Cambridge Assessment

A Level

Biology

Session: 1974
Type: Syllabus
Code: 870

BIOLOGY (870)

(*May not be taken with Social Biology, Botany or Zoology*)

Papers will be set as follows:

Paper 1 ($2\frac{1}{2}$ hours). Candidates will be required to answer five out of nine traditional-type questions.

Paper 2 ($1\frac{1}{2}$ hours) will consist of a number of structured short-answer questions based on any part of the syllabus and there will be no choice.

Paper 3 (1 hour) will consist of multiple-choice questions based on any part of the syllabus; there will be no choice.

A 3-hour Practical Examination. (see p. 59).

In addition, a Special Paper of $2\frac{1}{2}$ hours will be set containing more searching questions and candidates will be required to answer any four out of nine.

The Advanced Level syllabus has been built as a logical development from that at Ordinary Level. Although in some parts of the two syllabuses the wording is very similar, a more detailed study is expected at Advanced Level than at Ordinary Level.

Much current research is being done on some topics contained in the syllabus, e.g. the structure and function of sub-cellular particles (Section I) and on energy cycles (Section III). In consequence conflicting theories may be put forward and ideas may be modified as new evidence comes to light. Students should be encouraged to consider such evidence critically, it being assumed that students will have sufficient knowledge of elementary chemistry to comprehend physiological processes.

Biology is essentially an outdoor subject but in addition to field work students should also be encouraged to collect, for themselves, living material for laboratory investigations. To help help achieve this object, the syllabus gives considerable latitude to teachers in the choice of species for study.

The syllabus indicates examination requirements and need not be taken as a suggested order of teaching.

I. CYTOLOGY AND HISTOLOGY

Structure of typical plant and animal cells: cytoplasm, nucleus and ergastic substances (non-living cell inclusions). Mitosis.

Differentiation and structure of tissues, including vascular tissues of plants, blood, secretory tissue of gastric glands, and nerves.

The structure of the cell membrane, the cell wall in plants, the cytoplasm, plastids, mitochondria, microsomes and chromosomes should be considered briefly so that their functions and interrelations may be appreciated. The structure of the DNA molecule with its potentiality for self-replication, for providing a genetic code and for mutation, should be included. The occurrence and importance of RNA should be noted. Names of biochemical substances (rather than formulae) will be adequate and the work in this section should be closely related to the corresponding parts of Sections II and IV.

II. MORPHOLOGY, ANATOMY AND CLASSIFICATION

The principles of classification should be clearly understood, but it is unnecessary and undesirable that the classification of either animals or plants should be considered in detail. The student should be able to assign any common animal or plant to its correct phylum (or division) and in some cases to its class. For example, he should be able to see that a crayfish, a spider and a blowfly are all members of the Arthropoda and that the blowfly belongs to the Insecta. Similarly among plants he should be able to recognize that *Marchantia, Lunularia, Polytrichum* are all Bryophytes, the two former being liverworts and the last named a moss. Questions on the principles of classification will not be set in the theory papers, but an application of these principles may be required in the Practical Test.

1. Viruses: their characteristics and the difficulty of their classification as living organisms.

   Reference to one plant virus and one animal virus is required.

2. Bacteria: structure only of one spore-forming bacterium.

3. Protozoa: structure and reproduction of *Euglena, Amoeba* and *Paramecium.*

   Details of conjugation in *Paramecium* are not required.

4. Algae: vegetative structure only of *Pleurococcus* and of a filamentous alga.

5. Fungi: structure and life-history of yeast and one other saprophytic fungus, e.g. *Mucor* or *Rhizopus,* and one parasitic fungus, e.g. *Phytophthora.*

6. Coelenterata: structure and life-history of *Hydra.*

7. Annelida: structure and life-history of an earthworm (*Lumbricus*), excluding details of reproduction.

8. Bryophyta: morphology, anatomy and life-history of a liverwort, e.g. *Pellia,* and an outline of the life-history of a moss, e.g. *Mnium.*

9. Pteridophyta: external morphology of the sporophyte, morphology and anatomy of the gametophyte, and life-history of a member of the Filicales, e.g. *Dryopteris.*

10. Vegetative morphology and anatomy of a herbaceous monocotyledon; floral morphology of a cereal or a grass and one other monocotyledon, e.g. *Lilium*; morphology (vegetative and floral) and anatomy of a herbaceous and an arborescent dicotyledon, including the process of secondary thickening.

The morphology and anatomy should be studied in sufficient detail for an understanding of other sections of the syllabus. (See Section III. 8.)

11. Arthropoda: external structure of *Locusta* (or *Periplaneta*). Life-histories of *Calliphora* and *Apis mellifica.*

12. Chordata: external morphology of a fish, including gills. External features of a bird. Anatomy of a frog and a small mammal in sufficient detail for an understanding of other sections of the syllabus.

See also Section III. 8.

