ZIMBABWE SCHOOL EXAMINATIONS COUNCIL (ZIMSEC)

ADVANCED LEVEL SYLLABUS

BIOLOGY
(9190)

EXAMINATION SYLLABUS FOR 2013 – 2015
INTRODUCTION

This syllabus consists of a common core content to be studied by all candidates and four option topics of which a candidate will be assessed on one. It is assumed that candidates following this syllabus have studied 'O' Level Biology. Greater emphasis is placed on practical and contextual approach with respect to the applications of Biology and impact of recent developments on the needs of contemporary society. It encourages the use of several sources of information technology.

It is intended to keep the syllabus under constant review, to ensure that any new developments in Biology are incorporated so as to keep abreast of knowledge in the Biological Sciences. Candidates following this syllabus sit all 'A' level components in one examination only.

CANDIDATES ARE EXPECTED TO USE THE KNOWLEDGE GAINED IN EACH OF THE SECTIONS IN NEW SITUATIONS OR TO SOLVE RELATED PROBLEMS.
**AIMS**

This syllabus aims to:

1. Provide a basis for further studies in Biological Sciences and other related professional and vocational courses.

2. Develop abilities and skills that enable students solve day to day problems and become confident in a technological world.

3. Develop an awareness of the diversity of life, global environment and understand the need for conservation and its relevance to society.

4. Stimulate the desire for research in Biological Sciences and related areas to solve societal problems.

5. Appreciate the beneficial and detrimental aspects of the applications of Biology to society.

6. Promote an awareness of the use of information technology (IT) for communication as an aid to Biological research.
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. biological phenomena, facts, laws, definitions, concepts, theories;
2. biological vocabulary, terminology, conventions (including symbols, quantities and units);
3. scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety;
4. scientific quantities and their determination;
5. biological and technological applications with their social, economic and environmental implications.

The syllabus content defines the factual materials that candidates need to recall and explain. Questions testing the objectives above will often begin with one of the words: define, state, name, describe, explain, outline or suggest..

B  Handling information and solving problems

Students should be able, using oral, written, symbolic, graphical and numerical material 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 explanation for phenomena, patterns and relationships;
6. make predictions and propose hypotheses;
7. apply knowledge, including principles, to novel situations;
8. solve problems.

C  Experimental skills and investigations
Students should be able to:

1. follow a sequence of instruction;
2. use techniques, apparatus and materials;
3. make and record observations, measurements and estimates;
4. interpret and evaluate observations and experimental data;
5. devise and plan investigations, select techniques, apparatus and materials;
6. evaluate methods and techniques, and suggest possible improvements.
SCHEME OF ASSESSMENT

<table>
<thead>
<tr>
<th>Paper</th>
<th>Type of Paper</th>
<th>Duration</th>
<th>Marks</th>
<th>Weighting (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Multiple Choice</td>
<td>1h</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Structured, short answer and free response questions</td>
<td>2h 30 min</td>
<td>100</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>Structured questions (may include data response and comprehension) and free response questions</td>
<td>1h 30 min</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>Practical examination</td>
<td>2h 30 min</td>
<td>60</td>
<td>20</td>
</tr>
</tbody>
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**PAPER 1 (1 h, 40 marks)**

40 multiple choice questions based on the Core syllabus. All questions will be of the direct choice type with four options.

**PAPER 2 (2h, 30 min 100 marks)**

This paper will consist of questions based solely on Core topics. Section A will be a variable number of structured questions which will be compulsory. Section B will contain four free response questions from which candidates will choose two.

**PAPER 3 (1H, 30 min 50 marks)**

Candidates will be required to answer questions on ONE Option only.

For each Option, there will be two compulsory structured/data response/comprehension type questions, each of which will carry 15 marks. A further question will be presented in an either/or form and will be a free response question which carries 20 marks.
PRACTICAL ASSESSMENT

PAPER 4 (2h, 30 min  60 marks)

This paper will be a practical test set and marked by ZIMSEC. Each paper will include experiments and investigations based on the Core syllabus. Candidates will be expected to show evidence of the following skills in the handling of familiar and unfamiliar biological material:

- Planning
- Implementing
- Interpreting and Concluding

Where unfamiliar materials/techniques are required, full instructions will be given. Observation may be made using a microscope and/or hand lens.

Questions involving an understanding of the use of t- and chi- squared test may be set, but detailed computation of these tests will not be required in the examination. Candidates will be expected to show evidence of the following skills (Assessment Objectives C1 - C6)

IMPLEMENTING SKILL

(a) Carrying out experimental work in a methodical and organised way with due regard for safety and living organisms.

(b) Using apparatus and materials in an appropriate way.

(c) Making and recording:

(i) accurate and detailed observations including low power and high power drawings of a specimen.

(ii) measurements to the appropriate degree of precision allowed by the apparatus.

INTERPRETING AND CONCLUDING SKILL

(a) Assessing the reliability and accuracy of experimental data and techniques by identifying and assessing errors.

(b) Applying knowledge to explain and interpret experimental results to reach valid conclusions.

