CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT

O Level

Biology

Session: 1984
Type: Syllabus
Code: 5090

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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

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BIOLOGY (5090)—ORDINARY LEVEL AND SCHOOL CERTIFICATE

The intention of this syllabus is to lead to an understanding of biological processes. The similarity of the basic life processes in animals and plants has been stressed in Section I. In Section II, attention should be focused more on the study of the interdependence of organisms. Where possible all observations should be made on living organisms and, if appropriate, in their natural surroundings, so that the relationships among animals and plants become apparent. In order that the study of ecology in the field may be further encouraged, an optional fieldwork project scheme is now available, in the June examination only, for centres in the United Kingdom.

Because the cell is the basis of life, reference should be made wherever appropriate to the structure of cells and tissues, particularly in relation to their functions. When the cellular structure of particular animal or plant organs is being considered, this should, wherever possible, be demonstrated by means of a microscope or micro-projector.

An experimental approach to all physiological work is expected. An understanding of controls is essential, together with the realization that, when there are several variables, these must be investigated one at a time. Where appropriate, quantitative experiments should also be carried out. Practical work both in and outside the laboratory is of great importance, and one of its main educational values is the stimulation of interest in biology. It is impossible to over-emphasize the importance of accuracy and detail both in drawing plants and animals and in keeping other records.

The syllabus is not meant to be a teaching syllabus and the notes which are printed in smaller type are intended to help teachers to appreciate the scope of the examination. It is expected that teachers will develop a sequence of lessons that appeals to their own teaching methods. Knowledge of the differences between living and non-living matter, characteristics of living organisms and differences between plants and animals has been assumed, whilst from previous elementary courses many pupils may be familiar with some details of the life-cycles and natural habitats of certain organisms.

Form of the examination

Paper 1 (2 h)

(a) A variety of structured questions, designed to last one hour and carrying 40 marks.

(b) Four short essay-type questions, designed to last a total of one hour and carrying 40 marks. (Candidates will be required to answer one compulsory, open-ended question and any three of five other questions.)

Paper 2 (½ h)

30 multiple choice items, carrying 30 marks.

Paper 3 (1 h) (alternative to paper 6)

Two practical questions, carrying 40 marks.

Paper 6 (1 h) (alternative to paper 3)

Two written questions, designed to test experience of practical work and carrying 40 marks.

DETAILED SYLLABUS

I. LIFE PROCESSES

1. NUTRITION. Proteins, carbohydrates and fats, mineral salts, vitamins. Importance of water. Enzymes.

Tests for protein, starch, sugar and fat should be carried out by the student. Digestive enzymes (including amylase, maltase, pepsin, peptidase and lipase) and other enzymes (including those of plants) should be discussed. Temperature, pH and specificity in respect of enzyme action.

Nutrition of green plants: *(a)* photosynthesis; the form and internal structure of leaves in relation to photosynthesis, *(b)* mineral nutrition.

(a) Experiments should be performed to show the necessity for light, carbon dioxide and chlorophyll, and the formation of starch and oxygen. Knowledge of the intermediate stages of photosynthesis is not required.
(b) The functional importance of the following elements should be understood: nitrogen, magnesium, phosphorus. Experiments using water- or sand-cultures should be carried out.

Nutrition and structure of a common mould *(Mucor* or *Rhizopus)*.

Nutrition of animals: ingestion, digestion, absorption and assimilation of food in *(a) Amoeba* and *(b)* a mammal, including the alimentary canal and associated glands.

Candidates should be made familiar with the tooth structure and dentition of the mammal studied, and with the appearance and position of the internal organs referred to in the syllabus, through actual dissections shown them by the teacher. They will not be expected to reproduce from memory drawings of complete dissections they have seen.

Transport of materials within the organism: *(a)* the circulatory system of a mammal as a transport system; structure of the heart, arteries, veins and capillaries. Composition of the blood and a simple treatment of defence functions.

Names will only be required of the main blood vessels of the liver and kidney and those entering and leaving the heart. Blood should be examined microscopically. A tadpole's gill or tail, or alternatively the web of a frog's foot, may be used to demonstrate capillary circulation.

(b) The transport of materials in higher plants: the internal structure of roots and stems in relation to transport.

A simple treatment only is required of the structure of xylem vessels and of phloem sieve tubes. The rise of water in the xylem should be demonstrated by the use of dyes.

Diffusion, osmosis and turgor in relation to absorption of water and solutes. The transpiration stream in plants. Translocation.

Diffusion and osmosis should be shown with an artificial cell and with living material. Experiments on transpiration and transpiration rates should be performed both by weighing methods, and by using cobalt(II) chloride paper (or cobalt(II) thiocyanate paper).

