THE REPUBLIC OF UGANDA

Ministry of Education and Sports

HOME-STUDY LEARNING

SENIOR 5

BIOLOGY

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This material has been developed as a home-study intervention for schools during the lockdown caused by the COVID-19 pandemic to support continuity of learning.

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FOREWORD

Following the outbreak of the COVID-19 pandemic, government of Uganda closed all schools and other educational institutions to minimize the spread of the coronavirus. This has affected more than 36,314 primary schools, 3129 secondary schools, 430,778 teachers and 12,777,390 learners.

The COVID-19 outbreak and subsequent closure of all has had drastically impacted on learning especially curriculum coverage, loss of interest in education and learner readiness in case schools open. This could result in massive rates of learner dropouts due to unwanted pregnancies and lack of school fees among others.

To mitigate the impact of the pandemic on the education system in Uganda, the Ministry of Education and Sports (MoES) constituted a Sector Response Taskforce (SRT) to strengthen the sector's preparedness and response measures. The SRT and National Curriculum Development Centre developed print home-study materials, radio and television scripts for some selected subjects for all learners from Pre-Primary to Advanced Level. The materials will enhance continued learning and learning for progression during this period of the lockdown, and will still be relevant when schools resume.

The materials focused on critical competences in all subjects in the curricula to enable the learners to achieve without the teachers' guidance. Therefore effort should be made for all learners to access and use these materials during the lockdown. Similarly, teachers are advised to get these materials in order to plan appropriately for further learning when schools resume, while parents/guardians need to ensure that their children access copies of these materials and use them appropriately.
I recognise the effort of National Curriculum Development Centre in responding to this emergency through appropriate guidance and the timely development of these home study materials. I recommend them for use by all learners during the lockdown.

Alex Kakooza
Permanent Secretary
Ministry of Education and Sports

ACKNOWLEDGEMENTS

National Curriculum Development Centre (NCDC) would like to express its appreciation to all those who worked tirelessly towards the production of home–study materials for Pre-Primary, Primary and Secondary Levels of Education during the COVID-19 lockdown in Uganda.

The Centre appreciates the contribution from all those who guided the development of these materials to make sure they are of quality; Development partners - SESIL, Save the Children and UNICEF; all the Panel members of the various subjects; sister institutions - UNEB and DES for their valuable contributions.

NCDC takes the responsibility for any shortcomings that might be identified in this publication and welcomes suggestions for improvement. The comments and suggestions may be communicated to NCDC through P.O. Box 7002 Kampala or email admin@ncdc.go.ug or by visiting our website at http://ncdc.go.ug/node/13.

Grace K. Baguma
Director,
National Curriculum Development Centre

ABOUT THIS BOOKLET

Dear learner, you are welcome to this home-study package. This content focuses on critical competences in the syllabus.

The content is organised into lesson units. Each unit has lesson activities, summary notes and assessment activities. Some lessons have projects that you need to carry out at home during this period. You are free to use other reference materials to get more information for specific topics.

Seek guidance from people at home who are knowledgeable to clarify in case of a challenge. The knowledge you can acquire from this content can be supplemented with other learning options that may be offered on radio, television, newspaper learning programmes. More learning materials can also be accessed by visiting our website at www.ncdc.go.ug or ncdc-go-ug.digital/. You can access the website using an internet enabled computer or mobile phone.

We encourage you to present your work to your class teacher when schools resume so that your teacher is able to know what you learned during the time you have been away from school. This will form part of your assessment. Your teacher will also assess the assignments you will have done and do corrections where you might not have done it right.

The content has been developed with full awareness of the home learning environment without direct supervision of the teacher. The methods, examples and activities used in the materials have been carefully selected to facilitate continuity of learning.

You are therefore in charge of your own learning. You need to give yourself favourable time for learning. This material can as well be used beyond the home-study situation. Keep it for reference anytime.

Develop your learning timetable to ca ter for continuity of learning and other responsibilities given to you at home.

Enjoy learning

CELL BIOLOGY

Lesson 1: Parts of a Cell

Learning Outcome

By the end of this lesson, you should be able to describe cell structures specific to prokaryotic cells as seen under an electron microscope and state their functions.

Introduction

Like bricks are the basic units making a building, so are cells; they are the basic structural and functional units making up all living organisms. Cells are either eukaryotic or prokaryotic. Eukaryotic cells are those with well-developed membrane bound organelles such as the nucleus, chloroplast, mitochondrion and vacuoles. Examples include the plant and animal cells. Prokaryotic cells on the other hand, are those without these organelles. Examples include bacterial cell and the blue green algae.

Illustrations

PLANT CELL	BACTERIAL CELL

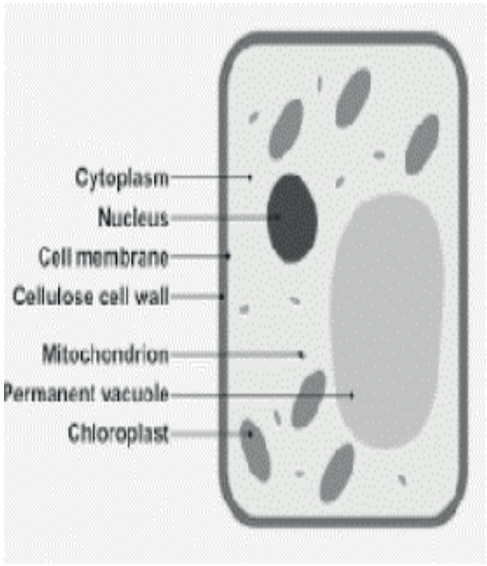
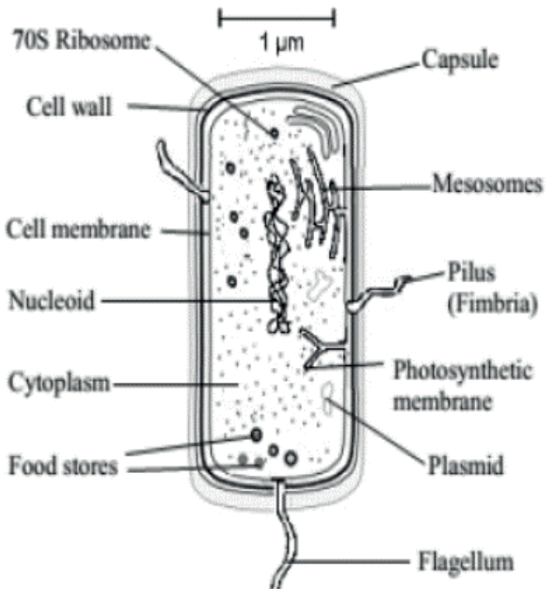

	

Figure 1:Plant cell as viewed under a light microscope	***Figure 2*: Bacterial cell as viewed under an electron microscope** (Find **diagram in Functional Approach, page 30 figure 2.24**)

The study of cell structure is known as **cytology** and this can be done using either a compound light microscope or an electron microscope. However, because an electron

microscope gives clearer and detailed images, at this level, we shall study cells mostly as viewed under an electron microscope.

