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BIOLOGY

The intention of this syllabus is to cover sufficient biological material to enable the pupil to obtain an appreciation of the variety of living organisms combined with some understanding of their anatomy and physiology. The similarity of the basic life processes has been stressed in Section I and therefore when teaching these processes, plants and animals should not be treated independently. In Section II attention should be focused on the study of whole organisms in relation to their environment.

As 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, quantitative experiments being carried out where appropriate.

The study of living organisms in their natural surroundings is especially necessary to demonstrate the interdependence of plants and animals. This study, together with practical work on such organisms in 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. The examples of species for study which are given at various points in the syllabus are suggestions only; they are not intended to preclude the study of other suitable species which the teacher may wish to use.

There will be two papers.

Paper 1 will be a $2\frac{1}{2}$-hour paper containing nine questions. Candidates will answer Question 1 (32 *marks*) and any four of the remaining questions (68 *marks*). A question on Section II paragraph 3 (ecology) will always be set. It should be understood that candidates need not repeat in writing information that has already been included in diagrams or drawings, but if these are chosen as the best means of giving information they should be suitably annotable.

Paper 2 will be a $1\frac{1}{2}$-hour practical test (45 *marks*) in which there will be no choice of question.

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 pupil himself. Digestive enzymes and other enzymes should be discussed, and their fundamental importance stressed, e.g. the action of catalase may be demonstrated readily by allowing a few drops of blood to fall into hydrogen peroxide solution.

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. (*b*) Experiments showing the importance of major elements, using water or sand-cultures should be carried out.

Nutrition and structure of a common mould, e.g. *Mucor* or *Rhizopus*, or *Penicillium*.

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 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.

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

(*b*) the transport of materials in higher plants: the internal structure of roots and stems in relation to transport. Diffusion, osmosis and turgor in relation to absorption of water and solutes. The transpiration stream in plants.

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 chloride paper (or cobalt thiocyanate paper). The rise of water in the xylem should be demonstrated by the use of dyes.

Food storage. The liver. Food storage organs in plants, including vegetative structures and seeds.

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

Breathing mechanisms in: an insect, e.g. locust, a bony fish, tadpole and frog, and a mammal.

Experiments should be carried out to demonstrate gaseous exchange and 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. Details of the courses of the tubules and their blood-vessels will not be required.
Reference should be made to the incidental small losses of nitrogenous products and mineral salts from the skin and to osmo-regulation.

Gaseous exchange in flowering plants.

4. Growth. Increase in size: regions of growth in stems and roots.

Change of form in plants: germination of seeds. Change of form in animals: metamorphosis of the frog and a butterfly or moth.

Experiments should be performed to show regions of growth in stems and roots. The structure of the cell should be considered simply (cell wall, cytoplasm, nucleus, vacuole). Details of cell and nuclear division

are not required. The germination of a cereal grain and at least one other type of seed should be studied from dormancy to the unfolding of the foliage leaves.

5. Response. Responses to stimuli exhibited by *Amoeba.*

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, water and gravity exhibited by plants.

Experiments on phototropism and geotropism in shoots, and geotropism and hydrotropism 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 acetic acid should be demonstrated.

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

Reference should be made to adrenalin and to growth hormones and sex hormones.

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.

Receptor organs: receptors in the skin and organs of special sense: (*a*) the eye: accommodation; correction of long-sight and short-sight; (*b*) the ear: hearing and balance.

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

6. Locomotion. Locomotion in *Amoeba* and in an insect, e.g. locust or other arthropod.

A consideration of the action of muscles on the exoskeleton is required and may be studied in an insect, but a larger arthropod (e.g. crayfish) may be used with advantage to demonstrate this.

The basic vertebrate pattern of locomotion as illustrated by a bony fish. The skeleton in a mammal. Locomotion in a mammal. The axial and appendicular skeleton.

Details of the skull, the bones of the carpus and the names of the individual bones of the pelvis are not required. 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 or hip, elbow or knee, and the way muscles act on bones to cause movement, should be considered.

Flight in birds. Adaptations to flight. Structure and functions of feathers.

7. Reproduction. Asexual reproduction in *Amoeba* and a mould e.g. *Mucor*, or *Rhizopus*, or *Penicillium*.

Sexual reproduction in an insect, e.g. locust, a bony fish, e.g. salmon or trout, the frog, a bird and a mammal.

Breeding habits of these animals should be considered, together with the parental care for the young organism. A simple study of the reproductive organs in a mammal, together with a general outline of the development, nutrition and respiration of the embryo.

Sexual reproduction in higher plants; the structure of flowers; pollination and fertilization; development of fruit and seed dispersal.

Principles of vegetative reproduction in flowering plants.

Structure can best be examined in a *large* flower, e.g. tulip.

