Cambridge Assessment

A Level

Biology

Session: 1984
Type: Syllabus
Code: 9260

Subject Syllabus
SS13(HCO)
1984
Biological Sciences

For All Centres

GENERAL CERTIFICATE OF EDUCATION
SCHOOL CERTIFICATE
HIGHER SCHOOL CERTIFICATE

EXAMINATION SYLLABUSES FOR

1984

BIOLOGICAL SCIENCES

UNIVERSITY OF CAMBRIDGE
LOCAL EXAMINATIONS SYNDICATE
INTERNATIONAL EXAMINATIONS

3/82/12M/DG

BIOLOGY (9260)—ADVANCED LEVEL AND HIGHER SCHOOL CERTIFICATE

This subject may not be taken with Social Biology or Zoology.

Aims and objectives of the syllabus

It is intended that the syllabus should

(a) reflect the current situation in biological sciences,

(b) be a suitable preparation for university courses in Biology, for biological studies in other institutes of higher education and for professional courses such as Medicine,

(c) be complete in itself, and perform a useful educational function for candidates not intending to study Biology at a higher level.

Abilities to be tested

1. Theory Papers

(a) Simple recall of facts and principles.

(b) The understanding and application of those facts and principles.

(c) The comprehension, interpretation and translation of data presented in a variety of graphical and other forms.

(d) The construction of hypotheses and the design of experiments.

(e) Biological judgement and evaluation.

(f) Communication and quality of expression.

2. Practical Paper

(a) Observation.

(b) Precise recording (including *accurate* drawing).

(c) Manipulative skills.

(d) The ability to handle familiar and unfamiliar biological materials.

(e) The ability to follow instructions (including the carrying out of experiments) within a given time.

(f) The ability to interpret the results of experiments and to pursue logical developments in the light of biological knowledge.

Form of the Examination

Paper 1 — This will be a 2½ h paper and will carry one-third of the total marks available for the examination. Candidates will be asked to answer four out of nine essay-type questions. Ten per cent of the marks *for the paper* will be awarded on a subjective basis for quality of expression. In order to be awarded a pass in the subject, candidates must achieve a certain minimum standard in this paper.

Paper 2 — This will last for 1½ h and will consist of a number of compulsory structured questions of varying lengths. Emphasis will be placed on questions involving the comprehension and presentation of data, on the comprehension of written passages and on genetics questions of a numerical type. The paper will carry 25% of the total marks available for the examination.

Paper 3 — This will be a multiple choice paper designed to last for 1 h and consisting of forty compulsory items. It will carry one-sixth of the total marks available for the examination.

Paper 4 (+5 +6* +8**) — This will be a practical test designed to last for 3 h and carrying 25% of the total marks available for the examination. The questions, which will be compulsory and of varying length, may include a physiological experiment and a dissection. Frogs will *not* be set as dissection material in the United Kingdom.

*Caribbean candidates only

**U.K. candidates for the November examination, who have taken the previous June examination, may elect to carry forward their June practical work.

Paper 7 — This is an optional Individual Study or Project, available to centres in the United Kingdom only (see separate note at end of booklet).

Paper 0 — This is an optional "Special" paper available to centres in the United Kingdom only, and will last for 2½ h. It is designed basically to give opportunities for candidates to show their ability to think independently and to give evidence of wide reading. For example, questions may ask for critical evaluation of biological theories and hypotheses or evidence for the ways in which physiological processes operate. Candidates may be expected to show an ability to correlate or compare information based on the different sections of the syllabus. In addition, the paper will often contain questions of a rather general nature which will require candidates to select and organize the most appropriate arguments and/or pieces of information with which to illustrate their answers.

Reports, in the form of notes by the examiners on the work of candidates, are circulated some months after the examination.

In order to pass in this subject, candidates must achieve the minimum aggregate mark for Grade E and must also reach pass standard in at least one of the Theory papers and reach a minimum standard in Paper 1.

