BIOLOGY
GCE ORDINARY LEVEL
5094

CONTENTS

INTRODUCTION

This syllabus is designed to have less emphasis on factual materials, but a much greater emphasis on the understanding and application of scientific concepts and principles. This approach has been adopted in recognition of the need for students to develop skills that will be of long-term value in an increasingly technological world, rather than focusing on large quantities of factual material, which may have only short-term relevance.

It is envisaged that teaching and learning programmes based on this syllabus will feature a wide variety of learning experiences designed to promote inquiry. Teachers are encouraged to use a combination of appropriate strategies in teaching topics in this syllabus. The assessment will be specifically intended to test skills, comprehension and insight in familiar and unfamiliar contexts.

AIMS

These are not listed in order of priority.

The aims are to:

1. provide, through well-designed studies of experimental and practical Biology, a worthwhile educational experience for all students, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:

    1.1 become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific importance

    1.2 recognise the usefulness, and limitations, of the scientific method and to appreciate its applicability in other disciplines and in everyday life

    1.3 be suitably prepared and stimulated for studies beyond Ordinary Level in Biology, in applied sciences or in science-dependent vocational courses

2. develop abilities and skills that:

    2.1 are relevant to the study and practice of science

    2.2 are useful in everyday life

    2.3 encourage efficient and safe practice

    2.4 encourage effective communication

3. develop attitudes relevant to science such as:

    3.1 concern for accuracy and precision

    3.2 objectivity

    3.3 integrity

    3.4 enquiry

    3.5 initiative

    3.6 inventiveness

4. stimulate interest in and care for the local and global environment

5. promote an awareness that:

   5.1 the study and practice of science are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations

   5.2 the applications of science may be both beneficial and detrimental to the individual, the community and the environment

   5.3 science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal

   5.4 the use of information technology (IT) is important for communications, as an aid to experiments and as a tool for the interpretation of experimental and theoretical results

ASSESSMENT OBJECTIVES

These describe the knowledge, skills and abilities which candidates are expected to demonstrate at the end of the course. They reflect those aspects of the aims which will be assessed.

A Knowledge with Understanding

Students should be able to demonstrate knowledge and understanding in relation to:

1. scientific phenomena, facts, laws, definitions, concepts, theories
2. scientific vocabulary, terminology, conventions (including symbols, quantities and units contained in 'Signs, Symbols and Systematics 16-19', Association for Science Education, 2000)
3. scientific instruments and apparatus, including techniques of operation and aspects of safety
4. scientific quantities and their determination
5. scientific and technological applications with their social, economic and environmental implications

The subject content defines the factual knowledge that candidates may be required to recall and explain. Questions testing those objectives will often begin with one of the following words: *define, state, describe, explain* or *outline*. (See the *Glossary of Terms*.)

B Handling Information and Solving Problems

Students should be able – in words or by using symbolic, graphical and numerical forms of presentation – to:

1. locate, select, organise and present information from a variety of sources
2. translate information from one form to another
3. manipulate numerical and other data
4. use information to identify patterns, report trends and draw inferences
5. present reasoned explanations for phenomena, patterns and relationships
6. make predictions and propose hypotheses
7. solve problems

These assessment objectives cannot be precisely specified in the subject content because questions testing such skills may be based on information which is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, reasoned or deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: *predict, suggest, calculate* or *determine*. (See the *Glossary of Terms*.)

C Experimental Skills and Investigations

Students should be able to:

1. follow a sequence of instructions
2. use techniques, apparatus and materials
3. make and record observations, measurements and estimates
4. interpret and evaluate observations and experimental results
5. plan investigations, select techniques, apparatus and materials
6. evaluate methods and suggest possible improvements

WEIGHTING OF ASSESSMENT OBJECTIVES

Theory Papers (Papers 1 and 2)

A Knowledge with Understanding, approximately 45% of the marks.

B Handling Information and Solving Problems, approximately 55% of the marks.

School-Based Science Practical Assessment (SPA) (Paper 3)

C Experimental Skills and Investigations, 100% of the marks.

SCHEME OF ASSESSMENT

Candidates are required to enter for Papers 1, 2 and 3.

Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice	1 hour	40	30%
2	Structured and free-response questions	1 hour 45 minutes	80	50%
3	School-based Science Practical Assessment (SPA)	---	96	20%

Theory Papers

Paper 1 (1 hour, 40 marks)

consisting of 40 compulsory multiple choice items of the direct choice type.

Paper 2 (1 hour 45 minutes, 80 marks)

consisting of two sections.

Section A will carry 50 marks and will consist of a variable number of compulsory structured questions.

Section B will carry 30 marks and will consist of 3 free response questions.

The first two questions are compulsory questions, one of which will be a data-based question carrying 8–12 marks.

The last question will be presented in an either/or form and will carry 10 marks.

School-based Science Practical Assessment (SPA)

Paper 3 (96 marks)

The School-based Science Practical Assessment (SPA) will be conducted to assess appropriate aspects of objectives C1 to C6. SPA will take place over an appropriate period that the candidates are offering the subject. The assessment of science practical skills is grouped into 3 skill sets:

Skill set 1 – Performing and Observing

Skill set 2 – Analysing

Skill set 3 – Planning

Each candidate is to be assessed only **twice** for each of skill sets 1 and 2 and only **once** for skill set 3.

Weighting and Marks Computation of the 3 Skill Sets

The overall level of performance of each skill set (skill sets 1, 2 and 3) is the sum total of the level of performance of each strand within the skill set.

The weighting and marks computation of the skill sets are as follows:

Skill Set	**No. of Assessments (a)**	**Max Marks per Assessment (b)**	**Weight (c)**	**Sub-total (a × b × c)**	**Weighting**
1	2	6	4	$2 \times 6 \times 4 = 48$	50%
2	2	4	3	$2 \times 4 \times 3 = 24$	25%
3	1	4	6	$1 \times 4 \times 6 = 24$	25%
Total Marks for SPA				96	

Please refer to the SPA Information Booklet for more detailed information on the conduct of SPA.

CONTENT STRUCTURE

THEMES		Topics
I. PRINCIPLES OF BIOLOGY	1.	Cell Structure and Organisation
	2.	Movement of Substances
	3.	Biological Molecules
II. MAINTENANCE AND REGULATION OF LIFE PROCESSES	4.	Animal Nutrition
	5.	Plant Nutrition
	6.	Transport in Flowering Plants
	7.	Transport in Humans
	8.	Respiration
	9.	Excretion
	10.	Homeostasis
	11.	Co-ordination and response
III. CONTINUITY OF LIFE	12.	Reproduction
	13.	Cell Division
	14.	Molecular Genetics
	15.	Inheritance
IV. MAN AND HIS ENVIRONMENT	16.	Organisms and their Environment

SUBJECT CONTENT

THEME I: PRINCIPLES OF BIOLOGY

Overview

A basic characteristic of life is the hierarchy of structural order within the organism. Robert Hooke (1635–1703), one of the first scientists to use a microscope to examine pond water, cork and other things, was the first to refer to the cavities he saw in cork as "*cells*", Latin for chambers. Subsequent scientists developed Hooke's discovery of the cell into the Cell Theory on which modern Biology is built upon. The Cell Theory states that all organisms are composed of one or more cells, and that those cells have arisen from pre-existing cells.

In this section, we study two key principles of biology. The first principle is the correlation of structure to function. This is illustrated by how each part of the cell is suited for its intended function. The second principle is that specialisation results in the division of labour which enables the cell to effectively carry out a number of vital life processes. A strong foundation in the principles of biology will pave the way for students to master the content in the subsequent topics.

1. Cell Structure and Organisation

Content

- Plant and Animal Cells
- Specialised Cells, Tissues and Organs

Learning Outcomes:

Candidates should be able to:

(a) identify cell structures (including organelles) of typical plant and animal cells from diagrams, photomicrographs and as seen under the light microscope using prepared slides and fresh material treated with an appropriate temporary staining technique:
- chloroplasts
- cell membrane
- cell wall
- cytoplasm
- cell vacuoles (large, sap-filled in plant cells, small, temporary in animal cells)
- nucleus

(b) identify the following membrane systems and organelles from diagrams and electron micrographs:
- endoplasmic reticulum
- mitochondria
- Golgi body
- ribosomes

(c) state the functions of the membrane systems and organelles identified above.