(c) Communicating information, results and ideas in clear and appropriate ways, including tabulation, line graphs and continuous prose.
RELATIONSHIP BETWEEN THE ASSESSMENT OBJECTIVES AND THE ASSESSMENT COMPONENTS

This is given in the Assessment Grid below:

<table>
<thead>
<tr>
<th>Assessment Objective</th>
<th>Weighting %</th>
<th>Assessment Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Knowledge with understanding</td>
<td>50</td>
<td>PAPERS 1,2,3</td>
</tr>
<tr>
<td>B Handling information and solving problems</td>
<td>30</td>
<td>PAPERS 1,2,3</td>
</tr>
<tr>
<td>C Experimental skills and investigations</td>
<td>20</td>
<td>PAPERS 4</td>
</tr>
</tbody>
</table>

This gives a general idea of the allocation of marks to assessment objectives A and B of the theory papers. However, the balance on each paper may vary slightly. Fifteen percent of the total marks will be awarded for awareness of the social, economic, environmental and technological implications and applications of Biology. These will be awarded within the 'Knowledge with understanding' and the 'Handling information and solving problems' categories.

Additional Information

Modern biological sciences draw extensively on concepts from the physical sciences. It is desirable, therefore, that by the end of the course, candidates should have a knowledge of the following topics, sufficient to aid understanding of biological systems, but no questions will be set directly on them.

- The electromagnetic spectrum
- Energy changes (potential energy, activation energy, chemical bond energy)
- Molecules, atoms, ions, electrons
- Acids, bases, pH, buffers
- Isotopes, including radioactive isotopes
- Oxidation and reduction
- Hydrolysis, condensation

Questions set in the examination may involve the basic processes of mathematics for the calculation and use of decimals, means, ratios and percentages.

Candidates may be required to:

(i) construct graphs or present data in other suitable graphical forms,

(ii) calculate rates of processes.

Candidates should be aware of the problems of drawing conclusions from limited data and should appreciate levels of significance, standard deviation and probability and the use of t-and chi-squared tests.
Structure of the syllabus

The syllabus is divided into two parts:

1. **The Core Syllabus**

   This is to be studied by all candidates. There are thirteen topics in the core syllabus.

   A  Cell Structure and Function  
   B  Biological Molecules and Water  
   C  Enzymes  
   D  Cell and Nuclear Division  
   E  Genetic Control and Genetic Engineering  
   F  Inherited Change and Evolution  
   G  Energetics  
   H  Transport  
   I  Regulation and Control  
   J  Ecology  
   K  Growth, Development and Reproduction  
   L  Biodiversity

2. **The Options Syllabus**

   Candidates will study and be assessed in **one** of the following options;

   1. Biotechnology,  
   2. Applications of Genetics,  
   3. Human Health and Disease,  
CORE SYLLABUS

A CELL STRUCTURE AND FUNCTION

Content

The role of a microscope (light and electron) in cell studies.
Cells as the basic units of living organisms, grouped into tissues and organs.
Detailed structure of typical animal and plant cells as seen under the electron microscope.
Outline functions of organelles in plant and animal cells.
The movement of substances into and out of cells.

Objectives:

Candidates should be able to:

1. use a graticule and stage micrometer to measure cells and be familiar with units (millimetre, micrometer, nanometer) used in cell studies;
2. explain and distinguish between resolution and magnification with reference to light microscopy and electron microscopy;
3. describe and interpret drawings and photographs of typical animal and plant cells as seen under the electron microscope, recognising the following membrane systems and organelles - rough and smooth endoplasmic reticulum, Golgi body, mitochondria, ribosomes, lysosomes, chloroplasts, cell surface membrane, nuclear envelope, centrioles, nucleus and nucleolus (reference should be made to the preparation techniques for electron microscopy);
4. outline the functions of the organelles listed in (3);
5. compare and contrast the structure of typical animal and plant cells;
6. draw plan diagrams of tissues (including a transverse section of a dicotyledonous leaf) and calculate the linear magnification of drawings;
7. compare and contrast the structure of prokaryotic cells with eukaryotic cells;
8. describe and explain the fluid mosaic model of membrane structure, including an outline of the roles of the phospholipids, cholesterol, glycolipids, proteins and glycoproteins;
9. outline the roles of membranes within cells and at the surface of cells;

10. describe and explain the process of diffusion, osmosis, active transport, endocytosis. Terminology described in the IOB's publication Biological Nomenclature should be used (no calculations involving water potential will be set)

11. investigate the effects on plant cells of immersion in solutions of different water potentials.
B BIOLOGICAL MOLECULES AND WATER

Content

The structure and properties of water, carbohydrates, lipids and proteins and their roles in living organisms.

Objectives

Candidates should be able to:

1. carry out tests for reducing and non-reducing sugars (including quantitative use of the Benedict's test), the iodine in potassium iodide solution test for starch, the emulsion test for lipids, and the biuret test for proteins;

2. describe the formation and breakage of a glycosidic bond;

3. describe the synthesis and molecular structure of starch, glycogen and cellulose and relate these structures to their functions in living organisms;

4. describe the molecular structure of a triglyceride and a phospholipid, and relate these structures to their functions in living organisms;

5. describe the structure of an amino acid and the formation and breakage of a peptide bond;

6. explain the meaning of the terms primary structure, secondary structure, tertiary structure and quartenary structure of proteins, and describe the types of bonding (hydrogen, ionic, disulphide and hydrophobic interactions) which hold the molecule in shape;

7. describe the molecular structure of haemoglobin, as an example of a globular protein, and that of collagen, as an example of a fibrous protein, and relate these structures to their functions (the importance of iron in the haemoglobin molecule should be emphasised);

8. describe structure and properties of water;

9. explain the roles of water in living organisms and as an environment for organisms.
C  ENZYMES

Content

Properties of enzymes.

Functions and mode of action of enzymes.

