Life Processes at the Cellular Level
ANSWERS

Cells

Cell Membrane
STOP AND CHECK (PAGE 7)

- The cell membrane is made from a phospholipid bilayer. A phospholipid has a phosphate head and fatty acid tails, while a bilayer means the phospholipids are in two rows.
- The function of the cell membrane is to surround the cell and control what enters and exits the cell, stopping harmful substances from getting in. It also helps maintain cell structure.

Cytoplasm
STOP AND CHECK (PAGE 9)

- The cytoplasm is the jelly-like material inside all cells.
- It has nutrients for the cell and lets the organelles float around inside it.

Nucleus
STOP AND CHECK (PAGE 9)

- Inside the nucleus is DNA which contains the instructions for the cell.

Mitochondria

STOP AND CHECK (PAGE 10)

- Mitochondria are called “powerhouses of the cell” because they make energy from sugar in food and the energy is used to power many different cell processes.
- Mitochondria have two membranes: the outer is smooth, but the inner is wavy (the waves are called cristae).
- Cristae increase the surface area so that reactions on the inner membrane are more efficient and more energy is made.
- The number of mitochondria a cell has depends on its function. The function of the cell controls how much energy it needs.

Chloroplasts

STOP AND CHECK (PAGE 11)

- Like mitochondria, chloroplasts have a smooth outer membrane. However, the inner membrane of a chloroplast is also smooth, not wavy like mitochondria.
- A chloroplast carries out photosynthesis, which traps light energy using chlorophyll to make sugar.
- Inside a chloroplast are a stack of disks. Each disk is called a thylakoid and a stack is called grana. The liquid around the stacks is the stroma.

Cell Wall

STOP AND CHECK (PAGE 12)

- Only plant cells have a cell wall.
- A cell wall is rigid, but a cell membrane is bendier. A cell wall also only gives shape and structure to a cell, while a cell membrane controls what goes into and out of a cell.

Cells

QUICK QUESTIONS (PAGE 12)

- There are many parts to a cell. The cell membrane, made of a phospholipid bilayer, controls what goes into and out of a cell and gives the cell structure. The jelly-like cytoplasm gives the cell nutrients and allows the organelles to float in it. A nucleus, which has a double membrane and contains DNA, is the control centre of the cell. Mitochondria, with a smooth outer membrane and a wavy inner membrane, turn sugar into energy. Chloroplasts, with a double membrane and stacks of thylakoids called grana, use light to make sugar. A cell wall, rigid and around the outside of the cell, gives plant cells structure.
- Plant and animal cells have a lot in common. Both need mitochondria to make energy for different processes, both have a nucleus to hold instructions for the cell, both have a cell membrane to control what gets into and out of the cell, and both need nutrients that are in the cytoplasm. However, only plant cells have chloroplasts, meaning that animal cells can't use light energy to make sugar. In addition, animals don't have cell walls as they move around and need to be flexible, but plants need to be more rigid.

Enzyme Activity

Enzymes: Biological Catalysts

STOP AND CHECK (PAGE 14)

- Enzymes catalyse, or speed up, biological reactions so they can happen fast enough to be useful.
- Enzymes are not considered living (or dead) because they are just bundles of protein.
- Enzymes, made of protein, speed up biological reactions but are not used up in the reaction.

How Enzymes Work

STOP AND CHECK (PAGE 15)

- The active site is where substrates bind for the enzyme to speed up the reaction.
- The lock and key model says that the substrate (the key) fits into the enzyme's active site (the lock) because their shapes match perfectly.
- The induced to fit model says that the enzyme's active site and the substrate slightly change shape so that they can fit together.

Factors Affecting Enzyme Activity

STOP AND CHECK (PAGE 17)

- A higher concentration of enzymes or substrates means that particles are more likely to collide with each other, increasing the rate of reaction.
- Enzyme saturation means that there is only a certain number of reactions a group of enzymes can deal with at once as each can only work on one reaction at a time. This means that there is a point where increasing substrate concentration will not cause the rate of reaction to continue to increase.

Temperature

STOP AND CHECK (PAGE 18)

- Increasing temperature increases the rate of reaction because particles are moving faster, so they are more likely to collide with another particle and cause a reaction. Enzymes work best at an optimum temperature.
- Much higher than the optimum temperature and enzyme activity completely stops as too many of the enzymes have been denatured.
- Denaturing means the enzyme has gotten so hot the active site loses its normal shape. This means that it can't speed up any more reactions.

pH

STOP AND CHECK (PAGE 19)

- The closer the surrounding pH is to the enzyme's optimum pH, the faster the rate of reaction.
- An enzyme's optimum pH is determined by where in the organism the enzyme is found.

