EXAMINATIONS COUNCIL OF ESWATINI

Biology

EGCSE

Eswatini General Certificate of Secondary Education



Syllabus

For Examination in 2027-2029

Changes in the EGCSE Biology (6884) for 2027-2029

1. The 2024 to 2026 syllabus has been revised.
2. Minor changes have been made to the syllabus. These include:
   - change in number format of topics to 1,2 3, and so on
   - changing some of the command words, 'list and define' to 'describe'
   - removal of reference to teaching time for each topic
   - unpacking of several topics so that it is clear what will be assessed, for example, topic 7 has additional objectives not meant to introduce new content but to provide clarity
   - unpacking of appendices so that they are now detailed
   - addition of reference section.

You are advised to read the whole syllabus before planning your teaching programme.

Changes in the content

Topic 4: neurones, sperm and egg cells have replaced goblet cells and muscle cells

Topic 8: mechanical digestion re-worded to physical digestion

Topic 15: variation and selection separated into two separate subtopics, 15.1 and 15.2 respectively

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BROAD GUIDELINES

The Ministry of Education and Training is committed, in accordance with the National Policy Statement on Education, to provide a Curriculum and Assessment System so that at the completion of senior secondary education (Form 4 and Form 5), learners will:

- be equipped to meet the changing needs of the Nation, and
- have attained internationally acceptable standards.

Eswatini's National Education Policy Directives

EGCSE syllabuses for studies in Form 4 and Form 5 will individually, and collectively, enable learners to develop **essential skills** and provide a broad **learning experience** which:

- inculcates values and attitudes as well as knowledge and understanding,
- encourages respect for human rights and freedom of speech,
- respects the values and beliefs of others, relating to issues of gender, culture and religion,
- develops desirable attitudes and behaviour towards the environment,
- provides insight and understanding of global issues which affect quality of life in Eswatini and elsewhere, e.g., the AIDS pandemic; global warming; maldistribution of wealth; and technological advances.

The National Curriculum for Form 4 and Form 5

Learners will be given opportunities to develop essential skills which will overlap across the entire range of subjects studied. These skills are listed below.

- Communication and language skills
- Numeracy skills: mathematical ideas, techniques and applications
- Problem-solving skills
- Technological awareness and applications
- Critical thinking skills
- Work and study skills
- Independent learning
- Working with others

To develop these skills, learners must be offered five compulsory subjects and at least two elective subjects chosen from one or more Fields of Study.

Compulsory Subjects

- SiSwati – either First Language or Second Language
- English Language
- Mathematics
- Science (Biology or Physical Science)
- Religious Education

Fields of Study

- Agriculture Field of Study
- Business Studies Field of Study
- Consumer Science Field of Study
- Social Sciences and Humanities Field of Study
- Technical Field of Study
- Science Field of Study

INTRODUCTION

The Eswatini General Certificate of Secondary Education (EGCSE) syllabuses are designed as two-year courses for examination in Form 5. Biology places considerable emphasis on understanding and use of scientific ideas and principles in a variety of situations, including those which are well-known to the learner and those which are new to them. It is anticipated that programmes of study based on this syllabus will feature a variety of learning experiences designed to enhance the development of skill and comprehension. This approach will focus teachers and learners on development of transferable life-long skills relevant to the increasingly technological environment in which people find themselves. It will also prepare candidates for an assessment that will, within familiar and unfamiliar contexts, test expertise, understanding and insight.

All EGCSE syllabuses follow a general pattern. The main sections are:

- Aims
- Assessment Objectives
- Assessment
- Curriculum Content

Biology falls into the Science Compulsory Subjects Group which includes Physical Science. It is also an Elective Subject in the following Fields of Study Groups: Agriculture, Consumer Science and Science.

PURPOSE

The EGCSE Biology syllabus prepares learners for life, helping them to:

- develop an informed curiosity about scientific principles and their applications in everyday life
- develop a lasting passion for learning, question ideas and use scientific language to communicate their perspectives and opinions
- confidently and innovatively solve unfamiliar problems in the world
- work methodically and safely when alone or collaboratively with others
- learn from their everyday experiences and interest in scientific issues that impact them, their communities and the environment.

