OXFORD IB PREPARED

BIOLOGY

IB DIPLOMA PROGRAMME

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OXFORD

Contents

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1 CELL BIOLOGY

1.1 INTRODUCTION TO CELLS

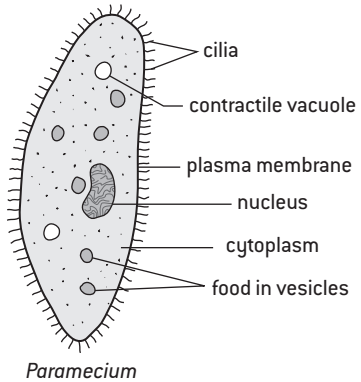
You should know:

- ✔ all living organisms are composed of cells.
- ✔ unicellular organisms consist of only one cell that carries out all functions of life in that organism.
- ✔ cell size is limited by the surface area to volume ratio of the cell.
- ✔ in multicellular organisms, specialized tissues can develop by cell differentiation.
- ✔ differentiation involves the expression of some genes and not others in a cell's genome.
- ✔ multicellular organisms have properties that emerge from the interaction of their cellular components.
- ✔ stem cell division and differentiation is necessary for embryonic development.

You should be able to:

- ✔ discuss exceptions to the cell theory, including striated muscle, giant algae and fungal hyphae.
- ✔ draw cells as seen under the light microscope.
- ✔ describe functions of life in *Paramecium* and a named photosynthetic unicellular organism.
- ✔ calculate the magnification and actual size of structures and ultrastructures shown in drawings or micrographs.
- ✔ explain the limitations of a cell having a large volume and small surface area.
- ✔ describe the therapeutic use of stem cells to treat Stargardt disease and one other example.
- ✔ discuss the ethics of using stem cells.

The ultrastructure of cells is studied in Topic 1.2. The process of cell respiration is studied in Topics 2.8 and 8.2. Nutrition is studied in Topic 6.1 and metabolism in Topic 8.1.



Paramecium

▲ **Figure 1.1.1.** *Paramecium* is a unicellular organism that obtains its food from the environment, digesting it in food vacuoles

All living organisms are formed of cells. Unicellular organisms are formed of only one cell that performs all the functions of life (nutrition, metabolism, growth, response, excretion, homeostasis and reproduction).

Multicellular organisms are composed of many cells that become specialized by differentiation, forming different tissues. These tissues form organs which together make up organ systems. In order to differentiate, cells must express different genes and therefore produce different proteins. All cells in an organism have the same genetic material, but if some genes are expressed and others are not, the resulting cells will be different.

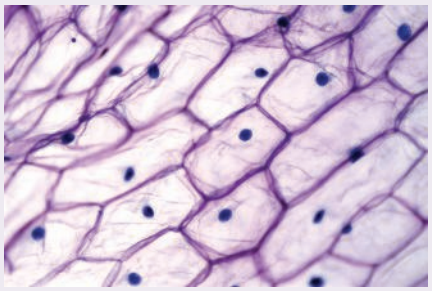
- **Cells** are the basic units of life.
- **Emergent properties** are properties that appear in a complex system (or an organism) but do not appear in the individual units.
- **Differentiation** is the change in a cell to become more specialized.
- **Stem cells** are cells that are capable of differentiation.

Example 1.1.1.

The micrograph shows onion epidermal cells seen under the light microscope with a magnification of ×400.

a) (i) Label the nucleus of one cell.

(ii) Calculate the actual width of this cell. Show your working.



b) Suggest how the surface area to volume ratio of a cell can affect its function.

Solution

a) (i) Any dark circle labelled.

(ii) The magnification is the size of the image divided by the actual size of the cell. Therefore the formula for actual size is:

$$\text{Actual size of cell} = \frac{\text{size of image}}{\text{magnification}}$$

To calculate the width of the cell, you first use a ruler to measure the width of the chosen cell (size of image).

For example, measured cell width = 10 mm

$$\text{Actual width of cell} = \frac{10\text{ mm}}{400}$$

$$\text{Actual width of cell} = 0.025\text{ mm}$$

b) If the ratio is too small the exchange of substances will be too slow, waste substances will accumulate and heat will not be lost efficiently.

Because stem cells have the ability to differentiate into any type of cell, they are used in the development of medical treatments for a wide range of conditions. These include physical trauma, degenerative conditions and genetic diseases such as Stargardt disease. However, there are ethical issues regarding the use of stem cells in the treatment of diseases. Much of the debate surrounding stem cells concerns the use of human embryonic cells. The use of adult stem cells from sources such as blood from the umbilical cord is more convenient and less controversial.