The storage of food in the liver, in two plant vegetative structures, in fruits and in seeds.

2. RESPIRATION. The process of respiration, involving oxidation of food substances and the release of energy in green plants, seeds, soil micro-organisms and animals.

Breathing mechanisms in an insect, a bony fish and a mammal.

Experiments should be carried out to demonstrate gaseous exchange and the production of heat. Anaerobic respiration is not required.

3. EXCRETION. Elimination of metabolic by-products in *(a) Amoeba, (b)* a mammal: excretion through the lungs and the kidneys; elimination of heat, temperature regulation by the skin.

The kidney should be treated as comprising cortex and medulla and consisting of a branched system of tubules, well supplied with blood-vessels, leading to the ureter. A nephron should be studied simply as a structure for filtration under pressure, followed by selective reabsorption of the filtrate.
Reference should be made to the incidental small losses of nitrogenous products and mineral salts from the skin and to osmoregulation.

Gaseous exchange in flowering plants.

4. GROWTH AND DEVELOPMENT: Regions of cell division and growth in stems and roots. Germination of one named seed (including conditions necessary for germination): life history of a housefly and its relation to disease.

Experiments should be performed to show regions of growth in stems and roots. The structure and division of the cell should be considered simply. Details of the structure of organelles other than the nucleus are not required (see I 8, mitosis).

5. RESPONSE. Tactic responses to light, water and contact exhibited by invertebrates.

Simple experiments on responses should be performed, e.g. with earthworms, woodlice, blowfly larvae.

Tropic responses to light and gravity exhibited by plants.

Experiments on phototropism and geotropism in shoots, and geotropism in roots, should be performed.

The control of response in plants: the hormone (auxin) explanation.

The effects of decapitating the coleoptiles of germinating cereals and applying indolyl ethanoic (acetic) acid should be demonstrated.

The control of response in animals: endocrine organs and hormones.

Reference should be made to insulin, adrenaline and thyroxine.

The nervous system: structure of the nerve cell (neurone), synapses, reflex arcs, simple and conditioned reflexes. Gross structure of the brain and spinal cord of a mammal related very simply to function.

Knowledge of localized functional areas within the cerebral hemispheres (e.g. speech centre) is not required.

Receptors.

(a) the eye: accommodation; correction of long-sight and short-sight;
(b) the ear: hearing and balance.
(c) a brief reference to receptors in the skin.

Simple experiments on reflexes should be performed by the pupil, e.g. 'knee jerk' (simple reflex), salivation on smelling food (conditioned reflex).

6. SKELETON AND LOCOMOTION. The skeleton in a mammal. The axial and appendicular skeleton. Antagonistic muscles.

A vertebra should be regarded as being composed of a body (centrum) carrying arches, neural spine and transverse processes with facets for articulation. The names of the articulatory processes will not be required.
A functional treatment is required. Different types of joint illustrated by shoulder and elbow, and the way muscles act on bones to cause movement, should be considered. Details of the skull, the bones of the carpus and the names of the individual bones of the pelvis are not required.

The exoskeleton in an insect or other arthropod.

A simple treatment only is required of an arthropod leg, its joints and the way in which muscles are attached.

7. REPRODUCTION. Binary fission in *Amoeba* and asexual reproduction in a mould *(Mucor* or *Rhizopus)*.
Sexual reproduction in a mammal. This should be compared briefly with reproduction in a bird and in a vertebrate with external fertilization.

A simple study of the reproductive organs in a mammal only, together with a general outline of the development, nutrition and respiration of the embryo.

Sexual reproduction in higher plants; the structure of flowers (one insect-pollinated example and one wind-pollinated example); one example of a natural method and one of artificial method of vegetative reproduction in flowering plants.

Fertilization should be considered without reference to microscopic detail other than the growth of the pollen tube and fusion of a nucleus from the pollen tube with a female nucleus in the ovule (production of endosperm is not required). A further study of the development of ovules and carpels to form seeds and fruits.
Dispersal in the types used to illustrate flower structure should be studied, and examples of wind, animal and self dispersal.

8. GENETICS. Variation within plant and animal species.

Candidates should be aware of genetic and environmental causal factors, and reference should be made to some human characters such as eye colour, skin colour, finger prints and tongue rolling.

Monohybrid inheritance.

Monohybrid crosses to illustrate complete and incomplete dominance should be studied, and the several examples should include some involving human characters such as albinism and the ABO blood groups. Reference should be made to the pioneer work of Mendel and of Morgan.

