5. Syllabus content

It is expected that any course in biology will be based on experimental work. Teachers are encouraged to develop appropriate practical work for candidates to facilitate a greater understanding of the subject. Candidates should be aware of the hazards and appropriate safety precautions to follow when handling equipment and reagents in experimental work.

1. Cell structure and organisation

Content

1.1 Plant and animal cells

1.2 Specialised cells, tissues and organs

Learning outcomes

Candidates should be able to:

(a) examine under the microscope an animal cell (e.g. from fresh liver) and a plant cell (e.g. from *Elodea,* a moss, onion epidermis, or any suitable, locally available material), using an appropriate temporary staining technique, such as iodine or methylene blue

(b) draw diagrams to represent observations of the plant and animal cells examined above

(c) identify, from fresh preparations or on diagrams or photomicrographs, the cell membrane, nucleus and cytoplasm in an animal cell

(d) identify, from diagrams or photomicrographs, the cellulose cell wall, cell membrane, sap vacuole, cytoplasm, nucleus and chloroplasts in a plant cell

(e) compare the visible differences in structure of the animal and the plant cells examined

(f) state the function of the cell membrane in controlling the passage of substances into and out of the cell

(g) state the function of the cell wall in maintaining turgor (turgidity) within the cell

(h) state, in simple terms, the relationship between cell function and cell structure for the following:

- absorption – root hair cells
- conduction and support – xylem vessels
- transport of oxygen – red blood cells

(i) identify these cells from preserved material under the microscope, from diagrams and from photomicrographs

(j) differentiate *cell, tissue, organ* and *organ system* as illustrated by examples covered in sections 1 to 12, 15 and 16.

2. Diffusion and osmosis

Content

2.1 Diffusion

2.2 Osmosis

2.3 Active transport

Learning outcomes

Candidates should be able to:

(a) define *diffusion as* the movement of molecules from a region of their higher concentration to a region of their lower concentration, down a concentration gradient

(b) define *osmosis* as the passage of water molecules from a region of higher water potential to a region of lower water potential, through a partially permeable membrane

(c) describe the importance of a water potential gradient in the uptake of water by plants and the effects of osmosis on plant and animal tissues

(d) define *active transport* as the movement of ions into or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration against a concentration gradient, using energy released during respiration

(e) discuss the importance of active transport as an energy-consuming process by which substances are transported against a concentration gradient, as in ion uptake by root hairs and glucose uptake by cells in the villi.

3. Enzymes

Content

3.1 Enzyme action

3.2 Effects of temperature and pH

Learning outcomes

Candidates should be able to:

(a) define *catalyst* as a substance that speeds up a chemical reaction and is not changed by the reaction

(b) define *enzymes* as proteins that function as biological catalysts

(c) explain enzyme action in terms of the 'lock and key' hypothesis

(d) investigate and describe the effects of temperature and of pH on enzyme activity.

4. Plant nutrition

Content

4.1 Photosynthesis

4.2 Leaf structure

4.3 Mineral nutrition

Learning outcomes

Candidates should be able to:

(a) understand that photosynthesis is the fundamental process by which plants manufacture carbohydrates from raw materials

(b) investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls

(c) state the equation (in words or symbols) for photosynthesis

(d) investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants)

(e) understand the concept of limiting factors in photosynthesis

(f) describe the intake of carbon dioxide and water by plants

(g) understand that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage

(h) explain why most forms of life are completely dependent on photosynthesis

(i) identify and label the cuticle, cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the microscope, and describe the significance of these features in terms of function, i.e.

- distribution of chloroplasts – photosynthesis
- stomata and mesophyll cells – gas exchange
- vascular bundles – transport

(j) understand the effect of a lack of nitrate and magnesium ions on plant growth.