Cell Structures Specific to Prokaryotic Cells

Activity 1

Instructions

Study the illustration of the bacterial cell in **Figure 2**. Use it together with the words given in the box below to fill in the blank spaces in the sentences that follow to make a meaningful paragraph on the description of cell structures specific to the prokaryotic cell and their functions.

resistant, flagellum, respiration, pili/fimbriae, capsule, protecting, elongated, nucleoid.

The…….. is the outer most layer of the prokaryotic cell made of slime. It is responsible for…… the cell. At specific points of the cell membrane are branched tubular extensions known as mesosomes, these carry out……. to produce energy just like the mitochondria in Eukaryotic cell. In the centre of the bacterial cell is a …..…….. which consists of one string-like strand of DNA carrying the hereditary material of the cell. The …….. is an elongated flexible cork-screw shaped structure which when present is used for movement. The ……. are numerous short protein filaments that extend outwards of the capsule used to attach to other cell for reproduction to occur by conjugation. The cell also consists of plasmids which appear as independent circles of DNA. These make the cell ……. to drugs.

Summary

The capsule, 70's ribosomes, flagellum, nucleoid, plasmids, pili/fimbriae and mesosomes are specific to prokaryotic cells. Their functions are embedded in the paragraph above. Other parts such as the cell wall, cell membrane and cytoplasm are also present in the eukaryotic cell. you will find these discussed in the next lesson.

Lesson 2: Cell structure and function

Objectives

By the end of this lesson you should be able to describe cell structures as seen under an electron microscope and state their functions.

Introduction

All the different parts of a cell are broadly divided into three major sub-divisions as shown and described in the table below.

Division	Description
Cytosol	is the fluid part of cytoplasm not contained within membrane-bound organelles.
Cell organelles	are separate structures within a cell that perform a specific function.
Cytoplasmic inclusions	are insoluble, non-living substances within the cytosol of a cell unable of carrying out any metabolic activity.

It is these that we shall be looking at in this lesson and the next. At the end of the discussion of each cell structure is (are) a question (s) to enhance your understanding of the structure when answered.

- **Cytoplasm**

This is an aqueous material which is a solution of chemicals that include simple ions like sodium, phosphates, chlorides, etc. and organic molecules e.g. ATP (Adenosine Tri Phosphate) and nucleotides. It contains all other organelles and it is a site for the occurrence of bio-chemical processes.

Question:

What role do the following substances play in the bio-chemical processes that occurred within a cell?

a) Simple ions such as sodium, phosphates and chlorides
b) Organic molecules such as ATP and nucleotides

- **Cell membrane**

The cell membrane is made up of proteins and phospholipids as major chemical groups. Other chemical groups present include cholesterol, glycoproteins (carbohydrate linked to a protein) and glycolipids (carbohydrate linked to a lipid). It mainly controls the entry and exist of materials in and out of the cell like a border between two countries does. To ably carry out this function, the cell membrane allows into the cell specific substance at its specific points while disallowing others. For this reason, it is said to be selectively permeable.

Question:
How do the following chemical groups present in the cell membrane enable it to carryout its functions:

a) proteins
b) phospholipids
c) cholesterol
d) glycoproteins
e) glycolipids

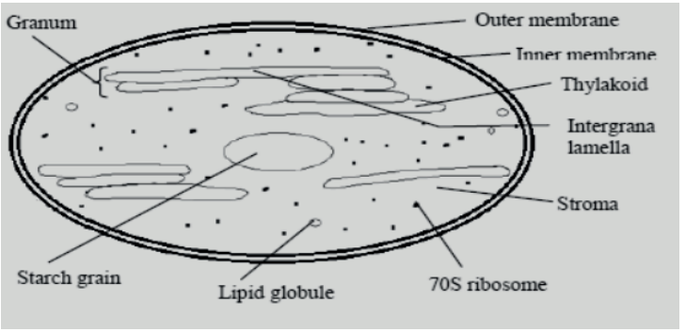
- **Nucleus**

The nucleus is bound by a double membrane known as the nuclear membrane (nuclear envelope). This possesses many pores which permit the passage of large molecules e.g. RNA between it and the cytoplasm. The cytoplasm-like material within the nucleus is called nucleoplasm. This contains the cells genetic material produced by a small body in itsCentre known as the nucleolus. Functionally, the nucleus**;** contains the genetic material of the cell and controls all the chemical activities of the cell like the brain coordinates all body activities.

Question: Why is the genetic material of the cell not directly in contact with other cell components but is rather enveloped in the nuclear membrane?

- **Chloroplast**

Illustration



(Structure in Biological Science, page 201 fig. 7.7)

From the structure above, you can see that the Chloroplasts is bound by a double membrane known as the chloroplast membrane or envelope. Within the chloroplast is a colourless gel (matrix) known as stroma. Stroma contains closed flattened sacks called thylakoids which are piled to form structures known as grana (granum-singular). Within the thylakoids is chlorophyll. Also present in the stroma are starch grains, DNA and oil droplets.

Activity

Study the structure of chloroplast above carefully and answers the following questions:
a)With evidence, state the function of the chloroplast in the plant cell?
b) Describe any 4 adaptations of the chloroplast to the function mentioned above?

- **Mitochondrion (mitochondria-plural)**
  Illustration

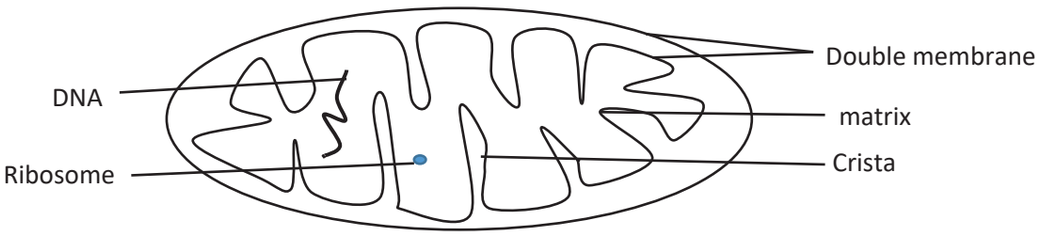


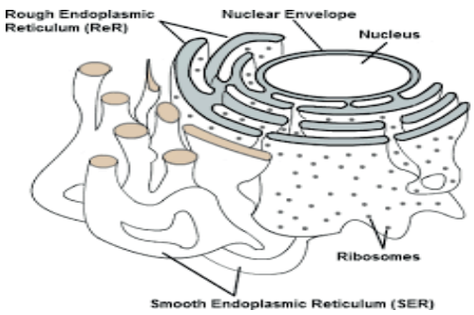
Fig. 9.12
(Diagram in Biological Science, page 276)

As you can observe in the diagram above, the mitochondrion is bound by a double membrane. The outer smooth membrane controls the entry and exit of chemicals. The inner one is folded inwards to give rise to numerous extensions called cristae which are the structures where cell respiration occurs. The remainder of the mitochondrion is the matrix which is a semi-liquid material containing proteins, lipids and traces of DNA. The mitochondria produce energy used by the cell, a process known as respiration.

