2 The cell as the basic unit of life

A. Revision Notes

Importance of water

- Water is a universal solvent that can dissolve many water soluble substances, e.g. glucose.
- It activates enzymes and provides medium for chemical reactions.
- It is a transport medium to provide nutrients such as glucose and minerals to cells and remove metabolic wastes from cells.
- It is a reactant of some metabolic reactions such as photosynthesis and digestion.
- It is a cooling agent by sweating in human and transpiration in plants.
- It is a temperature stabilizer as water has very high specific heat capacity.
- It is supporting agent to provide turgid internal support for plants; and to provide internal support in animals with hydrostatic skeleton.
- As an external medium, water provides buoyancy for aquatic plants and animals.

Tips for 5**

Electrolytes such as sodium and potassium are mineral ions that influence osmotic balance and are required for normal membrane function.

Importance of minerals

Mineral	Functions	Deficiency symptoms
Sodium (Na^+)	■ Maintain water balance of body. ■ Facilitate nerve signaling and muscle contraction.	Weakness, muscle cramps.
Magnesium (Mg^{2+})	■ As enzyme cofactor in human. ■ Forming chlorophyll in plants.	Central nervous system disorder. Chlorosis.
Calcium (Ca^{2+})	■ Bone and teeth formation. ■ Facilitate nerve signaling and muscle contraction. ■ blood clotting.	Loss of bone mass, muscle cramps, osteoporosis.
Iron (Fe^{2+})	Synthesis of haemoglobin.	Anaemia.
Potassium (K^+)	■ Maintain water balance of body. ■ Facilitate nerve signaling and muscle contraction.	Weakness, muscle cramp.
Phosphate (PO_4^{3-})	■ Bone and teeth formation. ■ Synthesis of nucleotides, cell membrane and ATP.	Weakness, loss of bone mass.
Nitrate (NO_3^{2-})	Synthesis of proteins in plants.	Yellow leaves, poor growth.

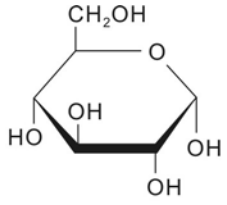
Biomolecules

1. Carbohydrates

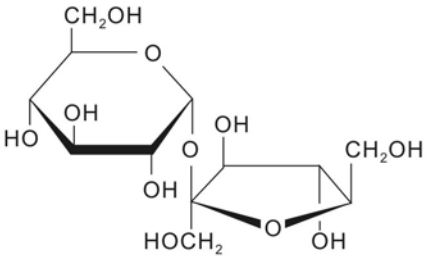
> **Tips for 5****
> Starch and glycogen are suitable forms of storage molecules. Both are insoluble in water, thus would not affect the osmotic balance inside the cells.

Building block units

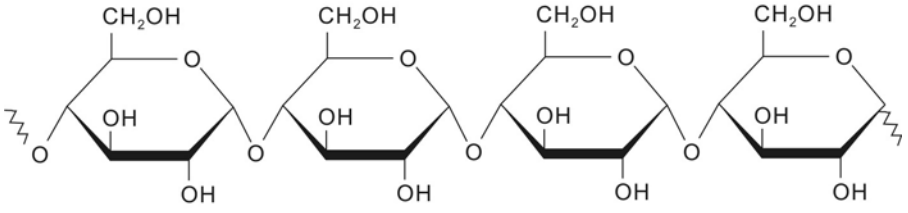
Hexose(6-carbon units) e.g. glucose



monosaccharide (glucose)



disaccharide (sucrose)



polysaccharide (amylose starch)

Functions

- As immediate energy source
  - can be easily oxidized to release energy in aerobic respiration.
- As energy storage
  - structures are highly compact, require small space to stored large number of glucose.
  - store in form of glycogen in liver and muscles in human, in form of starch in plants.
- As structural component
  - cellulose is the main component of plant cell walls.

> **Tips for 5****
> Chitin is structural component of fungal cell walls.
> Peptidoglycan is structural component of bacterial cell walls.