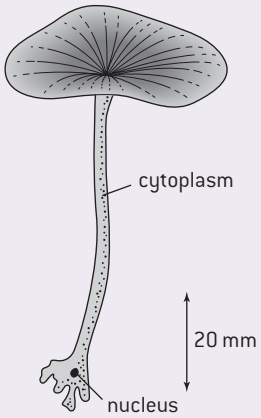
Assessment tip

You have to check whether your result makes sense. 1 mm is equal to 1000 µm, therefore the cell width is 25 µm, which is the average cell width.

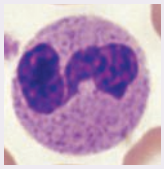
Example 1.1.2.

The pictures show drawings or micrographs from different cells with different magnifications not to scale. Which fully complies with the cell theory?

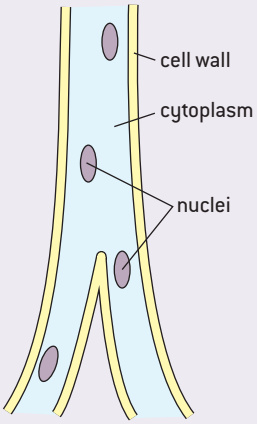
A Giant alga (*Acetabularia*)



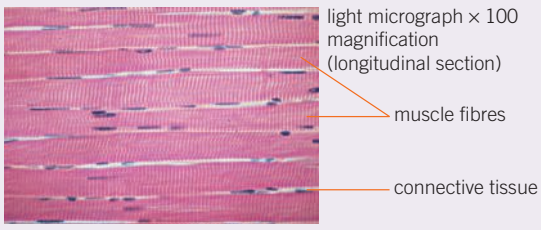
B White blood cell



C Fungal aseptate hyphae



D Striated muscle



Solution

The answer is **B**, white blood cell, because it is surrounded by a cell membrane and has genetic material. The giant alga is a very large organism consisting of only one cell. The size does not correspond to the typical cell. The fungal aseptate hyphae do not have divisions between cells, therefore the cell contains many nuclei. The striated muscle cells are much larger than any average cell and also contain many nuclei. All these are exceptions to the cell theory.

SAMPLE STUDENT ANSWER

Outline the use of human embryonic stem cells (hESC) to treat Stargardt disease. [2]

This answer could have achieved 2/2 marks:

Human embryonic stem cells are unspecialized and can differentiate into almost any cell. These hESC are inserted into the retina of the eye and specialize to become healthy retinal cells which allow a person to regain their vision.

▲ The answer is correct as it outlines the use of stem cells specifically for Stargardt disease.

This answer could have achieved 0/2 marks:

As human embryonic stem cells are undifferentiated cells and are totipotent, they are able to be made into any cell that is needed. The Stargardt disease can be treated by stem cells as adequate cells can be created that the Stargardt disease kills.

▼ This answer only makes a vague reference of what the stem cells are used for, therefore scoring no mark. It is important to read the question carefully and answer what is being asked. In this case, the stem cells being used to replace retinal cells or photoreceptors was a key issue to include in the answer.

1.2 ULTRASTRUCTURE OF CELLS

You should know:

- ✔ eukaryotes have a much more complex cell structure than prokaryotes.
- ✔ prokaryotes do not have cell compartmentalization.
- ✔ eukaryotes have a compartmentalized cell structure.
- ✔ electron microscopes have a much higher resolution than light microscopes, allowing observation of the ultrastructure of cells.

You should be able to:

- ✔ describe the general structure and function of organelles within animal and plant cells.
- ✔ explain how prokaryotes divide by binary fission.
- ✔ draw the ultrastructure of prokaryotic cells.
- ✔ draw the ultrastructure of eukaryotic cells.
- ✔ compare and contrast the structure of prokaryotic and eukaryotic cells.
- ✔ compare and contrast animal cells and plant cells.
- ✔ interpret and label structures in electron micrographs.

An introduction to cells is given in Topic 1.1.

- **Magnification** is how much an image has been enlarged.
- **Resolution** is the minimal distance at which two points that are close together can be distinguished.

Prokaryotic cells do not have a nucleus or membrane-bound organelles, their nuclear material is found in the nucleoid or nuclear region and their DNA is naked, not bound to proteins. Prokaryotic cells have a cell wall, pili and flagella, and a plasma membrane enclosing cytoplasm that contains 70S ribosomes. Eukaryotic cells have a plasma membrane enclosing cytoplasm that contains larger (80S) ribosomes, a nucleus, mitochondria and other membrane-bound organelles. Plant cells are eukaryotic, but they also contain a cell wall and chloroplasts, which are not found in animal cells.