Question: Why does the mitochondrion possess numerous cristae?

- **Endoplasmic Reticulum (E.R)**

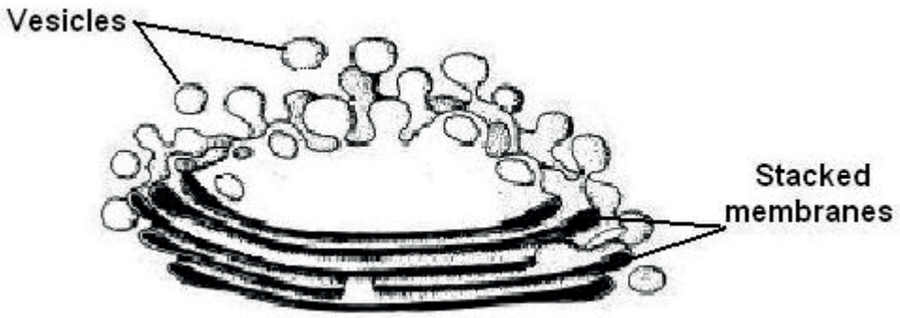
The ER is the system of membranes continuously extending from the outer nuclear membrane to form a cytoplasmic skeleton. Where these membranes are lined by ribosomes, they are called rough endoplasmic reticulum (R.E.R). This is concerned with protein synthesis. Where the membranes lack ribosomes, they are known as smooth endoplasmic reticulum (S.E.R). This is concerned with lipid synthesis.



In addition to protein and lipid synthesis, the E.R provides a large surface for chemical reactions; itis a pathway for the transportation of the materials in the cell; it stores synthesized materials and provides a structural skeleton to maintain cell shape.

Question: Compare the role of the rough endoplasmic reticulum (R.E.R) to that of the smooth endoplasmic reticulum (S.E.R) in a cell?

- **Golgi apparatus**

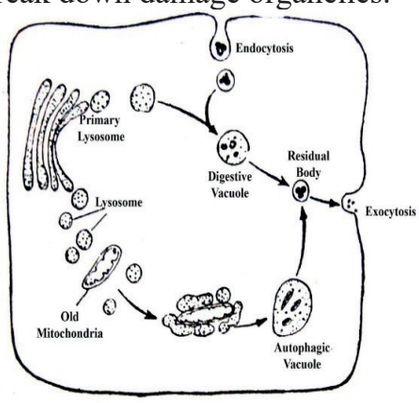


The Golgi apparatus appears as the smooth E.R. though more compact. It is composed of stacks of flattened sacks made of membranes. The stacks are fluid filled and pinch off small membranous sacks called vesicles at their ends. The Golgi apparatus is more developed in secretory cells and thus is used in production of glycoproteins, digestive enzymes and carbohydrates. It transports and stores lipids and also forms lysosomes

Question: Why do mammary glands and neurons have well developed Golgi apparatus while muscle cells have less developed Golgi apparatus?

- **Lysosomes**

This is a simple spherical sac containing digestive enzymes (hydrolytic enzymes) bound by a single membrane with no visible internal structures. The word lysosome comes from two words 'lysis' meaning splitting, 'soma' meaning body. Therefore, lysosomes are connected with the destruction of cells and their structures. Within a cell, lysosomes break down damage organelles.



Question: Point out any two processes in the body in which lysosomes are involved?

Lesson 3: Cell structure and function

Objectives

By the end of this lesson, you should be able to describe cell structures as seen under an electron microscope and state their functions.

Introduction

As previously done in lesson 3, at the end of the discussion of each cell structure is (are) a question (s) to enhance your understanding of the structure.

1. **Peroxosomes**
These are small roughly spherical organelles bound by single membrane. They contain metabolic enzymes mainly catalase enzyme which catalyses the breakdown of hydrogen peroxide which is a toxic bi-product of many chemical reactions within organisms.

Question: Suggest any one organ in the body containing a large number of peroxisomes? Give a reason for your answer?

2. **Vacuoles**
These are fluid filled sacs bounded by a single membrane. Within mature **plantcells**, there is usually one large central vacuole bound by a single membrane called a tonoplast.
The vacuole in plant cells may contain water, nutrients e.g. sugar and amino acids, anthocyanin (coloured pigments) and organic wastes e.g. tannins. In **animal cells,** vacuoles are small, temporary and occur in large numbers. Common types include; food vacuoles, phagocytic vacuoles and contractile vacuoles.

Question:
State the role of vacuoles in:
a) plant cells
b) animal cells

3. **Ribosomes**
These are small cytoplasmic granules found in cells. They are made up of RNA molecules and protein. They occur in groups called polysomes. They are important in protein synthesis.

Question: How are ribosomes structurally adapted for protein synthesis?

4. **Storage granules**
In plant cells, these exist as starch grains either in the chloroplast or in the cytoplasm. In animal cells, food is stored as glycogen in glycogen granules in the cytoplasm of animal cells. Oil/lipid droplets are also found in the cytoplasm of both plant and animal cells.

Question: Compare food stores in plant cells and those in animal cells?

5. **Micro tubules**

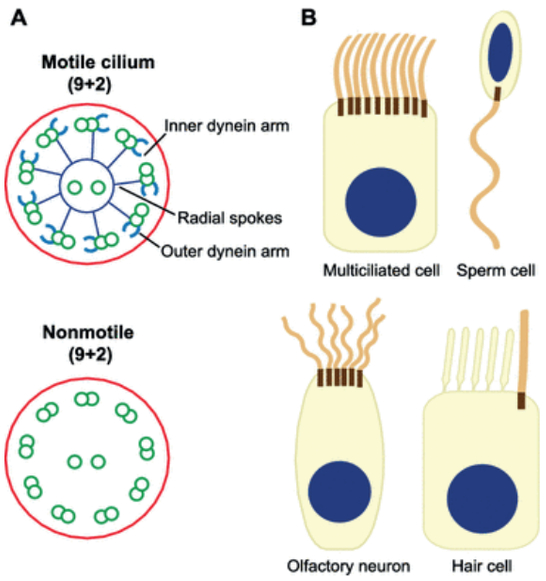
These are slender unbranched tubes occurring throughout living cells. They provide an internal skeleton to the cells. They provide routes along which materials are transported within the cell. They form a frame work along which cellulose cell wall in plants is laid. They are major components of the cilia and flagella. They are found in centrioles and spindle fibres in dividing cells.