5. Animal nutrition

Content

5.1 Nutrients
5.2 Diet
5.3 World food supplies
5.4 Human alimentary canal
5.5 Chemical digestion
5.6 Absorption and assimilation

Learning outcomes

Candidates should be able to:

(a) list the chemical elements that make up:
- carbohydrates
- fats
- proteins

(b) describe tests for:
- starch (iodine in potassium iodide solution)
- reducing sugars (Benedict's solution)
- protein (biuret test)
- fats (ethanol emulsion test)

(c) list the principal sources of, and describe the dietary importance of carbohydrates, fats, proteins, vitamins (C and D only), mineral salts (calcium and iron only), fibre (roughage) and water

(d) name the diseases and describe the symptoms resulting from deficiencies of vitamin C (scurvy), vitamin D (rickets), calcium (rickets) and iron (anaemia)

(e) understand the concept of a balanced diet

(f) explain why diet, especially energy intake, should be related to age, sex and activity of an individual

(g) state the effects of malnutrition in relation to starvation, heart disease, constipation and obesity

(h) discuss the problems that contribute to famine (unequal distribution of food, drought and flooding, increasing population)

(i) identify the main regions of the alimentary canal and the associated organs: mouth (buccal) cavity, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum and anus

(j) describe the main functions of these parts in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate

(k) identify the different types of human teeth and describe their structure and functions

(l) state the causes of dental decay and describe the proper care of teeth

(m) describe peristalsis

(n) explain why most foods must be digested

(o) describe:
- digestion in the alimentary canal
- the functions of a typical amylase, protease and lipase, listing the substrates and end-products

(p) describe the structure of a villus, including the roles of capillaries and lacteals

(q) describe the significance of villi in increasing the internal surface area

(r) state the function of the hepatic portal vein as the route taken by most of the food absorbed from the small intestine

(s) state:

- that large molecules are synthesised from smaller basic units:
  glycogen from glucose
  proteins from amino acids
  lipids (fats and oils) from glycerol and fatty acids
- the role of the liver in the metabolism of glucose and amino acids
- the role of fat as a storage substance
- that the formation of urea and the breakdown of alcohol occur in the liver.

6. Transport in flowering plants

Content

6.1 Water and ion uptake

6.2 Transpiration and translocation

Learning outcomes

Candidates should be able to:

(a) relate the structure and functions of root hairs to their surface area and to water and ion uptake

(b) state that transpiration is the evaporation of water at the surfaces of the mesophyll cells followed by the loss of water vapour from the leaves through the stomata

(c) describe:

- how water vapour loss is related to cell surfaces, air spaces and stomata
- the effects of air currents (wind), and the variation of temperature, humidity and light intensity on transpiration rate
- how wilting occurs

(d) investigate, using a suitable stain, the pathway of water in a cut stem

(e) explain the movement of water through the stem in terms of transpiration pull

(f) identify the positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves

(g) state the functions of xylem and phloem.

7. Transport in humans

Content

7.1 Circulatory system

Learning outcomes

Candidates should be able to:

(a) describe the circulatory system as a system of tubes with a pump and valves to ensure one-way flow of blood

(b) describe the double circulation in terms of a low pressure circulation to the lungs and a high pressure circulation to the body tissues and relate these differences to the different functions of the two circuits

(c) name the main blood vessels that carry blood to and from the heart, lungs, liver and kidneys

(d) describe the structure and function of the heart in terms of muscular contraction and the working of valves

(e) compare the structure and function of arteries, veins and capillaries

(f) investigate and state the effect of physical activity on pulse rate

(g) describe coronary heart disease in terms of the occlusion of coronary arteries and state the possible causes (diet, stress and smoking) and preventive measures

(h) identify red and white blood cells as seen under the light microscope on prepared slides, and in diagrams and photomicrographs

(i) list the components of blood as red blood cells, white blood cells, platelets and plasma

(j) state the functions of blood:

- red blood cells – haemoglobin and oxygen transport
- white blood cells – phagocytosis, antibody formation and tissue rejection
- platelets – fibrinogen to fibrin, causing clotting
- plasma – transport of blood cells, ions, soluble food substances, hormones, carbon dioxide, urea, vitamins and plasma proteins

(k) describe the transfer of materials between capillaries and tissue fluid.