PRIOR KNOWLEDGE AND SKILLS

Learners beginning this course should normally have completed the junior secondary school science or its equivalent.

PROGRESSION

EGCSE Biology qualification enables candidates to further their studies at tertiary institutions in Eswatini and beyond.

TEACHING HOURS

Appropriate teaching time for the Biology syllabus is Six (6) periods of forty (40) minutes each week over a period of sixty weeks/cycles.

TEACHER SUPPORT MATERIAL

A wide range of materials and resources are available to support teachers in Eswatini schools. The resources suit a variety of teaching and learning methods in the local context. Through targeted training forums, teachers can access the expert advice they need for teaching this syllabus. These materials are available under Biology in the programmes and qualification section of our website www.examscouncil.org.sz

EXAM PREPARATION RESOURCES

Examination reports, syllabuses, past papers and specimen papers are available on ECESWA website www.examscouncil.org.sz

SPECIAL REQUIREMENTS

Laboratories furnished with functional equipment for conducting practicals.

AVAILABLE GRADES

Candidates in this syllabus are eligible for Grades A* to G.

CONTENT OVERVIEW

Candidates learn the following topics:

Section	Topic
I - CHARACTERISTICS AND CLASSIFICATION OF LIVING ORGANISMS	1 Characteristics of living organisms 2 Classification and diversity of living organisms
II - ORGANISATION AND MAINTENANCE OF THE ORGANISM	3 Cell structure and organisation: the cellular nature of all living organisms 4 Levels of organisation 5 Size of specimens 6 Movement into and out of cells 7 Enzymes 8 Nutrition 9 Transportation 10 Respiration 11 Excretion in humans 12 Coordination and response
III - THE DEVELOPMENT OF THE ORGANISM AND THE CONTINUITY OF LIFE	13 Reproduction 14 Inheritance 15 Variation and Selection 16 Biotechnology and Genetic modification
IV - BIODIVERSITY AND ECOSYSTEMS	17 Biodiversity 18 Ecosystems 19 Pollution 20 Conservation

AIMS

The aims of the syllabus are the same for all learners. These aims are set out below and describe the educational purposes of a course in Biology for the EGCSE Examination. They are not listed in order of priority.

The aims are to:

1 provide, through well designed studies of experimental and practical science, 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, 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 prepared for studies beyond EGCSE in pure sciences, in applied sciences or in science dependent vocational courses;
   - 1.4 develop an understanding of the scientific skills essential for both further study, employment, and everyday life.

2 develop abilities and transferable skills that:
   - 2.1 are relevant to the study and practice of Biology;
   - 2.2 are useful in everyday life including handling data, problem solving and applying the scientific method;
   - 2.3 encourage efficient and safe practice;
   - 2.4 encourage clear and effective communication, using scientific terminology, notation and conventions;

3 develop attitudes relevant to Biology such as:
   - 3.1 concern for accuracy and precision;
   - 3.2 objectivity;
   - 3.3 integrity;
   - 3.4 enquiry;
   - 3.5 initiative;
   - 3.6 inventiveness;
   - 3.7 validity and reliability.

4 stimulate learner interest in, and care for, the environment.

5 promote an awareness that
   - 5.1 scientific theories and methods have developed, and continue to do so, as a result of the co-operative activities of groups and individuals;
   - 5.2 the study and practice of science is subject to social, economic, technological, ethical and cultural influences and limitations;
   - 5.3 the applications of science may be both beneficial and detrimental to the individual, the community and the environment;
   - 5.4 science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal.

ASSESSMENT OBJECTIVES

Assessment Objectives in Biology are:

AOA Knowledge with Understanding

AOB Handling Information and Solving Problems

AOC Experimental Skills and Investigations

A description of each Assessment Objective follows.

AOA KNOWLEDGE WITH UNDERSTANDING

Learners 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)

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 Curriculum Content defines the factual material that candidates may need to recall and explain. Questions testing these objectives will often begin with one of the following words: define, state, describe, explain (using your Knowledge and Understanding) or outline. (see Appendix: Glossary of Terms at the back of the syllabus.)

AOB HANDLING INFORMATION AND SOLVING PROBLEMS

Learners should be able, in words or using other written forms of presentation (i.e., symbolic, graphical and numerical), 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 of phenomena, patterns and relationships

6 make predictions and propose hypotheses

7 solve problems, including some of a quantitative nature.