Question:
Of what importance are the following cell structures**?**

a) Internal cell skeleton
b) Cilia and flagella
c) Spindle fibres

6. **Cilia and flagella**

These are almost identical except that cilia (cilium-singular) are shorter and more numerous than flagella (flagellum-singular).



Both are out-growth from cells and can grow either in one direction or both (cilia). They have a 9+2 arrangement of microtubules in which a pair of microtubule tubule in the centre is surrounded by 9 pairs of microtubules.

Consider the illustrations on the left:
Their function is to move the whole organism or to move materials within an organism.

Question: How does cilia differ from flagella functionally?

15. Centrioles

These are small hollow cylinders made up of a triplet of micro tubules. They arise from a distinct region of the cytoplasm called centrosome. Each centrosome has two centrioles. As cell division proceeds, the centrioles migrate to opposite poles of the cell where they synthesize spindles fibres.

Question: How are centrioles adapted for enabling the process of cell division?

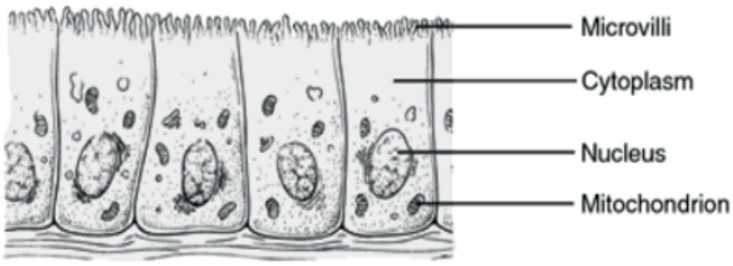
16. Microfilaments

These are very thin strands made up of a protein called actin and a smaller proportion of myosin which proteins are involved in muscle contraction.

Question: How are muscle fibres adapted structurally for contraction and relaxation?

17. Microvilli

These are tiny finger-like projections on the membranes of certain cells. Each microvillus contains bundles of actin and myosin filaments hence allowing them to contract which along with their large surface area facilitate absorption. **Below is an illustration Showing microvilli.**



Question: Suggest any two places in the body of organisms where microvilli are found? In each case state their specific function.

18. Cell wall

As it is already known to you, this is absent in animal cells but is present in plant cells. It consists of fine strands of cellulose embedded in a shapeless insoluble gel made of the polysaccharide pectin or lignin. The cell wall provides support to both herbaceous and wood plants, it contributes to movement of water in plants, it gives the overall shape of the cell and is a store for some food reserve.

Question:

How is the cell adapted to provide support in:

a) herbaceous plants?

b) wood plants?

Lesson 4: Comparing Plant and Animal Cells

Learning Outcome

By the end of this lesson, you should be able to state differences between animal and plant cells.

Introduction

The fact that plants and animals differ also means that their basic structural and functional units, which are the cells, differ. In this lesson, you are going to identify and state differences between plant and animal cells using the illustrations below of a plant and animal cells as viewed under an electron microscope.

Plant cell	Animal cell

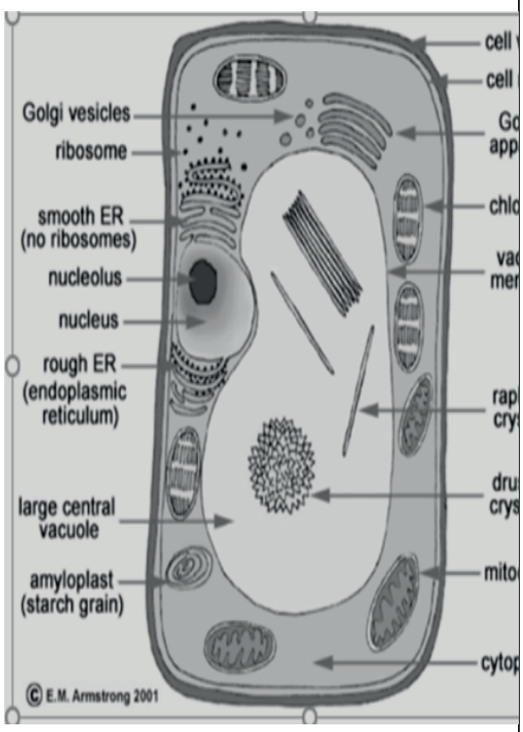
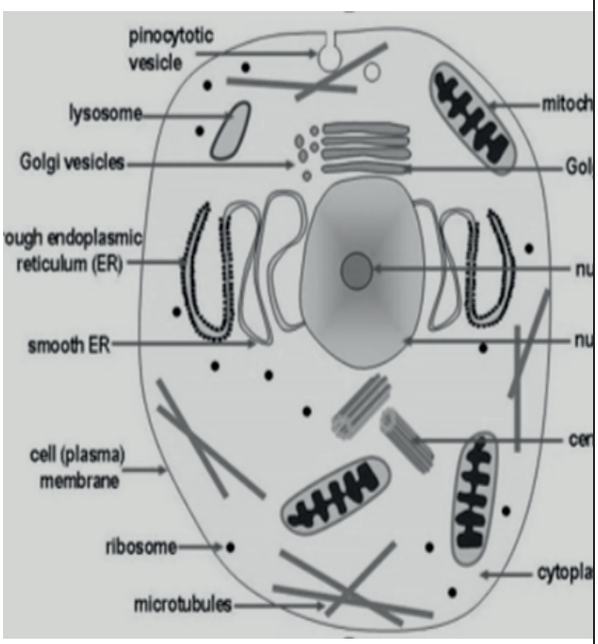

	

Diagram in Biological Science, page 135 figure. 5.11)	**Diagram in Biological Science, page 135 figure. 5.10**

Activity

1. Study the illustrations above and answer the questions that follow:

    a) List all parts that are common to both the animal and plant cell.

    b) List the parts present in the plant cell but are absent in the animal cell.

    c) List the parts present in the animal cell but are absent in the plants cell.

3a) Using your answers in 1a) above, state similarities between the plant and animal cells.

b) Using your answers in 1b) and 1c) above in addition to any other information you can obtain from the illustrations, state differences between the plant and animal cells.