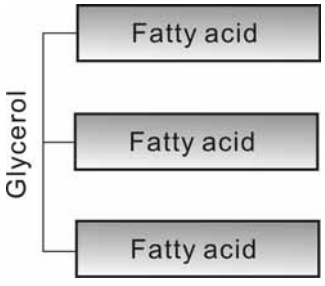
Different types of carbohydrates

	Monosaccharide	Disaccharide	Polysaccharide
Number of sugar units	One	Two	More than two
Solubility in water	Soluble	Soluble	Insoluble
Reducing power	Reducing	Reducing except sucrose	Non-reducing
Example	Glucose, fructose, galactose	Maltose (glucose + glucose) Sucrose (glucose + fructose) Lactose (glucose + galactose)	Starch, glycogen, cellulose, chitin, peptidoglycan

2. Lipids

Building block units

One glycerol molecule and three fatty acid molecules



Functions

- As energy source
  - When body is short of carbohydrates, lipids will be metabolized to supply energy.
  - they have high H:O ratio, thus produce more energy than carbohydrate per unit mass.
- As energy storage
  - store in form of fats in animal and oils in plants (seeds).
- As structural component
  - phospholipids are the major component of cell membranes and contribute to differential permeability of cell membrane: membrane permeable to lipid-soluble substances.
  - component of cytoplasm.
  - waxy layer in exoskeleton of insect and cuticle on leaves of plants act as a moisture barrier.
- As heat insulation
  - stored as adipose tissue under the skin to form an insulating layer which reduces heat loss due to low conductivity of fat.
- Protection
  - stored in important organ such as liver to act as shock-absorber for protection.
- Other
  - cholesterol as raw material to make steroid hormones to regulate physiological process.

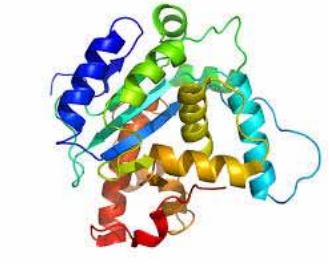
Tips for 5**

Lipids and amino acid can be broken down to carbon skeleton and enter the Krebs cycle to yield ATP. Both act as alternative energy source.

3. Proteins

Building blocks units

Amino acids



Functions

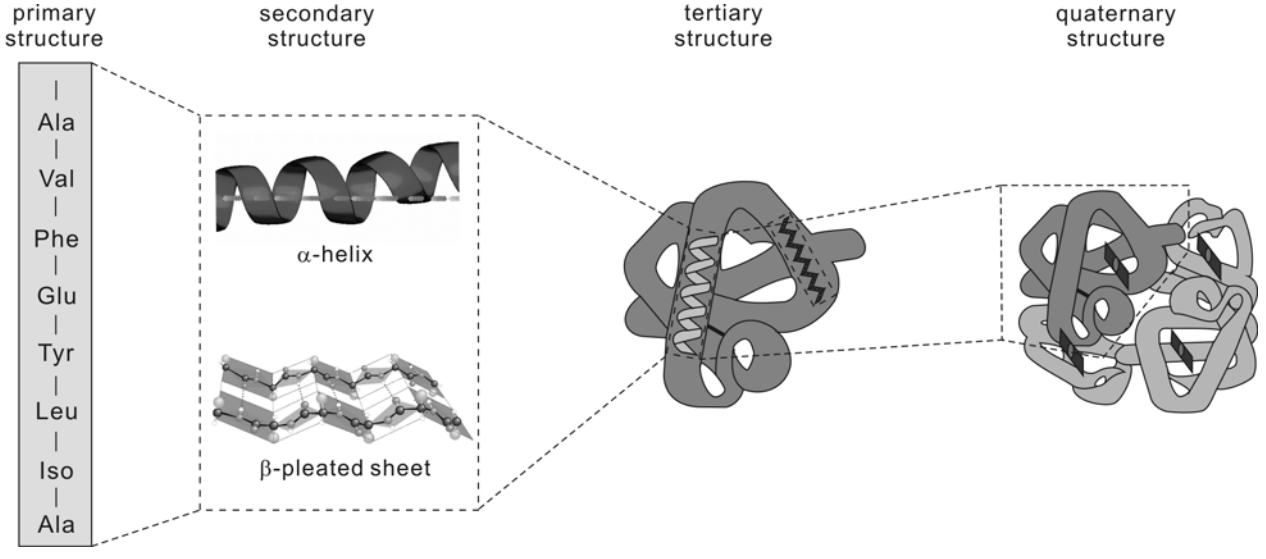
- As energy source
  - amino acid can be broken down to carbon skeleton and enter the Krebs cycle to yield ATP.
- As structural component
  - major component of cell membranes, contribute to differential permeability of cell membrane.
  - serve as channel which selectively enhances water-soluble molecules and ions to go through the membrane.
  - component of cytoplasm.
- Protection
  - keratin in fingernails for defense.
  - antibodies for defense.
- Regulate body activities as hormones
  - progesterone, a lipid hormone to control the menstrual cycle.
  - Follicle stimulating hormone, a protein hormone to control the maturation of ovarian follicle.
- Regulate chemical reactions
  - enzymes speed up chemical reactions.
- Transport
  - Haemoglobin carry oxygen to all parts of the body.