These assessment objectives cannot be precisely specified in the Curriculum Content because questions testing such skills may be based on information that 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: discuss, predict, suggest, calculate, explain or determine. (see Glossary of Terms at the back of the syllabus.)

AOC EXPERIMENTAL SKILLS AND INVESTIGATIONS

Learners should be able to:

1. demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
2. plan experiments and investigations
3. make and record observations, measurements and estimates
4. interpret and evaluate experimental observations and data
5. evaluate methods and suggest possible improvements.

SPECIFICATION GRID

The approximate weightings allocated to each of the Assessment Objectives in the assessment model are summarised in the table below.

Assessment Objectives	Paper 1 (marks)	Paper 2 (marks)	Papers 3 and 4 (marks)
AOA Knowledge with understanding	25-30	48-53	0
AOB Handling information and solving problems	10-15	27-32	0
AOC Experimental skills and investigations	0	0	40
Weighting in component %	27	53	20

Assessment objectives as a percentage of the qualification

Assessment Objectives	Weighting in EGCSE %
AOA Knowledge with understanding	50 (not more than 25% recall)
AOB Handling information and solving problems	30
AOC Experimental skills and investigations	20
Total	100

Teachers should take note that there is an equal weighting of 50% for skills (including handling information, solving problems, practical, experimental and investigative skills) and for knowledge and understanding. Teachers' schemes of work, and the sequence of learning activities should reflect this balance, so that the aims of the syllabus may be met, and the candidates prepared for the assessment.

SCHEME OF ASSESSMENT

All candidates must enter for three papers. These will be Paper 1, Paper 2 and one from the practical assessment Papers 3 (Practical Test) or 4 (Alternative to Practical).

A description of each paper follows.

Paper 1 (1 hour)

Compulsory short answer paper consisting of 40 marks.
The paper will test skills mainly in Assessment Objectives A and B.
This paper will be weighted at 27% of the final total available marks.

Paper 2 (1 hour 15 minutes)

Compulsory theory paper consisting of 80 marks of structured questions.
The questions will be based on all material and will test skills mainly in Assessment Objectives A and B.
This paper will be weighted at 53% of the final total available marks.

Practical Assessment

The purpose of this component is to test appropriate skills in Assessment Objective **C**.

Candidates must be entered for one of the following:

Either

Paper 3 Practical Test (1 hour 15 minutes) consisting of 40 marks, with questions covering experimental skills and investigations. (See Appendix: Assessment Criteria for Practicals.)

Or

Paper 4 Alternative to Practical (1 hour) consisting of 40 marks. This is a written paper designed to test familiarity with laboratory based procedures. (See Appendix: Assessment Criteria for Practicals.)

The practical assessment will be weighted at 20% of the final total available marks.

EXPERIMENTAL WORK

Experimental work is an essential component of all sciences. Experimental work within science education:

- gives candidates first-hand experience of phenomena
- enables candidates to acquire practical skills
- provides candidates with the opportunity to plan and carry out investigations
- promotes mastery of concepts.

This can be achieved by individual or group experimental work, or by demonstrations which actively involve the candidates.

Throughout the Curriculum Content section of this syllabus some clear indications are given of opportunities to use practical work, using the command words, for example '*describe*' 'perform *experiments* to…' and *'investigate*…' These instructions mean that such statements may be examined in terms of practical skills in Paper 3 or Paper 4, but also in terms of other skills (Assessment Objectives A and B) in Papers 1 and 2 covering such skills as planning, prediction, recall, explanation, handling data (including calculations) and interpretation of results.

CURRICULUM CONTENT

Notes:

(i) The Curriculum Content outlined below is designed to provide guidance to teachers as to what will be assessed in the overall evaluation of the learner. Throughout the course, attention should be drawn to the relevance of the concepts to the learner's everyday life and to the natural and man-made world. The specified content of the syllabus has been limited in order to encourage this approach and to permit flexibility in teaching programmes.

(ii) Due to the spiral nature of the curriculum, it is assumed that the elementary concepts of the syllabus have been covered during study at Junior Secondary level.

(iii) The main topic areas and concepts are indicated in **bold**.