Lesson 5: The fluid mosaic model of the plasmamembrane

Learning Outcome

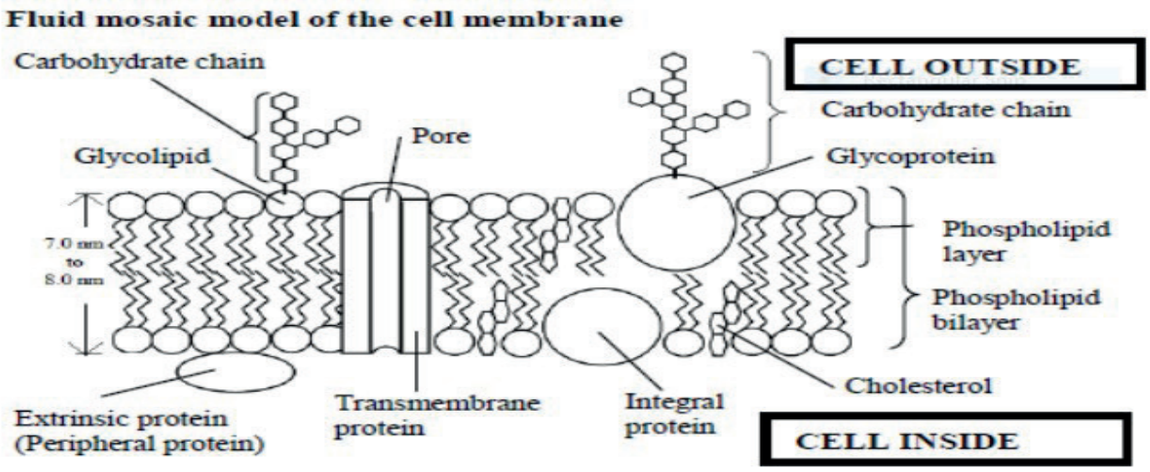
By the end of this lesson, you should be able to describe the fluid mosaic model of the plasma membrane.

Introduction

There are two theories that describe and explain the structure of the plasma membrane and the arrangement of the different chemical groups found in it. That is; the protein phospholipid sandwich theory proposed by Davson and Daniel and the fluid mosaic model proposed by Singer and Nicholson.

In this lesson, we shall focus onthe most recent theory/model, the fluid mosaic model.

The fluid mosaic model



(Diagram in Functional Approach, MBV Roberts, page 27 fig 2.22A)

To understand this model, you have to find a response to why Singer and Nicholson gave the model the name “fluid-mosaic”.

Activity

Match the terms fluid and mosaic, with the appropriate explanation.

Mosaic	The individual phospholipid and protein molecules observed in the illustration above can move laterally, giving the membrane a flexible structure that is constantly changing in shape.

Fluid

The protein molecules that are embedded within the phospholipid bilayer appear as patches of varying sizes and shapes with no regular arrangement.

Summary

From the illustration above do you notice that:

1. The membrane has two layers of phospholipid molecules, one facing outside the cell and the other inside the cell? This is why it's said to be a bimolecular layer of phospholipids.
2. The phospholipids are made up of two different parts; one, a ball like structure and another appearing like a tail? The ball-like structure is a phosphate head which is polar and hydrophilic (charged and interacts with water). The tail like structure on the other hand, is a lipid tail which is nonpolar and hydrophobic (not charged and does not interact with water).

3. There are 3 types of proteins in the membrane.
   a) **Extrinsic (peripheral or side) proteins**; are found at the inner and outer surfaces of the membrane pointing inside the cell and outside the cell respectively.
   b) **Intrinsic (integral) proteins;** are either partly fixed in any one of the phospholipid layers or run across the two phospholipid layers. Those running across both layers are known as **transmembrane proteins**. These may have a pore that allows polar substance to pass through it to form **channel proteins** or may have a binding site similar to the active site of an enzyme to form a **carrier protein**.
   c) **Glycoproteins**. These are proteins formed when a protein in the membrane is linked/connected to a short, branched carbohydrate. They work as antigens.
4. There are phospholipids connected to short, branched carbohydrates? These are known as glycolipids and are involved in cell-to-cell recognition.
5. There are molecules of cholesterol squeezed between the phospholipid molecules? These stabilize the membrane structure by preventing phospholipids from closely packing together.

Lesson 6: Cell Specialization

Learning Outcomes

By the end of this lesson, you should be able to:

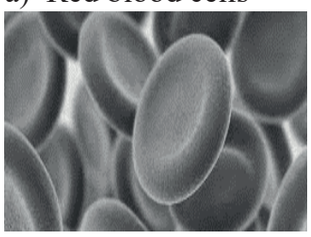
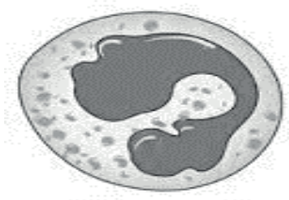
- state functions of named specialized cells.
- describe adaptations of named specialized cells.

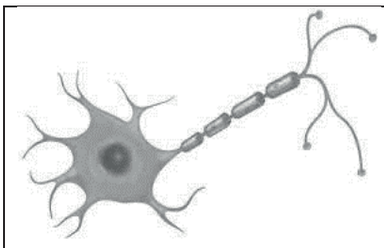
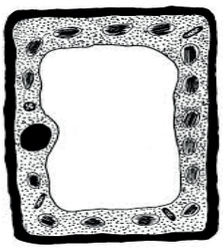
Introduction

In the most basic state, the cells of organisms contain almost similar structures. However, the structure and composition of a cell depending on where it is found and the function it performs vary. This modification in cells enables them to perform specific functions. This is known as cell specialization. Examples of specialized cells in organisms include, the red blood cell, nerve cell, white blood cell, sperm cells. etc.

Activity 1

State the function of each of the following specialized cells and in each case describe any three (3) ways in which the cell is adapted for carrying out its function.

Specialized cell	Function	Adaptations of the cell
a) Red blood cells 		
b) White blood cell 		
c) Nervous cell		

		
d) Sperm cell 		
e) Palisade cell 		

Summary

Besides cells being specialized to performing specific functions, some organisms are made up of a single cell in which all different functions and processes occur. Such organisms are said to be unicellular. Organisms which are made up of many cells are said to be multicellular. Unicellular organisms can exist on their own and do not need specialized exchange surfaces. Multicellular organisms on the other hand are more efficient due to specialization.

TOPIC: CELL PHYSIOLOGY

Lesson 1: Diffusion

Learning Outcome

By the end of the lesson, you should be able to describe the process of diffusion.

Introduction

Cells require a variety of raw materials in order to carry out bio-chemical reactions. These reactions result in formation of both useful products and wastes which have to be moved either within or out of the cell. How do cells acquire raw materials from their surrounding? And how do these useful and waste products move either within or out of the cell? In order to try and answer these questions, let's think about how goods enter and leave a country. Goods enter, leave or move within a country through the different forms of transport such as air, water, road and rail. In the same way, materials move into, within and out of body cells using different physiological processes. These are; pinocytosis, phagocytosis, active transport, diffusion and osmosis. However, in this lesson, we are going to focus on diffusion.

a) Diffusion

Activity 1: An experiment to demonstrate diffusion in gases.