Example 1.2.1.

Complete the table using a tick (✓) for "possible presence" or a cross (✗) for "lack of" to distinguish prokaryotic and eukaryotic cells.

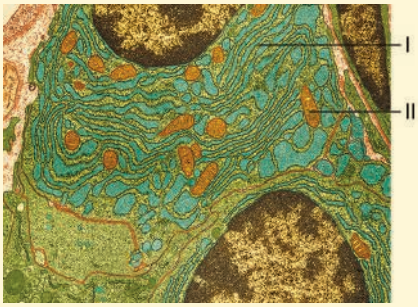
Solution

	Type of cell	
Characteristic	Prokaryotic	Eukaryotic
nuclear membrane	✗	✓
pili	✓	✗
flagellum	✓	✗
mitochondrion	✗	✓
70S ribosomes	✓	✗

The invention of electron microscopes led to greater understanding of cell structure. The maximum magnification of a light microscope is usually lower than × 2,000 and the maximum resolution is 0.2 µm. Beams of electrons have a much shorter wavelength compared with light waves, so electron microscopes have a much higher resolution. The maximum magnification of modern electron microscopes is around ×10,000,000 and the maximum resolution is less than 0.0001 µm.

SAMPLE STUDENT ANSWER

The electron micrograph shows the structures in a blood plasma cell.



a) Using the table, identify the organelles labelled I and II on the electron micrograph with their principal role. [2]

This answer could have achieved 0/2 marks:

Organelle	Name	Principal role
I	rough endoplasmic reticulum (RER)	transport proteins across cell
II	mitochondria	secretes ATP

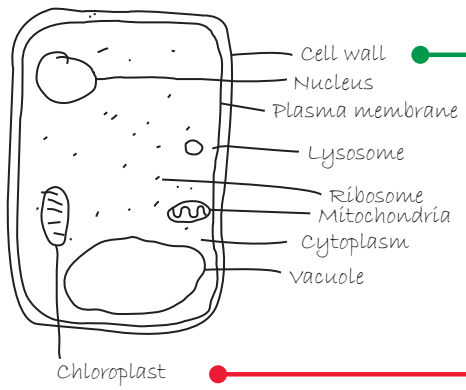
▼ Although the student did correctly identify the organelles, the functions are not correct. The RER does assist in transport across the cell, but in this case the principal role is to synthesize proteins. The mitochondria produce ATP, but they are not in charge of its secretion.

Assessment tip

You must be precise with the wording used.

b) Draw a labelled diagram of a eukaryotic plant cell as seen in an electron micrograph. [4]

This answer could have achieved 3/4 marks:



▲ This student scored the mark for correctly labelling the cell wall. The plasma membrane and the vacuole also scored a mark.

▼ The nucleus, ribosome, chloroplast and mitochondrion are not clear enough for a mark. Although the student correctly labelled the cytoplasm, the mark scheme did not include a mark for this.

Assessment tip

It is good practice to include multiple labels when answering this type of question because it increases the likelihood of identifying all the answers given in the mark scheme.

1.3 MEMBRANE STRUCTURE

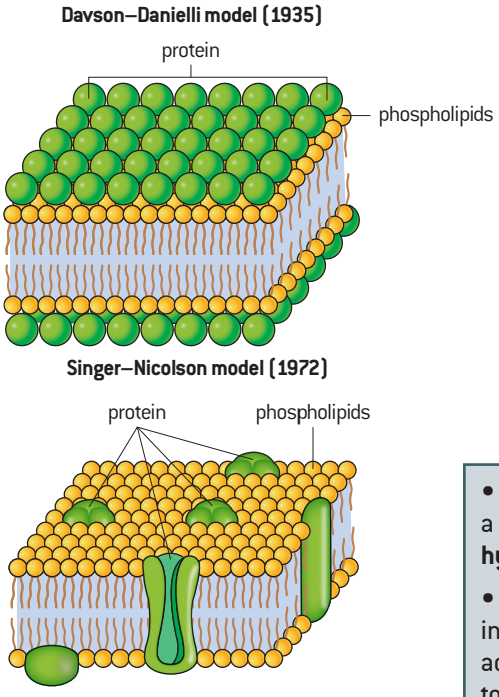
You should know:

- ✔ membranes are formed by phospholipids, cholesterol, proteins, lipoproteins and glycoproteins.
- ✔ membrane proteins are diverse in terms of structure, position in the membrane and function.
- ✔ molecules that have hydrophilic and hydrophobic properties are said to be amphipathic.
- ✔ phospholipids form bilayers due to their amphipathic properties.
- ✔ cholesterol is a component of animal cell membranes.