DETAILED SYLLABUS

Modern biology cannot effectively be studied without some understanding of the underlying physico-chemical principles. Candidates will therefore be expected to have an elementary knowledge of the topics set out below, but *only* in sufficient detail for an understanding of biological systems; *no* questions will be set directly on these topics.

The electromagnetic spectrum.
Energy concepts. (Laws of themodynamics. Potential energy. Activation energy Chemical bond energy).
Ions, molecules, acids, bases, pH, buffers.
Isotopes—stable and radioactive.
The colloidal state.
Oxidation, reduction, electron and hydrogen transfer.
Hydrolysis, condensation, phosphorylation, decarboxylation, deamination, transamination.

Similarly, large areas of modern genetics and ecology rely on statistical methods. Candidates will need an elementary knowledge of the topics listed below and questions on genetics and ecology may be set which involve the use of these concepts.

The arithmetic mean, mode and median.
Standard deviation and standard error.
Histograms, frequency diagrams and normal distribution curves.
Bimodal distribution.

Candidates will be assumed to have a knowledge of Biology to Ordinary Level.

Suggestions are given for the approximate teaching time to be devoted to each major section, based on a total of 270 hours.

I. CELL BIOLOGY (65 hours)

An elementary knowledge of the usefulness and limitations of techniques used by cell biologists: the light, phase-contrast and electron microscopes, cell and tissue culture, homogenisation, centrifugation, chromatography, electrophoresis, X-ray diffraction.

A. *FUNDAMENTAL CHEMICALS OF LIVING ORGANISMS*

Water—properties of water important in making it an ideal constituent and medium for living things.

Chemical nature, properties and physiological roles of the following substances. (Elementary details only are required. Candidates will *not* be expected to know full structural formulae.)

Carbohydrates

Monosaccharides: trioses, pentoses, hexoses.
Disaccharides. Polysaccharides.

Lipids

Fats.
Phospholipids—importance in membrane structure.

Proteins

Amino acids. Proteins as condensation products of amino acid units. Peptide linkage. The unlimited number of possible variations for polypeptides and proteins.
Primary, secondary and tertiary orders of protein structure.
Fibrous and globular proteins.
Conjugated proteins.
Importance of amino acid sequence in the physiological properties of sickle cell haemoglobin. Gene mutation.
Amphoteric, buffering and colloidal nature of proteins.
Denaturation of proteins.
Proteins as antigens and antibodies.

Nucleic Acids—(see section F)

B. *ENZYMES*

Influence of temperature and pH on enzyme activity.
The action and properties of enzymes, related to their structure as proteins.
Enzyme specificity. Denaturation.
Enzyme cofactors—one example of each of the following—a metal ion activator, an organic coenzyme related to a vitamin.
Enzyme inhibitors—end product inhibition, one example of a competitive inhibitor and one example of a non-competitive inhibitor.
The variety of enzymes—hydrolases, oxidoreductases, decarboxylases, transferases.

C. *CELLS*

Prokaryotic and eukaryotic cells.
Structure of "generalised" plant and animal cells. Fundamental differences between plant and animal cells. The plant cell wall.
Membranes—structure, functions and distribution of membranes in cells (including molecular structure); plasmalemma, tonoplast, selective permeability, active and passive transport, pinocytosis, phagocytosis.
Organelles—structure, functions and distribution of endoplasmic reticulum, ribosomes, Golgi apparatus, mitochondria, lysosomes, chloroplasts, centrioles.
Cytoplasm—ground substance and cell inclusions.
Nucleus—nuclear envelope, nucleolus, nuclear sap, chromosomes.
Units of length relevant to cell studies:
10^{-6} metres—micrometre (μm)
10^{-9} metres—nanometre (nm)
Candidates should be conversant with these units in relation to wavelengths, molecular size, membranes, colloidal particles, organelles, viruses, bacteria, protozoa, cell sizes and the resolving power of the light and electron microscopes.