Materials:

- a small dry empty transparent bottle
- a match box
- paper and pen

Procedure

1. Remove 4 matchsticks from the match box.
2. Hold the matchsticks together and light them at ago.
3. While still burning, drop them into the dry empty bottle and cover it with your palm.
4. Observe for at least 1 minute where the smoke comes from and where it goes after it s produced until when the match sticks are extinguished.

Note: Smoke is a mixture of gases such as carbon dioxide and tiny solid particles from the substance burned.

Questions:

1. Describe the distribution of the smoke at the:
   a) beginning of the experiment.
   b) end of the experiment.

2. How do you explain the distribution of the smoke in 1a) and b) above in terms of concentration?
3. a) Did the spreading of the smoke particles throughout the bottle require energy to take place?
   b) From your answer in 3a) is diffusion a passive or active process?

4. Use the following words **[less transparent, concentration gradient, energy, low, spreads, high]** to fill in the blank spaces in the sentences below to make a meaningful description and explanation of what was observed.

The smoke produced from the matchsticks ……..…….……. through the bottle. This is because the smoke particles from the matchsticks (where they were in a…….…….. concentration) moved to the space within the bottle (where they were in a …….. concentration) following the ……until the smoke particles were evenly distributed throughout the bottle making it ……This occurred with no use of ……..…….

Summary

A similar observation as above is made when tea leaves are added to a glass of water. With time, the brown colour of the tea leaves spreads through the water. This indicates that diffusion occurs either in gases or liquids. It involves the movement of either gas or liquid molecules from their region of high concentration to their region of low concentration (Down or along a concentration gradient or slope). Diffusion is a passive process and occurs until there is equal distribution of molecules throughout the gas or liquid.

Note that there are two kinds of diffusion; simple diffusion where molecules or ions move freely across the cell membrane without being aided and facilitated diffusion where molecules or ions move across the cell membrane being aided by protein carriers.

Lesson 2: Factors affecting the rate of diffusion

Learning Outcomes

By the end of the lesson, you should be able to:

- state how different factors affect the rate of diffusion.
- describe significance (importance) of diffusion to living organisms.

Introduction

The rate (speed) at which diffusion takes place is affected by factors such as concentration gradient, temperature, size/density of molecules, distance over which diffusion occurs and area of the surface over which diffusion occurs.

Activity 1

In this lesson, you will study the observations and explanations given below. Thereafter you will determine and conclude on how each of these factors affects the rate of diffusion. I have done the conclusion on the first factor, that is, concentration gradient for you. Use it as an example to make your conclusion on how other factors affect the rate of diffusion.

1. Concentration gradient

Observation:

When ***one spoon*** of tea leaves is gently added to hot water in a transparent glass container without stirring or shaking, ***it takes more time*** for the brown colour of the tea leaves to spread throughout the water. However, ***less time is taken*** for the brown colour of the tea leaves to spread when ***4 spoons*** of these same tea leaves are added at ago to the same amount of water.

Explanation:

4 spoons of tea leaves, is a ***higher concentration*** compared to ***one spoon*** of tea leaves. This means, ***the concentration gradient*** between the tea leaves and water is ***high*** when ***4 spoons*** of tea leaves are used, and ***low*** when ***1 spoon*** of tea leaves is used**.** Also note that ***the rate of diffusion is low when more time*** is taken for the colour to spread in the water, and ***high when less time*** is taken for the colour to spread.

Conclusion

From the observation and explanation above, we can conclude that on the one hand, *the higher the concentration gradient of the diffusing substance, the higher the rate of diffusion. On the other hand, the lower the concentration gradient of the diffusing substance, the lower the rate of diffusion.*

2. Temperature

Observation:

When one spoon of tea leaves is gently added to ***hot water*** in a transparent glass container without stirring or shaking, ***it takes less time*** for the brown colour of the tea leaves to spread throughout the water. However, **more time is taken** for the brown colour of the tea leaves to spread when this same amount of tea leaves is added to the same amount of ***cold water***.

Explanation:

Hot water has a ***high temperature.*** The tea leaves in this case have a ***high kinetic energy*** and ***move faster,*** so their brown colour ***takes less time*** to spread throughout the water. ***Cold water, however,*** has a ***low temperature***. The tea leaves in that case have a ***low kinetic energy*** and ***move slowly,*** so their brown colour ***takes more time*** to spread throughout the water. Note that ***the rate of diffusion is low when more time*** is taken for the colour to spread in the water, and ***high when less time*** is taken for the colour to spread.

Conclusion:

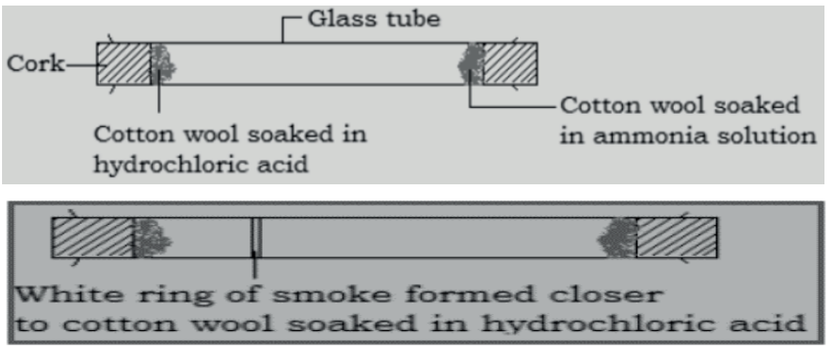
From the observation and explanation above, we can conclude that:……
……
……

3. Size/density of molecules

Observation:

When cotton wool soaked in concentrated aqueous ammonia is plunged into one side of an open ended glass tube and the other end plunged with cotton wool soaked in concentrated hydrochloric acid, a white ring is formed in the glass tube but closer to the end plunged with cotton wool soaked in hydrochloric acid.

Illustration



Explanation

The white ring formed is ammonium chloride from the reaction between ammonia gas (from the concentrated aqueous ammonia) and hydrogen chloride gas (from the concentrated hydrochloric acid solution). The ring is however formed closer to the hydrochloric acid end because ammonia gas has a lower molecular mass of 17g as compared to hydrogen chloride gas with 36.5g. So, the smaller less dense ammonia gas molecules move faster than the larger denser hydrogen chloride gas.