Four levels of protein structures *DSE-BIO: 13 IBQ10*

- Primary structure
  - proteins are made up of 20 amino acids.
  - amino acids are joined together to form polypeptide chain.
  - a sequence of amino acids in a polypeptide chain determine the final conformation of protein.
- Secondary structure
  - single polypeptide fold into a regular, repeating shape known as α-helix and β-sheet.
- Tertiary structure
  - the α-helix and β-sheet are connected, coiled and folded into a compact and globular 3D structure.
- Quaternary structure
  - The aggregation of two or more protein subunits, each has its own tertiary structure.

HKDSE corner

2013 Paper 1B essay questions require candidates to relate the role of protein structure to its functions.



The four levels of protein structure

Comparison between fibrous protein and globular protein

	Fibrous protein	Globular protein
Solubility in water	Insoluble	Soluble
Level of protein structure	Secondary structure (either α-helix and β-sheet)	Tertiary or quaternary structure
Function	Structural or supportive role	Highly diverse
Examples	■ Keratins in fingernail: protection. ■ Collagen: structural component of tendon and bone. ■ Fibrin: component of blood clots.	■ Insulin: regulate blood glucose level. ■ Haemoglobin: carry oxygen. ■ Immunoglobulin: immune response.

4. Nucleic acids

Building block units

Nucleotides composed of 5-carbon sugar, a nitrogenous base and a phosphate group.

Functions

- Carry genetic information coding for protein.
- Control the heredity features of organisms.

Comparison between DNA and RNA

	DNA	RNA
5-carbon sugar	deoxyribose	oxyribose
Nitrogenous bases	adenine (A), thymine (T), guanine (G), cytosine (C)	adenine (A), uracil (U), guanine (G), cytosine (C)
Structure	double and single strands	single strand

Test for biomolecules

1. Reducing sugar (All monosaccharides and disaccharides except sucrose)

Benedict's test

- Add equal volume of Benedict's solution into a food extract.
- Heat the mixture in a boiling water bath.
- Benedict's solution turns from blue to brick-red precipitate if reducing sugar is present.

Tips for 5**

Design investigations to compare the content of biomolecules in different samples.

2. Glucose

Clinistix paper

- Dip the test end of the strip into a food sample.
- The strip turns from pink to blue if glucose is present.

3. Starch

Iodine test

- Add a few drops of iodine solution into a food sample.
- Iodine solution turns from brown to blue-black if starch is present.

4. Lipids

- Emulsion test
  - Add ethanol to about $2cm^3$ above the level of a food sample and shake thoroughly.
  - Add 2 cm^3 of distilled water to the same tube, shake the mixture again.
  - A milky emulsion is formed if a lipid is present.
- Grease spot test
  - Add a drop of food sample on a piece of filter paper.
  - Hold the filter paper near a table lamp, a translucent spot appears. The spot shows the presence of a lipid if it remains on the paper after drying (permanent translucent spot).
  - Further proof : Dip the filter paper with the dry spot into an organic solvent such as ether for a few minutes.
  - Take it out and allow it to dry again in the air.
  - The translucent spot disappears.

5. Proteins

- Biuret test
  - Add a few drops of Biuret reagent to a food sample, shake the mixture gently.
  - The solution changes from blue to purple if a protein is present.
- Albustix paper
  - Dip the test end of the strip into food samples.
  - The strip changes from yellow to green if a protein is present.

TIPS FOR 5**

Give elaboration on how historical events of the development of the cell theory are linked with the nature of science:

i. Science is a process of ongoing inquiries.
ii. Science is affected by the technology and the types of equipment available at the time.

History of the development of the cell theory

Year	Scientist	Historical Events
1665	Robert Hooke (British scientist)	■ He use a primitive microscope (30X) to observe a piece of cork from the oak bark. ■ He observed a network of tiny boxlike compartments from thin slice of cork. ■ He called these boxes 'cells'. But actually, it is not cell, what he saw were the cell walls of cork tissue.
Few years later	Antonie van Leeuwenhoek (Dutchman microbiologist)	■ He produced better microscope (300X) and he became the first to observe living cells. ■ He reported the discovery of protozoa. He saw bacteria for the first time nine years later.
1830	Robert Brown (Scottish botanist)	■ He found that every plant cell he looked at contained a rounded structure called nucleus.
1839	Matthias Schleiden (a German botanist) Theodor Schwann (a German physiologists)	■ They proposed that both plants and animals are made up of cells and they also proposed that cells are the basic unit of structure and function in all organisms (the first and second ideas of cell theory).
1855	Rudolf Virchow	■ He proposed the theory that all cells come from pre-existing cells by division (the third idea of cell theory).