Inhibitors

STOP AND CHECK (PAGE 20)

- Inhibitors either bind to the enzymes' active site (competitive inhibitors) or bind to another part of the enzyme to change the shape of the active site (non-competitive inhibitors). Both types reduce or stop enzyme activity,

Enzyme Activity

QUICK QUESTIONS (PAGE 20)

- Enzymes are biological catalysts made of protein that speed up biological reactions without being used up. They let reactions occur at speeds that are more useful to the organism than would happen naturally.
- Enzymes catalyse reactions through substrates binding to their active sites. The lock and key model says that the active site and the substrate fit together exactly, while the induced fit model says they both slightly change shape so they fit. The induced fit model is the way enzymes actually work, while the lock and key model is a biologist's fantasy.
- Enzyme activity can be altered in different ways. Increasing the substrate or enzyme concentration increases the rate of reaction as particles are more likely to collide, but only up until a saturation point. Temperature increases the rate of reaction as particles are moving faster and more likely to collide, but only up to an optimum temperature, after which the active site denatures. The closer the pH is to the enzyme's optimum, the faster the rate of reaction. Inhibitors can bind to the active site or another part of an enzyme to reduce enzyme activity.

Movement of Materials

Passive Transport

STOP AND CHECK (PAGE 23)

- Diffusion is when substances move from high to low concentration, without needing energy.
- While osmosis and diffusion both don't require energy, and both are the movement of substances from a high to a low concentration. Osmosis is only for water.
- Unlike diffusion, facilitated diffusion is for larger molecules that cannot move across the cell membrane by themselves, so they need special channels and proteins to get around.

Active Transport

STOP AND CHECK (PAGE 25)

- Active transport needs ATP energy because it moves against its concentration gradient, or against the way the substances want to go.
- Active transport requires special pumps that use energy to move substances from low to high concentrations.
- Endocytosis and exocytosis are both ways of moving material into and out of a cell and both use sections of the cell membrane to do so. They both need ATP. However, exocytosis is for moving material out by forming sacs around the material and combining it with the cell membrane. In comparison, endocytosis is for material moving in and works in reverse, with sacs of cell membrane forming around the material.

Movement of Materials

QUICK QUESTIONS (PAGE 25)

- When red blood cells are in a solution of higher solute concentration, the water concentration in the cells is higher than the surroundings, so water moves down the concentration gradient and out of the cell, so it shrinks. A lower solute concentration, however, would have a higher water concentration outside the red blood cell, so water goes into the cell, making it expand.
- The key difference between active and passive transport is that passive transport has material moving from high to low concentration and active transport has material moving from low to high concentration. For example, osmosis moves water from high to low concentration, while endocytosis can move larger material into a cell from low to high concentration. This means that active transport needs energy but passive transport doesn't.

Photosynthesis

Defining Photosynthesis

STOP AND CHECK (PAGE 26)

- Photosynthesis happens in the chloroplasts of plant cells.
- Photosynthesis needs light, water and carbon dioxide.
- Photosynthesis produces glucose and oxygen.
- Photosynthesis is the process plants undergo to convert carbon dioxide and water, along with the help of light energy, into glucose and oxygen so the plant can carry out life processes.

Photosynthesis Equation

STOP AND CHECK (PAGE 27)

- Word equation:

Water + Carbon dioxide + Light energy → Glucose + Oxygen

- Balanced symbol equation:

$$6H_2O + 6CO_2 + \text{Light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

Types of Reactions

STOP AND CHECK (PAGE 28)

- Light-dependent reactions need light to provide the energy to split water into hydrogen and oxygen, ready for the second stage. As a result, this will only happen during daylight.
- The light-dependent stage produces hydrogen and oxygen.
- The light-independent stage produces glucose.

The Chloroplast: Maximising Photosynthesis

STOP AND CHECK (PAGE 30)

- Chloroplasts have a double membrane, and both are smooth. Inside a chloroplast are a stack of disks. Each disk is called a thylakoid and stacks are called grana. The liquid around the stacks is the stroma.
- There are two main ways chloroplasts maximise the rate of photosynthesis: the clear appearance of the stroma allows the maximum amount of light to get to the chlorophyll while stacking the thylakoid discs increases surface area and so more light can be absorbed.

Photosynthesis

QUICK QUESTIONS (PAGE 30)

- Photosynthesis is the process plants use to make sugar with the help of light energy. The word equation is:

$$\text{Water} + \text{Carbon Dioxide} + \text{Light energy} \rightarrow \text{Glucose} + \text{Oxygen}$$

This sugar is needed by plants to then make energy and carry out life processes.

- During the light-dependent stage, light energy is captured by chlorophyll in the thylakoid stacks and used to split water into hydrogen and oxygen. During the light-independent stage, these products are combined with carbon dioxide during the Calvin cycle to make glucose.

Respiration

Defining Aerobic Respiration

STOP AND CHECK (PAGE 32)

- The reactants for respiration are glucose and oxygen.
- The products of aerobic respiration are ATP energy, as well as carbon dioxide and water as waste products.
- Aerobic respiration is a process that uses glucose and oxygen to create ATP energy, which is needed for life processes in cells.