Conclusion:

From the observation and explanation above, we can conclude that:

……
……
……
……

5. Distance over which diffusion occurs

Observation:

Structures where diffusion takes place are lined by a ***thin epithelium*** (thin outer lining tissue). E.g. The alveoli of the lungs involved in exchange of respiratory gases and the ileum involved in absorption of digested.

Explanation:

A ***thin epithelium*** provides a ***short distance over which diffusion*** occurs.

Conclusion:

From the observation and explanation above, we can conclude that:

……
……
……

6. Surface area over which diffusion occurs

Observation:

The lungs involved in exchange of respiratory gases and the ileum involved in absorption of digested ***by diffusion*** are ***highly folded***. However, also note that such parts need to maintain a ***high rate*** of exchanging materials ***by diffusion.***

Explanation:

A ***highly folded surface*** provides a ***large surface over which diffusion*** occurs.

Conclusion:

From the observation and explanation above, we can conclude that:

……
……
……

Question:

Apart from the examples given under the observations above on how the rate of diffusion is affected by surface area and the distance over which it occurs, suggest:

a) any other three ways in which diffusion is important to living organisms but specifically at cellular level?

……
……
……
……

Summary:

The rate of diffusion is affected by the factors above even as you've been able to correctly state in your conclusions. As we have seen above, diffusion is essential in living organisms in enhancing different body physiological processes such as food absorption, gaseous exchange, urine formation etc.

Lesson 3: Osmosis

Objectives:

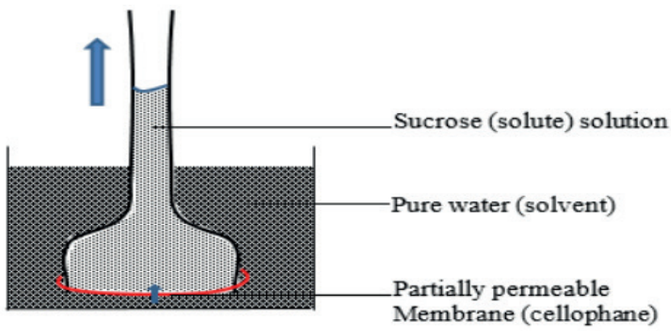
By the end of the lesson, you should be able to:

- describe the term osmosis.
- define terms used in Osmosis.

Introduction

Did you know that osmosis is somewhat similar to diffusion? In both processes the substance moves down a concentration gradient, that is, from its region of high concentration to its region of low concentration. However, osmosis unlike diffusion is restricted to movement of water or solvent molecules across a semi-permeable membrane.

Illustration to demonstrate osmosis using an osmometer



Do you see the solid arrows facing upwards? Those indicate the net flow of water (solvent) into the solution. The membrane at the bottom being partially permeable, allows water molecules to pass into the thistle funnel from the beaker. As a result of net flow of water into the funnel, the solution rises up the tube as indicated by the arrow.

Activity 1:

Study the introduction above and come up with a sentence to describe the term osmosis?

……

……

…….

Activity 2:

In this activity, you're required to study the statements below and basing on them define the different terms used in osmosis.

1. Osmotic potential:

A concentrated solution as compared to a dilute solution, easily allows water molecules to move into it by osmosis. As a result, a concentrated solution is said to have a higher osmotic potential than a dilute solution.

Define osmotic potential?

……
……

2. **2) Osmotic pressure:**

There is need to apply a higher pressure on a dilute solution to prevent water molecules from it moving into another solution as compared to the pressure that would be applied on a concentrated solution. It's as a result of this that a dilute solution is said to have a higher osmotic pressure than a concentrated solution.

Define osmotic pressure?

……
……

3. **Water potential of a cell (**this is also represented by μ_{cell}**):**

Water easily moves out of a dilute solution by osmosis as compared to a concentrated solution. Basing on this, a dilute solution is said to have a higher water potential than a dilute solution.

Define water potential?

……
……

4. Solute potential (this is also represented by μ_s**):**

A concentrated solution is said to have a higher solute potential than a dilute solution. This is because the concentrated solution contains more solute than the dilute solution. Also note that addition of solute into a solution lowers its water potential.

Define water potential?

……
……

5. **Pressure potential (**this is represented by μ_p**)**

This is a force extended on the cell contents by the cell wall as a result of reaching the cell wall after water absorption. It has a positive value**.**

Summary

The water potential of pure water is zero. The water potential and solute potential of a cell are always negative while the pressure potential is positive**.** These three can be related using the formula below**.**

Water potential (Negative) μ cell	**=**	**Solute potential (Negative) μ s**	**+**	**Pressure potential Positive) μ p**

From this formula, when any two of them are given, the one not given can be calculated. Other terms commonly used under osmosis to refer to solutions include hypotonic, hypertonic and Isotonic. A hypotonic solution is one which is more dilute compared to another solution, a hypertonic solution is one which is more concentrated than the other being compared to it. Lastly, an isotonic solution is one having the same concentration as another being compared to it.

Lesson: Importance of osmosis and active transport

Learning Outcomes

By the end of the lesson, you should be able to:

- describe significance of osmosis in plants.
- define active transport and state its significance to living organisms.