**Objectives:**

Candidates should be able to:

1. describe the lock and key hypothesis and induced-fit model of enzyme action;

2. explain that enzymes are globular proteins which catalyse metabolic reactions;

3. explain the mode of action of enzymes in terms of an active site, enzyme/substrate complex, lowering of activation energy and enzyme specificity;

4. follow the time course of an enzyme-catalysed reaction, by measuring rates of formation of products (for example using catalase) or rate of disappearance of substrate (for example using amylase);

5. investigate and explain the effects of temperature, pH, enzyme concentration and substrate concentration on the rate of enzyme catalysed reactions, and explain these effects;

6. explain the effects of competitive and non-competitive inhibitors on the rates of enzyme activity;
D  CELL AND NUCLEAR DIVISION

Content

Mitosis and Meiosis

Objectives:

Candidates should be able to:-

1. explain how growth, repair and asexual reproduction can be brought about by mitosis;

2. explain the need for the production of genetically identical cells and fine control of replication;

3. explain how cancer is a result of uncontrolled cell division and list factors which can increase the chances of cancerous growth;

4. describe with the aid of diagrams, the behaviour of chromosomes during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell membrane and centrioles; (Names of the main stages are expected.)

5. make, stain and observe microscopically a root tip squash;

6. explain what is meant by homologous pairs of chromosomes;

7. explain the meanings of the terms haploid and diploid, and the need for a reduction division prior to fertilisation in sexual reproduction;

8. describe with the aid of diagrams, the behaviour of chromosomes during meiosis, and the associated behaviour of the nuclear envelope, cell membrane and centrioles. (Names of the main stages are expected, but not the sub-divisions of prophase);

9. explain how meiosis can lead to variation.
E   GENETIC CONTROL AND GENETIC ENGINEERING

Content

Structure and replication of DNA
Role of DNA in protein synthesis
Recombinant DNA technology
Ethical implications of genetic engineering

Objectives

Candidates should be able to:

1. describe the structure of DNA and RNA and explain the importance of base pairing and hydrogen bonding;
2. explain how DNA replicates semi-conservatively during interphase;
3. state that a gene is a sequence of nucleotides as part of a DNA molecule, which codes for a polypeptide;
4. describe how the information on DNA is used to construct polypeptides, including the role of messenger RNA, transfer RNA and the ribosomes;
5. explain that, as enzymes are proteins, their synthesis is controlled by DNA;
6. explain how a change in the sequence of the DNA nucleotides may affect the amino acid sequence in a protein, and hence the phenotype of the organism;
7. explain sickle cell anaemia and phenylketonuria (PKU) as examples of genetic mutation;
8. outline the use of restriction enzymes for removing sections of DNA;
9. describe the formation of recombinant DNA;
10. outline the use of recombinant DNA technology in Biotechnology, with reference to the synthesis of human insulin by bacteria and human Factor VIII;
11. describe the benefits and hazards of genetic engineering with reference to specific examples;
12. discuss the social and ethical implications of genetic engineering.
INHERITED CHANGE AND EVOLUTION

Content

The passage of information from parent to offspring.
The nature of genes and alleles and their role in determining the phenotype.
Monohybrid and dihybrid crosses.
Natural and artificial selection.

Objectives:

Candidates should be able to:

1. explain how meiosis and fertilisation lead to variation;
2. explain the terms locus, allele, dominant, recessive, codominant, homozygous, heterozygous, phenotype and genotype;
3. use genetic diagrams to solve problems involving monohybrid and dihybrid crosses, including those involving sex linkage, codominance and multiple alleles (but not involving autosomal linkage or epistasis);
4. use genetic diagrams to solve problems involving test crosses;
5. explain, with examples, how the environment may affect the phenotype;
6. explain, with examples, how mutation may affect the phenotype;
7. explain, with examples, how environmental factors act as forces of natural selection;
8. explain how natural selection may bring about evolution;
9. describe one example of artificial selection.
G ENERGETICS

Content

The need for energy in living organisms.
Photosynthesis as an energy-trapping process.
Respiration as an energy-releasing process.
Aerobic respiration.
Anaerobic respiration.

Objectives:

Candidates should be able to:

1. outline the need for energy in living organisms as illustrated by anabolic reactions, active transport, movement and the maintenance of body temperature;
2. describe the structure and synthesis of ATP;
3. describe the universal role of ATP as the energy 'currency' in all living organisms;
4. explain the photoactivation of chlorophyll resulting in the conversion of light energy into ATP and reduced NADP (a description of cyclic and non-cyclic photophosphorylation is expected but no further biochemical detail is required);
5. describe in outline the Calvin cycle involving the light independent fixation of carbon dioxide by combination with a 5C compound (RuBP) to yield two molecules of GP (PGA), a 3 C compound, and the subsequent conversion of GP into carbohydrates, amino acids and lipids (regeneration of RuBP should be understood in outline only, knowledge of C_4 plants is required);
6. describe the structure of a dicotyledonous leaf, palisade cells and a chloroplast and relate their structure to their roles in photosynthesis;
7. discuss limiting factors in photosynthesis and carry out investigations on the effects of limiting factors, such as light intensity, CO_2 concentration and temperature on the rate of photosynthesis;
8. outline glycolysis, as phosphorylation of glucose and the subsequent splitting of hexose phosphate (6C) into two triose phosphates (3C) molecules which are then further oxidised to pyruvate, with a small yield of ATP and reduced NAD;
9. explain that when oxygen is available, pyruvate is converted to acetyl (2C) coenzyme A, which then combines with oxaloacetate (4C) to form citrate (6C);
10. outline the Krebs cycle occurring in the mitochondrion, explaining that citrate is reconverted to oxaloacetate in a series of small steps in the matrix of the
mitochondrion (no other biochemical detail is required);

11. explain that these processes involve decarboxylation and dehydrogenation, and describe the role of NAD;

12. describe the process of oxidative phosphorylation in the mitochondrion, including the role of oxygen (no details of carriers are required);

13. explain the production of a small yield of ATP from anaerobic respiration and the formation of ethanol in yeast and lactate in mammals;

14. explain the relative energy values of carbohydrates, lipid and protein as respiratory substrates;

15. define the term respiratory quotient (RQ);

16. carry out investigations on the effect of temperature on respiration rate, using simple respirometers to measure RQ.
TRANSPORT

Content

Transport in plants.
Transport in mammals.

