesterol levels, as well as raise your HDL and lower your triglyceride levels.

c. Physical Activity. Not being physically active is a risk factor for heart disease. Regular physical activity can help lower LDL (bad) cholesterol and raise HDL (good) cholesterol levels. It also helps you lose weight. You should try to be physically active for 30 minutes on most, if not all, days.

d. Habits and addictions: Cigarette smoking is known to increase the risk of developing heart disease (as well as other diseases). Stopping smoking will decrease the risk of developing these diseases.

3. Things you cannot do anything about also can affect cholesterol levels. These include:

- Age and Gender. As people get older, their cholesterol levels rise. Before the age of menopause, women have lower total cholesterol levels than men of the same age. After the age of menopause, women's LDL levels tend to rise.

- Heredity. Your genes partly determine how much cholesterol your body makes. High blood cholesterol can run in families. Family history of early heart disease (heart disease in father or brother before age 55; heart disease in mother or sister before age 65) could indicate a greater chance of getting heart disease.

Activity 5

a. False: A **large** portion of the protoplasm is protein.
b. True although more correctly, it could be termed a metalloprotein.
c. False: All amino acids are made of carbon, hydrogen, oxygen and **nitrogen. Sulphur is present in some amino acids.**
d. False: Proteins do provide some energy, but they are not the most important source of energy in the diet.
e. True
f. True
g. False: The **monomer** of proteins is the amino acid.
h. True
i. True
j. True

Lesson 2

Activity 1

1. Table describing organelles and their structure and function.

Organelle	Structure	Function
nucleus	nuclear membrane with pores; contains DNA/chromosomes; nucleolus is a dense mass in the nucleus	controls cell functioning (metabolism); controls inheritance of genetic information from generation to generation of cell and organism
mitochondrion	double membrane, inner membrane folded; filled with jelly-like matrix which has enzymes and ribosomes	produces ATP during the process of cellular respiration (ATP is the cell's form of energy)
endoplasmic reticulum	system of hollow folded membranes and channels	stores and transports protein; may link two cells
chloroplast (plant cells only)	double membrane, inner membrane system of interconnected thylakoids; matrix called the stroma; contains pigment chlorophyll	photosynthesis
Golgi apparatus	stacks of folded membranes; buds off vesicles/lysosomes from swollen ends	processes proteins; stores and transports products
cell sap vacuole (plant cells only)	single membrane – the tonoplast, large, filled with cell sap	maintains turgor pressure in plant cells; stores water
ribosome	very tiny; non-membrane-bound; two sub-units	makes proteins
lysosome	small, membrane-bound vesicle	stores products made by Golgi

2. Table showing the differences between plant and animal cells.

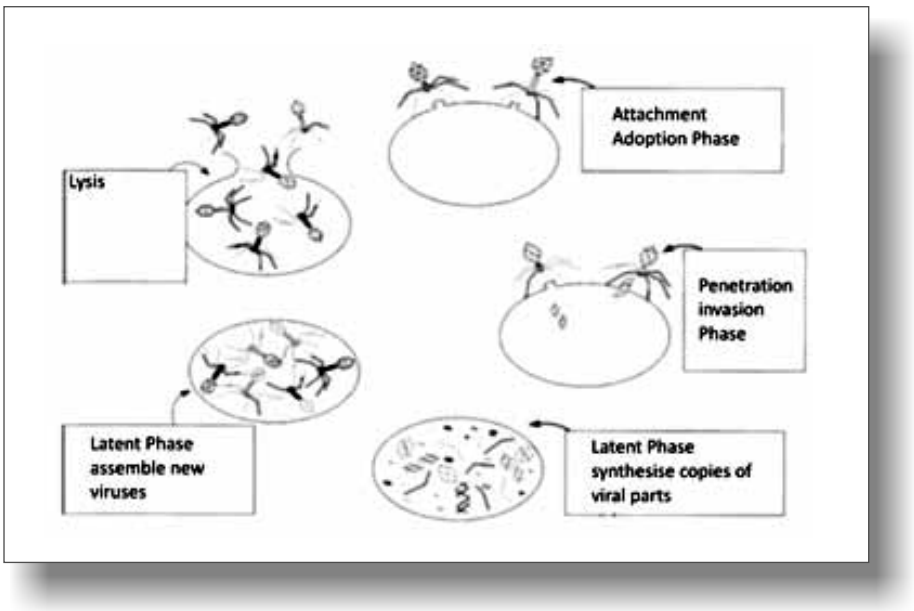
Animal Cells	Plant Cells
Rounded in shape or very irregular shape	Regular, often with corners
No cell wall outside the cell membrane	A cell wall outside the cell membrane
Small vacuoles	A large vacuole when fully grown
Do not have plastids	Have plastids
Have centrioles for cell division	Do not have centrioles for cell division