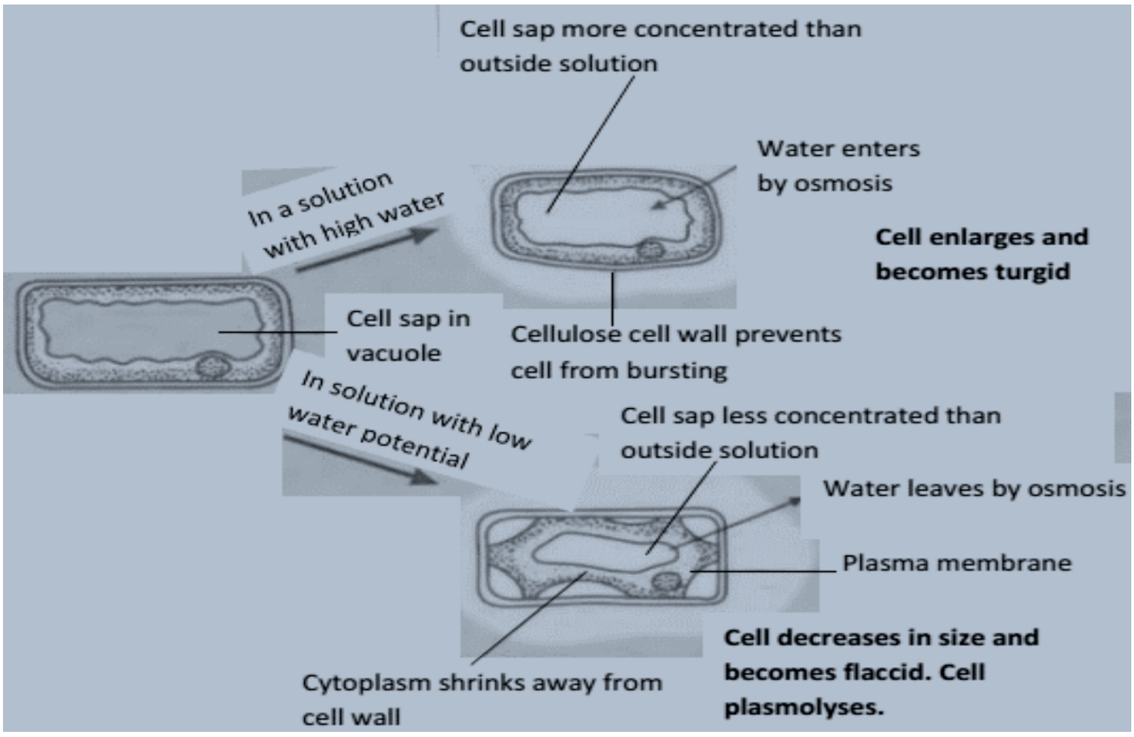
Introduction

From your Senior Two work on ***Transport***, you learnt that ***plant cells of the roots have a higher solute potential compared to that of their surrounding region in the soil.*** This allows water to be drawn from the surrounding into the cells by osmosis which brings about their swelling. The inflow of water into the vacuole by osmosis, develops an internal hydrostatic force which presses the protoplasm against the cell wall. This force is known as turgor pressure. Turgor pressure is opposed by an opposite force exerted by the cell wall against the cell contents known as water potential.

On the one hand, when turgor pressure reaches its maximum and the cell wall can no more be stretched, full turgor is said to be achieved and the cell becomes fully turgid. This makes the cells stand erect as well as other plant structures such as leaves and non-woody stems.

On the other hand, when a plant cell is immersed in a hypertonic solution, it loses water by osmosis. Its volume decreases hence the protoplast shrinks to an extent of pulling away from the cell wall. This shrinkage is called plasmolysis. Plasmolysis usually happens to plants exposed to extremely salty water. When a plant loses more water by evaporation than it can absorb, in that its stem and leaves fall, it is said to have wilted.

The explanation above can be summarized by the illustration below:



You can also check Functional Approach; MBV Roberts, page 52, figure 4.5.

Question:
Basing on the introduction above, describe any three ways in which osmosis is important to plants?

Active transport

In the introduction of this lesson, I reminded you of the fact that ***plant cells of the roots have a higher solute concentration as compared to their surrounding region in the soil.*** Basing on this fact, the cells in plant roots have more solute such as ions like Na^+, K+, ureate ion and amino acids than the soil.

Activity

Using a words or group of words given in the text box, complete the description of how plants absorb the solute mentioned above from the soil. Basing on this description, define the term ***active transport***.

against the concentration gradient, high concentration, energy, low concentration

In the same way you would require energy to go up a hill, plants use ……..in absorbing solute from the soil.This is because these solutes move …….... That is, from the soil where they are in …… to the vacuoles of the cells of the plant roots where they are in ……....

Define active transport?

……

……

Question:

Besides absorption of solutes such as mineral ions and amino acids from the soil by plant roots, identify any other three ways in which active transport is significant in living organisms?

……

……

……

Summary

As pointed out in this lesson that active transport uses energy to occur, the following observation suggests evidence for that statement; it is only found in living systems which are continuously producing energy by respiration; increase in temperature and oxygen concentration increases the rate of active transport; when formation or use of ATP is inhibited by such agents as cyanide, active transport will not take place; lastly, cells that take part in active transport contain a large number of mitochondria.

Lesson 5

Learning Outcomes

By the end of the lesson, you should be able to differentiate:

i) Endocytosis from Exocytosis
ii) Phagocytosis from Pinocytosis

Introduction

Endocytosis

The same way you would interpret the term "Endo" in endoskeleton to mean internal or inside, is how it is interpreted here. Therefore, endocytosis refers to the process by which substances are moved into cells. It involves the invagination (folding)of the plasma membrane to form a flask-shaped depression which envelops the material. The neck of the flask then closes, and the invagination becomes sealed off to form a vesicle which moves into the cell.

Note: When a liquid-like substance is taken in by the cell the process is referred to as **pinocytosis** or **cell drinking**. And solid particles are taken in by **phagocytosis** or **cell eating**.

Pinocytosis

This involves continuous formation of tiny channels (pinocytotic channels) at the cell surface by invagination of the plasma membrane. These channels provide a means by which liquids are brought into the cell through formation of vacuoles.

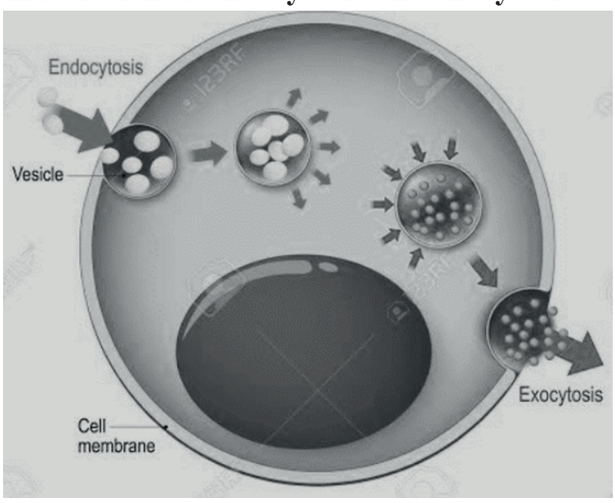
Phagocytosis

During phagocytosis, the solid substance is taken into the cell through a phagocytic vesicle. Lysosomes fuse with the vesicle and secrete digestive enzymes into the vesicle. These digest the substance and the soluble products of digestion are then absorbed into the surrounding cytoplasm.

Exocytosis

"Exo" is the opposite "Endo" so it means external or outside. Therefore, exocytosis refers to the process by which substances are moved out of cells. Here a vesicle containing the substance to be moved moves towards the surface of the cell and fuses with the plasma membrane. The vesicle then opens to the exterior and its contents leave the cells.

Illustration of endocytosis and exocytosis



Activity

1. State any two similarities between:

a) Endocytosis and exocytosis.

b) Phagocytosis and pinocytosis

2. State any two differences between:

a) Endocytosis and exocytosis

b) Phagocytosis and pinocytosis

Summary

These physiological processes are significant in cells in the following ways: Phagocytosis and pinocytosis provide a means of feeding in amoeba and other unicellular organisms. Phagocytosis is used by phagocytic white blood cells to engulf foreign bodies in the body thus protecting organisms from infections, while exocytosis provides a means by which enzymes, hormones, antibodies and cell wall precursors are released from cells.

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