Objectives:

Candidates should be able to:

1. describe the structure and explain the function of the xylem vessels, sieve tube elements and companion cells, and be able to recognise these in sections of an herbaceous dicotyledonous leaf and stem under the light microscope;

2. describe the pathway by which water is transported from root to leaves;

3. explain the movement of water between plant cells and between them and the environment in terms of water potential (terminology described in IOB's publication Biological Nomenclature should be used; no calculations involving water potential will be set);

4. explain the relationship between transpiration and gaseous exchange;

5. explain the mechanisms of translocation;

6. describe the adaptations of xerophytic plants and mesophytic plants, with respect to transpiration;

7. describe the structure of arteries, veins and capillaries in relation to their functions and be able to recognise these vessels under the light microscope;

8. explain the role of haemoglobin in the transport of O\textsubscript{2} and explain the significance of the oxygen dissociation curves of haemoglobin at different CO\textsubscript{2} levels (Bohr effect);

9. explain the significance of the difference in the affinity for oxygen between

   (i) haemoglobin and myoglobin;
   (ii) maternal haemoglobin and foetal haemoglobin;

10. describe the cardiac cycle;

11. explain how heart action is initiated and controlled;

12. explain the factors which influence the heart rate and pulse rate;

13. explain the significance of resting pulse rate in relation to physical fitness;

14. design and carry out experiments to investigate the effects of exercise on the body
(Teachers should satisfy themselves that any exercise undertaken by candidates can be done safely);

15. appreciate how much exercise needs to be taken for significant sustained improvement in aerobic fitness;

16. explain the meaning of the terms systolic blood pressure, diastolic blood pressure and hypertension;

17. discuss the long term consequences of exercise on the cardiovascular system and the benefits of maintaining a physically fit body.
I REGULATION AND CONTROL

Content

Homeostasis.
Nervous and hormonal control. Excretion.

Objectives

Candidates should be able to:

1. recognise the need for control in organised systems and explain the principles of homeostasis in terms of receptors, effectors, ‘negative and positive feedback’;

2. describe and explain the homeostatic functions of the liver in terms of carbohydrate metabolism, fat metabolism, breakdown of erythrocytes, detoxification and deamination of amino acids;

3. recognise the need for communication systems within organisms;

4. describe and explain the transmission of an action potential along a myelinated neurone (the importance of $\text{Na}^+$ and $\text{K}^+$ ions in the impulse transmission should be emphasised);

5. describe the structure of a cholinergic synapse and explain how it functions, including the role of $\text{Ca}^{2+}$ ions;

6. describe the structure of a cholinergic gland, with reference to the islets of Langerhans in the pancreas;

7. explain how the blood glucose concentration is regulated by insulin and glucagon;

8. describe the detailed structure of the nephron and associated blood vessels (candidates are expected to be able to interpret the histology of the kidney as seen in sections under the light microscope);

9. explain the functioning of the kidney in the control of water and metabolic waste levels of the body fluids (the note concerning osmoregulation in animals in the IOB’s publication Biological Nomenclature should be consulted. Reference should be made to the counter current multiplier and exchange system);

10. outline the mechanism of dialysis in the case of kidney failure.
J ECOLOGY

Content
Levels of ecological organisation.
Recycling of nutrients.
Energy flow through ecosystems.
Effects of human activities.
Conservation involves preservation, management and reclamation.
The African elephant.
Conservation may involve conflicts of interest.

Objectives:
Candidates should be able to:

1. define the terms habitat, niche, population, community and ecosystem, and state examples of each;
2. describe the way in which energy flows along food chains and webs;
3. explain how energy losses occur along food chains, and discuss the efficiency of energy transfer between trophic levels;
4. describe how carbon and nitrogen are cycled within an ecosystem, including the roles of microorganisms;
5. describe and explain how the use of fossil fuels and deforestation may affect the environment and discuss measures which could be taken to reduce the harmful consequences;
6. discuss the economic and ethical reasons for maintaining biodiversity;
7. explain, using specific examples, how conservation may involve preservation, management and reclamation;
8. explain that conservation is a dynamic process;
9. discuss the conservation of the African elephant with regard to population numbers, reasons for concern, measures introduced and international cooperation required;
10. appreciate the conflicts of interest in 7, 8 and 9 above and discuss the possible views of the local population, tourists, conservationists and the governments of the countries concerned;
11. discuss the possible conflict of interest between production and conservation, with reference to the use and effects of nitrogen-containing fertilisers, and describe alternatives to their use.

Note: An ecosystem should be studied in relation to an area familiar to the candidates.
K GROWTH DEVELOPMENT AND REPRODUCTION

Content

Growth.
Development. Asexual reproduction.
Sexual reproduction in plants.
Sexual reproduction in animals.