You should be able to:

- ✔ draw the fluid mosaic model in two dimensions.
- ✔ explain the fluidity and permeability of the plasma membrane.
- ✔ analyse electron micrographs of plasma membranes.
- ✔ analyse information that led to the proposal of the Davson–Danielli model and its later falsification leading to the Singer–Nicolson model.

The ultrastructure of cells was studied in Topic 1.2.



▲ **Figure 1.3.1.** Models of membrane structure

The structure of phospholipids is discussed in Topic 2.3, and transport across membranes is discussed in Topic 1.4.

The cell membrane is formed by a double layer of phospholipids. Phospholipids are amphipathic; this means they have a hydrophilic part and a hydrophobic part. The hydrophilic heads face both the outside and the inside of the cell while the hydrophobic part is in the middle of the bilayer. The low melting point of phospholipids in the bilayer is determined by the kinking of the long chain of fatty acids occurring at unsaturated bonds. This determines that some phospholipids are found in the liquid state while others are in the solid state, making the membrane fluid. In animal cells, cholesterol embedded in this double layer will control this fluidity and permeability to some solutes.

Proteins are embedded in the phospholipid bilayer. Some proteins are found crossing from side to side (integral transmembrane proteins), some partly inside (integral), whereas others are only on the outside (peripheral). Lipoproteins and glycoproteins can also be found on the outside of the cell membrane.

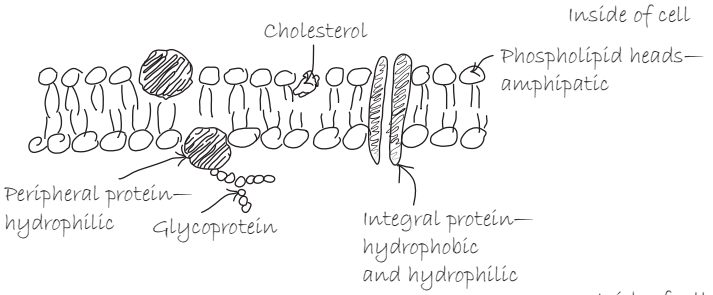
- **Amphipathic** molecules contain a **hydrophilic** (water-loving) and a **hydrophobic** (water-repelling) part.
- **Transmembrane proteins** are integral membrane proteins that span across the membrane. It is very hard to separate them from the membrane, but this can be done using detergents or solvents.
- **Integral proteins** are embedded in the phospholipid bilayer and protrude on only one side of the membrane. They are difficult to separate from the phospholipid bilayer.
- **Peripheral proteins** are temporarily attached either to the surface of the phospholipid bilayer or to integral proteins. They can be separated from the membrane using salts.

Davson and Danielli proposed a cell membrane model with two layers of protein, and a layer of phospholipids between these layers. This model was falsified by Singer and Nicholson. When the membrane was split open it revealed irregular rough surfaces and therefore could not be a constant layer. Membrane proteins were shown to be mobile and not fixed in place, confirming the fluid mosaic structure.

SAMPLE STUDENT ANSWER

Draw a labelled diagram that shows the positions of proteins within the cell membrane. [3]

This answer could have achieved 2/3 marks:



▲ This answer scored one mark for the labelled integral protein shown crossing the membrane (transmembrane). The second mark was for the glycoprotein.

▼ The phospholipid bilayer is drawn but not labelled. Also the protein labelled as peripheral protein is shown embedded in the bilayer, not on the membrane surface; it is really an integral protein.

1.4 MEMBRANE TRANSPORT

You should know:

- ✔ particles move across membranes by simple diffusion, facilitated diffusion, osmosis and active transport.
- ✔ fluidity of membranes allows materials to be taken into cells by endocytosis or released by exocytosis.
- ✔ vesicles move materials within cells.

You should be able to:

- ✔ describe the structure and explain the function of sodium–potassium pumps for active transport in axons.
- ✔ describe the structure and explain the function of potassium channels for facilitated diffusion in axons.
- ✔ provide reasons why tissues or organs used in medical procedures need to be bathed in a solution of the same osmolarity as the cytoplasm.
- ✔ estimate osmolarity in tissues by bathing samples in hypotonic and hypertonic solutions.