III. PHYSIOLOGY

1. An elementary study of the chief constituents of cells to allow an understanding of physiological processes: acids, bases, salts, carbohydrates, fats, a typical amino acid, and proteins. Colloids, membrane permeability, diffusion, turgor-pressure, and osmosis. Rates of chemical change, catalysis and enzyme action.

Qualitative and quantitative experiments should be carried out on osmosis and on enzymes, the latter to show general and specific enzyme characteristics.

2. Nutrition.

(*a*) Holophytic nutrition; intake of water and mineral salts; photosynthesis; transport and storage within the plant; the water economy of the plant as a whole; the effect of environmental factors on rates of photosynthesis and of transpiration.

The process of photosynthesis may be considered in two parts—the photochemical part and the path of carbon. It should be possible to give a reasonable explanation of the principles concerned, e.g. electron activation in chlorophyll, water as a source

of hydrogen, presence of a hydrogen acceptor formation of ATP and its role in energy-exchange, the cyclic process involving different carbon compounds, without going into biochemical details of the substances named. The importance of an energy supply and of the cell vacuole and its membrane in the absorption of mineral salts should be pointed out, but details of current theories on the subject are not expected. Quantitative experiments should be included in the study of photosynthesis and transpiration. For photosynthesis, the work should include experiments on the effect of varying (i) the intensity of light, (ii) the concentration of carbon dioxide, (iii) the temperature. For transpiration, experimental work should include a consideration of the physical principles involved in water loss from the plant and a study of the effects on such loss of varying the environmental factors. Structural details of storage organs are not required.

(*b*) Holozoic nutrition: constituents of a balanced diet; intake, digestion, absorption and assimilation of food, including transport and storage. The role of the mammalian heart, circulatory and blood system in physiological processes.

3. Respiration.

(*a*) The sources of energy and the processes of energy exchange in plant and animal metabolism; aerobic and anaerobic respiration.

It is important to emphasize principles more than biochemical formulae. The breakdown of glucose to pyruvic acid and the importance of phosphate supply should be made clear without attempting to name all the intermediate compounds. The fact that it is a controlled breakdown of glucose in well-defined stages in which some energy is stored in ATP should be stressed. The different fates of pyruvic acid in aerobic and anaerobic respiration should be explained, includng reference to the quantity of useful energy made available in each case. The part played by mitochondria should be included here. The importance of glycogen, lactic acid and an oxygen debt in the energy supply of muscles should be considered. Experiments involving measurements should be carried out on repiration. They should include those showing the influence of the substrate on the amount of energy released and of environmental factors on the rate of the process.

(*b*) Temperature control in mammals and birds.

The relationships between size, metabolic rate and external temperatures should be discussed. The significance of homoiothermy and the factors involved in its maintenance, e.g. food supply, muscular activity, skin structure, circulation, sweating, panting, the role of the hypothalamus, should be considered.

4. Excretion: osmo-regulation and water balance in animals; the formation of metabolic waste products and their elimination in a mammal and flowering plant.

5. Growth: growth in size; the balance of anabolism and katabolism. Change in form: ecdysis in arthropods; metamorphosis; growth changes before and after birth in mammals; germination changes in seeds; primary and secondary meristems in angiosperms.

Measurements should be made of the growth of small animals (e.g. mice) using weighing methods, and relating growth to food intake. Observations should also be made of growth in plants by weighing and by measurements of the length increases in stems and in roots. Metamorphosis should be studied with reference to the insects mentioned in Section II, and to the frog. An outline of the development of a mammal is required, emphasizing the modes of nutrition of the embryo. Details of mammalian embryology are not required.

Experiments in water uptake, production of enzymes, and heat production, should be performed, and qualitative and quantitative observations made on the stages in germination of an example of a monocotyledon and an example of a dicotyledon. The examples that should be studied are given in Section II.

6. Response.

(*a*) Responses to stimuli by *Amoeba, Paramecium,* an earthworm and an insect.

An appreciation of the fundamental irritability of protoplasm and the resulting behaviour patterns in comparatively primitive organisms is required. Simple experiments should be performed with the types of animal mentioned.

(*b*) Tropic and nastic responses in plants.

Externally observable aspects of these phenomena (presentation time, latent period, summation) should be studied experimentally as far as possible.

(*c*) Photoperiodism.

Externally observable aspects of photoperiodism (presentation time, latent period, summation) should be studied experimentally as far as possible and the results contrasted with those of tropic and nastic responses (see also Section V).

(*d*) Hormones and endocrines; phytohormones and growth substances.

This section should be broadly treated, contrasting hormone control with nervous control. The importance of endocrine balance in animals should be stressed; pathological details of the results of imbalance are not required.

(*e*) The structure and function of the central and autonomic nervous systems in mammals. Cranial nerves and spinal nerves. Sense organs: the eye, ear and skin.

Knowledge of the main functional regions of the brain is required, together with a knowledge of the structure of the spinal cord as seen in transverse section and of a neurone. No other *detailed* structural knowledge is required.

7. Locomotion: *Amoeba, Euglena, Paramecium*; animals without a skeleton, e.g. earthworm; animals with an exoskeleton, e.g. Arthropoda; animals with an endoskeleton, e.g. bony fish, bird and a mammal.