Objectives:

Candidates should be able to:

1. explain how growth occurs;
2. describe the techniques for the measurement of the growth of microorganisms, plants and animals and discuss the problems of measurement;
3. measure the growth of a chosen organism, including dry mass;
4. distinguish between absolute and relative growth rates;
5. recognise different types of growth curves and explain patterns of growth;
6. explain development as a progressive series of changes, including the specialisation of cells, growth and development;
7. outline the roles of the hypothalamus and the pituitary gland in human growth and development;
8. describe the role of thyrotrophin releasing hormone (TRH) from the hypothalamus and thyroid stimulating hormone (TSH) from the pituitary gland in the control of thyroxine secretion;
9. describe the role of the thyroid gland and the functions of thyroxine;
10. discuss the natural advantages and disadvantages of asexual reproduction and explain its evolutionary consequences;
11. describe how knowledge of growth and development has been used commercially to develop methods of artificial propagation;
12. describe the mechanisms and compare the outcomes of self-pollination and cross-pollination;
13. describe anther structure and pollen formation;
14. describe ovule development;
15. describe, and explain the significance of double fertilisation in the embryo sac;
16. describe the structural changes which occur after fertilisation leading to the development of the embryo within the seed and the ovary into the fruit;
17. describe the reasons for, and the advantages of, seed dormancy;
18. explain the interactions of plant growth substances in the control of seed dormancy;
19. explain the factors that control flowering in short-day plants;
20. describe the use of plant growth regulators in fruit maturation;
21. recognise and describe the microscopic structure of the ovary and testis (prepared slides from a small mammal may be used);
22. describe and explain *gametogenesis*;
23. describe the structures of egg and sperm;
24. explain how gametogenesis is controlled by hormones;
25. describe the menstrual cycle and explain the role of hormones;
26. describe the passage of sperm from the testes to the oviduct during sexual intercourse;
27. state how and where fertilisation occurs;
28. discuss contraception, in vitro fertilisation and abortion from biological and ethical viewpoints;
29. describe and explain the roles of the placenta and the transport mechanisms involved in placental transfer;
30. discuss the effect of the lifestyle of the mother on fetal development;
31. describe the role of hormones in pregnancy, birth and lactation;
32. outline the role of hormones in pre-menstrual tension, replacement therapy and menopause
L DIVERSITY OF ORGANISMS

Content

Principles of classification.
Diagnostic features of organisms.

Objectives

Candidates should be able to:

1. classify organisms into five kingdoms: prokaryotae, protista, fungi, plantae and animalia;
2. state the diagnostic features of the five kingdoms;
3. use diagnostic features to divide kingdoms into phyla, classes, orders, families, genera and species;
4. list the diagnostic features of bacteria, fungi, protozoa and algae;
5. list the diagnostic features of bryophytes, filicinophytes, coniferophytes and angiospermophytes;
6. explain the extent to which bryophytes, filicinophytes, coniferophytes and angiospermophytes are adapted to life on land;
7. list the diagnostic features of the following phyla: Cnidaria, Platyhelminthes, Nematoda, Mollusca, Annelida, Arthropoda, Echinodermata and Chordata.

N.B For each phylum limit examples to one (no questions on specific organisms will be set).
OPTIONS SYLLABUS

Candidates will study and be assessed on ONE of the following Options.

OPTION 1 - BIOTECHNOLOGY

Introduction

This Option is intended to develop:

- an understanding of integrated cross-curricular approaches making use of various scientific disciplines and processes;
- an understanding of the importance of microorganisms in food biotechnology;
- an understanding of genetic principles and genetic diversity for application in:
  - medical biotechnology;
  - agricultural biotechnology;
  - environmental biotechnology;
  - industrial biotechnology;

- an understanding of the ethics, behaviour and values of biotechnology and society;
- an understanding of how biotechnology is relevant to issues of national education.
1  THE SCOPE OF BIOTECHNOLOGY

Content

The application of various scientific disciplines through integrative processes.

Objectives

Candidates should be able to:

1.1 explain what is meant by the term biotechnology;
1.2 distinguish between old and new biotechnology techniques;
1.3 describe the interdisciplinary endeavour in the synthesis of one therapeutic product;
1.4 evaluate three requirements for adapting basic research findings into useful products for society;
1.5 discuss the need for government regulations on ethical issues arising from the development of biotechnology.

2  FOOD BIOTECHNOLOGY

Content

Use of effects of various microorganisms in food products.
Cottage food biotechnology.
Recent and novel applications of biotechnology in the food industry.
Transgenic plants and animals for the food industry.

Candidates should be able to:

2.1 describe spoilage problems and benefits caused by microorganisms;
2.2 describe and explain the role of biotechnology in the production of cheese, traditional sour milk, yoghurt, mutwiwa;
2.3 explain how fermentation and enzymes are used in food production and how food colouring can be obtained from organisms;
2.4 describe the use of microorganisms as a food source, with reference to the production of mucoprotein and yeast extract;
2.5 discuss the application of two recent advances in food biotechnology using transgenic plants or animals;
2.6 Outline factors such as regulation and labelling, required for commercialising biotechnological products.
3  MEDICAL BIOTECHNOLOGY

Content

Antibiotics.
Antibodies.
Production of therapeutic products.
Molecular diagnostics and gene probes.
Gene therapy.