(iv) To avoid any confusion concerning the symbol for litre, dm^3 will be used in place of *l* or litre.

SECTION I - CHARACTERISTICS AND CLASSIFICATION OF LIVING ORGANISMS

All learners should be able to:

1.0 Characteristics of living organisms

1 describe the characteristics of living organisms by describing the terms:
   (a) nutrition as obtaining the organic substances and mineral ions from which organisms gain their energy and the raw materials for growth and tissue repair
   (b) excretion as the removal of toxic materials and the waste products of metabolism from organisms
   (c) respiration as the release of energy from food substances in all living cells
   (d) sensitivity as the ability to sense and respond to changes in the surroundings
   (e) reproduction as producing offspring, preventing extinction of the species
   (f) growth as an increase in size, mass and complexity of an organism
   (g) movement as a change in position of the whole body or any part of the organism

2.0 Classification and diversity of living organisms

1 list the seven levels of classification of organisms in hierarchical order (taxa) as: kingdom, phylum, class, order, family, genus and species
2 describe the binomial system as the system of naming organisms using two names, genus and species
3 describe the main characteristics of the five kingdoms of organisms as: plantae, animalia, fungi, prokaryotae and protoctista
4 state that animals are classified into vertebrates and invertebrates
5 classify, using visible, external characteristic features:
   (a) vertebrates into the classes: fishes, amphibians, reptiles, birds and mammals
   (b) invertebrates into the phyla: arthropods, annelids, nematodes and molluscs
   (c) arthropods into the classes: insects, crustaceans, arachnids and myriapods
   (d) flowering plants into monocotyledons and dicotyledons
   (Local examples to be studied as appropriate)
6 list the main features used in the classification of the following groups: viruses, bacteria and fungi, and their adaptation to the environment, as appropriate
7 construct and use simple dichotomous keys based on easily identifiable features

SECTION II - ORGANISATION AND MAINTENANCE OF THE ORGANISM

All learners should be able to:

3.0 Cell structure and organisation: the cellular nature of all living organisms

1 identify and describe the structure of a plant cell (palisade cell) and an animal cell (liver cell), as seen under the light microscope and other parts seen from images from the electron microscope, and state their functions (cell membrane, cytoplasm, nucleus, cell wall, vacuole, chloroplast, ribosome, mitochondrion)

2 relate the structures of parts of the cell to their functions (cell membrane, chloroplast, mitochondrion)

3 describe the differences in structure between typical animal and plant cells

4.0 Levels of organisation

1 describe development as an increase in complexity through the differentiation of cells

2 describe tissue as a group of cells of similar structure that work together to perform a special function

3 relate the structure of the following to their functions:
- (a) palisade mesophyll cells – photosynthesis
- (b) ciliated cells in respiratory tract – movement of mucus
- (c) sperm and egg cells (gametes) – reproduction
- (d) root hair cells – absorption
- (e) xylem vessels – conduction and support
- (f) neurones – conduction of electrical impulses
- (g) red blood cells – transport

4 describe:
- (a) organ as several tissues grouped together to make a structure with a special function
- (b) organ system as a group of organs with closely related functions
  (use examples of organs and organ systems, as illustrated by examples covered in Sections II and III)

5 identify the different levels of organisation in drawings, diagrams and images

5.0 Size of specimens

1 state and use the formula: magnification = image size ÷ actual size

2 calculate magnification and size of biological specimens using millimetres as units

3 convert measurements between millimetres (mm) and micrometres (μm)