The study of voluntary muscle should include its innervation, an elementary study only of the biochemical changes during muscle contraction, the production of mechanical energy and the development of an oxygen debt during activity. Some reference should be made to muscle tone and fatigue.

8. Reproduction.

(*a*) Sexual reproduction: the formation of haploid gametes and the part played by meiosis; fertilization. The development of the zygote. The different sexes: chromosomes, secondary sexual characters.

Meiosis should be dealt with so that its significance in halving the number of chromosomes is clear. The formation of gametes and the place in the life-cycle where meiosis occurs should be considered in a mammal and a flowering plant. Examples of external fertilization and internal fertilization should be described and the method related to the environment. Pollination as a method of transferring immobile gamets should be considered; self-pollination and cross-pollination in anemophilous and entomophilous flowers. Reference should be made to the development of the embryo in flowering plants and the formation of endospermous and non-endospermous seeds. Membranes of eggs in water, and of eggs not in water; embryonic membranes and the placenta in mammals. Details of mammalian embryology are not required. It is suggested that examples of organisms tested in Section II be used in the study of the principles of sexual reproduction.

(*b*) Asexual reproduction and the essential difference from sexual reproduction. Reference should be made to parthenogenesis in insects.

It is suggested that examples of organisms listed in Section II be used in the study of the principles of asexual reproduction.

IV. VARIATION IN AND EVOLUTION OF LIVING THINGS

Variation within and between species—mutation, chromosome aberration, polyploidy. Natural selection. Evidence for the concept of organic evolution. Genes and the mechanism of inheritance: qualitative and quantitative characters.

The nature of the evidence for evolution should be discussed. Some of the arguments are to be found in the earlier chapters of *Origin of Species*. Stress should be placed upon present-day knowldege of the behaviour of chromosomes and genes, including random assortment, linkage groups and the effects of crossing over, rather than on the pioneer and historic work of Mendel. A modern conception of the general mechanism of inheritance in plants and animals is required, togeher with some knowledge of heredity in man. Practical work in genetics should be encouraged. For example, suitable genotypes of *Drosophila* might be used to study inheritance of qualitative characters, both independently segregating and linked. It is suggested that Johannsen's classical experiments on *Phaseolus vulgaris* might be repeated to study the expression of quantitative characters. Analyses of an F2 population following crossing between two pure-breeding lines differing markedly in seed size should enable appreciation of the inheritance. Differences between inheritance of qualitative and quantitative characters and the role of the environment in determining gene character expression should be discussed.

V. LIVING THINGS IN RELATION TO ENVIRONMENT

Factors of the environment (climatic, edaphic and biotic) and their effects upon organisms. Interdependence of plants and animals in their normal habitat: saprophytism, parasitism, symbiosis and commensalism.

The study of a well-defined ecological habitat, made over a period of at least one complete school year, will be expected, including the interrelationships of the plants and animals within it. It is better to study a relatively small area (e.g. a pond, a hedgerow, or a rockpool) rather than a large area from which only superficial data could be collected in the time available.
In any ecological exercise, accurate identification of the organisms being studied is the first essential; the second is their distribution within the habitat. In the case of plants, detailed distribution maps may be prepared; permanent quadrats or other marked regions of the habitat would allow accurate records to

be made throughout the year enabling precise appearance and distribution of plants to be recorded. Sampling data of animal abundance and distribution should be taken whenever practicable.
Habitat factors should be defined and the association of particular organisms with their intimate environmental conditions should be related as quantitatively as is possible. Characteristics enabling adaptation of organisms to their prevailing environment should be described; any such characteristic seeming to confer a selective advantage should be studied in detail.
Life-cycles of some species should be examined. Population studies should be carried out, wherever possible, to determine differences between potential and actual reproductive capacities of organisms. Such differences should be interpreted to indicate the significance, i.e. when in the life-history they occur and what factors are responsible. The interdependence of organisms within the chosen habitat should be studied and the pertinence to this interdependence of such factors as the cyclic distribution of elements, the gaseous balance of the medium, food relationships and protection, discussed.
Data collected in such a study may be used both to answer ecological questions set on the theory paper and for the project work which may be offered as an additional item for examination (see p. 86).

VI. PRACTICAL EXAMINATION

A practical examination is designed to test the candidate's ability:

1. To make observations on living and preserved specimens and record them accurately in writing or by using clear drawings or diagrams.

2. To use the pertinent features of specimens as a basis for their identification.

3. To carry out detailed instructions for dissection and to display, draw and label the dissections.

If a dissection is set, detailed instructions will be provided to enable the candidate to dissect any suitable animal supplied.

4. To carry out detailed instructions for the staining and temporary mounting of specimens for microscopic examination, and to draw and interpret such specimens. The examiners may also ask candidates to make mounts of such insect parts as legs or tracheae, or, by using smear techniques to make mounts of other animal material. Appropriate instructions will be given in the question paper.