Activity 2

Table comparing prokaryotic and eukaryotic cells:

Prokaryotic cells	Eukaryotic cells
smaller	larger
simple in structure	complex in structure
no nuclear membrane around DNA; no nucleolus	nuclear membrane around DNA; nucleolus present
no membrane-bound organelles	membrane-bound organelles such as mitochondria, ER, chloroplasts, lysosomes etc
small ribosomes	larger ribosomes
single circular chromosome	many linear chromosomes

Activity 3



Activity 4

1. True.

2. Partially true. Only if the needle or syringe has been contaminated with HIV.

3. False. There are no known cases of HIV infection via toilet seats.

4. False. It does not matter how healthy or unhealthy you are, if you engage in risky activities such as unprotected sex or sharing needles with infected drug addicts, you stand a chance of being infected. (Remember that not all people are honest. You may not know if the person you are having sex with, or sharing needles with, is telling you the truth that he/she is not infected.)

5. False. This depends on the partners involved, what they did before they met, whether either has unprotected sex outside of the marriage or injects drugs using contaminated equipment. Marriage by itself offers no guarantees of safety.

6. Basically true, IF both partners are known to be HIV negative before the sexual relationship starts.

7. False. Only condoms offer women protection against HIV, and even condoms cannot offer complete safety. Other forms of contraception do not offer protection from HIV.

8. False. There is no evidence of transmission via this route, but it is sensible not to share toothbrushes for general health reasons.

9. False. Most people with HIV will look perfectly healthy. Looks are therefore a useless way of assessing risk.

10. False. Knowing someone well offers no reliable guide to whether or not they are infected with HIV.

11. False. Anal sex is equally risky regardless of whether it takes place between two men or a man and a woman.

12. False. There is no evidence of transmission in this way, although kissing when there are sores or cuts in the mouth may pose some risk.

13. True. HIV is present in cervical and vaginal secretions as well as in (menstrual) blood, so there is the possibility of transmission this way.

14. True. HIV is present in semen so there is a possibility of transmission in this way.

15. True. Condoms used properly will help to prevent transmission of HIV from an infected partner to an uninfected partner. Condoms are not 100% safe though. Use a lubricant which is water based, as oil based lubricants can weaken the condom. When buying condoms check the 'sell by' date. Condoms should not be left in the sun, pierced or reused.

Activity 5

Some ideas that might be included in the researched article for a youth magazine:

Reasonably effective ways to reduce the transmission of influenza include good personal health and hygiene habits such as: not touching your eyes, nose or mouth;

frequent hand washing with soap and water, or with alcohol-based hand cleaners; covering coughs and sneezes; not spitting; avoiding close contact with sick people; and staying home yourself if you are sick.

People with the flu are advised to get plenty of rest, drink plenty of liquids, avoid using alcohol and smoking (which make the symptoms worse) and, if necessary, take medications to relieve the fever and muscle aches associated with the flu. Most people will recover completely in about one to two weeks, but others may develop life-threatening complications such as pneumonia. Influenza, thus, can be deadly, especially for the weak, young and old, or chronically ill such as people with advanced HIV infection. Other high-risk groups include pregnant women and young children.

Activity 6

1. Tuberculosis (TB) is a disease caused by germs that are spread from person to person through the air. TB usually affects the lungs, but it can also affect other parts of the body, such as the brain, the kidneys, or the spine. In most cases, TB is treatable; however, persons with TB can die if they do not get proper treatment.