D. *MITOSIS*

Stages of nuclear division following the precise duplication of chromosomes in interphase. Behaviour of chromosomes in the various phases. Cytoplasmic cleavage and cell separation. Differences between mitosis in plants and animals. Significance of mitosis. Abnormal events—changes in chromosome numbers, polyploidy.

E. *MEIOSIS*

Stages of meiosis and their significance. Random assortment of maternal and paternal chromosomes. Crossing over. Differences between mitosis and meiosis. Non-disjunction resulting in extra chromosomes, chromosome mutation.

F. *NUCLEIC ACIDS AND GENETIC CODING*

Nucleotides. Nucleic acids as polymers and nucleotide units.
DNA—distribution, structure and replication.
The triplet code for amino acids.
Structure of RNA compared with DNA. The roles of RNA— transcription of genetic code into messenger RNA, translation by ribosomes and transfer RNA in protein synthesis—significance of polyribosomes.
The gene concept—one gene: one polypeptide hypothesis.
Experimental evidence supporting the DNA—genetic code hypothesis and relating DNA replication to mitosis.

G. *CELL SPECIALISATION*

Specialisation of plant cells in following tissues—primary meristems, parenchyma, collenchyma, sclerenchyma, xylem, phloem.
Specialisation of animal cells, illustrated by ciliated epithelial cells, glandular epithelial cells, nerve cells, red blood cells.

II. THE PHYSIOLOGY OF ORGANISMS (100 hours)

Candidates will be expected to possess sufficient knowledge of the structure of organisms for an understanding of their function; work should include dissection and microscopic examination where appropriate.

The principle generally followed is that dissection from memory will only be required of organisms and systems specifically mentioned in the syllabus. In such cases, outline instructions only will be given. For dissections of unfamiliar material, full instructions will be given.

The examiners will expect candidates to have dissected an earthworm (United Kingdom Centres only), a cockroach or locust and a small mammal. If an animal other than the above is required to be dissected, detailed instructions will be provided. Frog dissections will not be set in the United Kingdom.

With regard to microscopic studies, the examiners expect that the following will have been included in practical classes: mouthparts of cockroach or locust; histology of mammalian ileum, kidney, spinal cord, blood, blood vessels, ovary and testis. The structure of a leaf, primary stem and primary root of a herbaceous dicotyledon. Floral reproductive structure of an angiosperm.

Slides of unfamiliar material may also be set in the practical examination, in order to test powers of observation and interpretation.

Life as a process in which organisms continually use energy in order to maintain themselves at a low level of entropy: energy needed for osmotic, mechanical, electrical and chemical work and for heat production.

H. *THE HOLOPHYTIC NUTRITION OF PLANTS:*

1 An experimental study of photosynthesis in the whole plant; measurements of photosynthetic rate and the effects on this of variations in the wavelength and intensity of light, in the concentration of carbon dioxide and in temperature.

2. An outline of the photosynthetic process to include:
   - *(a)* trapping of light energy—the photoactivation of chlorophyll resulting in the splitting of water, the release of oxygen and the production of reduced coenzyme and ATP.
   - *(b)* fixation of CO_2 which combines with a 5-C compound to yield a 3-C organic acid (PGA);
   - *(c)* reduction of PGA by reduced coenzyme to form triose phosphate, some of which condenses to form hexose phosphates, sucrose and starch;
   - *(d)* recycling of remainder of triose phosphate to provide a continuous supply of 5-C CO_2 acceptor.

   (Reference should also be made to the biochemical pathway of photosynthesis in "C_4" plants).

3. Transport and fate of carbohydrates; storage of food reserves.

4. Leaf structure in relation to the uptake of CO_2 and the trapping of light energy.

I. *THE HOLOZOIC NUTRITION OF ANIMALS.*

Emphasis should be laid on the essential difference between animals and plants. Both need a respiratory substrate of high energy content: plants obtain this by photosynthesis, but animals need an external source of such material.