8. Respiration

Content

8.1 Aerobic respiration

8.2 Anaerobic respiration

8.3 Human gas exchange

Learning outcomes

Candidates should be able to:

(a) define *respiration* as the release of energy from food substances in all living cells

(b) define *aerobic respiration* as the release of a relatively large amount of energy by the breakdown of food substances in the presence of oxygen

(c) state the equation (in words or symbols) for aerobic respiration

(d) state the uses of energy in the human body: muscle contraction, protein synthesis, cell division, active transport, growth, the passage of nerve impulses and the maintenance of a constant body temperature

(e) define *anaerobic respiration* as the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen

(f) state the equation (in words or symbols) for anaerobic respiration in humans and in yeast

(g) describe the effect of lactic acid production in muscles during exercise

(h) know the percentages of the gases in atmospheric air and investigate and state the differences between inspired and expired air

(i) investigate and state the effect of physical activity on rate and depth of breathing

(j) identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries

(k) state the characteristics of, and describe the role of, the exchange surface of the alveoli in gas exchange

(l) describe the role of cilia, diaphragm, ribs and intercostal muscles (external and internal) in breathing.

9. Excretion

Content

9.1 Structure and function of kidneys

9.2 Kidney dialysis

Learning outcomes

Candidates should be able to:

(a) define *excretion* as the removal of toxic materials and the waste products of metabolism from organisms

(b) describe the removal of carbon dioxide from the lungs

(c) identify on diagrams and name the kidneys, ureters, bladder, urethra and state the function of each (the function of the kidney should be described simply as removing urea and excess salts and water from the blood; details of kidney structure and nephron are **not** required)

(d) describe dialysis in kidney machines as the diffusion of waste products and salts (small molecules) through a membrane; large molecules (e.g. protein) remain in the blood.

10. Homeostasis

Content

10.1 Structure and function of the skin

Learning outcomes

Candidates should be able to:

(a) define *homeostasis* as the maintenance of a constant internal environment

(b) explain the concept of control by negative feedback

(c) identify, on a diagram of the skin, hairs, sweat glands, temperature receptors, blood vessels and fatty tissue

(d) describe the maintenance of a constant body temperature in humans in terms of insulation and the role of temperature receptors in the skin, sweating, shivering, blood vessels near the skin surface and the coordinating role of the brain.

11. Coordination and response

Content

11.1 Nervous system

11.2 Receptors

11.3 Reflex action

11.4 Hormones

Learning outcomes

Candidates should be able to:

(a) state that the nervous system (brain, spinal cord and nerves) serves to coordinate and regulate bodily functions

(b) identify, on diagrams of the central nervous system, the cerebrum, cerebellum, pituitary gland and hypothalamus, medulla, spinal cord and nerves

(c) describe the principal functions of the above structures in terms of coordinating and regulating bodily functions

(d) describe the gross structure of the eye as seen in front view and in horizontal section

(e) state the principal functions of component parts of the eye in producing a focused image of near and distant objects on the retina

(f) describe the pupil reflex in response to bright and dim light

(g) outline the functions of sensory neurones, relay neurones and motor neurones

(h) discuss the function of the brain and spinal cord in producing a coordinated response as a result of a specific stimulus (reflex action)

(i) define a *hormone* as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs and is then destroyed by the liver

(j) state the role of the hormone adrenaline in boosting the blood glucose concentration and give examples of situations in which this may occur

(k) state the role of the hormone insulin in controlling blood glucose concentration

(l) describe the signs (increased blood glucose concentration and glucose in urine) and treatment (administration of insulin) of diabetes mellitus.

12. Support, movement and locomotion

Content

12.1 Bones

12.2 Joints

12.3 Antagonistic muscles

Learning outcomes

Candidates should be able to:

(a) identify and describe, from diagrams, photographs and real specimens, the main bones of the forelimb (humerus, radius, ulna and scapula) of a mammal

(b) describe the type of movement permitted by the ball and socket joint and the hinge joint of the forelimb

(c) describe the action of the antagonistic muscles at the hinge joint.

13. The use and abuse of drugs

Content

13.1 Antibiotics

13.2 Effects of heroin

13.3 Effects of alcohol

13.4 Effects of tobacco smoke

Learning outcomes

Candidates should be able to:

(a) define a *drug* as any externally administered substance that modifies or affects chemical reactions in the body

(b) describe the medicinal use of antibiotics for the treatment of bacterial infection

(c) describe the effects of the abuse of heroin: a powerful depressant, problems of addiction, severe withdrawal symptoms and associated problems such as crime and infection, e.g. AIDS

(d) describe the effects of excessive consumption of alcohol: reduced self-control, depressant, effect on reaction times, damage to liver and social implications

(e) describe the effects of tobacco smoke and its major toxic components (nicotine, tar and carbon monoxide) on health: strong association with bronchitis, emphysema, lung cancer and heart disease, and the association between smoking during pregnancy and reduced birth weight of the baby

(f) recognise the fact that many people regard smoking as no longer socially acceptable.