2. Multidrug-resistant TB (MDR-TB) is TB that is resistant to at least two of the best anti-TB drugs, isoniazid and rifampicin. These drugs are considered first-line drugs and are used to treat all persons with TB disease.

3. Drug-susceptible TB and MDR-TB are spread the same way. TB germs are put into the air when a person with TB disease of the lungs or throat coughs, sneezes, speaks, or sings. These germs can float in the air for several hours, depending on the environment. Persons who breathe in the air containing these TB germs can become infected. TB is not spread by:

    - shaking someone's hand
    - sharing food or drink
    - touching bed linen or toilet seats
    - sharing toothbrushes
    - kissing

4. Resistance to anti-TB drugs can occur when these drugs are misused or mismanaged. Examples include when patients do not complete their full course of treatment; when health-care providers prescribe the wrong treatment, the wrong dose, or length of time for taking the drugs; when the supply of drugs is not always available; or when the drugs are of poor quality.

5. There is a vaccine for TB disease called Bacille Calmette-Gurin (BCG). It is used in South Africa to prevent severe forms of TB in children.

6. The general symptoms of TB disease include feelings of sickness or weakness, weight loss, fever, and night sweats. The symptoms of TB disease of the lungs may also include coughing, chest pain, and coughing up blood. Symptoms of TB disease in other parts of the body depend on the area affected. If you have these symptoms, you should contact your doctor or local health department.

7. People who have a healthy immune system will not contract the TB infection. However, people with HIV have weakened immune systems and therefore they are less likely to fight off the infection.

8. a. Bar graph

   b. 1971

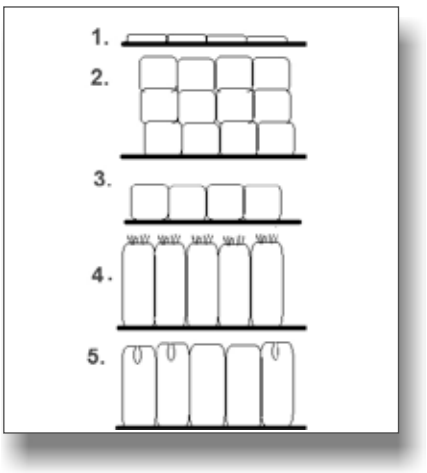
   c. The incidence of TB was fairly stable from 1992 to about 1996. The incidence of TB began to increase rapidly to about 2004. Although the incidence is still increasing, it is not quite as rapid as it was.

Lesson 3

Activity 1

Name of tissue	Description of tissue
Simple squamous	A single layer of cells that are thin and flat; they form the lining of cavities such as the mouth, blood vessels and lungs.
Simple cuboidal	One layer of cells that are roughly square or cube-like in shape; found in glands, duct and portions of the kidney tubules.
Simple columnar	A single layer of tall cells that are found in places like the lining of the intestine and gallbladder.
Stratified squamous	Many layers of cells are present; this is the type of epithelium that makes up the skin surface and lining of the mouth and throat.
Stratified columnar	Many layers of cells, the topmost layer is made up of tall cells; found in the mammary ducts and epididymus of the testes.
Glandular	Columnar and cuboidal cells often become capable of secreting substances such as enzymes, hormones, mucus, sweat and saliva.
Ciliated	The free surface of the cells have small hair-like structures that can move and sweep particles along the surface.

Activity 2



Activity 3

1. epithelial
2. connective
3. muscle
4. nerve
5. nerve

Activity 4

E – atoms, molecules

F – organelles

D – cell

B – tissue

C – organ

A – system

G – organism

Activity 5

1.	A	2.	C	3.	A	4.	D	5.	B
6.	D	7.	A	8.	B	9.	D	10.	C
11.	B	12.	A	13.	C	14.	A	15.	C
16.	A	17.	D	18.	A	19.	B	20.	D

Activity 6

1.

