A Cell structure
Content
• The microscope in cell studies
• Cells as the basic units of living organisms
• Detailed structure of typical animal and plant cells, as seen under the electron microscope
• Outline functions of organelles in plant and animal cells
• Characteristics of prokaryotic and eukaryotic cells

Learning Outcomes
Candidates should be able to:
(a) [PA] use an eyepiece graticule and stage micrometer scale to measure cells and be familiar with units (millimetre, micrometre, nanometre) used in cell studies;
(b) explain and distinguish between resolution and magnification, with reference to light microscopy and electron microscopy;
(c) describe and interpret drawings and photographs of typical animal and plant cells, as seen under the electron microscope, recognising the following: rough and smooth endoplasmic reticula, Golgi apparatus, mitochondria, ribosomes, lysosomes, chloroplasts, cell surface membrane, nuclear envelope, centrioles, nucleus and nucleolus;
(d) outline the functions of the structures listed in (c);
(e) [PA] compare and contrast the structure of typical animal and plant cells;
(f) [PA] draw and label low power plan diagrams of tissues and organs (including a transverse section of stems, roots and leaves) and calculate the linear magnification of drawings;
(g) [PA] calculate linear magnification of drawings and photographs;
(h) [PA] calculate actual sizes of specimens from drawings and photographs;
(i) describe the structure of a prokaryotic cell and compare and contrast the structure of prokaryotic cells with eukaryotic cells;
(j) use the knowledge gained in this section in new situations or to solve related problems.

B Biological molecules
Content
• Structure of carbohydrates, lipids and proteins and their roles in living organisms
• Water and living organisms

Learning Outcomes
Candidates should be able to:
(a) [PA] carry out tests for reducing and non-reducing sugars (including using colour standards as a semi-quantitative use of the Benedict’s test), the iodine in potassium iodide solution test for starch, the emulsion test for lipids and the biuret test for proteins;
(b) describe the ring forms of α-glucose and β-glucose;
(c) describe the formation and breakage of a glycosidic bond with reference both to polysaccharides and to disaccharides including sucrose;
(d) describe the molecular structure of polysaccharides including starch (amylose and amylopectin), glycogen and cellulose and relate these structures to their functions in living organisms;
(e) describe the molecular structure of a triglyceride and a phospholipid and relate these structures to their functions in living organisms;
(f) describe the structure of an amino acid and the formation and breakage of a peptide bond;
(g) explain the meaning of the terms primary structure, secondary structure, tertiary structure and quaternary structure of proteins and describe the types of bonding (hydrogen, ionic, disulfide and hydrophobic interactions) that hold the molecule in shape;
(h) describe the molecular structure of haemoglobin as an example of a globular protein, and of collagen as an example of a fibrous protein and relate these structures to their functions (the importance of iron in the haemoglobin molecule should be emphasised);
(i) describe and explain the roles of water in living organisms and as an environment for organisms;
(j) use the knowledge gained in this section in new situations or to solve related problems.
C Enzymes
Content
• Mode of action of enzymes
• Factors that affect enzyme action

Learning Outcomes
Candidates should be able to:
(a) explain that enzymes are globular proteins that catalyse metabolic reactions;
(b) explain the mode of action of enzymes in terms of an active site, enzyme/substrate complex, lowering of activation energy and enzyme specificity;
(c) [PA] follow the progress of an enzyme-catalysed reaction by measuring rates of formation of products (for example, using catalase) or rates of disappearance of substrate (for example, using amylase);
(d) [PA] investigate and explain the effects of temperature, pH, enzyme concentration and substrate concentration on the rate of enzyme-catalysed reactions;
(e) explain the effects of competitive and non-competitive inhibitors on the rate of enzyme activity;
(f) use the knowledge gained in this section in new situations or to solve related problems.

D Cell membranes and transport
Content
• Fluid mosaic model of membrane structure
• Movement of substances into and out of cells

Learning Outcomes
Candidates should be able to:
(a) describe and explain the fluid mosaic model of membrane structure, including an outline of the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins;
(b) outline the roles of cell surface membranes;
(c) describe and explain the processes of diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis (terminology described in the IOB’s publication Biological Nomenclature should be used; no calculations involving water potential will be set);
(d) [PA] investigate the effects on plant cells of immersion in solutions of different water potential;
(e) use the knowledge gained in this section in new situations or to solve related problems.

E Cell and nuclear division
Content
• Replication and division of nuclei and cells
• Understanding of chromosome behaviour in mitosis

Learning Outcomes
Candidates should be able to:
(a) explain the importance of mitosis in the production of genetically identical cells, growth, repair and asexual reproduction;
(b) [PA] describe, with the aid of diagrams, the behaviour of chromosomes during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell membrane, centrioles and spindle (names of the main stages are expected);
(c) explain how uncontrolled cell division can result in cancer and identify factors that can increase the chances of cancerous growth;
(d) explain the meanings of the terms haploid and diploid and the need for a reduction division (meiosis) prior to fertilisation in sexual reproduction;
(e) use the knowledge gained in this section in new situations or to solve related problems.

F Genetic control
Content
• Structure and replication of DNA
• Role of DNA in protein synthesis

Learning Outcomes
Candidates should be able to:
(a) describe the structure of RNA and DNA and explain the importance of base pairing and the different hydrogen bonding between bases;
(b) explain how DNA replicates semi-conservatively during interphase;
(c) state that a gene is a sequence of nucleotides as part of a DNA molecule, which codes for a polypeptide and state that a mutation is a change in the sequence that may result in an altered polypeptide;
(d) describe the way in which the nucleotide sequence codes for the amino acid sequence in a polypeptide with reference to the nucleotide sequence for HbA (normal) and HbS (sickle cell) alleles of the gene for the \( \beta \)-haemoglobin polypeptide;
(e) describe how the information on DNA is used during transcription and translation to construct polypeptides, including the role of messenger RNA (mRNA), transfer RNA (tRNA) and the ribosomes;
(f) use the knowledge gained in this section in new situations or to solve related problems.