1. Cell theory

- All organisms are made up of one or more cells.
- Cells are the basic units of structure and function in all organisms.
- New cells are formed only by the division of pre-existing cells.

> **TIPS FOR 5****
> The features of advances in microscopy are increase in magnification and resolution.

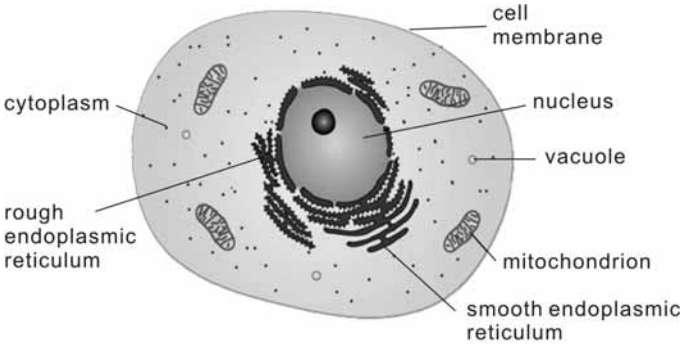
2. Microscope technology *AL-BIO: 11 I Q3*

	Light microscope	Transmission microscope	Scanning electron microscope
Light source	It uses transmitted light to pass through the specimen.	It uses electron beams to pass through the specimen.	It bounces electrons off the specimen.
Sample	Live or dead	Dead	Dead
Image view	Two-dimensional, color images.	Two-dimensional, black and white images.	Three-dimensional, black and white images.
Resolution / Magnification	Lowest, subcellular cell. structures cannot be observed.	Highest, subcellular cell structures can be observed.	Moderate, only surface features can be observed.
Sample preparation	Samples do not need to be fixed and processed.	Samples have to be fixed and sectioned in order to preserve and stabilize cell structure.	Sample have to be fixed and coated with a thin layer of heavy metal, in order to preserve and stabilize cell structure.
	Ultra-thin sections are not needed.	Ultra-thin sections must be used.	Ultra-thin sections are not needed.

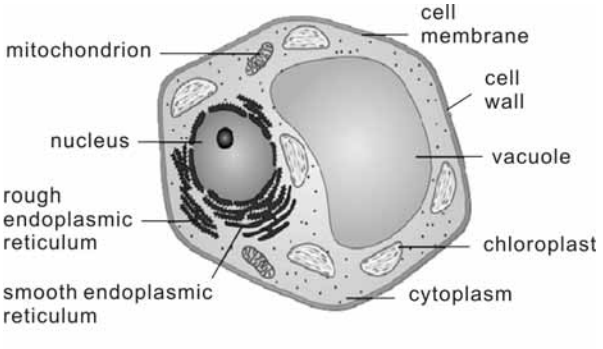
3. Differences between plant cells and animal cells

Features	Animal cells	Plant cells
1. Shape	Irregular cell shape	Regular cell shape
2. Cell wall	No cell wall	Have cell wall
3. Chloroplast	No chloroplast	Have chloroplast
4. Food reserve	Glycogen granules as food reserves	Starch as food reserves
5. Vacuole	Small or no vacuole	Large, central vacuole

4. Sub-cellular structures and their functions *AL-BIO: 00 I Q1; DSE-BIO: 17 1BQ4a*



Subcellular structures in animal cell



Subcellular structures in plant cell

> **TIPS FOR 5****
> Identify cell organelles, as seen under the light and electron microscopes.

Subcellular structures	Membrane structure	Functions	Cells with high abundance of the organelles
Nucleus	Double	■ Contains the chromosomes and store the genetic information coding for proteins. ■ It controls the heredity characteristics of an organisms.	All eukaryotic cells have nucleus.
Rough endoplasmic reticulum	Single	■ The site of protein synthesis and transport as it contains ribosome.	Cells with high protein making activity (e.g. enzyme-secreting cells/ pancreatic cells).
smooth endoplasmic reticulum	Single	■ The site of lipid and steroid hormones synthesis and transport. ■ It does not contain ribosome.	Cells produces steroid hormones (e.g. cells of the ovaries and testes).
Mitochondria	Double	■ The main site of aerobic respiration for ATP production.	Cells with high metabolic activity (e.g. liver cells, skeletal muscle cells and sperm cells, epithelial cell of the small intestine).
Chloroplast	Double	■ The site of photosynthesis.	Green plant cells.
Cell wall	None	■ Protection, support and give shape to plant cell.	All plant cells have cell wall.
Vacuole	Single	■ Storage of water, sugars, pigments and metabolic wastes.	Both plant cells and animal cells.

TIPS FOR 5**

Relate the abundance of organelles in specific cells to their physiological significance.