Objectives:

Candidates should be able to:

3.1 explain what is meant by the term biosensor with reference to the monitoring of blood glucose;
3.2 describe the major types of infective organisms and the major categories of drugs, which can affect human health;
3.3 describe the use of immunisation and of the major categories of drugs in medicines;
3.4 explain what is meant by a monoclonal antibody;
3.5 describe the use of monoclonal antibodies in diagnosis and treatment;
3.6 describe, in detail, the production of human growth hormones and vaccines and discuss the biosafety of each;
3.7 explain the reasons for the use of microorganisms in the large-scale production of insulin and human growth hormone;
3.8 describe one application of molecular diagnostics and explain the technique involved;
3.9 explain the basis of gene therapy and discuss its possible benefits and hazards.
4 AGRICULTURAL BIOTECHNOLOGY

Content

Gene bank. Soil-less culture.
Use of microorganisms and chemicals for yield improvement.
Tissue culture.
Genetic engineering and transgenic plants and animals.
Pest-resistant crop plants.

Objectives

Candidates should be able to:

4.1 describe the maintenance and use of seed banks and sperm banks;
4.2 describe one example of soil-less culture e.g. hydroponics and aeroponics, and assess its advantage over conventional farming methods;
4.3 describe the techniques and two uses of tissue culture in agriculture;
4.4 evaluate the significance of genetic engineering in improving the quality and yield of crop plants and animals;
4.5 evaluate the relevance of agriculture biotechnology to a land-scarce nation;
4.6 discuss the ethical and medical implications of consuming transgenic food products;
INDUSTRIAL AND ENVIRONMENTAL BIOTECHNOLOGY Content

Water pollution.
Sewage and industrial waste disposal.
Biodegradation of xenobiotic compounds.
Composting.

Objectives

Candidates should be able to:

5.1 describe the sources, implications and possible uses of microorganisms in the prevention of pollution e.g. in oil spills;

5.2 discuss the importance of good water management;

5.3 describe and explain the role of microbes in sewage disposal, composting and waste recycling, leading to bioremediation;

5.4 describe the roles of microorganisms in the extraction of heavy metals;

5.5 describe the uses of named organisms and substrates in the production of biogas and gasohol;

5.6 explain the technique of enzyme immobilisation;

5.7 explain the advantages of enzyme immobilisation in manufacturing industries;

5.8 carry out an experiment to demonstrate the use of immobilised enzymes, such as amylase immobilised in alginate.
OPTION 2 - APPLICATIONS OF GENETICS

This Option is intended to develop:

an understanding of the causes of variation;
an understanding of the principles and used of selective breeding;
an understanding of the importance of genetic diversity;
an understanding of the ways in which organisms can be modified by genetic engineering;
an understanding of some aspects of human genetics and an appreciation of their medical, ethical and social implications.

1 VARIATION

Content

The effect of genotype and environment on phenotype.

Objectives

Candidates should be able to:

1.1 explain, with examples, what is meant by the terms gene *mutation* and *chromosome mutation*;
1.2 describe the difference between *continuous* and *discontinuous* variation;
1.3 explain the genetic basis of continuous and discontinuous variation by reference to the number of genes which control the characteristic;
1.4 recognise that both genotype and environment contribute to phenotypic variance ($V_p = V_G + V_E$) (no calculations of heritability will be expected);
1.5 describe two examples of the effect of the environment on the phenotype;
1.6 describe interaction at one locus (dominance)
1.7 describe gene interaction between loci (epistasis);
1.8 predict phenotypic ratios in problems involving epistasis;
1.9 explain the meaning of the terms linkage and cross-over;
1.10 explain the effect of linkage and crossing-over on the phenotypic ratios from dihybrid crosses.
2 SELECTIVE BREEDING

Content

The desirable characteristic of organisms can be selected by selective breeding.

Objectives

Candidates should be able to:

2.1 outline the principles of selective breeding and explain why selective breeding is carried out;

2.2 explain, with practical details, how the process of selective breeding may be carried out in one named plant example and one named animal example;

2.3 compare selective breeding with the evolutionary process;

2.4 explain the use of progeny testing;

2.5 discuss the advantages, disadvantages and use of artificial insemination (AI);

2.6 describe the use of, and the techniques used in, embryo transplantation;

2.7 discuss the ethical implications of the use of AI, in vitro fertilisation and embryo transplantation in animals and their social and ethical implications in humans.

3 GENETIC DIVERSITY

Content

The problems of inbreeding;
The need to maintain genetic resources;
The development of resistance;

Objectives

Candidates should be able to:

3.1 describe the harmful effects of inbreeding;

3.2 explain the need to maintain a gene bank for possible future use, including conserving wild types and rare breeds as genetic resources;

3.3 describe the maintenance and use of seed banks and sperm banks;

3.4 describe the process of cloning plants from tissue culture;
3.5 describe the genetic basis of resistance in prokaryotes and in eukaryotes;

3.6 explain with specific examples how selective breeding is used to produce disease-resistant varieties in plants and animals;

3.7 describe the evolution of antibiotic resistance in bacteria and pesticide resistance in insects and discuss the implications of the evolution of such resistance.

HUMAN GENETICS

Content

Genetic disorders in humans.
Genetic screening and genetic counselling.
Gene therapy, its possible benefits and hazards.
Genetic fingerprinting and its uses.
The significance of genetic constitution for tissue compatibility in transplant surgery.