G Transport

Content

• The need for, and functioning of, a transport system in multicellular plants
• The need for, and functioning of, a transport system in mammals
• Structure and functioning of the mammalian heart

Learning Outcomes

Candidates should be able to:

(a) explain the need for transport systems in multicellular plants and animals in terms of size and surface area to volume ratios;
(b) define the term transpiration and explain that it is an inevitable consequence of gas exchange in plants;
(c) [PA] describe how to investigate experimentally the factors that affect transpiration rate;
(d) [PA] describe the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants;
(e) [PA] describe the structure of xylem vessel elements, sieve tube elements and companion cells and be able to recognise these using the light microscope;
(f) relate the structure of xylem vessel elements, sieve tube elements and companion cells to their functions;
(g) explain the movement of water between plant cells, and between them and their environment, in terms of water potential (no calculations involving water potential will be set);
(h) describe the pathways and explain the mechanisms by which water is transported from soil to xylem and from roots to leaves;
(i) outline the roles of nitrate ions and of magnesium ions in plants;
(j) [PA] describe how the leaves of xerophytic plants are adapted to reduce water loss by transpiration;
(k) explain translocation as an energy-requiring process transporting assimilates, especially sucrose, between the leaves (sources) and other parts of the plant (sinks);
(l) explain the translocation of sucrose using the mass flow hypothesis;
(m) [PA] describe the structures of arteries, veins and capillaries and be able to recognise these vessels using the light microscope;
(n) explain the relationship between the structure and function of arteries, veins and capillaries;
(o) [PA] describe the structure of red blood cells, phagocytes and lymphocytes;
(p) state and explain the differences between blood, tissue fluid and lymph;
(q) describe the role of haemoglobin in carrying oxygen and carbon dioxide;
(r) describe and explain the significance of the dissociation curves of adult oxyhaemoglobin at different carbon dioxide levels (the Bohr effect); (s) describe and explain the significance of the increase in the red blood cell count of humans at high altitude;
(t) describe the external and internal structure of the mammalian heart;
(u) explain the differences in the thickness of the walls of the different chambers in terms of their functions;
(v) describe the mammalian circulatory system as a closed double circulation;
(w) describe the cardiac cycle;
(x) explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkyne tissue);
(y) use the knowledge gained in this section in new situations or to solve related problems.

H Gas exchange and smoking

Content

• The gas exchange system
• Smoking and smoking-related diseases

Learning Outcomes

Candidates should be able to:
(a) [PA] describe the structure of the human gas exchange system, including the microscopic structure of the walls of the trachea, bronchioles and alveoli with their associated blood vessels;
(b) [PA] describe the distribution of cartilage, ciliated epithelium, goblet cells and smooth muscle in the trachea, bronchi and bronchioles;
(c) describe the functions of cartilage, cilia, goblet cells, smooth muscle and elastic fibres in the gas exchange system;
(d) describe the process of gas exchange between air in the alveoli and the blood;
(e) describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system;
(f) describe the signs and symptoms of lung cancer and chronic obstructive pulmonary disease (emphysema and chronic bronchitis);
(g) describe the effects of nicotine and carbon monoxide on the cardiovascular systems;
(h) explain the link between smoking and atherosclerosis, coronary heart disease and strokes;
(i) evaluate the epidemiological and experimental evidence linking cigarette smoking to disease and early death;
(j) discuss the difficulties in achieving a balance between prevention and cure with reference to coronary heart disease, coronary by-pass surgery and heart transplant surgery;
(k) use the knowledge gained in this section in new situations or to solve related problems.

I Infectious disease

Content
• Cholera, malaria, tuberculosis (TB) and HIV/AIDS
• Antibiotics

Learning Outcomes
Candidates should be able to:
(a) define the term disease (see page 37) and explain the difference between an infectious disease and non-infectious diseases (limited to sickle cell anaemia and lung cancer; see pages 40 and 41);
(b) describe the causes of the following diseases: cholera, malaria, TB, HIV/AIDS, smallpox and measles;
(c) explain how cholera, measles, malaria, TB and HIV/AIDS are transmitted;
(d) discuss the roles of social, economic and biological factors in the prevention and control of cholera, measles, malaria, TB and HIV/AIDS (a detailed study of the life cycle of the malarial parasite is not required);
(e) discuss the global patterns of distribution of malaria, TB and HIV/AIDS and assess the importance of these diseases worldwide;
(f) outline the role of antibiotics in the treatment of infectious diseases;
(g) use the knowledge gained in this section in new situations or to solve related problems.

J Immunity

Content
• The immune system
• Vaccination

Learning Outcomes
Candidates should be able to:
(a) [PA] recognise phagocytes and lymphocytes under the light microscope;
(b) state the origin and describe the mode of action of phagocytes (macrophages and neutrophils);
(c) describe the modes of action of B-lymphocytes and T-lymphocytes;
(d) explain the meaning of the term immune response, making reference to the terms antigen, self and non-self (see section 5);
(e) explain the role of memory cells in long-term immunity;
(f) relate the molecular structure of antibodies to their functions;
(g) distinguish between active and passive, natural and artificial immunity and explain how vaccination can control disease (see section 5);
(h) discuss the reasons why vaccination programmes have eradicated smallpox but not measles, tuberculosis (TB), malaria or cholera;
(i) use the knowledge gained in this section in new situations or to solve related problems.