The cell membrane controls the entrance and exit of substances to and from the cell. Substances can pass in or out by active or passive transport. Active transport usually occurs against a concentration gradient; therefore it requires energy. Passive transport does not require energy and includes simple diffusion, facilitated diffusion and osmosis. Small molecules pass through by simple diffusion. However, charged molecules do not diffuse through the hydrophobic part of the membrane. Ions with positive or negative charges cannot easily diffuse through, while polar molecules, which have partial positive and negative charges over their surface, diffuse at very low rates. Slightly larger molecules pass by facilitated diffusion; channel proteins enable the diffusion of some molecules. Water molecules pass through by osmosis.

Substances that cannot enter through channel proteins because they are too large require bulk transport; this is transport in membrane-bound vesicles. Bulk transport into the cell is called endocytosis and bulk transport exiting the cell is called exocytosis. In endocytosis, the fluidity of the cell membrane allows the membrane to surround the particle to be ingested. In exocytosis, vesicles formed in the Golgi complex fuse with the membrane to transport the substances out of the cell.

The ultrastructure of cells was given in Topic 1.2 and the structure of cell membranes was discussed in Topic 1.3.

- **Passive transport** is the movement across the membrane without the use of energy.
- **Facilitated diffusion** is the passive transport of molecules or ions across the cell membrane through specific transmembrane proteins (channel proteins).
- **Active transport** is the movement across the membrane requiring energy in the form of ATP.
- **Osmosis** is the passage of water through a selectively permeable membrane, from a higher water potential (lower solute concentration) to a lower water potential (higher solute concentration).

Example 1.4.1.

The potassium channels in the axons can show an open or closed configuration. This change in structure depends on the charge present on each side of the membrane; therefore these channels are called voltage-gated.

a) Explain how the disposition of the proteins of the potassium channel in the membrane assists in the movement of ions.

b) Suggest the mode of transport of potassium through these channels.

Solution

a) The proteins of the channel are transmembrane proteins. The hydrophobic parts of the proteins are embedded in the tails of fatty acids of the phospholipid bilayer. The hydrophilic sections of the proteins are on the surface of the inner part of the membrane in contact with the cytoplasm, and on the surface of the part of the membrane in contact with the outside of the cell. The proteins make a tunnel, where the inside is also hydrophilic, allowing the passage of ions (and water) through the centre, acting therefore as a channel. These channels are very specific; they allow only potassium ions to pass through, not smaller sodium ions which have the same charge.

b) Facilitated diffusion, because it occurs through a protein channel and it does not require energy.

Example 1.4.2.

Compare and contrast osmosis and active transport.

Solution

The tick (✓) means it occurs, the cross (✗) that it does not occur.

	Osmosis	Active transport
Movement across cell membrane	✓	✓
Transmembrane protein required	✓	✓
Energy required	✗	✓
In the direction of a concentration gradient	✓	✗

Assessment tip

You do not need to answer the question in a table, but it helps to make sure you are really comparing the two modes of transport. Remember you need at least one similarity and one difference. If the question is worth 3 marks you need to write at least three characteristics.

The sodium–potassium pump allows a nervous impulse to occur along the axons of neurons. This involves the movement of sodium and potassium ions by facilitated diffusion through membrane proteins forming channels. The concentration gradient allowing for these movements is built up by the sodium–potassium pump protein, which carries out this process through active transport. Three sodium ions are transported across the protein to the outside of the cell against a gradient using 2 ATP molecules. Two potassium ions can then enter the cell by diffusion.

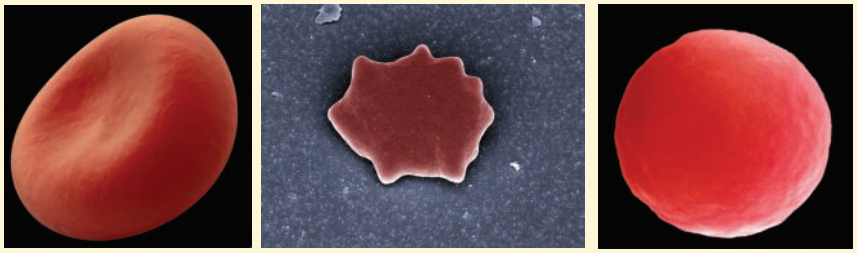
- **Osmolarity** is the measurement of the solute concentration of a solution, expressed as the total mass of solute (or osmoles) per litre of solution.
- An **isotonic solution** shares the same concentration as the tissues or cells it is bathing.
- A **hypertonic solution** has a higher solute concentration than the tissues (or cells) it bathes.
- A **hypotonic solution** has a lower solute concentration than the tissue it bathes.