Objectives

Candidates should be able to:

1.1 describe cystic fibrosis, albinism and Down's syndrome in humans, and explain how they are inherited;

1.2 describe how genetic screening is carried out;

1.3 discuss the advantages and disadvantages of genetic screening and the need for genetic counselling;

1.4 explain the theoretical basis of gene therapy and discuss its possible benefits and hazards;

1.5 explain the theoretical basis of genetic fingerprinting and outline how it is carried out;

1.6 explain the significance of genetic compatibility in transplant surgery, with reference to ABO blood groups and the major histocompatibility (HLA) system.
OPTION 3 - HUMAN HEALTH AND DISEASE

Introduction

This Option is intended to develop:

- an understanding of what is meant by health and disease;
- an appreciation of disease in a global context and the factors that affect distribution of disease globally;
- an understanding of the principles upon which preventive medicine is based;
- an understanding of how our bodies attempt to maintain good health;
- a positive attitude and approach to health as being more than simply the absence of disease.

1.0 HEALTH AND DISEASE

Content

Health and disease
Global disease distribution.

Objectives

Candidates should be able to:

1.1 discuss what is meant by health and discuss whether health is more than simply the absence of disease;

1.2 explain, with one example of each, what is meant by the following categories of disease or illness, physical, mental, social, infectious, non-infectious, degenerative, inherited, self-inflicted and deficiency;

1.3 discuss the reasons for the global distribution of measles, TB, coronary heart disease and HIV/AIDS.
2.0 DIET

Content

Importance of diet in relation to health.

Objectives:

Candidates should be able to:

2.1 discuss what constitutes a balanced diet;

2.2 discuss relevant quantities required by people of both sexes and of different age, activity, pregnancy and lactation;

2.3 explain what is meant by the term dietary reference value (DRV) and describe how these values should be used;

2.4 describe the roles of essential amino acids, essential fatty acids and vitamins A and D in the body;

2.5 discuss the consequences of malnutrition with reference to starvation, protein deficiency, anorexia nervosa, deficiencies of vitamins A and D and obesity.

3.0 DRUGS

Content

Tobacco
Alcohol
Heroin

Objectives

Candidates should be able to:

3.1 discuss the meaning of the term drug;

3.2 discuss the difference between socially acceptable and illicit drugs;

3.3 distinguish between psychological and physical dependence;

3.4 explain the meaning of drug tolerance, with reference to tobacco, alcohol and heroin;

3.5 describe the effects of tar and carcinogens in tobacco smoke on the gaseous exchange system;

3.6 describe the effects of nicotine and carbon monoxide on the cardiovascular system with reference to atherosclerosis, coronary heart disease and strokes;
3.7 Evaluate the epidemiological evidence linking cigarette smoking to disease and early death;
3.8 discuss the difficulty in achieving a balance between prevention and cure with reference to coronary heart disease, coronary by-pass surgery and heart transplant surgery;
3.9 describe the immediate and long term consequences or alcohol consumption on the brain, on the peripheral nervous system and on the liver;
3.10 discuss the social consequences of excessive alcohol use with particular reference to drinking and driving, aggressive behaviour, intra-family violence, family breakdown and petty crime;
3.11 discuss the effects of heroin on the nervous system and on behaviour.

4.0 INFECTIOUS DISEASES

Cholera, malaria, TB and AIDS.
Antibiotics

Objectives

Candidates should be able to:
4.1 describe the causes and symptoms of cholera, malaria, TB and HIV/AIDS;
4.2 explain how cholera, malaria, TB, and HIV/AIDS are transmitted and assess the importance of these diseases worldwide;
4.3 discuss the roles of social, economic and biological factors in the prevention and control of cholera, malaria, TB and HIV/AIDS (a detailed study of the life cycle of the malaria parasite is not required);
4.4 discuss the global distribution of malaria, tuberculosis, coronary heart disease and sickle cell anaemia;
4.5 outline the role of antibiotics in the treatment of infectious disease.
5.0 IMMUNITY

Immune system
Vaccination

Objectives

Candidates should be able to:

5.1 recognise phagocytes and lymphocytes under the light microscope;

5.2 describe the origin, maturation and mode of action of phagocytes;

5.3 explain the meaning of the term immune response;

5.4 distinguish between B- and T-lymphocytes in their mode of action in fighting infection and describe their origin and functions;

5.5 distinguish between humoral and cell-mediated immune responses;

5.6 explain the role of memory cells in long-term immunity;

5.7 relate the molecular structure of antibodies to their function;

5.8 distinguish between active and passive, natural and artificial immunity, and explain how vaccination can control disease;

5.9 discuss the reasons why vaccination has eliminated smallpox but not measles, TB, malaria or cholera;

6.0 outline the role of the immune system in allergies, with reference to asthma and hay fever.
OPTION 4 - APPLIED PLANT AND ANIMAL SCIENCE

Introduction

This Option is intended to develop:

- an understanding of the far reaching effects of applied science in food production;
- an appreciation that Biology can be studied in relation to the needs of people;
- an understanding of the factors that contribute to plant growth and yield;
- an understanding of the global distribution of crops and farm animals;
- an appreciation that increased productivity has had considerable social and economic effects.

1. PLANT METABOLISM AND PRODUCTIVITY

Content

- Efficiency of energy conversion in plants.
- Measurement of crop yields.
- Role of plants growth regulators.

Objectives

Candidates should be able to:

1.1 describe the structural differences between C3 and C4 plants;
1.2 explain the economic importance of C3 plants as crops in temperate regions and C4 plants as crops in tropical regions;
1.3 describe the efficiency of energy conversion, in terms of intercepted radiation and dry matter production;
1.4 describe the measurement of yields as harvest in terms of biomass, harvestable dry matter and digestible energy;
1.5 outline the roles of auxins, gibberellins, cytokinins and abscisic acid as plant growth regulators;
1.6 describe how plant growth regulators are used to improve plant performance with reference to seedless fruits and rooting compounds.
2.0 SOIL FERTILITY

Content

Nitrogen fixation
Irrigation and drainage

Objectives

2.1 discuss the importance of soil texture, aeration, pH and water content (field capacity) on the growth of plants;
2.2 explain how soil is improved by adding lime and farmyard manure;
2.3 describe the role of Rhizobium in nitrogen fixation and discuss its possible use as an alternative to fertilisers in the future;
2.4 assess the need for irrigation and drainage for the growth of crop plants.