System	Major organs in the system	Functions of the system
skeletal	bones, cartilage, ligaments	movement, gives body shape, protects organs, stores minerals, produces red blood cells
muscular	skeletal, smooth and cardiac muscles	movement, heat generation
integumentary	skin, nails, hair, sweat glands	protection, fat storage, vitamin production, regulates body temperature, receives stimuli from environment
circulatory	heart, blood vessels	transport
lymphatic	lymph vessels, nodes, spleen, thymus	drainage of tissue fluid, immunity, absorption of fat
digestive	mouth, oesophagus, stomach, liver, gall bladder, pancreas, intestines	breaking down of foods, absorption of nutrients into blood
respiratory	nose, lungs, trachea, bronchi	gaseous exchange
excretory	kidneys, ureters, bladder, urethra	filters wastes from blood, maintains salt and water balance
nervous	brain, spinal cord, nerves, sense organs	co-ordination of internal organ function, response to external environment
endocrine	various endocrine glands	produce hormones to regulate growth, maintains homeostasis
reproductive	ovaries, testes	sexual reproduction

2. The lymphatic system is dependent on the blood circulatory system to provide tissue fluid and white blood cells; on the skeletal muscles to move the lymph in the vessels; the digestive system to provide fats for absorption

3. The digestive system relies on the muscular system to move food along the digestive tract (pathway) and to mechanically break down foods; circulatory system to transport nutrients to cells, lymphatic system for absorption of fats.

Activity 7

a. All your systems are working, but those that are most active: nervous system, muscular system, skeletal system, gaseous exchange system

b. All your systems are working, but those that are most active: nervous system (sensing the food), digestive system (processing the food), skeletal and muscular system (locomotion, eating)

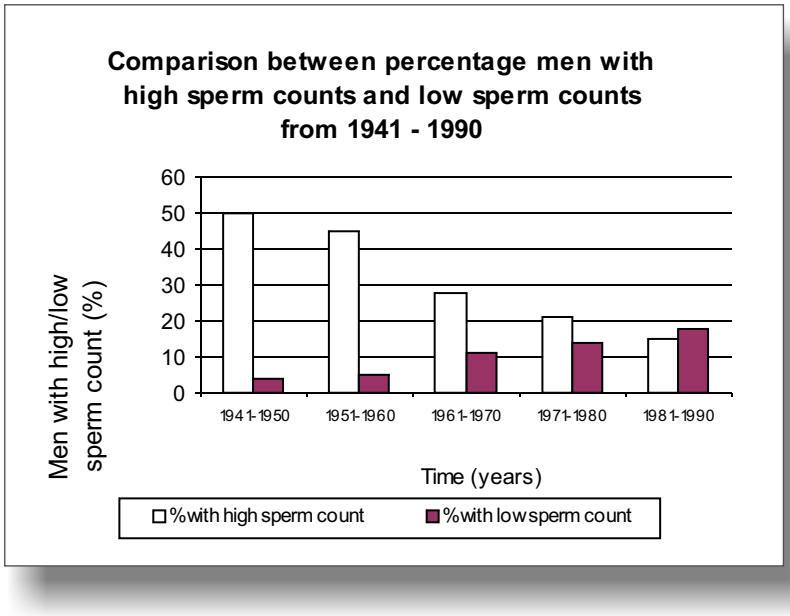
c. Probably all of the systems! They are co-ordinated by the nervous and endocrine systems.

d. All your systems work, but some work far less actively than when you are awake.

Lesson 4

Activity 1

1. 17%

2. 

3. The percentage of men with low sperm counts has increased from 1941 to 1990.
   OR:
   The percentage of men with high sperm counts has decreased from 1941 to 1990.

4. To increase chance of fertilisation since there is a reduced number of egg cells.
   OR:
   Many millions of sperms increase the chances of fertilization since many sperms are destroyed/ get lost.

