TOPIC 1 – CELLS AND MICROORGANISMS
Question Booklet

1.1 CELL THEORY

1. List the conditions that must be met for life to exist. Choose three of these conditions and explain their requirement for life to exist.
2. Describe the fundamental principles of Cell Theory.

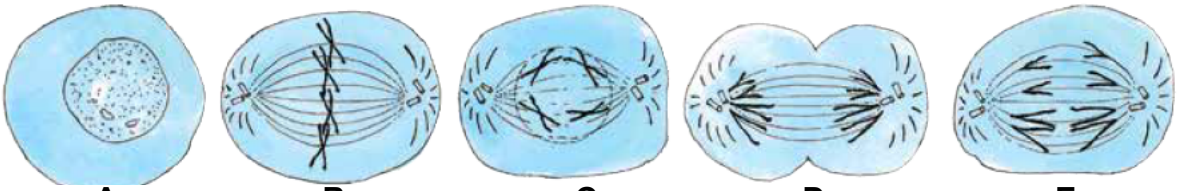
1.2 PROKARYOTES AND EUKARYOTES

1. Identify whether each of the following statements are true or false:
    a. Cells are typically too small to be seen with an unaided eye.
    b. Bacterial cells are typically larger than animal cells.
    c. Viral particles are smaller than microbial cells.
2. Identify whether each of the following statements are true or false:
    a. Prokaryotes are unicellular organisms, comprising bacteria.
    b. The presence of a membrane-bound nucleus in its cells provides evidence that an organism is a eukaryote.
    c. All eukaryotes are multicellular organisms.
3. List two similarities between prokaryotic and eukaryotic cells.
4. Describe four key differences between prokaryotic and eukaryotic cells.
5. A scientist wishes to examine ribosomes in a liver cell. Where should the scientist look: in the nucleus or cytoplasm? Explain.
6. Prokaryotic and eukaryotic cells share a number of similar structures. State two of the common structures they share and describe their key features.

1.3 CELL DIVISION

1. Identify whether each of the following statements is true or false:
    a. Sister chromatids separate at metaphase.
    b. During interphase, double-stranded chromosomes are visible.
    c. Cytokinesis is the last step in a cell cycle.
    d. Binary fission does not involve DNA replication.
2. Do you agree or disagree with each of the following claims about mitosis? Briefly explain.
    a. The nuclear envelope is visible throughout the process.
    b. Mitosis would occur in the developing limb of a larval frog.
    c. Mitosis in plants is significantly different from mitosis in animals.
3. Describe the key steps in binary fission.

4. Below are a series of drawings, all of the same cell at some stage during mitosis.
    a. Starting with cell A, place the drawings in the sequence that the stages would occur during mitosis.
    b. Draw what you would expect to see next in the sequence.



A B C D E

5. Arrange the following events in animal cell replication in the correct order:
    a. Attachment of the spindle to the chromosomes.
    b. Breakdown of the nuclear envelope.
    c. Condensation of chromosomes.
    d. Decondensation of chromosomes.
    e. Pinching of cell into two.
    f. Re-formation of the nuclear envelope.
    g. Separation of sister chromatids.
    h. Alignment of chromosomes on the metaphase plate.
    i. Separation of two identical daughter cells.

6. After a cell with 10 chromosomes completed mitosis, its daughter cells were examined. One daughter cell was found to contain 11 chromosomes and the other daughter cell had only 9 chromosomes. Suggest a possible explanation in biological terms for this observation.

1.4 ENERGY

1. Is the following statement true or false? Explain your answer.
    a. The release of energy from glucose takes place through the process of photosynthesis.

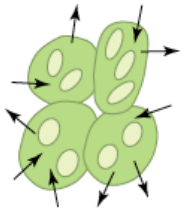
2. ATP could be described as a ‘very busy molecule’. Briefly explain why this label is appropriate.

3. What is the distinguishing feature of a heterotroph?

4. Where in a cell is sunlight energy transformed to the chemical energy of organic molecules?

5. What are:
    a. The inputs of photosynthesis?
    b. The outputs of photosynthesis?
    c. The inputs of aerobic respiration?
    d. The outputs of aerobic respiration?
    e. The inputs of anaerobic respiration?
    f. The outputs of anaerobic respiration in human skeletal muscle?
    g. The outputs of anaerobic respiration in yeast?

6. Water is split into hydrogen and oxygen in photosynthesis. What happens to the oxygen atoms?
7. What change occurs in the rate of aerobic respiration by heart muscles when a person changes from resting to strenuously exercising?
8. What produces the 'holes' in a slice of bread?
9. The image below represents a group of photosynthesizing cells in a leaf. The arrows represent compounds entering and leaving the leaves. Explain which compounds the input arrows and the output arrows could represent when the cells are in:
    a. Bright sunlight
    b. Darkness



10. Identify the following:
    a. The gas that is taken up from the atmosphere in photosynthesis.
    b. The gas that is released from cells in anaerobic respiration.
    c. The gas that is essential for aerobic respiration.
    d. The gas that is the product of photosynthesis in green plants.
11. Identify and explain two key differences between the processes of:
    a. Photosynthesis and cellular respiration.
    b. Aerobic and anaerobic respiration.