5. Differences between prokaryotes and eukaryotes

	Prokaryotes	Eukaryotes
Size	Relatively smaller.	Relatively larger.
Presence of nucleus	Do not have true nucleus.	Have true nucleus.
Presence of membrane-bound organelles	Do not have membrane-bound organelles.	Have membrane-bound organelles.
Organization of DNA	Chromosomal DNA is circular and locates in nucleoids.	Chromosomal DNA is linear and locates in nucleus.

B. Multiple Choice Questions

1. Water is essential to life, but contaminated drinking water may be very harmful. In 2015, many housing estates of Hong Kong were found to have water supply with lead contamination problems. What are the adverse effects to human health if there is high level of lead in drinking water?

   (1) Low blood pressure in adults.
   (2) Delays in physical or mental development in infants.
   (3) Young children may have deficits in learning.

   A. (1) only
   B. (1) and (2) only
   C. (2) and (3) only
   D. (1), (2) and (3)

2. Charlotte bought a bottle of fertilizer for her garden plants. The label contains three large letters: **KPN** and some descriptions. What is incorrect for the following descriptions?

   A. KPN stand for the inorganic minerals of potassium, phosphates and nitrates.
   B. K is vital for plant growth and has regulatory roles.
   C. P helps plants to build up its cell proteins.
   D. N is significant to maintain cell turgidity.

3. Amino acids are basic units of protein. Which of the following is the correct molecular structure of the two ends of an amino-acid?

   A. N_2H and COOH
   B. H_2N and COOH
   C. H_2N and COH
   D. N_2H and COH

4. Which of the following combinations contain only carbohydrates?

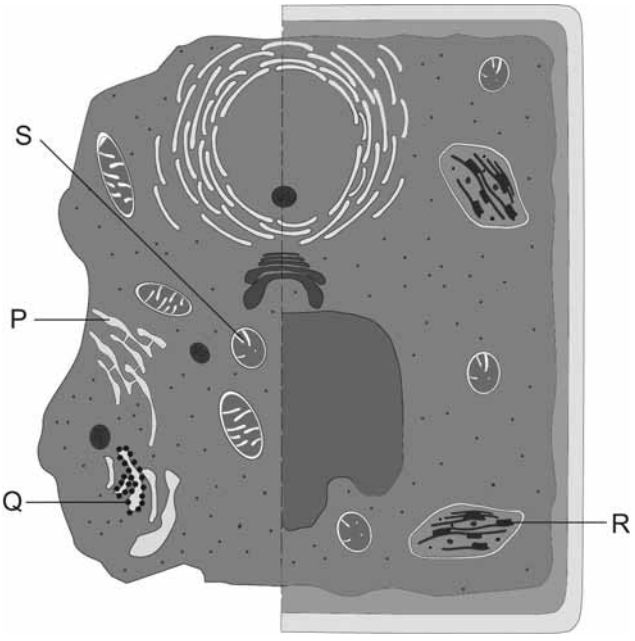
   A. Glucose, starch and cellulose.
   B. Starch, haemoglobin and chlorophyll.
   C. Cellulose, albumin, fructose.
   D. Chlorophyll, nitrates, glucose.

5. Which of the following cells should contain many mitochondria?

   (1) Plant root hair tip cells
   (2) Sperm cell
   (3) Muscle cells

   A. (2) only
   B. (1) and (2) only
   C. (2) and (3) only
   D. (1), (2) and (3)

Directions: Questions 6 and 7 refer to the following diagram.



6. Which of the following combinations is correct?

	Rough endoplasmic reticulum	chloroplast	mitochondrion
A.	P	R	S
B.	Q	S	R
C.	Q	R	S
D.	P	S	R

7. What features most clearly distinguish the above cell from being an animal cell?

A. It has only a few mitochondria and a large central vacuole.
B. It has a cell wall and many chloroplasts containing green pigments.
C. Its shape is one that the cross-section is almost a rectangle.
D. Its vacuole is large enough to hold a large amount of cell sap and crystals.

8. During the preparation of temporary mount for the examination of plant leaf epidermal cells, care should be taken to ensure that

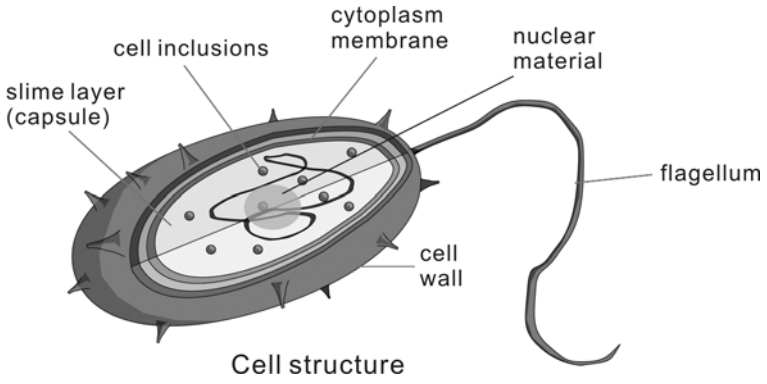
(1) the specimen should not be too large that it cannot be fully covered by the cover-slip.
(2) water should be added to the specimen but the outside of the slide and cover-slip should be dry.
(3) the stage of the microscope should be horizontal and is not tilted.
(4) the leaf should be freshly taken from a living plant.