Activity 2

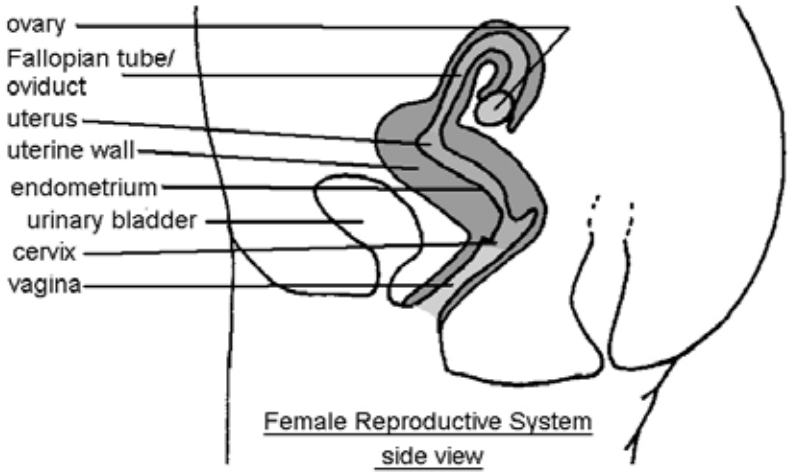
1. A: acrosome; B: nucleus;
   C: mitochondria; D: midpiece/neck

   a. C releases energy for sperm to use when swimming.

b. Semen is alkaline which neutralizes the acidic pH of the urethra.

c. 35°C ligaments supporting the scrotum slacken in hot weather so that the scrotum hangs away from the body, ligaments supporting the scrotum tighten in cold weather so that the scrotum is drawn towards the body.

Activity 3



Activity 4

Name of hormone	Where it is produced	Functions
Follicle Stimulating Hormone or FSH	pituitary gland	stimulates the primary follicles to develop into secondary follicles
Oestrogen	Graafian follicle	stimulates endometrium of uterus the thicken
Luteinising hormone or LH	hypophysis of brain	stimulates ovulation
Progesterone	corpus luteum	maintains endometrium and uterus through pregnancy

Activity 5

1. The breakdown/discharge of the lining/blood/endometrium of the uterus.

2. From day 0 5

3. A decrease / lowering / drop in the level of progesterone

4. Uterus lining becomes thicker/more vascular/more glandular.

5. To prevent the breakdown of the uterine lining to prevent spontaneous abortion (miscarriage) / retain the foetus / prevent premature labour.

Activity 6

1. Answer: d
   Notes: The amnion is the tough outer membrane which acts as a shock absorber and secretes fluid which prevents the embryo from drying out.

2. Answer: c
   Note: Although the mother's and baby's blood are close, lying in vessels and capillaries that are next to each other, the blood never mixes. A transfer of substances takes place across capillary walls by means of diffusion.

3. Answer: b
   Notes: Implantation is when the blastocyst embeds itself in the endometrium; ovulation is when an oöcyte is released from the ovary; gestation is another word for pregnancy.

4. Answer: b

5. Answer: b
   Notes: It is the hormone oxytocin that stimulates uterine contractions.

6. Answer: c
   Notes: Even ‘safe’ medical drugs taken for pain or flu can cross the placental barrier. A pregnant woman should check with her doctor before taking any medication at all.

Activity 7

Method	Affect on human reproduction
Condom✓	Acts as a barrier✓/stops sperm getting into the vagina✓
Loop/IUD✓	It prevents fertilised eggs✓/embryos from becoming attached to the uterine wall✓ and is highly effective
Femidom✓	Acts as a barrier✓ /stops sperm getting into the uterus✓/Fallopian tubes

Diaphragm✓	It covers the cervical opening✓ and prevents sperm from entering the uterus✓ and is fairly effective.
Contraceptive pill✓	Contains artificially produced hormones which prevents the production of eggs✓/ovulation/signalling the body that it is already pregnant. It changes the lining of the cervix✓/ womb. It is a very reliable method
Spermicides✓	It contains a chemical substance that kills sperm✓ and acts as a barrier✓/prevents sperm from entering the Fallopian tubes. They are not very reliable on their own.
Contraceptive injections✓	It contains progesterone✓/combination of oestrogen and progesterone which stops ovulation✓/ changes the lining of the womb and the cervix. It works for 2 to 3 months and are very effective.
Male sterilisation✓ - vasectomy	The sperm ducts are cut✓ and tied. Semen without sperm is produced✓ and is a very effective method of contraception.
Female Sterilisation✓ - tubal ligation	The fallopian tubes are cut✓ and tied during a small surgical operation preventing the fusion of sperm and egg. ✓
Withdrawal✓	The penis is removed✓ out of the vagina before ejaculation✓ but is not a safe method because many sperms are released during sexual intercourse
Rhythm✓	Sexual intercourse is avoided✓ during ovulation✓ but is not a safe method of contraception because it is impossible to be 100% sure when ovulation will occur