(d) compare the structure of typical animal and plant cells.

(e) 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

(f) differentiate cell, tissue, organ and organ system.

Use the knowledge gained in this section in new situations or to solve related problems.

2. Movement of Substances

Content

- Diffusion
- Osmosis
- Active Transport

Learning Outcomes:

Candidates should be able to:

(a) define *diffusion* and discuss its importance in nutrient uptake and gaseous exchange in plants and humans.

(b) define *osmosis* and discuss the effects of osmosis on plant and animal tissues.

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

Use the knowledge gained in this section in new situations or to solve related problems.

3. Biological Molecules

Content

- Water and Living Organisms
- Carbohydrates, Fats and Proteins
- Enzymes

Learning Outcomes:

Candidates should be able to:

(a) state the roles of water in living organisms.

(b) list the chemical elements which make up:
- carbohydrates
- fats
- proteins

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

(d) state that large molecules are synthesised from smaller basic units:
- glycogen from glucose
- polypeptides and proteins from amino acids
- lipids such as fats from glycerol and fatty acids

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

(f) explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity.

(g) investigate and explain the effects of temperature, pH on the rate of enzyme catalysed reactions.

Use the knowledge gained in this section in new situations or to solve related problems.

THEME II: MAINTENANCE AND REGULATION OF LIFE PROCESSES

Overview

Life is sustained through the integrated organisation of the whole organism. In humans, the maintenance and regulation of life processes include nutrition, transport, respiration, excretion, homeostasis and co-ordination and response. The key overarching theme in the study of the organ systems is the correlation between form and function.

4. Animal Nutrition

Content

- Human Alimentary Canal
- Chemical Digestion
- Absorption and Assimilation

Learning Outcomes:

Candidates should be able to:

(a) describe the functions of main regions of the alimentary canal and the associated organs: mouth, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum, anus, in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate.

(b) describe peristalsis in terms of rhythmic wave-like contractions of the muscles to mix and propel the contents of the alimentary canal.

(c) describe digestion in the alimentary canal, the functions of a typical amylase, protease and lipase, listing the substrate and end-products.

(d) describe the structure of a villus and its role, including the role of capillaries and lacteals in absorption.

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

(f) state the role of the liver in:

- carbohydrate metabolism
- fat metabolism
- breakdown of red blood cells
- metabolism of amino acids and the formation of urea
- breakdown of alcohol, including the effects of excessive alcohol consumption

Use the knowledge gained in this section in new situations or to solve related problems.

5. Plant Nutrition

Content

- Leaf Structure
- Photosynthesis

Learning Outcomes:

Candidates should be able to:

(a) identify and label the cellular and tissue structure of a dicotyledonous leaf, as seen in transverse section under the microscope and describe the significance of these features in terms of their functions, such as the:

- distribution of chloroplasts in photosynthesis
- stomata and mesophyll cells in gaseous exchange
- vascular bundles in transport

(b) state the equation, in words and symbols, for photosynthesis.

(c) outline the intake of carbon dioxide and water by plants.

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

(e) investigate and discuss the effects of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plant).

(f) discuss light intensity, carbon dioxide concentration and temperature as limiting factors on the rate of photosynthesis.

Use the knowledge gained in this section in new situations or to solve related problems.

6. Transport in Flowering Plants

Content

- Water and Ion Uptake
- Transpiration and Translocation

Learning Outcomes:

Candidates should be able to:

(a) identify the positions and explain the functions of xylem vessels, phloem (sieve tube elements and companion cells) in sections of a herbaceous dicotyledonous leaf and stem, under the light microscope.

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

(c) explain the movement of water between plant cells, and between them and the environment in terms of water potential. (Calculations on water potential are **not** required).

(d) outline the pathway by which water is transported from the roots to the leaves through the xylem vessels.

(e) define the term *transpiration* and explain that transpiration is a consequence of gaseous exchange in plants.

(f) describe:

- the effects of variation of air movement, temperature, humidity and light intensity on transpiration rate
- how wilting occurs

(g) define the term *translocation* as the transport of food in the phloem tissue and illustrate the process through translocation studies.

Use the knowledge gained in this section in new situations or to solve related problems.