4 express magnification using a times (×) symbol

6.0 Movement in and out of cells	
6.1 Diffusion	
1	describe diffusion as the movement of particles from a region of their higher concentration to a region of their lower concentration, down a concentration gradient
2	describe the importance of diffusion of gases and solutes to living organisms
3	investigate the factors that influence diffusion (surface area, temperature, concentration gradient, distance)
6.2 Osmosis	
1	describe osmosis as the net movement of water molecules from a region of their higher concentration (higher water potential) to a region of their lower concentration (lower water potential), through a partially permeable membrane
2	investigate and describe the effects of osmosis on animal and plant tissues in solutions of different concentrations
3	explain the effect of osmosis on plant and animal tissues using the terms plasmolysis, turgid, flaccid, turgor pressure, isotonic, hypertonic, hypotonic
4	explain the importance of water potential and osmosis in the uptake and loss of water by organisms
6.3 Active transport	
1	describe active transport as the movement of particles through a cell membrane from a region of their lower concentration to a region of their higher concentration using energy from respiration
2	discuss the importance of active transport as a process for movement across membranes e.g. mineral ion uptake in root hair cells, uptake of glucose by epithelial cells of villi and in kidney tubules
7.0 Enzymes	
1	describe a catalyst as a substance that increases the rate of a chemical reaction and is not changed by the reaction
2	describe enzymes as proteins that function as biological catalysts
3	investigate and describe the effect of changes in temperature and pH on enzyme activity with reference to optimum temperature and denaturation
4	explain enzyme action in terms of the ‘lock and key’ hypothesis with reference to: active site, enzyme-substrate complex, substrate and product
5	explain the specificity of enzymes in terms of the complementary shape and fit of the active site with the substrate

6 explain the effect of changes in temperature on enzyme activity in terms of kinetic energy, shape and fit, frequency of effective collisions and denaturation

7 explain the effect of changes in pH on enzyme activity in terms of shape and fit and denaturation

8.0 Nutrition

8.1 Plant nutrition

8.1.1 Photosynthesis

1 describe photosynthesis as the fundamental process by which plants manufacture simple sugars from carbon dioxide and water in the presence of light energy and chlorophyll

2 state the word equation for photosynthesis as:
carbon dioxide + water → glucose + oxygen in the presence of light and chlorophyll

3 state the balanced chemical equation for photosynthesis as:
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

4 describe the intake of the raw materials for photosynthesis and the trapping and storing of energy (conversion of light energy into chemical energy)

5 outline the subsequent use and storage of the carbohydrates made in photosynthesis, limited to:
(a) starch as an energy store
(b) cellulose to build cell walls
(c) glucose used in respiration to provide energy
(d) sucrose for transport in the phloem
(e) nectar to attract insects for pollination

6 perform the starch test on a leaf

7 investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls

8 investigate and describe the effect of light and dark conditions on gas exchange in an aquatic plant using hydrogencarbonate indicator solution

9 investigate and describe the effects of varying light intensity and carbon dioxide concentration on the rate of photosynthesis

10 describe the term limiting factor as the external factor which restricts the effects of others (when a number of factors are needed, it is the one in shortest supply)

11 identify and explain the limiting factors of photosynthesis in different environmental conditions

12 explain the use of carbon dioxide enrichment, optimum light and optimum temperatures in greenhouse systems

8.1.2 Leaf structure

1 state that most leaves have a large surface area and are thin, and explain how these features are adaptations for photosynthesis

2 identify the cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section diagrams and images:
chloroplasts, cuticle, guard cells and stomata, upper and lower epidermis, palisade mesophyll, spongy mesophyll, air spaces, vascular bundles, xylem and phloem

3 explain how the structures listed in (8.1.2.2) adapt leaves for photosynthesis

8.1.3 Mineral requirements

1 describe the importance of:
- (a) nitrate ions for amino acid synthesis
- (b) magnesium ions for chlorophyll synthesis

2 investigate the effects of nitrate ion and magnesium ion deficiency on plant growth

3 describe the uses of nitrogen fertilisers and local alternatives (e.g. kraal manure)

8.2 Human nutrition

8.2.1 Nutrients

1 list the main chemical elements that make up: carbohydrates, fats and proteins

2 describe the synthesis of large molecules from smaller basic units: simple sugars to starch and glycogen, amino acids to proteins, fatty acids and glycerol to fats and oils

3 describe and carry out tests for:
- (a) starch using iodine solution
- (b) reducing sugars using Benedict's solution
- (c) vitamin C using DCPIP
- (d) protein using the biuret test
- (e) fats using ethanol

4 state the principal dietary sources and describe the importance of:
- (a) carbohydrates
- (b) fats
- (c) proteins
- (d) vitamins, limited to C and D
- (e) mineral salts, limited to calcium and iron
- (f) fibre or roughage
- (g) water

5 describe the deficiency symptoms for:
- (a) vitamins, limited to C and D
- (b) mineral salts, limited to calcium and iron