SAMPLE STUDENT ANSWER

Red blood cell 1 is a normal red blood cell.

Red blood cell 2 and red blood cell 3 are two red blood cells that have been placed in solutions with different concentrations of solutes (osmolarities).

red blood cell 1 | red blood cell 2 | red blood cell 3



a) Deduce, with a reason, which red blood cell has been placed in a hypertonic solution. [1]

This answer could have achieved 1/1 marks:

Red blood cell 2, because all water left the cell by osmosis to try to even out the concentration gradient.

▲ The answer scores one mark because it identifies the shrunken cell.

This answer could have achieved 0/1 marks:

Red blood cell 1 was placed in the hypertonic solution, because it is thicker than a normal blood cell.

▼ The answer does not acknowledge that it is red blood cell 2 (because it has shrunk or lost water, or that its volume has decreased).

b) State what change there has been in the cell surface area to volume ratio in red blood cell 3. [1]

This answer could have achieved 1/1 marks.

It has decreased.

1.5 THE ORIGIN OF CELLS

You should know:

- ✔ cells can be formed only by division of pre-existing cells.
- ✔ the first cells must have arisen from non-living material.
- ✔ the endosymbiotic theory can explain the origin of eukaryotic cells.

You should be able to:

- ✔ analyse evidence from Pasteur's experiments that spontaneous generation of cells and organisms does not now occur on Earth.
- ✔ use modern apparatus to design an experiment that repeats Pasteur's experiment.

Stanley Miller and Harold Urey carried out experiments to show how the first cells might have arisen from non-living material. They passed steam through a mixture of methane, hydrogen and ammonia, representing the early Earth atmosphere. Electrical discharges were used to simulate lightning. They found that amino acids and other carbon compounds needed for life were produced.

The endosymbiotic theory explains the evolution of eukaryotic cells from prokaryotic cells. Mitochondria are thought to be aerobic prokaryotes that were engulfed by other prokaryotes and remained

In Topic 5.1 you will study the evidence for evolution.

inside the cells. Likewise, chloroplasts are thought to have been photosynthetic prokaryotes engulfed by other prokaryotes. Both these organelles maintain many of the features of prokaryotic cells, such as their own circular DNA and 70S ribosomes, and they also possess double membranes produced by the endocytic mechanism.

Assessment tip

Negative questions are not very frequent, but you must look out for them, as they can lead to confusion.

Example 1.5.1.

Which is **not** evidence for the endosymbiotic theory?

A. Prokaryotes can carry out photosynthesis

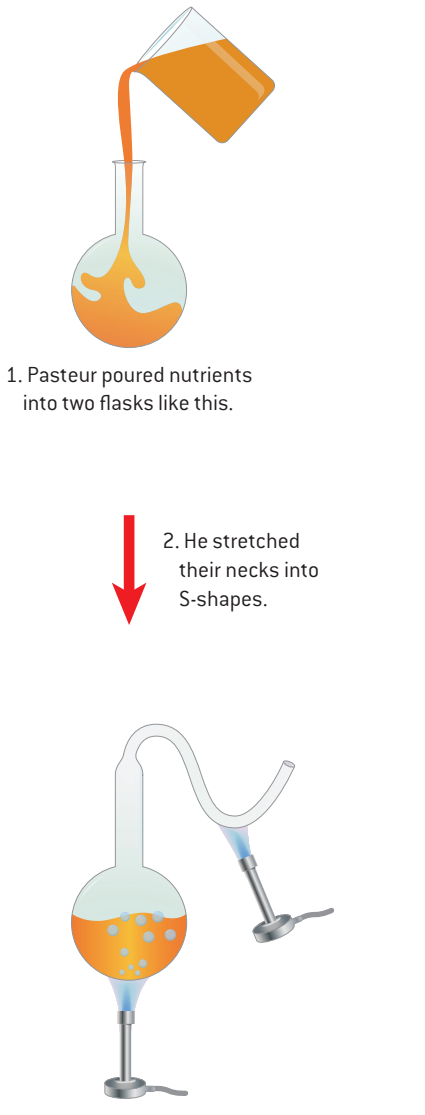
B. Mitochondria have a double membrane

C. Chloroplasts have 70S ribosomes

D. Chloroplasts have DNA

Solution

The correct answer is **A**, as although this is a true statement, the fact that some prokaryotes are photosynthetic does not show that these were engulfed by other prokaryotes.



