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AS Level Biology

Topic 3: Cells, Microscopy and the Immune System

AQA Biology (7401) | Mark Scheme | 100 marks

Instructions

- Answer **all** questions.
- In calculations show your working and give your answer to an appropriate number of significant figures.
- In extended-response questions you should write in clear, well-organised continuous prose.
- There are 17 questions in this paper. The total mark is **100**.

1. This question is about eukaryotic cell structure.

(a) Name the organelle that is the site of aerobic respiration in a eukaryotic cell. **(1)**

✓ mitochondrion (1)

(b) Name the organelle responsible for modifying and packaging proteins for secretion. **(1)**

✓ Golgi apparatus (body) (1)

(c) State the function of a ribosome. **(1)**

✓ site of protein synthesis / translation (1)

(d) State one structural difference between rough endoplasmic reticulum and smooth endoplasmic reticulum. **(1)**

✓ rough ER has ribosomes on its surface, smooth ER does not (1)

2. This question is about the functions of cell organelles.

(a) Describe the structure and function of the nucleus. **(3)**

✓ surrounded by a (double-membraned) nuclear envelope with pores (1)
✓ contains chromatin/DNA (and a nucleolus) (1)
✓ controls the cell's activities / site of DNA replication and transcription / makes ribosomes (in the nucleolus) (1)

(b) Describe the structure of a mitochondrion and explain how it is adapted to its function. **(3)**

✓ has a double membrane, the inner one folded into cristae (1)
✓ the folds give a large surface area (for enzymes / reactions of respiration) (1)
✓ contains a fluid matrix (with enzymes/DNA) for the reactions of respiration (1)

(c) Name two organelles found in plant cells that are not found in animal cells. **(2)**

✓ chloroplast (1)
✓ cell wall / (large/permanent) vacuole (1)

3. This question is about chloroplasts.

(a) State the function of a chloroplast. **(1)**

✓ site of photosynthesis (1)

(b) Name the stacks of membranes inside a chloroplast where the light-dependent reactions occur. **(1)**

✓ thylakoids (grana) (1)

(c) Name the fluid that surrounds the membranes inside a chloroplast. **(1)**

✓ stroma (1)

4. This question is about the differences between prokaryotic and eukaryotic cells.

(a) State three structures always found in a prokaryotic cell. **(3)**

✓ cell wall (containing murein) (1)
✓ cell-surface membrane (1)
✓ cytoplasm (with ribosomes) / circular DNA (any one) (1)

(b) State three ways in which a prokaryotic cell differs from a eukaryotic cell. **(3)**

✓ prokaryotes have no nucleus / DNA is free in the cytoplasm and circular (1)
✓ prokaryotes have no membrane-bound organelles (e.g. mitochondria) (1)
✓ prokaryotes have smaller (70S) ribosomes / a cell wall made of murein (1)

(c) Some prokaryotic cells contain plasmids. State what a plasmid is. **(1)**

✓ a small (circular) loop of DNA (separate from the main DNA) (1)

5. Viruses are described as acellular and non-living.

(a) Name three structures found in all viruses. **(3)**

✓ genetic material (DNA or RNA) (1)
✓ a protein coat / capsid (1)
✓ attachment proteins (1)

(b) Explain why viruses are described as acellular. **(1)**

✓ they are not made of cells / have no cell structure (no cytoplasm/membrane/organelles) (1)

6. This question is about the use of microscopes to study cells.

(a) State what is meant by the *magnification* of a microscope. **(1)**

✓ how many times larger the image is than the (real size of the) object (1)

(b) State what is meant by the *resolution* of a microscope. **(1)**

✓ the minimum distance between two points at which they can still be seen as separate (1)

(c) Explain why a transmission electron microscope (TEM) has a higher resolution than an optical (light) microscope. **(2)**

✓ electrons have a much shorter wavelength than light (1)
✓ so smaller objects/structures can be distinguished as separate (1)

(d) Give one advantage of using an optical microscope rather than an electron microscope. **(1)**

✓ specimens can be living / can see in colour / it is cheaper and easier to use (any one) (1)

7. This question compares the transmission electron microscope (TEM) and the scanning electron microscope (SEM).

(a) State one advantage of a TEM over an SEM. **(1)**

✓ a TEM has a higher resolution (than an SEM) (1)

(b) State one advantage of an SEM over a TEM. **(1)**

✓ an SEM produces a 3-D image / the specimen does not need to be thin (1)

(c) Explain why specimens viewed with an electron microscope cannot be living. **(2)**

✓ the specimen is placed in a vacuum (1)
✓ living cells would be damaged / could not survive (water would boil) in a vacuum (1)

8. A student measured a cell using an optical microscope. The image of the cell measured 40 mm and the magnification used was ×400.