14. Microorganisms and biotechnology

Content

14.1 Microorganisms
14.2 Food biotechnology
14.3 Industrial biotechnology

Learning outcomes

Candidates should be able to:

(a) list the main characteristics of the following groups: viruses, bacteria and fungi
(b) outline the role of microorganisms in decomposition
(c) explain the role of yeast in the production of bread and alcohol
(d) outline the role of bacteria in yoghurt and cheese production
(e) describe the use of fermenters for large-scale production of antibiotics and single cell protein
(f) describe the role of the fungus *Penicillium* in the production of penicillin.

15. Relationships of organisms with one another and with the environment

Content

15.1 Energy flow
15.2 Food chains and food webs
15.3 Carbon cycle
15.4 Nitrogen cycle
15.5 Parasitism
15.6 Effects of humans on the ecosystem
15.7 Pollution
15.8 Conservation

Learning outcomes

Candidates should be able to:

(a) state that the Sun is the principal source of energy input to biological systems
(b) describe the non-cyclical nature of energy flow
(c) define the following terms and establish the relationship of each in food webs:
- *producer* – an organism that makes its own organic nutrients, usually using energy from sunlight through photosynthesis
- *consumer* – an organism that gets its energy by feeding on other organisms
- *herbivore* – an animal that obtains its energy by eating plants
- *carnivore* – an animal that obtains its energy by eating other animals
- *decomposer* – an organism that obtains its energy from dead or waste organic matter
- *food chain* – a chart showing the flow of energy (food) from one organism to the next, beginning with the producer (e.g. mahogany tree → caterpillar → songbird → hawk)

(d) describe energy losses between trophic levels and infer the advantages of short food chains
(e) describe and interpret pyramids of numbers and of biomass
(f) describe and state the importance of the carbon cycle

(g) describe the nitrogen cycle in making available nitrogen for plant and animal protein, including the role of bacteria in nitrogen fixation, decomposition and nitrification (details of denitrification and the names of individual bacteria are **not** required)

(h) understand the role of the mosquito as a vector of disease

(i) describe the malarial pathogen as an example of a parasite and describe the transmission and control of the malarial pathogen (details of the life cycle of the pathogen are **not** required)

(j) describe the effects of humans on the ecosystem with emphasis on examples of international importance (tropical rainforests, oceans and important rivers)

(k) describe the consequences of deforestation in terms of its effects on soil stability, climate and local human populations

(l) evaluate the effects of:

water pollution by sewage, by inorganic waste and by nitrogen-containing fertilisers

air pollution by greenhouse gases (carbon dioxide and methane), contributing to global warming

air pollution by acidic gases (sulfur dioxide and oxides of nitrogen), contributing to acid rain

pollution due to insecticides

(m) discuss reasons for conservation of species with reference to maintenance of biodiversity, management of fisheries and management of timber production

(n) discuss reasons for recycling materials, with reference to **named** examples.

16. Development of organisms and continuity of life

Content

16.1 Asexual reproduction

16.2 Sexual reproduction in plants

16.3 Sexual reproduction in humans

16.4 Sexually transmitted diseases

Learning outcomes

Candidates should be able to:

(a) define *mitosis* as cell division giving rise to genetically identical cells in which the chromosome number is maintained and state the role of mitosis in growth, repair of damaged tissues, replacement of worn out cells and asexual reproduction

(b) define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent and describe **one named**, commercially important application of asexual reproduction in plants

(c) define *meiosis* as a reduction division in which the chromosome number is halved from diploid to haploid

(d) state that gametes are the result of meiosis (reduction division)

(e) define *sexual reproduction* as the process involving the fusion of haploid nuclei to form a diploid zygote and the production of genetically dissimilar offspring

(f) identify and draw, using a hand lens if necessary, the sepals, petals, stamens and carpels of **one**, locally available, **named**, insect-pollinated, dicotyledonous flower, and examine the pollen grains under a light microscope