1. Feeding: ingestion and preparation for digestion of animal and vegetable material.

To include specialisations of mammalian tooth types (restricted to one carnivore example and one herbivore example) and the mouthparts of either a locust or a cockroach.

2. The concept of a balanced diet.

3. Digestion—the functions of an alimentary system. The digestive process in mammals.

4. Absorption, transport and fate of foodstuffs in mammals. Advantage of fat as a storage material.

J. *THE UTILISATION OF ENERGY-CONTAINING SUBSTRATES.*

1. Mobilisation and transport of respiratory substrates from energy reserves.

2. Oxygen supply to respiring cells in plants and animals. External sources of oxygen: problems and advantages of water and air as oxygen sources; structure and mode of action to teleost gills, mammalian lungs and the insect tracheal system; oxygen transport within the organism.

3. An outline of aerobic cellular respiration to include:
   - *(a)* breakdown of reserves to yield active hexose phosphates which split to give two molecules of triose phosphate;
   - *(b)* oxidation of triose phosphate to pyruvate with only small yield of energy;
   - *(c)* oxidative decarboxylation of pyruvate in the TCA cycle (without biochemical detail);
   - *(d)* production of energy via an electron transfer system, whereby oxygen is reduced to water;
   - *(e)* the role of ATP in the coupled reactions of intermediary metabolism.

4. Anaerobic respiration: formation of lactate or ethanol; reduced yield of ATP.

K. *MAINTENANCE OF THE INTERNAL ENVIRONMENT*

The concept of homeostasis: the advantages for a multicelled organism of an approximately constant internal environment.

1. Regulation of water and ions.

(a) Plants: uptake of water and ions by plant roots. The mechanism of stomatal action and the role of stomata in regulating water loss.

(b) Animals: structure of the human kidney and its operation in regulating the water and ion content of the body fluids. Elimination of metabolic wastes in man.

2. Temperature control in plants and animals.

(a) Plants: temperature increase as an inevitable consequence of exposure of photosynthetic structures to radiant energy; evaporative cooling by transpiration.

(b) Animals: problems posed by the inevitable generation of heat owing to higher metabolic rates of animals. Temperature regulation in Man.

L. *COORDINATION AND CONTROL*

(a) Chemical coordination and control.

(i) Indolyl ethanoic (acetic) acid, gibberellic acid, abscisic acid and ethene ethylene); the control of fruit development, stem elongation, apical dominance, abscission, flowering and dormancy.

(ii) Hormonal control of ecdysis and metamorphosis in insects.

(iii) The endocrine system in Man: the function of thyroxine, adrenaline, and insulin in relation to metabolic activity. The role of hormones in the control of reproduction. (The importance of endocrine balance and the concept of negative feedback should be stressed; pathological details of the results of imbalance need not be stressed.)

(b) Nervous coordination and control.

(i) Neurone and synapse; nature of nervous impluse and synaptic transmission.

(ii) A brief consideration of the increasing complexity of nervous systems, illustrated by reference to coelenterates, annelids, arthropods and Man.

(iii) The layout of the mammalian nervous system and an outline of control by central and autonomic systems. Reflex arcs.

(iv) A brief survey of mammalian receptors, including a detailed study of the eye and its functions in normal vision.

M. *CIRCULATION AND TRANSLOCATION*

(a) Plants; xylem and the ascent of sap; transpiration; the cohesion-tension theory; root pressure. Phloem and translocation; hypotheses for the mechanism of movement of solutes in the phloem.

(b) Animals; the role of a circulatory system in physiological processes; the structure and functions of blood and lymph in mammals; the heart as a pump; initiation and control of heart action; structure of blood vessels in relation to function.

N. *REPRODUCTION, DEVELOPMENT AND GROWTH*

(a) Animals. Histology of mammalian ovary and testis; gametogenesis; fertilisation.

The maintenance of the mammalian embryo, including the functions of amnion and placenta (a brief reference to extra-embryonic membranes in birds should be made by way of introduction). Change in form: ecdysis and metamorphosis in insects.