3.0 CROP PRODUCTION

Content

Global distribution of crop plants.
Crop cultivation.
Monoculture.

Objectives:

Candidates should be able to:

3.1 describe the global distribution of cassava, maize, rice and wheat;
3.2 discuss the reasons for the choice of crops grown in different areas of the world. (Reference should be made to nutritional, environmental, cultural and economic factors);
3.3 describe the cultivation of either wheat or maize with reference to ploughing, drilling, pest, weed and disease control, fertiliser input, harvesting and storage;
3.4 discuss the advantages and disadvantages of monoculture;
3.5 describe how knowledge of growth and development has been used commercially to develop methods of artificial propagation;
3.6 describe the cloning of plants from tissue culture;
3.7 discuss the advantages and disadvantages of cloning (reference to the cloning of food plants is expected but no practical details of tissue culture are required).

4 LIVESTOCK PRODUCTION

CONTENT

Factors affecting choice of livestock.
Intensive and extensive production.
Animal husbandry and disease control.
Efficiency of energy conversion.
Implication of intensive production.

Objectives

Candidates should be able to:

4.1 discuss the social environmental and economic features that determine the choice of animals to be reared;

4.2 distinguish between intensive and extensive livestock production;

4.3 discuss the production of either pigs or cattle with reference to nutritional requirements, pest and disease control;

4.4 discuss the efficiency of energy conversion in livestock and the ways in which productivity is maximised;

4.5 discuss the implications of intensive animal production with reference to environmental impact and animal welfare.

5. THE WORLD FOOD PROBLEM

Content

Production and distribution of food in the SADC and around the world.
Problems of food surpluses and shortages.

Objectives

Candidates should be able to:

5.1 discuss the uneven distribution of food resources in the world;

5.2 discuss the problems of food supply in developing countries and the conflict between growing crops for export and food for local consumption.
RESOURCES LIST

The following list of reading material is recommended as resource material to aid teachers and students studying Biology at this level:

(a) Biological Science by D. J. Tailor, N.P.O. Green and G.W. stout and edited by R. Soper,

(b) Advanced Biology by Mary Jones and Geoff Jones,

(c) A.S. Level Biology by Phil Bradfield, John Dodds, Judy Dodds and Norma Taylor,

(d) Applications of Genetics by Jennifer Gregory,

(e) Biology – a functional approach by M.B.V. Roberts,

(f) ‘A’ Level Biology – Workout by G. W. stout and N.P.O Green,

(g) Biology Concepts & Connections by N.A. Campbell, L.G. Mitchell and Jane B. Reece,

(h) Growth, Development and Reproduction by Dennis Taylor,

(i) Letts – A-Level Biology Questions and Answers by Morton Jenkins.

(j) Biology (Topical) 1991-2001 Redspot by Redspot Publisher – Singapore.


(l) T. address http://www.biolinks.org
    http://www.biozones.org

Below is a list of basic material and apparatus which would be found in a well-equipped Bio Lab but it is by no means exhaustive.

- test tubes & heat resistant boiling tubes
- test tube holders or similar such
- test tube racks or similar such
- Bings 2 fit t.t./b.t
- specimen tubes with corks
- a means of heating e.g. bunsen burner
- thermometers
- measuring glinders
- means of measuring small volumes e.g. syringes of various sizes 1cm³, 2cm³, 5cm³, 10 + 20
- teat pipettes
- beakers
- tripod stands + gauzes
- filter funnels + filter paper
- petri dishes (plastic)
- white tiles or other suitable surface on which cut
- glass slides + cover slips
- conical flasks
- clamp stands + bosses
- visking tubing
- capillary tubing
- soda glass tubing
- pepa towelling or tissue
- cotton wool
- solid glass rods
- black pepa/aluminium foil
- means of marking glassware (water resistant)
- haud lenses (x8)
- forceps
- scissors
- mounted needle
- scalpel or solid edged razor blade
- mortars & pestles
- safety goggles
- microscope and lamp (in built illuminations with high & low power objective lenses)
- eye piece graticles and stage micrometers
- bench lamp with flexible arm balance (to 0.1g)
- water baths or equivalent
- cork borers
- stop clock/timer showing seconds
- simple respirometer
- pipe cleaners
- apparatus to measure rate and depth of breathing

Stocks of:

- Iodine in KI soln
- Benedict’s solution
- Biuret reagent
- Ethanol (for fat tests)
- Ethylated spirit (extraction of chlorophyll)
- Sucrose (use AR for non-reducing sugar test)
- Glucose
- Starch
- Potassium hydroxide
- Sodium Chloride
- Dil HC2 acid
- Hydrogen Carbonate indicator
- Sodium Bicarbonate/Sodium Hydrogen Carbonate
- Lime H₂O
- Distilled/deionised H₂O
- Universal indicator paper + chart
- Litmus pepa
- Eosin/red ink
- Methylene blue
- Vaseline
- DCPIP
- Ascorbic acid
- Enzymes' analyse, diastase, pepsin, tripsin
  Catalase can be obtained from potatoes or liver.