(g) state the functions of the sepals, petals, anthers and carpels

(h) use a hands lens to identify and describe the anthers and stigmas of **one**, locally available, **named**, wind-pollinated flower, and examine the pollen grains under a light microscope

(i) outline the process of pollination and distinguish between self-pollination and cross-pollination

(j) compare, using fresh specimens, an insect-pollinated and a wind-pollinated flower

(k) describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (production of endosperm and details of development are **not** required)

(l) investigate and describe the structure of a non-endospermic seed in terms of the embryo (radicle, plumule and cotyledons) and testa, protected by the pericarp (fruit wall)

(m) state that seed and fruit dispersal by wind and by animals provides a means of colonising new areas

(n) describe the external features of **one**, locally available, **named** example of a wind-dispersed fruit or seed and of **one named** example of an animal-dispersed fruit or seed

(o) investigate and state the environmental conditions that affect germination of seeds: suitable temperature, water and oxygen

(p) describe the uses of enzymes in the germination of seeds

(q) identify on diagrams of the male reproductive system and state the functions of the testes, scrotum, sperm ducts, prostate gland, urethra and penis

(r) identify on diagrams of the female reproductive system and state the functions of the ovaries, oviducts, uterus, cervix and vagina

(s) compare male and female gametes in terms of size, numbers and mobility

(t) describe the menstrual cycle, with reference to the alternation of menstruation and ovulation, the natural variation in its length and the fertile and infertile phases of the cycle

(u) explain the role of hormones in controlling the menstrual cycle (including FSH, LH, progesterone and oestrogen)

(v) describe fertilisation and early development of the zygote simply in terms of the formation of a ball of cells that becomes implanted in the wall of the uterus

(w) state the function of the amniotic sac and the amniotic fluid

(x) describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products (**no** structural details are required)

(y) describe the special dietary needs of pregnant women

(z) describe the advantages of breast milk compared with bottle milk

(aa) describe the following methods of birth control:
natural, chemical (spermicides), mechanical, hormonal and surgical

(bb) explain that syphilis is caused by a bacterium that is transmitted during sexual intercourse

(cc) describe the symptoms, signs, effects and treatment of syphilis

(*dd*) discuss the spread of human immunodeficiency virus (HIV) and methods by which it may be controlled.

17. Inheritance

Content

17.1 Variation
17.2 Chromosomes and DNA
17.3 Monohybrid inheritance
17.4 Selection
17.5 Genetic engineering

Learning outcomes

Candidates should be able to:

(a) describe the difference between *continuous* and *discontinuous variation* and give examples of each
(b) state that a chromosome includes a long molecule of DNA
(c) state that DNA is divided up into sections called genes
(d) explain that genes may be copied and passed on to the next generation
(e) define a gene as a unit of inheritance and distinguish clearly between the terms *gene* and *allele*
(f) describe complete dominance using the terms *dominant, recessive, phenotype* and *genotype*
(g) describe *mutation* as a change in the structure of a gene (e.g. sickle cell anaemia) or in the chromosome number (e.g. 47 in Down's syndrome instead of 46)
(h) name radiation and chemicals as factors that may increase the rate of mutation
(i) predict the results of simple crosses with expected ratios of 3:1 and 1:1, using the terms *homozygous, heterozygous, F_1 generation* and *F_2 generation*
(j) explain why observed ratios often differ from expected ratios, especially when there are small numbers of progeny
(k) explain *codominance* by reference to the inheritance of the ABO blood group (phenotypes A, B, AB, O, gene alleles I^A, I^B and I^O)
(l) describe the determination of sex in humans (XX and XY chromosomes)
(m) describe *variation* and state that competition leads to differential survival of organisms, and reproduction by those organisms best fitted to the environment
(n) assess the importance of natural selection as a possible mechanism for evolution
(o) describe the role of artificial selection in the production of economically important plants and animals
(p) explain that DNA controls the production of proteins
(q) state that each gene controls the production of one protein
(r) explain that genes may be transferred between cells (reference should be made to transfer between organisms of the same or different species)
(s) explain that the gene that controls the production of human insulin can be inserted into bacterial DNA
(t) understand that such genetically engineered bacteria can be used to produce human insulin on a commercial scale
(u) discuss potential advantages and dangers of genetic engineering.