7. Transport in Humans

Content

- Circulatory System

Learning Outcomes:

Candidates should be able to:

(a) identify the main blood vessels to and from the heart, lungs, liver and kidney.

(b) 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, plasma proteins

(c) list the different ABO blood groups and all possible combinations for the donor and recipient in blood transfusions.

(d) relate the structure of arteries, veins and capillaries to their functions.

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

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

(g) outline the cardiac cycle in terms of what happens during systole and diastole. (Histology of the heart muscle, names of nerves and transmitter substances are **not** required).

(h) describe coronary heart disease in terms of the occlusion of coronary arteries and list the possible causes, such as diet, stress and smoking, stating the possible preventative measures.

Use the knowledge gained in this section in new situations or to solve related problems.

8. Respiration

Content

- Human Gaseous Exchange
- Aerobic Respiration
- Anaerobic Respiration

Learning Outcomes:

Candidates should be able to:

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

(b) state the characteristics of, and describe the role of, the exchange surface of the alveoli in gaseous exchange.

(c) describe the removal of carbon dioxide from the lungs, including the role of the carbonic anhydrase enzyme.

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

(e) describe the effect of tobacco smoke and its major toxic components – nicotine, tar and carbon monoxide, on health.

(f) define and state the equation, in words and symbols, for aerobic respiration in humans.

(g) define and state the equation, in words only, for anaerobic respiration in humans.

(h) describe the effect of lactic acid in muscles during exercise.

Use the knowledge gained in this section in new situations or to solve related problems.

9. Excretion

Content

- Structure and Function of Kidneys
- Kidney Dialysis

Learning Outcomes:

Candidates should be able to:

(a) define *excretion* and explain the importance of removing nitrogenous and other compounds from the body.

(b) outline the function of kidney tubules with reference to ultra-filtration and selective reabsorption in the production of urine.

(c) outline the role of anti-diuretic hormone (ADH) in the regulation of osmotic concentration.

(d) outline the mechanism of dialysis in the case of kidney failure.

Use the knowledge gained in this section in new situations or to solve related problems.

10. Homeostasis

Content

- Principles of Homeostasis
- Skin

Learning Outcomes:

Candidates should be able to:

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

(b) explain the basic principles of homeostasis in terms of stimulus resulting from a change in the internal environment, a corrective mechanism and a 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 co-ordinating role of the brain.

Use the knowledge gained in this section in new situations or to solve related problems.

11. Co-ordination and Response

Content

- Receptors – Eye
- Nervous System – Neurones (Reflex Action)
- Effectors – Endocrine Glands

Learning Outcomes:

Candidates should be able to:

(a) state the relationship between receptors, the central nervous system and the effectors.

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

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

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

(e) state that the nervous system – brain, spinal cord and nerves, serves to co-ordinate and regulate bodily functions.

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

(g) discuss the function of the brain and spinal cord in producing a co-ordinated response as a result of a specific stimulus in a reflex action.

(h) 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 broken down by the liver.

(i) explain what is meant by an endocrine gland, with reference to the islets of Langerhans in the pancreas.

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

(k) explain how the blood glucose concentration is regulated by insulin and glucagon as a homeostatic mechanism.

(l) describe the signs, such as an increased blood glucose level and glucose in urine, and the treatment of *diabetes mellitus* using insulin.

Use the knowledge gained in this section in new situations or to solve related problems.

THEME III: CONTINUITY OF LIFE

Overview

The many aspects of form and function that we have examined in this syllabus can be viewed in the widest context as various adaptations aimed at ensuring reproductive success. Reproduction is vital for the survival of species across generations. In 1953, James Watson and Francis Crick developed the model for deoxyribonucleic acid (DNA), a chemical that had then recently been deduced to be the physical carrier of inheritance. In this section, we examine how genes interact to produce hereditary characteristics in the offspring. This section focuses on understanding the processes involved in the continuity of life and how genetic information is passed from one generation to the next.

12. Reproduction

Content

- Asexual Reproduction
- Sexual Reproduction in Plants
- Sexual Reproduction in Humans
- Sexually Transmitted Diseases

Learning Outcomes:

Candidates should be able to:

(a) define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent.

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

(c) 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 microscope.

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

(e) use a hand lens to identify and describe the stamens and stigmas of one, locally available, named, wind-pollinated flower, and examine the pollen grains under a microscope.