(a) Calculate the actual length of the cell in micrometres (µm). Show your working. (1 mm = 1000 µm) **(3)**

✓ actual size = image size / magnification = 40/400 = 0.1 mm (1)
✓ convert to µm: 0.1 × 1000 (1)
✓ = 100 µm (1)

(b) The student then viewed a different structure whose actual length was 5 µm. The image measured 2 mm. Calculate the magnification of this image. **(3)**

✓ convert to the same units: 2 mm = 2000 µm (1)
✓ magnification = image size / actual size = 2000/5 (1)
✓ = ×400 (1)

9. This question is about cell fractionation and ultracentrifugation, used to separate organelles.

(a) Before fractionation, tissue is placed in a cold, isotonic, buffered solution. Explain why the solution must be: (i) cold, (ii) isotonic, (iii) buffered. **(3)**

✓ cold: to reduce/stop enzyme activity (so organelles are not broken down) (1)
✓ isotonic: to prevent organelles bursting or shrinking by osmosis (same water potential) (1)
✓ buffered: to keep the pH constant (so organelles/proteins are not damaged) (1)

(b) Describe the homogenation step of cell fractionation. **(2)**

✓ the tissue is broken up / blended (homogenised) (1)
✓ to break open the cells and release the organelles (into solution) (1)

(c) During ultracentrifugation, the sample is spun and the speed is increased in stages. Explain why the organelles separate out in order of their density (heaviest first). **(3)**

✓ the tube is spun at a low speed first (1)
✓ the heaviest/most dense organelles (e.g. nuclei) sediment to the bottom forming a pellet (1)
✓ the supernatant is spun again at a higher speed to sediment the next heaviest organelles, and so on (1)

10. This question is about defence against pathogens and antigens.

(a) State what is meant by the term *antigen*. **(2)**

✓ a molecule (usually a protein) that triggers an immune response (1)
✓ found on the surface of cells / identified as self or non-self (1)

(b) Explain how the immune system distinguishes the body's own cells from foreign cells. **(2)**

✓ each type of cell has specific antigens / molecules on its surface (1)
✓ the immune system recognises self antigens, and responds to non-self (foreign) antigens (1)

11. This question is about phagocytosis, a non-specific defence mechanism.

(a) Describe the process of phagocytosis of a pathogen by a phagocyte. **(4)**

✓ the phagocyte recognises / is attracted to the (foreign antigens on the) pathogen (1)
✓ the phagocyte engulfs the pathogen, enclosing it in a vesicle (phagosome) (1)
✓ a lysosome fuses with the vesicle and releases lysozymes / hydrolytic enzymes (1)
✓ the enzymes hydrolyse / digest the pathogen (1)

(b) After digesting the pathogen, the phagocyte becomes an antigen-presenting cell. Explain what this means and why it is important. **(2)**

✓ it displays the pathogen's antigens on its (cell-surface) membrane (1)
✓ this activates / stimulates other cells (e.g. T cells) in the specific immune response (1)

12. This question is about the cellular response involving T lymphocytes.

(a) Describe the role of T helper cells in the immune response. **(3)**

✓ T helper cells have receptors complementary to the antigen presented (1)
✓ they bind to the antigen (on an antigen-presenting cell) and become activated (1)
✓ they stimulate / release chemicals (cytokines) that activate B cells, cytotoxic T cells and phagocytes (1)

(b) Describe the role of cytotoxic T cells. **(2)**

✓ they kill / destroy abnormal cells and cells infected with a pathogen (1)
✓ they release a protein (perforin) that makes holes in the cell-surface membrane (so the cell dies) (1)

13. This question is about the humoral response involving B lymphocytes and antibodies.

(a) Describe how a specific B cell is selected and activated when a pathogen enters the body. **(3)**