Structure and pollination should be studied in an 'open' flower, e.g. tulip, a flower with protected essential organs, e.g. antirrhinum, and also in a grass. Fertilization should be considered without reference to microscopic detail other than the growth of the pollen tube and fusion of nuclei.

Dispersal in the types used to illustrate flower structure should be studied, and examples of wind, animal and self dispersal.

Detailed reference should be limited to three different types.

II. INTERDEPENDENCE OF LIVING ORGANISMS

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

The importance of maintaining a biological balance may be studied by means of aquaria but reference should also 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.

Relationships beneficial to man; the carbon and nitrogen cycles showing the role of green plants, animals, saprophytic and parasitic organisms. Fixation of nitrogen.

Relationships harmful to man; disease organisms. Fungi, bacteria and viruses. Transmission of disease organisms and methods of control.

Reference should be made to two insect vectors of disease and candidates should have sufficient knowledge of the life-history of these insects for an understanding of the methods of control that are adopted. Disease of both plants and animals should be mentioned.

2. Soils. Physical and chemical properties of soils. The soil as a medium for plant and animal life.

Candidates should make an elementary study of the physical and chemical properties of soils supported by simple experiments. When considering soil as a medium for life attention should be paid to the effect of differing physical and chemical characteristics of soils on soil animals and plants and to their agricultural properties.

3. Relationship of Plants and Animals to their Environment. Candidates will be expected to have carried out a simple ecological study.

It is anticipated that candidates will carry out this work in small groups or even individually, rather than as whole forms. It is important that the studies shall consist not merely of a diary of uncollated observations. The studies should be based on correct identification and include observations on life-histories and/or seasonal changes; they should also include consideration of any important environmental factors that may have led to adaptations. Accurate recording, both qualitative and quantitative, should be encouraged. A study of a small number of species in their habitat, or even a single species, is more valuable than a study that embraces a large number of species.

Topics under this heading need not be excluded by schools in large towns; several of the suggested studies could be carried out equally well in town or country.

The following studies are given as suitable examples but the list is not intended to be exhaustive.

Garden weeds. The following is a suggested outline of procedure, suitable for a group of, say, 4—12 pupils:

On a given area of garden, examine five or six of the commonest weed species present, accurately identify, carefully record the characteristic morphological features of each and classify as annual, biennial or perennial.

Make careful records of the growth and development of each throughout the year. The following records are suggested—date of emergence of seedlings or start of vegetative growth, date of opening of first flower, length of the period over which the individual plant and the species flowers and fruits, accurate drawings of the appearance of seedlings, vegetative plants, flowers, fruits and seeds, mechanism of fruit or seed dispersal.

Describe what happens to the plants if the land on which they are growing is disturbed by man, whether or not they are killed and if so whether and when new seedlings or plant parts arise.

Quantitative data should be collected on numbers of seedlings or vegetative shoots of each species emerging in a prescribed area and the numbers surviving to produce seeds. Using a small number of plants, an estimate can be made of the number of seeds produced per plant and per unit area studied; some estimate can also be made of the differing numbers of seeds per plant and per unit area when weeds have grown alone and in close proximity to other crop and weed plants.

Seeds might be collected from plants and an attempt made to germinate a proportion of these at different times after harvesting. After seed dispersal, cores of soil might be taken, spread out to a depth of about ½ in. in boxes, kept moist and the number of young plants emerging and the time of their appearance recorded. Seedlings should be removed after identification. After the above records have been taken, the teacher should discuss with the pupils the ecological significance of the results, showing which ecological factors are important in the habitat studied, why the plants considered survive in that environment, in which other environments would they be likely to be found and how they could be controlled.

Trees. A study of trees could be conducted in public gardens or parks, or copses and could be restricted to coniferous or deciduous species, or even a single species. Suitable aspects for study include pests, galls, modes of seed dispersal.

Animals in a particular habitat, e.g. soil animals or animals in a pond, or stream, or arthropods, or birds of a selected habitat. It is important that some attention be paid to the physical conditions that prevail.

Special habitats in which the flora and fauna are relatively restricted e.g. rock pools, tree stumps, sand dunes, shingle beaches, old walls.

III. PRACTICAL EXAMINATION

The practical examination will be designed to test the ability of the candidate to make accurate observations from common plants and animals. For this he should be familiar with the use of a hand lens of not less than ×6 magnification. He should be trained to make both simple and accurate drawings and brief notes as a means of recording his observations.

Candidates may be asked to test for food substances, e.g. Fehling's solution for reducing sugars, iodine solution for starch, Sudan III for fats, Millon's reagent for proteins.

Candidates may be asked to carry out simple operations involving the use of mounted needles, scalpels or razor blades, on plant and animal material.

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.

Schools are asked to build up reference collections of preserved materials which can if necessary be used in examinations. It is not expected that teachers should themselves obtain the material, but rather that pupils should be encouraged to collect specimens as they become available.