1.5 MOVEMENT ACROSS MEMBRANES

1. What are the two major components of a plasma membrane?
2. Identify whether each of the following statements is true or false:
    a. The plasma membrane is present as a boundary in all living cells.
    b. The plasma membrane consists of layers of proteins in which phospholipids are embedded.
    c. A key role of the plasma membrane is the control of transport of materials into or out of cells.
3. What part of a plasma membrane is responsible for its flexibility?
4. Briefly describe the fluid mosaic model of the plasma membrane.
5. Is the plasma membrane impermeable, selectively permeable, or fully permeable? Explain.
6. Identify two functions of the plasma membrane.
7. What advantage might result from creating several membrane-enclosed compartments within a cell?
8. What is the process by which bulk materials are exported out of cells?
9. Identify one difference between diffusion and active transport.
10. What process is involved in the movement of water down its concentration gradient and across a layer of cells from outside the body to inside?

11. Data for three different shapes, each having the same volume, is given below:

Cell	Shape	Dimensions	Surface area	Volume	SA:V ratio
A	flat sheet	$10 \times 10 \times 0.1$	204	10	20.4
B	cube	$2.15 \times 2.15 \times 2.15$	28	10	2.8
C	sphere	diameter: 1.67	22	10	2.2

a. If these shapes represented cells, which cell (A, B or C) would be most efficient in moving required materials into and removing wastes from the cell? Explain.
b. Which cell would be least efficient? Explain.
c. Can you suggest a biological consequence of your conclusion?

12. Two cells (P and Q) have the same volume, but the surface area of cell P is 10 times greater than that of cell Q.
a. Placed in the same environment, which cell would be expected to take up dissolved material at a greater rate? Why?
b. What might reasonable be inferred about the shapes of these two cells?
c. Which measure: surface area or volume determines the rate at which essential materials can be supplied to a cell?
d. Which measure: surface area or volume determines the needs of a cell for essential materials?

1.6 MICROORGANISMS

1. Determine whether the following statements are true or false:
a. All microorganisms are prokaryotic.
b. Microorganisms require different, specific conditions for optimal growth.
c. High and low temperatures can be used to preserve food and prevent microorganism growth and food spoilage.

2. Describe how microorganisms can be used to help treat diabetes in humans.

3. List the key requirements for optimal microorganisms' growth.

4. Explain why cyanobacteria can be beneficial to environments with low levels of trees and plants.

5. List five safe food hygiene practices that can prevent microorganism contamination.

6. Describe how moisture can be used in food preservation. Relate your answer to the growth requirements for microorganisms.

TOPIC 1 – CELLS AND MICROORGANISMS
Solutions

1.1 CELL THEORY

1. MRS GREN (Movement, Respiration, Sensitivity, Growth, Reproduction, Excretion, Nutrition). Explanations for chosen conditions need to explain how the condition indicates life (1-2 sentences for each condition).
2. 1 – cells are the structural and functional units of living things. 2 – all living things are made of cells, or the product of cells. 3 – every cell arises from a pre-existing cell. 4 – cells contain hereditary material.

1.2 PROKARYOTES AND EUKARYOTES

1.
   a. TRUE
   b. FALSE (animal cells are more complex and much larger)
   c. TRUE
2.
   a. TRUE
   b. TRUE (bacteria do not contain a nucleus)
   c. FALSE (there are a few unicellular eukaryotes – eg: some protozoa, algae, fungi)
3. Both prokaryotes and eukaryotes contain DNA and a cell membrane, both have the ability to make proteins, both have ribosomes, both contain cytoplasm.
4. Prokaryotes are smaller, simpler cells with no nucleus and a single, circular chromosome. They undergo cell division via binary fission. Eukaryotes are larger, complex cells with a nucleus and multiple, linear chromosomes. They undergo cell division via mitosis.
5. The scientist should look in the cytoplasm (ribosomes are not found in the nucleus of cells).
6. Similar structures: cell membrane, nucleic acids, proteins, ribosomes. Explanation of key features should be 1-2 sentences for each structure. Key features include composition of the structure, or the key roles they play in the cell.

1.3 CELL DIVISION

1.
   a. FALSE (sister chromatids are separated in Anaphase)
   b. FALSE (chromosomes are decondensed at this stage)
   c. TRUE
   d. FALSE (DNA must always be replicated before division)
2.
   a. DISAGREE (nuclear membrane dissolves during Prophase)
   b. AGREE (mitosis is used for growth – limb is growing)
   c. DISAGREE (mitosis is very similar in plants and animals)

3. 1 – single, circular chromosome replicates and fixes to the membrane. 2 – membrane expands and grows apart. 3 – new membrane forms between two rings of DNA. 4 – cells separate into two identical daughter cells, each with their own circular chromosome.