A. (1) and (2) only
B. (3) and (4) only
C. (1), (2) and (3) only
D. (1), (2), (3) and (4)

9. Many years ago, schools allowed students to pick up cells from their cheek inside to make preparation of live animal cells. Now it is forbidden in Hong Kong because

A. this may cause spread of blood borne diseases like AIDS.
B. it is dirty and disgusting to take cells from the cheek inside.
C. cheek cells easily die on the slide and under the cover-slip.
D. it causes pain and blood shedding in this process.

10. The diagram below is a bacterium.



Cell structure

Bacteria are called prokaryotes because

A. they are very simple organisms and always exist as one cell only.
B. a true nucleus is not found and the organelles are not bound by membranes.
C. each of them has a cell wall and sometimes there is a capsule.
D. they have cytoplasm and usually have flagella.

Answers:

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
C	D	B	A	D	C	B	C	A	B

C. Structured Questions

1. Galactosemia, excessive accumulation of galactose in the blood is a rare inherited fatal disease. It occurs in people who lack the enzyme that converts galactose to glucose. People with galactosemia cannot have lactose in food such as milk or milk products. (10 marks)

(a) (i) Suggest the reason for excluding lactose from the diet? (4 marks)

- When a person drinks milk product that contains lactose, the body break down lactose into glucose and galactose by the enzyme lactase.(1)
- People with galactosemia lack the enzyme to convert galactose to glucose. (1)
- leading to insufficient galactose metabolism. (1)
- too much galactosemia then accumulate in the blood and cause health problem. (1)

(ii) People with milk intolerance are unable to produce the enzyme lactase. Is galactosemia the same as milk intolerance? Explain your answer. (2 marks)

- No, galactosemia differs from milk intolerance. (1)
- People with galactosemia can break down lactose into glucose and galactose but people with milk tolerance do not. (1)

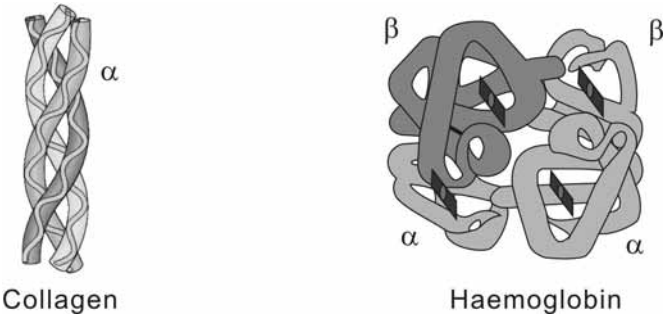
(b) In order to compare the amount of lactose in two different brands of milk, a student performed Benedict's test. Below are steps that the student has done for his investigation.

(1) Put 5 mL each of the two brands of milk into separate boiling tubes.
(2) Add 3 mL of Benedict's solution to each tube, mix well.
(3) Place the boiling tubes in a 40°C water bath for 10 minutes.
(4) Compare the amounts of brick-red precipitate produced in the mixtures.

The above investigation has two mistakes. Suggest and explain how you could improve the investigation. (4 marks)

- Benedict's solution should be added in excess instead of 3 mL (1) so that the amount of precipitate formed is proportional to the amount of the reducing sugar in the sample. (1)
- The mixture needs to be heated in a boiling water bath (>70°C) instead of 40°C water bath (1) in order to provide higher heat energy for the reaction. (1)

2. The diagram shows a haemoglobin molecule and a collagen molecule. Both exhibit different conformations of protein molecules. (8 marks)



Collagen Haemoglobin

(a) Describe the protein conformation of collagen and haemoglobin. (2 marks)

- Collagen has three polypeptide chain in α-helix structure. (1)
- Haemoglobin has multiple binding of four protein subunits. (1)

(b) Describe how protein molecules can be organized into different conformations of collagen and haemoglobin. (6 marks)