6 state the causes of scurvy and rickets

8.2.2 Diet

1 describe a balanced diet as a diet containing all the nutrients in correct amounts and proportions to sustain a healthy life

2 explain
   (a) how age, gender, and activity affect the dietary needs of humans
   (b) the effects of malnutrition in relation to starvation, coronary heart disease, constipation and obesity

3 discuss the special dietary needs for people living with:
   (a) high blood pressure in relation to salt and fat intake
   (b) sugar diabetes in relation to carbohydrate, fruit and vegetable intake

8.2.3 Human alimentary canal

1 describe:
   (a) ingestion as the intake of food into the mouth
   (b) physical digestion as the breakdown of food into smaller pieces without chemical change to food molecules
   (c) chemical digestion as the breakdown of large, insoluble food molecules into smaller, soluble ones using enzymes
   (d) absorption as the process by which digested food molecules pass across the wall of the intestine into the blood or lymph
   (e) assimilation as use of food molecules by cells in the processes of growth, reproduction and repair (i.e. building up the cell/incorporating into the cell)
   (f) egestion as the passing out of undigested food, in the form of faeces, through the anus

2 identify in diagrams and images the main organs of the digestive system, in relation to:
   (a) alimentary canal: mouth, oesophagus, stomach, small intestine (duodenum and ileum), large intestine (colon and rectum), and anus
   (b) associated organs: salivary glands, pancreas, liver, and gall bladder

3 describe the functions of the organs of the digestive system listed in (a) and (b), in relation to:
   (a) ingestion – the taking of substances, e.g. food and drink, into the body
   (b) digestion – the breakdown of food
   (c) absorption – the movement of nutrients from the intestines into the blood
   (d) assimilation – uptake and use of nutrients by cells
   (e) egestion – the removal of undigested food from the body as faeces

4 describe diarrhoea and outline its treatment using oral rehydration therapy

8.2.4 Physical digestion

1 state that physical digestion increases the surface area of food for the action of enzymes in chemical digestion
2 identify in diagrams and images the types of human teeth: incisors, canines, premolars and molars
3 identify and describe parts of a human tooth, limited to: enamel, dentine, pulp cavity, nerves, blood vessels, and cement, and understand that teeth are embedded in bone and the gums
4 describe the functions of the types of human teeth in physical digestion of food
5 describe dental decay stating its causes and ways of prevention
6 explain the probable action of fluoride in reducing dental decay
7 describe the function of the stomach in physical digestion
8 describe and explain the process of peristalsis

8.2.5 Chemical digestion

1 state the role of chemical digestion in producing small soluble molecules that can be absorbed
2 describe the functions of enzymes as follows:
   (a) amylase breaks down starch to maltose
   (b) maltase breaks down maltose to glucose on the membranes of the epithelium lining the small intestine
   (c) proteases (limited to pepsin (in acidic conditions) and trypsin (in alkaline conditions) break down protein to amino acids
   (d) lipase breaks down fats and oils to fatty acids and glycerol
3 state where, in the digestive system, amylase, protease and lipase are secreted and where they act
4 describe the functions of hydrochloric acid in gastric juice, limited to killing harmful microorganisms in food and providing an acidic pH for optimum enzyme activity
5 explain that bile is an alkaline mixture that neutralises the acidic mixture of food and gastric juices entering the duodenum from the stomach, to provide a suitable pH for enzyme action

8.2.6 Absorption

1 describe the adaptations of the ileum for absorption
2 describe and explain:
   (a) the significance of villi and microvilli in increasing the internal surface area of the ileum
   (b) the structure of a villus
   (c) the role of capillaries and lacteals in villi

8.2.7 Assimilation

1 state the role of the hepatic portal vein in the transport of absorbed food to the liver
2 describe:
   (a) the role of the liver in the metabolism of glucose
   (b) the role of the liver in the assimilation of amino acids by converting them to proteins
   (c) the role of fat as a storage substance
3 describe deamination as the removal of the nitrogen-containing part of amino acids to form urea