4. Below are a series of drawings, all of the same cell at some stage during mitosis.
    a. Order: A – C – B – E – D
    b. Drawing should include separated cells with DNA in each.

5. Order: C – B – H – A – G – E – F – D – I

6. Spindle may not have correctly joined to one chromosome in metaphase, therefore a complete replicated chromosome was pulled into one of the daughter cells, leaving the other daughter cell with one missing chromosome.

1.4 ENERGY

1.
    a. FALSE. Glucose is produced in photosynthesis, but broken down to ATP (energy) in respiration.

2. ATP is constantly being broken down to ADP (releasing energy), then being reformed into ATP (storing energy). This constant cycle is used in all cells and makes it a 'busy molecule'.

3. Heterotrophs cannot produce their own food (or similar).

4. Chloroplasts.

5.
    a. Carbon dioxide, water
    b. Glucose, oxygen
    c. Glucose, oxygen
    d. Carbon dioxide, water, energy
    e. Glucose
    f. Lactic acid
    g. Ethanol, carbon dioxide

6. The oxygen atoms are released as oxygen gas.

7. As the person strenuously exercises, more energy will be required in cells (as they are expending energy for body movement), therefore increasing the rate of respiration.

8. Carbon dioxide formed from yeast fermentation (anaerobic respiration).

9.
    a. INPUTS: sunlight, carbon dioxide, water. OUTPUTS: oxygen, glucose
    b. INPUTS: oxygen, glucose. OUTPUTS: carbon dioxide, water, energy

10.
    a. Carbon dioxide
    b. Carbon dioxide
    c. Oxygen
    d. Oxygen

11.

a. Photosynthesis only occurs in autotrophs and produces glucose from water and carbon dioxide. Aerobic respiration occurs in all organisms and breaks down glucose to produce energy (ATP), releasing carbon dioxide and water.

b. Aerobic respiration requires oxygen and produces 36 ATP molecules in total. Anaerobic respiration occurs in the absence of oxygen and produces 2 ATP molecules in total.

1.5 MOVEMENT ACROSS MEMBRANES

1. Phospholipids (bilayer), proteins (embedded in membrane)

2.

a. TRUE

b. FALSE (proteins are embedded in phospholipids)

c. TRUE

3. Phospholipid bilayer

4. Plasma membrane is made up of a phospholipid bilayer, embedded with proteins. This structure provides a mosaic appearance. The phospholipids and proteins are not fixed, but instead move, providing membrane fluidity.

5. Membrane is semi-permeable. Some substances are permitted to pass through the membrane, other molecules require proteins to move across the membrane due to size, charge or polarity.

6. The membrane provides a barrier to maintain the internal composition of the cell, and is involved in the transport of materials in and out of the cell (endo-/exocytosis, diffusion, osmosis).

7. Allows for easy exchange of materials and messages within the cell.

8. Exocytosis.

9. Diffusion is a passive process, whereas active transport requires energy.

10. Osmosis (movement of water across a semi-permeable membrane).

11.

a. Cell A is the most efficient cell (highest SA:V ratio).

b. Cell B is the least efficient (lowest SA:V ratio).

c. Cells are less likely to be cuboid in shape due to inefficient exchange of materials. Longer, flatter cells provide a more efficient exchange of materials.

12.

a. Cell P would take up materials quicker (higher SA:V ratio).

b. Cell P may have a convoluted membrane (to increase surface area), whereas it is likely Cell Q is a simple sphere or cube shape (low surface area).

c. Surface area.

d. Volume.

1.6 MICROORGANISMS

1.
   a. FALSE (fungi and protists are eukaryotic)
   b. TRUE
   c. TRUE

2. Plasmids (small bits of DNA) can be taken from bacteria. A gene of interest (gene for insulin growth) can be inserted into the plasmid and returned to the bacteria. As a result of this, the bacteria will begin to produce the insulin protein, which can be harvested and given to humans to treat diabetes.

3. Microorganisms require particular temperature, nutrient concentrations, pH, and moisture levels for optimal growth.

4. Cyanobacteria are photosynthetic (produce oxygen), which would be beneficial in an environment where little oxygen was being produced by trees and plants (due to low numbers).

5. Any safe food practices acceptable here (eg: washing hands thoroughly, cleaning surfaces, refridgerating food, etc.).

6. Dehydrating food to remove moisture can make living conditions unfavourable for microorganism growth. This, in turn, can help preserve the food for longer periods of time. In a similar manner, moisture (water) is frozen when food is frozen, making water inaccessible for microorganisms (thus limiting their growth).