(b) Plants. Flower structure, development of pollen and ovules, pollination (reference should be made to wind, insect and self-pollination), fertilization, development of ovule into seed. Seed germination and seedling growth. Apical growth and cell differentiation in a flowering plant. (Questions relating to lateral meristems and cambial activity will not be set.)

(c) The essential difference between sexual and asexual reproduction and its genetic consequences. Brief reference to the occurrence of asexual reproduction throughout the animal and plant kingdoms, including parthenogenesis in insects and vegetative propagation in plants.

(d) Quantitative aspects of growth: measurement and analysis of growth; absolute and specific (relative) growth rates. Problems of measurement of growth in mass of animals and plants.

O. *MOVEMENT AND LOCOMOTION*

(a) The particular need for movement in animals.

(i) Cilia, flagella, cytoplasmic streaming in amoeboid movement.

(ii) Structure properties and mode of action of striated muscle; innervation, synaptic events, role of sarcoplasmic reticulum and calcium ions in initiating contraction, sliding filament theory, role of myoglobin. Oxygen debt after activity in mammals, maintained continuous activity in insects.

(iii) Locomotion in earthworms, insects (flying and walking), fishes and Man.

(b) Plant movements, i.e. cyclosis, turgor changes, differential growth rates producing tropic responses.

III. DIVERSITY AND EVOLUTION
(35 hours for P, Q and R; 35 hours for S and T)

P. *VARIATION*

Variation within species: The phenotype as the result of interaction of the genotype and environmental factors. Continuous and discontinuous variation.

Q. *GENETICS*

Monohybrid and dihybrid ratios; multiple alleles; polygenic inheritance; linkage and crossing over. Sex determination and sex linkage.

Evidence for the role of chromosomes in heredity.

A simple introduction to population genetics: the concept of the gene pool; the Hardy-Weinberg equation and its applications.

> The study of heredity should include some examples of human characteristics such as the ABO blood groups, the Rhesus factor, red-green colour blindness, haemophilia. Students should carry out one experimental exercise in genetics involving recognition of phenotypic characters and measurement of ratios in successive generations. Questions will be set from time to time to test candidates' familiarity with the practical details of such experimental studies.

R. *EVOLUTION*

The concept of organic evolution, and the nature of the evidence for it. Theories concerning the origin of life.

The origin of inherited variation, including gene mutation, chromosomal changes and recombination. Mutagens.

Selection. Darwin and Natural Selection. Examples of natural and artificial selection (e.g. melanism in moths; drug resistance in bacteria; breeding of farm animals).

Genetic isolation and the origin of species. Isolating mechanisms. Adaptive radiation, with special reference to one class, e.g. insects, birds or mammals.

S. *TAXONOMY*

Concept of the species: difficulties of precise definition. The binominal system of Linnaeus, and the hierarchy of taxa. Artificial and natural classifications; the advantages and the limitations of the phylogenetic approach. Construction and use of dichotomous keys.

T. *THE DIVERSITY OF ORGANISMS*

A survey of the plant and animal kingdom to enable the student

(a) to gain an understanding of the wide range of living organisms,

(b) to be able to assign common organisms to the correct phylum (or division) and in some specified cases the class, and

(c) to appreciate some of the fundamental patterns of organisation and adaptation in living organisms, such as the alternation of generations in archegoniate plants or the evolution of the waterproof exoskeleton of insects.

The study should be based on the **general taxonomic features** of the organisms, with deeper study **only where specified** (either below of elsewhere in the syllabus). Living specimens should be examined wherever possible, and should be related to their natural habitats. **Named** examples will be expected.

*Viruses (including phage): characteristics, transmission, action as causative agents of disease.

*Bacteria: a brief review, including reference to autotrophic and heterotrophic nutrition. Prokaryotic organisation in a spore former.

*Algae: a unicellular, a filamentous and a fucoid example.