- Proteins are composed of 20 amino acids. (1)
- Amino acids are linked by peptide bonds into a polypeptide chain. (1)
- Some polypeptide chains can coil up into α-helix structure and form collagen molecules. (1)
- Some polypeptide chains can coil up into β-sheet structure. (1)
- α-helix and β-sheet structures of polypeptide chains further coil up into a three dimensional shape of a polypeptide, known as protein subunit. (1)
- The binding of four protein subunits to form a single functional structure make up haemoglobin. (1)

3. The table below lists some historical events leading to the development of cell theory.

Time	Scientists	Historical Event
1665	Robert Hooke	He discovered boxlike structure in a cork slice and coined the term 'cell' to science.
1830	Robert Brown	He discovered the nucleus in plant cells.
1839	Matthias Schleiden Theodor Schwann	They observed that both plants and animals are made up of cells. They worked out the first two principles of cell theory.
1855	Rudolf Virchow	He worked out the third principles of cell theory, which built on the work of Theodor Schwann.

(a) State the principle of cell theory according to the following statements. (3 marks)

(1) During mitotic cell division, the duplicated chromosomes separate and move to opposite ends of the cell, forming two identical daughter nuclei. The cytoplasm then divides, forming two daughter cells.

- New cells are formed only by the division of pre-existing cells. (1)

(2) Fungi can be unicellular or multicellular.

- All organisms are made up of one or more cells. (1)

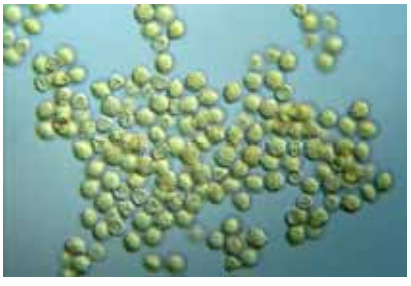
(3) Cells are the smallest unit having all the seven characteristics of life.

- Cells are the basic units of structure and function in all organisms. (1)

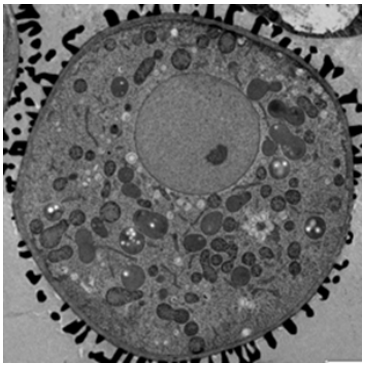
(b) Explain how the historical events in the development of the cell theory demonstrate the following aspects of the nature of science listed in the table below. (3 marks)

Nature of Science	Elaboration
Science relies on development of technology.	Robert Hooke was unable to observe organelles inside the cell. The development of microscopy technology with higher magnification, allows scientists to observe the sub-cellular structures. (1)
Science is based on evidence.	Both Matthias Schleiden and Theodor Schwann used the data from their observation to develop the principles of cell theory. (1)
Development of scientific knowledge is based on our previous understanding of other theories and concepts.	Theodor Schwann's work laid the foundation and gave background knowledge for more research which finally helped Rudolf Virchow to further develop the science knowledge of cell theory. (1)

4. The following photomicrographs are images of the same type of cells obtained by using three different types of microscopes. (9 marks)



Photomicrograph (1)



Photomicrograph (2)

Photomicrograph (3)

(a) Identify the types of microscopes used to produce these three different images of the same types of cells. Give reasons to support your answer. (6 marks)

- Photomicrograph 1: Light microscope. (1)
- Pollens are small without details of the sub-cellular structures seen. (1)
- Photomicrograph 2: Transmission electron microscope. (1)
- Details of the sub-cellular structures seen. (1)
- Photomicrograph 3: Scanning electron microscope. (1)
- Three dimensional image was seen (1)

(b) Compare and contrast the types of microscopes used in making photomicrograph (2) and (3). (3 marks)

- Both use electron beams instead of light. (1)

ANY TWO of the following (2)

- TEM produces two dimensional images while SEM produces three-dimensional image.
- TEM reveals the internal structures of the specimen while SEM reveals the external structures of the specimen.
- TEM has higher magnification than SEM.