▲ **Figure 1.5.1.** Pasteur's experiments

In the past many people believed that living things could spring up from non-living materials. Their belief was based on observations they had made, such as maggots appearing in rotten meat. This idea was called spontaneous generation. Pasteur's experiments with broth in swan-necked flasks were carried out to prove whether microbes could be spontaneously generated or whether they could come only from pre-existing cells.

Pasteur investigated how broths turned bad in the following way. Since he knew that excess heat could kill living things, he boiled some broth in flasks to kill anything that might be living in it at the start. He then heated the necks of the glass flasks until they were soft, and pulled them out into a long, thin, curving tube called a swan-neck. The broths in the flasks did not go bad. Then Pasteur broke open one of the flasks and exposed the broth to the open air and this time he noticed that the broth did go bad. This made Pasteur conclude that there was something in the air that was affecting broth. In the swan-necked flasks where the broth was clear, whatever was affecting the broth might have settled in the bend of the neck and therefore not reached the broth. To test his idea he tipped a swan-necked flask so that some of the broth went into the bend where dust and other particles may have collected, and then he tipped it back again. The broth in this second flask then went bad. Pasteur concluded that whatever was causing the change could be carried by air currents, but it must be heavier than air as it settled in the bend in the swan-neck.

Example 1.5.2.

What theory did Pasteur falsify with his experiments?

A. Independent assortment

B. Spontaneous generation

C. Endosymbiosis

D. Evolution

Solution

The correct answer is **B**, as with his experiments Pasteur showed that microorganisms could not grow in a broth unless dust particles (covered in microbes) were allowed into the flask.

1.6 CELL DIVISION

You should know:

- ✔ two genetically identical daughter nuclei are produced from the division of the nucleus during mitosis.
- ✔ chromosomes condense by supercoiling.
- ✔ interphase is a very active phase of the cell cycle with many processes occurring in the nucleus and cytoplasm.
- ✔ the stages of mitosis are prophase, metaphase, anaphase and telophase.
- ✔ cytokinesis is cell division occurring after mitosis.
- ✔ cyclins are involved in the control of the cell cycle.
- ✔ mutagens, oncogenes and metastasis are involved in the development of primary and secondary tumours.

You should be able to:

- ✔ analyse data to see the correlation between smoking and the incidence of cancers.
- ✔ identify the phases of mitosis in cells viewed with a microscope or in a micrograph.
- ✔ determine the mitotic index from a micrograph.

Sister chromatids are two parts of a chromosome attached to each other by a centromere in the early stages of mitosis. When sister chromatids have separated to form individual structures they are referred to as chromosomes.

- **Interphase** is the stage of the cell division before mitosis. Cells grow, forming organelles (G1 stage), DNA is duplicated (S stage) and synthesis of proteins that are involved in nuclear division occurs (G2 stage).
- **Mitosis** is nuclear division consisting of four stages: prophase, metaphase, anaphase and telophase.
- **Prophase** is the stage where chromatin condenses and associates with histones forming chromosomes, the nuclear membrane disappears and spindle fibres are formed. Chromosomes attach to spindle fibres.
- **Metaphase** is the stage where chromosomes are aligned in the equator of the cell.
- **Anaphase** is the stage where sister chromatids (V shape, with the vertex pointing to the poles) are separated to the opposite poles of the cell.
- **Telophase** is the last stage of mitosis, where a nuclear membrane forms around each set of chromosomes that begin to uncoil.
- **Cytokinesis** is a process that occurs along with telophase. The cytoplasm of the parental cell divides into two daughter cells. Cytokinesis in animals is produced by cell strangling while in plants it is by formation of a plate.

You will study how DNA replicates before cell division in Topic 2.7. You will also study how cells divide to produce gametes in Topic 3.3.

Assessment tip

When answering a question relating to mitosis, you need to be clear that mitosis is the nuclear division while cytokinesis is cell division.

Example 1.6.1.

a) State two processes occurring during prophase.

b) (i) Define 'centromere'.

(ii) Explain the reason centromeres are facing either opposite pole.

c) Define 'mitotic index'.

Sir Richard Timothy Hunt discovered a new protein in fertilized sea urchin eggs (*Arbacia punctulata*). Cyclin was synthesized soon after the eggs were fertilized and increased in levels during interphase, but the levels decreased quickly in the middle of mitosis. The fact that the amount of cyclins drops periodically at different cell division stages proved to be of importance for cell cycle control.