*Fungi: a saprophytic and a parasitic example, with special reference to the contrasted modes of nutrition.

*Bryophyta: a liverwort.

Pteridophyta: ferns and club-mosses. Knowledge of the internal anatomy of stem, root and leaf is **not required.

**Spermatophyta: Angiospermae.

> *The main features only of the internal structure are required.
>
> **A *simple outline* of the life history of a homosporous and a heterosporous pteridophyte and a typical flowering plant should be studied in order to gain an understanding of the phenomenon of alternation of generations, the development of heterospory and the evolution of the seed habit. The three examples should be seen as variations on a botanical theme of great importance. The studies of the life histories should include the morphology of the sporophyte, the nature of the sporangia (without cellular detail), the occurrence of meiosis during spore formation, a simple account of the haploid gametophyte generation, fertilisation and the broad lines along which the zygote develops to form the next sporophyte generation.

Protozoa: Mastigophora (Flagellata), Sarcodina (Rhizopoda) and Ciliata.

Coelenterata: including one example exhibiting clearly a hydroid and a medusoid phase.

Nematoda.

Annelida.

Arthropoda: with special reference to the classes Insecta and Crustacea.

Chordata; with special reference to the sub-phylum Vertebrata and its main classes. Colonisation of the land by the vertebrates should be considered.

IV. ORGANISMS AND THEIR ENVIRONMENT (35 hours)

U. *ENVIRONMENT*

The concept of the environment, habitat and niche. Definitions of ecosystem, ecosphere and community.

The concept of environmental limiting factors; climatic, edaphic and biotic factors. These aspects should be dealt with by reference to some of the major environments of the candidate's own region.

V. *RELATIONSHIPS*

1. Energy relationships.

   The concept of energy flow. A simple quantitative treatment of: solar energy utilisation, producers, consumers, trophic levels, food chains, food webs and the pyramids of numbers, biomass and energy. Carbon and Nitrogen cycles.

2. Interactions and populations.

   The concept of dynamic equilibrium in ecosystems. A simple treatment of population dynamics by reference to the main factors affecting populations; size and distribution, birth rate, death rate, competition, emigration and immigration. Succession—natural and deflected succession. Associations; parasitism, symbiosis.

W. *QUANTITATIVE ECOLOGY*

A study of the uses and limitations of the basic methods employed in determining simple population parameters, such as size, distribution, density and change.

1. Soil sampling techniques and soil analysis—pH, particle size, water content and organic content. Extraction of fauna by means of Tulgrenn funnels.
2. Quadrats, line and belt transects and some of their modifications. Other unit sampling devices, including light traps and mammal traps.
3. Methods of measuring frequency, density, percentage cover and population size (e.g. capture/recapture techniques).
4. The use of keys for identification.

   This section should be taught in relation to well defined habitats and/or artificial populations of organisms such as flour beetles and hay infusions. Candidates will not be expected to have had practical experience of all the above methods but will be expected to be aware of their use.

Note on the practical paper

Candidates may be required:

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 dissection. (See introduction to section II);

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.
   The cutting of sections will not be required in the examination: any sections for staining and mounting will be supplied from Cambridge. *Plan drawings* of microscopic sections should not include any cell structure.

5. to carry out simple biochemical tests, e.g. food tests such as the use of Fehling's or Benedict's solutions for reducing sugars, iodine solution for starch, ethanol emulsion test for fats, biuret test for proteins;

6. to perform simple physiological experiments (e.g. the effect of temperature on the activity of a given enzyme), record the results suitably and accurately, interpret the data intelligently.

Candidates may be required to use a hand-lens and a microscope. Drawings of specimens should be large and correctly proportioned (e.g. in dissections the thickness of all blood vessels and nerves should be accurately shown). Relevant structures only should be labelled. Labelling lines should be neatly drawn and should not be intersected by other lines.
Memorized textbook drawings or diagrams, bearing little likeness to the candidate's specimens or observations are of no value.