The influence on the quality of human life:

- limits family size
- unwanted pregnancies - which allows better care for the children
- higher standard of living
- less dependent on debt/ more psychologically stable children
- prevents the transfer of STD's
- the use of e.g. condoms can increase life span
- and decrease the spread of diseases to other people
- might cause conflict - e.g. the use of IUD could be seen by some people as a form of abortion which may not be acceptable to some religions

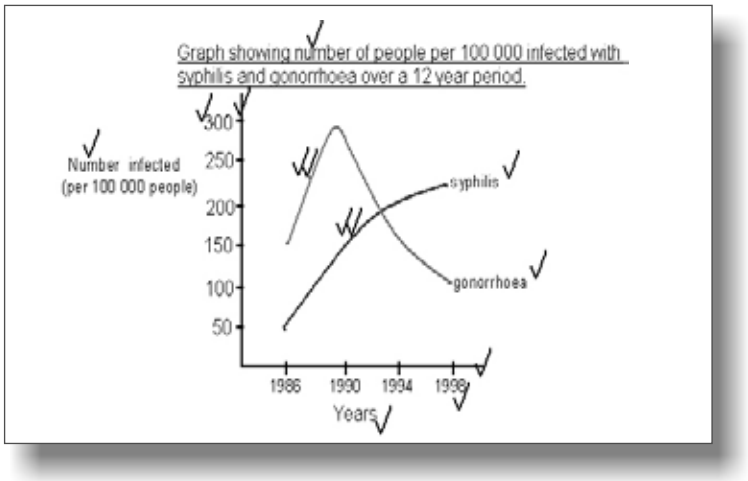
Activity 8

1. a. While in uterus there is no contact between baby's blood and mother's blood√ during birth there is blood in the uterus/ and tearing in the vagina √ baby's skin may tear/cut/get a wound √ allowing transmission of HIV√

   b. Other causes of transmission between mother and baby√ e.g. using an unsterilised needle√ to get a vitamin injection √ or blood transfusion √ but the blood is contaminated √

   c. Graph would differ in that there would be a much lower % of HIV transmission during birth√ v little bleeding during caesar√

2. a. see below



   b. The number of people with syphilis increased steadily, but appear to be levelling off. The number of people infected with gonorrhoea rose steadily but then dropped sharply.

Lesson 5

Activity 1

1. a. two cells

   b. 56 chromatids

   c. 28 chromosomes

   d. the same

   e. the same

2. a. 8

   b. 4

   c. The 2 daughter cells are identical in all respects to each other and to the parent cell; has 4 chromosomes each

   d. Responsible for growth of an organism
   Responsible for replacement of cells that are worn out or damaged

   Meiosis: What is the difference between homologous chromosomes and chromatids?

   Every diploid body cell has two copies of each chromosome. For example, there are two copies of chromosome 1: one copy came from the organism's father and is called the paternal homologue while the other came from the mother and is called the maternal homologue. Together they are called a homologous pair. Just before mitosis, and meiosis first division, the DNA replicates. This means that each chromosome will have a copy of itself. The copies are called sister chromatids.

Activity 2

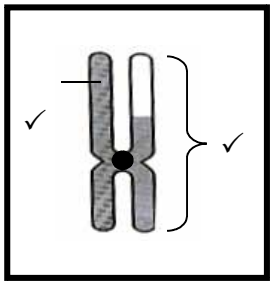
a. A. chromosome
   B. centromere
   C. chromatid
   D. chiasma

b. crossing over/synapsis

c. genetic variation/recombination of genetic material

d. prophase I

e. see below



Activity 3

Mitosis	Meiosis
produces 2 identical daughter cells	produces 4 non-identical daughter cells
one nuclear division	two nuclear divisions
takes place in somatic/body cells	takes place in reproductive organs (testes and ovaries)
for purposes of growth and replacement of old/damaged cells	for purposes of producing genetically unique gametes
results in 2n (diploid) cells	results in n (haploid) cells called gametes