9.0 Transportation

9.1 Transport in plants

9.1.1 Water uptake

1 identify in diagrams and images root hair cells and state their functions
2 state that the large surface area of root hairs increases the uptake of water and mineral ions
3 outline the passage of water through the root, stem and leaf: root hair cells, root cortex cells, xylem, mesophyll cells
4 identify in diagrams and images the position of xylem, phloem, epidermis, cortex and pith as seen in sections of roots, stems and leaves of non-woody dicotyledonous plants
5 investigate, using a suitable stain, the pathway of water through the above-ground parts of a plant

9.1.2 Transpiration

1 describe transpiration as the loss of water vapour from leaves
2 describe how transpiration rate is related to: the large internal surface area provided by the interconnecting air spaces between mesophyll cells and the size and number of stomata
3 investigate and explain the effects of variation of temperature, humidity, light intensity and air movement on transpiration rate using a potometer
4 explain the mechanism by which water and dissolved mineral ions move up the xylem in terms of transpiration pull that draws up a column of water molecules, held together by forces of attraction between water molecules
5 explain how and why wilting occurs
6 discuss the adaptations of the leaf, stem and root to different environments, with emphasis on local examples
7 relate the structure of xylem vessels to their function, limited to:
   (a) thick walls with lignin (details of lignification are not required)
   (b) no cell contents
   (c) cells joined end to end with no cross walls to form a long continuous tube

9.1.3 Translocation

1 describe translocation as the movement of sucrose and amino acids from sources (regions of production) to sinks (regions of storage or of utilisation in respiration or growth)
2 describe translocation of applied chemicals, including systemic pesticides, throughout the plant
3 compare the role of transpiration and translocation in the transport of materials

9.2 Transport in humans

9.2.1 Blood circulation

1 describe the circulatory system as a system of blood vessels with a pump and valves to ensure one-way flow of blood
2 describe the double circulation in terms of a low pressure circulation to the lungs and a high pressure circulation to the body tissues and relate these differences to the different functions of the two circuits

9.2.2 Heart

1 identify in diagrams and images the structure of the mammalian heart, limited to: muscular wall, septum, left and right ventricles, left and right atria, one-way valves (atrioventricular and semilunar) and its associated major blood vessels (vena cava, aorta, coronary artery, pulmonary artery and pulmonary vein)
2 explain the relative thickness of:
   (a) the muscle walls of the left and right ventricles
   (b) the muscle walls of the atria compared to those of the ventricles
3 explain the importance of the septum in separating oxygenated and deoxygenated blood
4 describe the function of the mammalian heart in terms of the contraction of muscles of the atria and ventricles and the action of the valves
5 state that blood is pumped away from the heart in arteries and returns to the heart in veins
6 state that the activity of the heart may be monitored by: ECG, pulse rate and listening to sounds of valves closing
7 investigate and explain the effect of exercise on heart rate
8 state the function of the coronary blood vessels
9 describe the causes, effects, preventive measures and control of high blood pressure
10 describe coronary heart disease in terms of the blockage of coronary arteries
11 explain the possible risk factors for coronary heart disease as diet, smoking, stress, lack of exercise, genetic predisposition and age
12 discuss the roles of diet and exercise in the prevention of coronary heart disease

9.2.3 Arteries, veins and capillaries

1 describe the structure and functions of arteries, veins and capillaries, limited to: relative thickness of wall, diameter of the lumen and the presence of valves in veins
2 explain how structure of arteries, veins and capillaries are related in to their functions

9.2.4 Blood

1 identify red blood cells, phagocytes, lymphocytes and platelets as seen under a light microscope from prepared slides, diagrams and photomicrographs
2 describe the components of blood: red blood cells, platelets, plasma, phagocytes and lymphocytes
3 describe the functions of the following components of blood:
   (a) red blood cells in transporting oxygen, including the role of haemoglobin
   (b) white blood cells in in engulfing pathogens by phagocytosis (phagocytes) and antibody production (lymphocytes)
   (c) platelets in clotting in terms of conversion of fibrinogen to fibrin only
   (d) plasma in the transport of blood cells, ions, nutrients, urea, hormones and carbon dioxide
4 describe the transfer of materials between capillaries and tissue fluid