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

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

(h) 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).

(i) identify on diagrams of the male reproductive system and give the functions of: testes, scrotum, sperm ducts, prostate gland, urethra and penis.

(j) identify on diagrams of the female reproductive system and give the functions of: ovaries, oviducts, uterus, cervix and vagina.

(k) briefly 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 with reference to the effects of progesterone and estrogen only.

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

(m) state the functions of the amniotic sac and the amniotic fluid.

(n) describe the function of the placenta and umbilical cord in relation to exchange of dissolved nutrients, gases and excretory products. (Structural details are **not** required).

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

Use the knowledge gained in this section in new situations or to solve related problems.

13. Cell Division

Content

- Mitosis
- Meiosis

Learning Outcomes:

Candidates should be able to:

(a) state the importance of mitosis in growth, repair and asexual reproduction.

(b) explain the need for the production of genetically identical cells and fine control of replication.

(c) identify, with the aid of diagrams, the main stages of mitosis.

(d) state what is meant by *homologous pairs* of chromosomes.

(e) identify, with the aid of diagrams, the main stages of meiosis. (Names of the sub-divisions of prophase are **not** required).

(f) define the terms *haploid* and *diploid*, and explain the need for a reduction division process prior to fertilisation in sexual reproduction.

(g) state how meiosis and fertilisation can lead to variation.

Use the knowledge gained in this section in new situations or to solve related problems.

14. Molecular Genetics

Content

- The Structure of DNA
- The Role of DNA in Protein Synthesis
- Genes
- Genetic Engineering and Medical Biotechnology

Learning Outcomes:

Candidates should be able to:

(a) outline the relationship between DNA, genes and chromosomes.

(b) state the structure of DNA in terms of the bases, sugar and phosphate groups found in each of their nucleotides.

(c) state the rule of complementary base pairing.

(d) state that DNA is used to carry the genetic code, which is used to synthesise specific polypeptides.

(e) state that each gene is a sequence of nucleotides, as part of a DNA molecule.

(f) explain that genes may be transferred between cells. Reference should be made to the transfer of genes between organisms of the same or different species – transgenic plants or animals.

(g) briefly explain how a gene that controls the production of human insulin can be inserted into bacterial DNA to produce human insulin in medical biotechnology.

(h) outline the process of large-scale production of insulin using fermenters.

(i) discuss the social and ethical implications of genetic engineering, with reference to a named example.

Use the knowledge gained in this section in new situations or to solve related problems.

15. Inheritance

Content

- The Passage of Information from Parent to Offspring
- The Nature of Genes and Alleles, and their Role in Determining the Phenotype
- Monohybrid Crosses
- Variation
- Natural and Artificial Selection

Learning Outcomes:

Candidates should be able to:

(a) define a *gene* as a unit of inheritance and distinguish clearly between the terms *gene* and *allele*.

(b) explain the terms dominant, recessive, codominant, homozygous, heterozygous, phenotype and genotype.

(c) 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.

(d) explain why observed ratios often differ from expected ratios, especially when there are small numbers of progeny.

(e) use genetic diagrams to solve problems involving monohybrid inheritance. (Genetic diagrams involving autosomal linkage or epistasis are **not** required).

(f) explain co-dominance and multiple alleles with reference to the inheritance of the ABO blood group phenotypes – A, B, AB, O, gene alleles I^A, I^B and I^O.

(g) describe the determination of sex in humans – XX and XY chromosomes.

(h) describe mutation as a change in the structure of a gene, such as in sickle cell anaemia, or in the chromosome number, such as the 47 chromosomes in the condition known as Down syndrome.

(i) name radiation and chemicals as factors which may increase the rate of mutation.

(j) describe the difference between continuous and discontinuous variation and give examples of each.

(k) state that competition which arises from variation leads to differential survival of, and reproduction by, those organisms best fitted to the environment.

(l) give examples of environmental factors that act as forces of natural selection.

(m) assess the importance of natural selection as a possible mechanism for evolution.

(n) give examples of artificial selection such as in the production of economically important plants and animals.

Use the knowledge gained in this section in new situations or to solve related problems.