Activity 4

1. a. DNA

   b. 1: hydrogen bond; 2: phosphate;
   3: deoxyribose sugar; 4: thymine;
   5: cytosine

   c. nucleotide

   d. DNA controls the functioning of the cell; it contains the information for the structure and functioning of the whole organism which is passed down from generation to generation inheritance.

   e. T A C A T G G A T C

   f. ii – the strands are held together by weak hydrogen bonds

Activity 5

1. No, only the section that needs to be copied i.e. only one gene.

2. In order to expose the DNA bases to other nucleotides. The exposed half strand of DNA forms a template to be copied to form mRNA.

3. Enzymes control the process and break the hydrogen bonds and remake them after the mRNA has been formed.

4. Because it copies the original genetic code and carries it to the cytoplasm, like a messenger.

5. The two strands recombine again due to enzymes remaking the hydrogen bonds between the nitrogenous bases. The DNA then rewinds into a double helix. It can be copied again. DNA never leaves the nucleus.

6. The code for the sequence of amino acids in a protein is transcribed or copied to mRNA.

Activity 6

1. a. The synthesis of mRNA from a DNA template/by complementary matching of the nitrogenous bases in DNA.

   b. The process of converting the information carried by mRNA to the correct sequence of amino acids to form a particular protein.

2. CAA – UAC – ACC (in sequence).

3. Phenylalanine Valine Methionine (in sequence).

Activity 7

P_1: (brown) × (blue) [phentotype]
Bb × bb [genotype]

	B	b
b	Bb	bb
b	Bb	bb

F_1: 2Bb : 2bb
1Bb : 1bb [genotype]
50% blue [phenotype]

Activity 8

a. sickle cell anaemia

b. 100% - (78+7+10)% = 5%
5/100 x 1200/1 = 60 people

c. Parents can decide whether or not to abort the foetus. It would help prepare parents to manage with such a child.

Lesson 6

Activity 1

1. Plants capture radiant energy from the sun:
ingredients of photosynthesis: sunlight, carbon dioxide and water
results of photosynthesis: glucose and oxygen

2. Chemical equation:
   $CO_2 + H_2O \rightarrow$ glucose ($C_6H_{12}O_6$) + O_2
   reactants: sunlight comes from sun, water from the ground (absorbed by the roots) and carbon dioxide from the atmosphere

3. Products: oxygen goes into atmosphere, glucose is used by the plant to make ATP (energy) or it is converted into starch and other products which build the body of the plant

4. Photosynthesis is an anabolic process because complex molecules are built up from simpler molecules.

5. Cellular respiration is a catabolic process because more complex molecules are broken down into simpler ones.

6. Without the sun, life on earth would be impossible. The warmth from the sun is needed to maintain life as well as the radiant energy for photosynthesis.

Activity 2

Not all people eat the correct balanced diet for their energy needs and become malnourished.
Some people eat too little food. They either do this by choice such as people who diet to lose weight or in a controlled manner. Some people have eating disorders such as anorexia and are unable to eat correctly. There are many people who have no choice as they simply do not have access to sufficient food. They cannot afford a balanced diet, or a wide range of foods is not available where they live.

Some people eat too much food. Their bodies store the excess nutrients as fat and they can become obese. The extra body mass can strain their hearts and affect their health in other ways.

Some people have access to healthy balanced diets, but choose to eat junk foods and unhealthy foods. These people may need to be educated to make correct choices, or they need to understand that they will harm their bodies and health by eating incorrectly.

Activity 3

Test your understanding of the equation representing cellular respiration:

1. glucose ($C_6H_{12}O_6$) + $O_2 \rightarrow CO_2 + H_2O$

2. glucose $C_6H_{12}O_6$

3. It needs to be broken down and converted into the energy-rich molecule ATP.

4. ATP

5. carbon dioxide and water

6. catabolic a complex molecule is broken down into simpler molecules

7. protein synthesis, muscle cell contraction, active transport of substances into and out of the cell, movement of organelles and substances within the cell, cell division etc.