Chromosomes and genes. Mitosis and meiosis.

A simple outline account of mitosis and meiosis is required. In mitosis, emphasis should be laid on the exact duplication of the genetic material. In meiosis the pairing of the homologous chromosomes and their subsequent separation, with the resultant halving of the chromosome number and segregation of characters should be stressed.
Crossing-over and the structural details of the DNA molecule are not required.

Sex chromosomes and sex determination.

Mutation.

A mutation should be considered simply as a change in a chromosome or a gene. The natural occurrence and the artificial induction of mutations should be mentioned. The role of mutations as the raw material upon which natural selection operates to produce evolutionary change should be emphasized.
A consideration of the evidence for evolution is not required.

II. INTERDEPENDENCE OF LIVING ORGANISMS

1. FOOD RELATIONSHIPS. Nutritional dependence of all life on photosynthesis. Food chains; biological equilibrium.

Reference should be made to the consequences of natural disturbances of, as well as man's interference with, nature, e.g. the consequence of the destruction of rabbits in the United Kingdom through the epidemic of myxomatosis in 1954–55; the destruction of bird life by means of poisonous sprays used for pest control and the possible implications.

The carbon and nitrogen cycles, showing the role of green plants, animals and microorganisms.

2. DISEASE. A brief study of **four** diseases (one from each of lists A, B, C, and D) with reference to their causative agents, transmission and control.
A Influenza, Rubella, Smallpox.
B Tuberculosis, Cholera, Gonorrhoea.
C Amoebic dysentery, Malaria, Sleeping sickness.
D *Phytophthora, Puccinia, Erysiphe.*

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3. SOILS. *(a)* Composition and properties of soil: sand, clay, chalk, organic matter. Flocculation of clay. Soil acidity and the use of soil indicators.

Different soil types should be handled, and the separation of a soil into sand, silt and clay fractions demonstrated.

(b) Air and water in soils. Water-retaining properties of humus and clay. Capillarity; drainage of soil.

Water-holding capacity and drainage of a sandy soil and a clay soil should be simply demonstrated by pouring water over dry samples of these soils in funnels.

4. *RELATIONSHIP OF PLANTS AND ANIMALS TO THEIR ENVIRONMENT. Candidates will be expected to have made one of the following simple ecological studies: **either** *(a)* a study in some detail of a single animal species or a single plant species in its natural habitat, **or** *(b)* a study of the animal and plant population in one **natural** habitat.

FIELD WORK PROJECT SCHEME

The scheme is optional and applies only to Centres in the United Kingdom, for the Summer examination.

Project Approval

Suggested outlines of projects, based on section II 4 of the syllabus, must be submitted to the Syndicate not later than 1 November in the calendar year preceding the examination. After approval by the Syndicate's examiners, final application should be made on the appropriate form by 20 January.

Size of Work Group

No limit is set on the number of candidates permitted to undertake any one project, although it is anticipated that most studies will be carried out by groups of four to twelve students. However, *individual reports* must be submitted in all cases.

Nature of acceptable work

1. Where appropriate, studies should include such features as:

(a) identification and characteristics of the species;
(b) quantitative sampling, methods of collecting;
(c) recognised methods of survey and census (one method suitable for animals and one suitable for plants), e.g. linear belt transects, quadrats, capture-recapture;
(d) problems posed by the environment and adaptation of species;
(e) physical features of the environment and their effect on the life of the organisms;
(f) food chains or webs, pyramid of numbers, primary producers, primary and secondary consumers, interdependence of species. Influence of man.

2. The work must be investigatory, although background reading should be encouraged and reference made to it in the written account (if appropriate). Any sources of reference must be acknowledged.

3. Whereas the progamme of study must be carried out by the pupils themselves, *it is the responsibility of the teacher to guide, or even select, such problems as suit their investigatory abilities* and to suggest such methods of investigation as are likely to be effective. 16-year-old children should not be expected to be competent research workers, but to be able to learn something of the scientific process by being involved in an enquiry (or enquiries) which they themselves carry out.

4. Whilst it is difficult to give precise guidance on the time to be devoted to field work projects, it is suggested that, *for work to be minimally acceptable*, it should occupy pupils for at least the equivalent of *10 periods of 40 mins*. Pupils should be

* For centres in the United Kingdom (Summer examination), section II 4 will be examined by an optional field-work project scheme only.

discouraged from spending so much time on their project that their normal class work suffers.

5. Throughout the period of project work, teachers should encourage first-hand involvement by pupils with aspects of living organisms and natural history, but *the principles of conservation* should always be paramount and actively discussed with them: work based on collections should never seriously deplete the natural population of a given species or group.