✓ the antigen binds to a (complementary) receptor/antibody on a specific B cell (1)
✓ this (with help from T helper cells) activates the B cell (clonal selection) (1)
✓ the B cell divides by mitosis to form clones (clonal expansion) (1)

(b) Describe the role of plasma cells. **(2)**

✓ plasma cells secrete / produce (large numbers of) antibodies (1)
✓ the antibodies are specific to / complementary to the antigen (1)

(c) Explain the role of memory cells in the immune response. **(3)**

✓ memory cells remain in the body for a long time (after infection) (1)
✓ on a second exposure to the same antigen they divide rapidly (1)
✓ plasma cells are produced quickly, so antibodies are made faster and in greater amounts (secondary response) (1)

14. An antibody is a protein with a specific structure related to its function.

(a) State what is meant by the term *antibody*. **(1)**

✓ a protein (with a variable region) produced by (plasma) cells, specific to / complementary to an antigen (1)

(b) Describe how an antibody leads to the destruction of a pathogen by agglutination. **(2)**

✓ each antibody has two binding sites so it can bind to two pathogens / antigens (1)
✓ this clumps the pathogens together (agglutination) so they can be engulfed by phagocytes more easily (1)

15. Vaccination can provide protection against disease.

(a) Explain how a vaccine provides long-term protection (immunity) against a disease. **(3)**

✓ the vaccine contains antigens (of the pathogen) (1)
✓ this stimulates an immune response and the production of memory cells (1)
✓ on later exposure to the pathogen, memory cells produce antibodies quickly (secondary response) so the person does not become ill (1)

(b) State the difference between *active* and *passive* immunity. **(2)**

✓ active immunity: the body makes its own antibodies (after exposure to an antigen) (1)
✓ passive immunity: antibodies are introduced/given from outside the body (the body does not make them) (1)

(c) Explain what is meant by *herd immunity*. **(2)**

✓ when a large proportion of the population is vaccinated/immune (1)
✓ there are few susceptible individuals, so the pathogen cannot spread easily, protecting those who are not immune (1)

16. This question is about the human immunodeficiency virus (HIV).

(a) Describe how HIV replicates inside a host T helper cell. **(4)**

✓ HIV attachment proteins bind to receptors on the (T helper) cell and the virus enters the cell (1)
✓ reverse transcriptase converts the viral RNA into DNA (1)
✓ the viral DNA is inserted into the host cell's DNA (1)
✓ the host cell makes new viral proteins/particles (which assemble and leave the cell) (1)

(b) Explain why a person with AIDS is more likely to suffer from infections. **(3)**

✓ HIV destroys / reduces the number of T helper cells (1)
✓ so B cells are not activated / fewer antibodies are made / the immune response is weakened (1)
✓ so pathogens cannot be destroyed effectively (the person cannot fight infections) (1)

(c) Explain why antibiotics are not effective against viruses such as HIV. **(2)**

✓ antibiotics target structures/processes found in bacteria (e.g. cell walls, ribosomes, enzymes) (1)
✓ viruses do not have these structures / use the host cell's machinery, so there is no target (1)

17. The ELISA test uses antibodies to detect the presence of a specific antigen in a sample, such as in the diagnosis of HIV.

(a) State what the abbreviation ELISA stands for. **(1)**

✓ enzyme-linked immunosorbent assay (1)

(b) Outline how an ELISA test can be used to show whether a specific antigen is present in a sample. **(4)**

✓ the antigen in the sample binds to / is bound by an antibody attached to the well (1)
✓ a second antibody, with an enzyme attached, is added and binds to the antigen (1)
✓ the well is washed to remove any unbound (second) antibody (1)
✓ a substrate is added and a colour change shows the antigen is present (the enzyme acts on the substrate) (1)

(c) Explain why the well must be washed before the substrate solution is added. **(1)**

✓ to remove any (second) antibody that has not bound, so a false positive colour change does not occur (1)

(d) The second antibody used in the test is described as a monoclonal antibody. Explain why monoclonal antibodies are suitable for use in diagnostic tests such as ELISA. **(3)**

✓ monoclonal antibodies are identical / specific to one antigen (1)
✓ they will only bind to the (one) target antigen being tested for (1)
✓ so the test gives a reliable / specific result (binds only the correct antigen) (1)