Aerobic Respiration Equation

STOP AND CHECK (PAGE 32)

- Word Equation:

$$\text{Glucose} + \text{Oxygen} \rightarrow \text{ATP} + \text{Water} + \text{Carbon dioxide}$$

- Balanced symbol equation:

$$C_6H_{12}O_6 + 6O_2 \rightarrow ATP + 6H_2O + 6CO_2$$

Anaerobic Respiration

STOP AND CHECK (PAGE 33)

- Anaerobic respiration occurs when there is limited oxygen.
- Fermentation in muscle cells produces a little ATP as well as lactic acid as a bi-product.

The Mitochondrion: Maximising Aerobic Respiration

STOP AND CHECK (PAGE 34)

- Two ways cells maximise the rate of aerobic respiration are by having wavy cristae which increase the surface areas for respiration to occur over, and by having different numbers of mitochondria depending on energy needs.

Respiration

QUICK QUESTIONS (PAGE 34)

- The purpose of aerobic respiration is to use glucose and oxygen to create ATP energy for life processes.
- In aerobic respiration, ATP is made from glucose and oxygen through three different stages. For fermentation, only a small amount of energy is made due to the lack of oxygen. Fermentation only goes through part of the process that aerobic respiration does.
- Fermentation in humans can occur during intense exercise as there is not enough oxygen for aerobic respiration to happen.
- The surface area in mitochondria is maximised by folding the inner membrane into wiggly cristae. This increases the rate of aerobic respiration as there is more space for the electron transport chain to occur.

Cell Division

Cell Cycle

STOP AND CHECK (PAGE 37)

- The four stages of the cell cycle are G1 phase, S phase, G2 phase and M phase.
- During G1 phase, the cell grows. During S phase, DNA is replicated. During G2 phase, the cell continues to grow. During M phase, mitosis (cell division) occurs.

DNA Replication

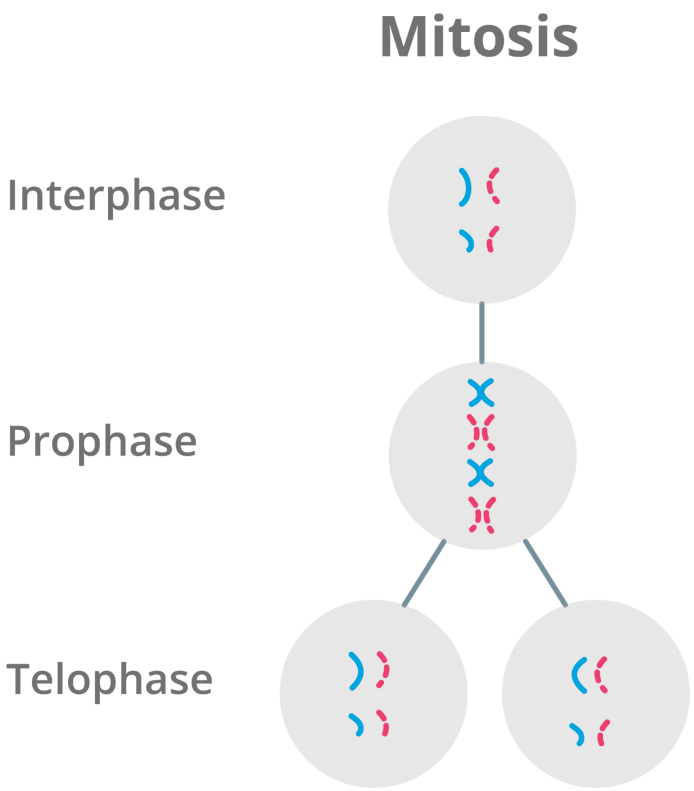
STOP AND CHECK (PAGE 39)

- DNA is replicated so all cells have a copy of the genetic information.
- DNA replication happens during the S phase.
- New nucleotides are added in the 3′ to 5′ direction to the template strands.
- The leading and lagging strands are replicated differently as DNA strands are anti-parallel but the enzymes involved can only work in one direction.
- DNA replication is semi-conservative as one strand is from the old chromosome and one strand is new.

Mitosis

STOP AND CHECK (PAGE 40)

- The purpose of mitosis is to produce two identical daughter cells, so the body can grow and repair itself.
- DNA is replicated by going through the following steps:
    - Interphase
    - Prophase
    - Metaphase
    - Anaphase
    - Telophase



Cell Division

QUICK QUESTIONS (PAGE 40)

- The four stages of the cell cycle are G1 phase (the cell grows), S phase (DNA is replicated), G2 phase (the cell continues to grow) and M phase (mitosis happens).
- During DNA replication an enzyme splits the DNA strands are separated. New nucleotides are added to each using complementary base-pairing rules. This continues until all DNA has been copied.
- The purpose of mitosis is to produce two identical daughter cells, so the body can grow and repair. There are a few different stages to mitosis. In humans, mitosis rates are highest during infancy and in places that are exposed to harsh environments, such as the skin. In plants, mitosis rates are highest during seasonal growth periods (often spring) and in roots and leaves, which are the most likely parts to get damaged.