Criteria for Assessment of Project Work

It is not possible to assess field work projects according to fixed criteria, but it is expected that many of the following components can be identifiable in work. These should be borne in mind when the assessment is made.

(i) A perceptive description of the nature of the topic and the problems involved, and evidence of background reading.
(ii) design of the investigation and the principles on which it is based,
(iii) selection of relevant questions and hypotheses for investigation,
(iv) the quality of the practical part of the study and care in the collection of data,
(v) the presentation of data and its handling as evidence,
(vi) the ability to make deductions from the evidence or data acquired,
(vii) the ability to assess the limitations of the data,
(viii) the recognition of further questions which the study raises,
(ix) perseverance in the face of practical difficulties,
(x) originality of the approach to the **whole** project.

25 marks are available and teachers are asked to allocate them according to the following guide:

25–24 Outstanding work—work which meets to a high degree the criteria listed above.
23–20 Very good work—work of genuinely scientific quality, revealing a sound understanding of the problems tackled.
19–16 Good work—carefully organised or detailed work, well written up, showing competence at completing the assignment(s) though possibly requiring some help with the design and/or methods of investigation.
15–12 Adequate work—work showing the completion of the investigation(s), revealing some understanding of the problem(s) being tackled though a failure to understand the subtleties; written account well presented, evidence of working when advised what to do.
11–8 Modest work—work showing endeavour and a complete account, though lacking the evidence of much originality or understanding of the science involved.
7–4 Weak work—work of, at best modest value—lacking a scientific treatment.
3–1 Poor work—possibly incomplete and fundamentally lacking in scientific quality.
0 No work submitted.

Moderation

1. The teacher's assessment must reach the Syndicate not later than 1 May in the year of the examination, and should be accompanied by three reports (from the top, bottom and middle of the class).

2. The Syndicate's moderators will check these sample reports against the teacher's assessment, and will visit schools where some discrepancy is evident.

3. The moderators will visit 20 per cent of those schools submitting projects (including those mentioned in 2).

4. All reports and other evidence of field work should be available for moderation during the month of May.

Bonus

Projects will be awarded a bonus mark which may raise a candidate's overall marks so as to improve his performance in the subject by a maximum of one letter grade.

PRACTICAL EXAMINATION

1. The practical examination is designed to test candidates for the following abilities:

(a) to follow carefully a sequence of instructions within a set time allowance;

(b) to use familiar, and unfamiliar techniques to record their observations and make deductions from them;

(c) to recognize and observe features of familiar and unfamiliar biological specimens, record their observations and make deductions about functions of whole specimens or their parts;

(d) to make clear line drawings of the specimens *provided,* indicate magnification and to label familiar structures;

(e) to interpret unfamiliar data and draw conclusions from their interpretation;

(f) to employ manipulation skills in assembling apparatus, in using chemical reagents and in using such instruments as mounting needles, scalpels and razor blades, forceps and scissors;

(g) to observe reactions, read simple measuring instruments and perform simple arithmetical calculations.

2. Candidates may be asked to carry out simple physiological experiments, involving tests for food substances, enzyme reactions, hydrogencarbonate indicator solution, decolourising leaves, etc. It is expected that glassware and instruments normally found in a laboratory e.g. beakers, test-tube racks, funnels, thermometers, droppers and so on, should be available for these experiments.

3. Candidates may be asked to carry out simple operations, involving the use of the above mentioned instruments (*f*) on plant or animal material. Accurate observations of these specimens will need a hand lens of not less than ×6 magnification for each candidate.

4. The material set will be closely related to the subject matter of the syllabus, but will not necessarily be limited to the particular types mentioned therein. In order to assist their own practical work, and to supply possible examination specimens, schools are asked to build up a reference collection of material, e.g. bones of the rabbit or rat.

Footnote

The food tests expected in paragraph 2 above are as follows.

Reducing sugars—Fehling's or Benedict's solution.
Non-reducing sugars—Fehling's or Benedict's solution after hydrolysis with dilute hydrochloric acid.
Starch—Iodine solution.
Fats—Ethanol emulsion test.
Protein—biuret test.

OBJECTIVES OF THE EXAMINATION AS A WHOLE

In addition to the practical skills outlined above, the examination is designed to test the following abilities:

(a) the recall and understanding of facts and principles,
(b) the application of these facts and principles to new situations,
(c) the comprehension and interpretation of quantitative data expressed in graphical or other forms,
(d) certain higher abilities including the formulation of hypotheses, the design of experiments, analysis, evaluation and synthesis.

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