D. Essay-type Questions

- **Candidates are required to present their answers in essay form.**
- **3 marks to logical presentation and clarity of expression.**

Mark	Clarity of expression	Relevance to the question	Logical and systemic presentation
3	Answers are easy to understand and fluent	No or little irrelevant materials	Answers are well organized
2	Answers are understandable with some inappropriate use of words	A few irrelevant materials	Answers are organized
1	Answers are not easy to understand	Some irrelevant materials	Answers are disorganized but paragraphing is obvious
0	Answers are difficult to understand	Lots of irrelevant materials	Answers are not orderly connected and properly planned

1. Describe and explain how properties of carbohydrates correlate with their functions. (11 marks)

- Both starch and glycogen function as energy-storage molecules. They are readily hydrolyzed to release glucose molecules for the production of ATP. Also, they are insoluble in water and thus osmotically inactive. (3)
- Cellulose provides structural support in plant cell walls as fibers in cellulose have high tensile strength. (2)
- Glucose is an immediate source of energy. It is easily oxidized to release energy during respiration. Besides, it is soluble in water so that it can be easily transported in blood. (3)
- + 3 marks for logical presentation and clarity of expression (refer to the table above)

Candidates are required to present their answers in essay form. 8 marks will be allocated to relevant content, and 3 marks to logical presentation and clarity of expression.

Mark award for content: Key Points

Functions	Properties relate to the functions
■ Energy-storage molecules. (1)	■ Readily hydrolyze. (1) ■ Insoluble in water. (1)
■ Structural support in plant cell walls. (1)	■ High tensile strength. (1)
■ Immediate source of energy. (1)	■ Easily oxidized. (1) ■ Soluble in water. (1)

(8 marks)

2. Carbohydrates and lipids have some similar functions in living organisms. Describe these functions and explain how they are different in these functions. (13 marks)

- Both serve as source of energy. However, carbohydrates are broken down into pyruvate while triglycerides are broken down into fatty acids before enters Krebs cycle to yield energy. Besides, triglycerides have high H:O ratio, thus produce more energy than carbohydrate per unit mass. (4)
- Both serve as structural components. However, cellulose is the structural component of plant cell wall while phospholipids are structural components of the cell membrane. (3)
- Both can be used as energy storage. Carbohydrates store in the form of glycogen in human liver and muscles, and in the form of starch in plants but triglycerides store in adipose tissue. (3)
- + 3 marks for logical presentation and clarity of expression (refer to p.18).

Candidates are required to present their answers in essay form. 10 marks will be allocated to relevant content, and 3 marks to logical presentation and clarity of expression.

Mark award for content: Key Points

Similar functions	Differences in the functions
Source of energy. (1)	Carbohydrate: break down into pyruvate. (1) Triglycerides: break down into fatty acids. (1) Triglycerides produce more energy. (1)
Structural components. (1)	Cellulose: plant cell wall. (1) Phospholipids: cell membrane. (1)
Energy storage. (1)	Carbohydrate: glycogen and starch. (1) Triglyceride: adipose tissue. (1)

(10 marks)

3. Eukaryotic cells have membrane-bound compartments in which specific metabolic activities take place. Briefly describe the structural compartment of eukaryotic cells and the importance of compartmentalization in eukaryotic cells.
(14 marks)

- Eukaryotic cells are compartmentalized by membrane-bound organelles and each organelle perform unique function. For example, nucleus contains the chromosomes and stores the genetic information coding for proteins. Rough endoplasmic reticulum contains ribosome and it is the site of protein synthesis and transport. Smooth endoplasmic reticulum is the site of lipid synthesis and transport. (3)
- Besides, mitochondria is the main site of aerobic respiration for ATP production while chloroplast is the site of photosynthesis for the synthesis of glucose. (2)
- Compartmentalization plays an important role in eukaryotic cells. Different processes require different environment and pH, compartmentalization allows incompatible chemical reactions to be separated and therefore react each in its own optimum condition. (1)
- It also allows incompatible chemical reactions to take place simultaneously. Moreover, the membranes and the interior space of each type of organelle contain unique proteins enable each organelle to perform unique function. Also, compartmentation increases the surface area of the cell membrane, e.g. inner mitochondrial membrane. This allows more metabolic processes to take place at membranes. (3)
- + 3 marks for logical presentation and clarity of expression (refer to p.18).

Candidates are required to present their answers in essay form. 11 marks will be allocated to relevant content, and 3 marks to logical presentation and clarity of expression.

Mark award for content: Key Points

Structural compartment of eukaryotic cells
■ Nucleus: stores genetic information coding for proteins. (1)
■ Rough endoplasmic reticulum: site of protein synthesis and transport. (1)
■ Smooth endoplasmic reticulum: site of lipid synthesis and transport. (1)
■ Mitochondria: ATP production. (1)
■ Chloroplast: site of photosynthesis. (1)
■ Cell wall: support and give shape to plant cells. (1)
■ Vacuole: stores water, sugar, pigments and metabolic wastes. (1)
Importance of compartmentalization
■ Separate incompatible chemical reaction. (1)
■ Allow incompatible chemical reaction proceed simultaneously. (1)
■ Unique proteins allow each organelles to perform unique function. (1)
■ Increase surface area of membrane to allow more metabolic processes to take place. (1)

(11 marks)