THEME IV: MAN AND HIS ENVIRONMENT

Overview

All living organisms are part of a complex network of interactions called the web of life. This section focuses on the interrelationships among living things. These include two major processes. The first is the cycling of nutrients, as illustrated by the carbon cycle. The second major process is the flow of energy from sunlight to organisms further down the food chain.

16. Organisms and their Environment

Content

- Energy Flow
- Food Chains and Webs
- Carbon Cycle
- Effects of Man on the Ecosystem
- Environmental Biotechnology

Learning Outcomes:

Candidates should be able to:

(a) briefly describe the non-cyclical nature of energy flow.

(b) explain the terms producer, consumer and trophic level in the context of food chains and food webs.

(c) explain how energy losses occur along food chains, and discuss the efficiency of energy transfer between trophic levels.

(d) describe and interpret pyramids of numbers and biomass.

(e) describe how carbon is cycled within an ecosystem.

(f) evaluate the effects of:

- water pollution by sewage and by inorganic waste
- pollution due to insecticides including bioaccumulation up food chains and impact on top carnivores

(g) outline the roles of microbes in sewage disposal as an example of environmental biotechnology.

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

Use the knowledge gained in this section in new situations or to solve related problems.

PRACTICAL GUIDELINES

Scientific subjects are, by their nature, experimental. It is therefore important that the candidates carry out appropriate practical work to support and facilitate the learning of this subject. Over the course of study, candidates could be exposed to the following range of experiments/techniques/skills:

1. Candidates should be able to:
   (a) follow carefully a sequence of instructions within a set time allowance;
   (b) use familiar and unfamiliar techniques to record their observations and make deductions from them;
   (c) recognise and observe features of familiar and unfamiliar biological specimens, record their observations and make deductions about functions of whole specimens or their parts;
   (d) make clear line drawings of the specimens provided, indicate magnification and label familiar structures;
   (e) interpret unfamiliar data and draw conclusions from their interpretations;
   (f) design/plan an investigation to solve a problem;
   (g) comment on a procedure used in an experiment and to suggest an improvement;
   (h) employ manipulative skills in assembling apparatus, in using chemical reagents and in using such instruments as mounted needles, scalpels and razor blades, forceps and scissors;
   (i) observe reactions, read simple measuring instruments and perform simple arithmetical calculations;
   (j) measure to an accuracy of 1 mm, using a ruler.

2. Candidates may be asked to carry out simple physiological experiments, involving tests for food substances {see 3(c)}, enzyme reactions, hydrogencarbonate indicator solution, cobalt(II) chloride paper 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 physiological experiments, involving the use of the instruments mentioned in 1(h), on plant or animal materials. Accurate observations of these specimens will need a hand lens of not less than x6 magnification for each candidate.

4. The material used in experiments 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, schools are asked to build up a reference collection of material.

5. When planning practical work, teachers should make sure that they do **not** contravene any school, education authority or government regulations which restrict the sampling, in educational establishments, of urine, saliva, blood or other bodily secretions and tissues.

GLOSSARY OF TERMS USED IN BIOLOGY PAPERS

It is hoped that the glossary will prove helpful to candidates as a guide, i.e. it is neither exhaustive nor definitive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context.

1. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

2. *Comment* is intended as an open-ended instruction, inviting candidates to recall or infer points of interest relevant to the context of the question, taking account of the number of marks available.

3. *Compare* requires candidates to provide both similarities and differences between things or concepts.

4. *Define* (*the term(s)* …) is intended literally, only a formal statement or equivalent paraphrase being required.

5. *Describe* requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena.

6. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula.

7. *Discuss* requires candidates to give a critical account of the points involved in the topic.

8. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about the points of principle and about the values of quantities not otherwise included in the question.

9. *Explain* may imply reasoning or some reference to theory, depending on the context.

10. *Find* is a general term that may be variously interpreted as calculate, measure, determine, etc.

11. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified, this should not be exceeded.

12. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or mass, using a balance.

13. *Outline* implies brevity, i.e. restricting the answer to giving essentials.

14. *Predict* or *deduce* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted from an earlier part of the question.

15. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value.

    S*ketch*, when applied to diagrams, implies that a simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

16. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.

17. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer, or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus'.

18. *What is meant by (the term(s) ...)* normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in light of the indicated mark value.