Solution

a) During prophase chromatin condenses and associates with histones forming chromosomes, the nuclear membrane disappears and spindle fibres are formed.

b) (i) The centromere is the structure of the chromosome (DNA) that holds together both chromatids. It is also the point of attachment to the spindle fibres.

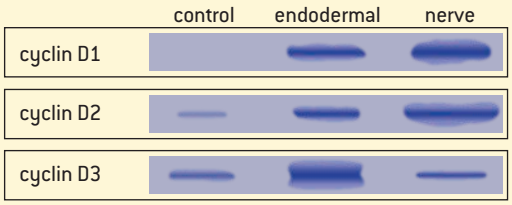
(ii) During anaphase, the sister chromatids are pulled by the spindle fibres to opposite poles. As the centromere is attached to the spindle fibre, the centromere always goes first towards the pole. One sister chromatid migrates to one pole and the other sister chromatid migrates to the opposite pole.

c) Number of cells in mitosis divided by total number of cells seen under the microscope.

SAMPLE STUDENT ANSWER

During the development of multicellular organisms, cells differentiate into specific cell lines. A study was carried out on the early stages of differentiation in cells from mouse embryos that were grown in cultures. Two differentiated cell lines were studied, one from the inner embryonic tissue (endodermal cells) and the other from external embryonic tissue (nerve cells). A culture of undifferentiated cells was used as a control group.

The role of regulators during cell differentiation was studied. After 96 hours of incubation, a sample was taken of each cell line and the cyclins separated by gel electrophoresis. The presence of different cyclins D1, D2 and D3 was analysed in the three cell lines. The image shows the results. The size and intensity of the bands is an indicator of the quantity of cyclins.



a) Compare and contrast the amounts of the different cyclins in nerve cells and control cells. [2]

This answer could have achieved 2/2 marks:

There is no cyclin D1 in control cells, while there is a very high amount in nerve cells. There is about three times as much cyclin D2 in nerve cells than control cells. Cyclin D3 is the most prominent of the cyclins in the control cells and the least prominent in the nerve cells. However, there is almost the same amount of cyclin D3 in nerve cells than control cells.

▲ This answer scores full marks because it compares all cyclins in both types of tissues.

b) Using the data, discuss the possible role of the three cyclins in the differentiation of nerve and endodermal cell lines. [3]

This answer could have achieved 2/3 marks:

As cyclin D3 is in greater quantity in the endodermal cells, it could indicate that this leads to an increase in differentiation. As both the endodermal and control cells have the same amount of cyclin D1, it may be responsible for the differentiation of undifferentiated cells, but not of nerve or endodermal cell lines. Cyclin D2 is more present in nerve cells than endodermal cells. This suggests that the higher presence of cyclin D2 lowers the rate of differentiation.

▲ The answer correctly mentions cyclin D3 in relation to endodermal differentiation, and D2 specific for nerve differentiation.

▼ The answer does not mention that cyclin D1 is most likely what causes differentiation as the control group contains none of it.

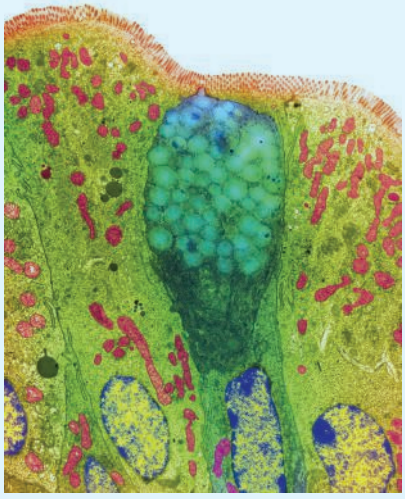
Assessment tip

As this is a discussion, the answer could have mentioned that there is limited data to determine roles of cyclins as there are very complex processes involved.

Practice problems for Topic 1

Problem 1

The electron micrograph shows a section of the epithelium of the small intestine.



Identify **two** structures present in these cells that show they are involved in the uptake of food.

Problem 2

Glucose is a six-carbon sugar that provides energy needed by cells. Because glucose is a large molecule, it is difficult for it to be transported across the membrane through simple diffusion. Explain how glucose is transported into a cell such as a red blood cell down a concentration gradient.

Problem 3

a) Describe the experimentation that led to the proposal of the Davson–Danielli model of the cell membrane and its later falsification leading to the Singer–Nicolson model.

b) Outline the process of endocytosis.

Problem 4

Describe the experiment of Miller and Urey into the origin of organic compounds.

Problem 5

Cells go through a repeating cycle of events in growth regions such as plant root tips and animal embryos. Outline this cell cycle.