9.2.5 Immunity

1 describe the immune system in terms of antibody production and phagocytosis
2 describe a pathogen as a disease-causing organism
3 describe active immunity as defence against a pathogen by antibody production in the body
4 explain that active immunity is gained after an infection by a pathogen or by vaccination
5 describe and explain the process of vaccination:
   (a) weakened pathogens or their antigens are put into the body
   (b) the antigens stimulate an immune response by lymphocytes which produce antibodies
   (c) memory cells are produced that give long-term immunity
6 explain the role of vaccination in controlling the spread of diseases
7 explain that passive immunity is a short-term defence against a pathogen by antibodies acquired from another individual, including across the placenta and in breast milk
8 describe tissue rejection and how it is prevented
9 outline the lymphatic system in terms of lymphatic vessels and lymph nodes
10 describe the function of the lymphatic system in circulation of body fluids and the production of lymphocytes.

10.0 Respiration

10.1 Aerobic respiration

1 describe aerobic respiration as the breakdown of glucose in the presence of oxygen to release energy in cells.

2 state the word equation for aerobic respiration as:
glucose + oxygen → carbon dioxide + water

3 state the balanced chemical equation for aerobic respiration as:
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy

4 describe the uses of energy in the human body i.e. muscle contraction, protein synthesis, cell division, active transport, growth, passage of nerve impulses and maintenance of constant body temperature

5 investigate the uptake of oxygen by respiring organisms, such as arthropods and germinating seeds

10.2 Anaerobic respiration

1 describe anaerobic respiration as the breakdown of glucose in the absence of oxygen to release energy in cells

2 state the word equation for anaerobic respiration in yeast as:
glucose → alcohol + carbon dioxide

3 state the balanced chemical equation for anaerobic respiration in yeast as:
$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

4 describe the role of anaerobic respiration in brewing and in bread-making using yeast

5 investigate and describe the effect of temperature on respiration in yeast

6 state the word equation for anaerobic respiration in muscles during vigorous exercise as:
glucose → lactic acid

7 state the balanced chemical equation for anaerobic respiration in muscles as:
$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

8 describe the production and effect of lactic acid in muscles during exercise

9 outline how the oxygen debt is removed after exercise, limited to:
   (a) continuation of fast heart rate to transport lactic acid in the blood from the muscles to the liver
   (b) continuation of deeper and faster breathing to supply oxygen for aerobic respiration of lactic acid
   (c) aerobic respiration of lactic acid in the liver

10 compare aerobic respiration and anaerobic respiration in terms of relative amounts of energy released

10.3 Gaseous exchange

1 identify in diagrams and images the following parts of the breathing system: trachea, bronchi, bronchioles, alveoli, lungs, diaphragm, ribs, external and internal intercostal muscles and associated capillaries
2 describe the features of gas exchange surfaces in humans in terms of large surface area, thin epithilia, good blood supply and good ventilation with air
3 describe and explain gaseous exchange in the alveoli
4 describe the role of the ribs, the internal and external intercostal muscles and the diaphragm in producing volume and pressure changes leading to the ventilation of the lungs
5 investigate and explain the link between physical activity rate and depth of breathing in terms of: an increase in physical activity causing an increased carbon dioxide concentration in the blood, which is detected by the brain, leading to an increased rate and greater depth of breathing
6 investigate and explain the differences in composition between inspired and expired air using limewater or hydrogen carbonate indicator to test for carbon dioxide
7 describe the effects of tobacco smoke and its major toxic components on the respiratory system, in relation to: emphysema, chronic bronchitis and lung cancer

11.0 Excretion in humans

1 identify in diagrams and images the kidneys and associated blood vessels, ureters, bladder and urethra
2 state the functions of the different parts of the human urinary system (kidneys and associated blood vessels, ureters, bladder and urethra)
3 identify in diagrams and images the structure of the kidney in terms of cortex, medulla and pelvis
4 state that urea is formed through deamination of excess amino acids
5 describe the function of the kidney in terms of the removal of urea, excess water, and hormones and drugs broken down by the liver
6 describe the structure and function of a nephron, limited to: glomerulus, renal capsule, tubule, loop of Henle, collecting duct)
7 describe:
   (a) the role of the glomerulus in the filtration from the blood of water, glucose, urea and ions
   (b) the role of the nephron in the reabsorption of all of the glucose, some of the ions and most of the water back into the blood
   (c) the formation of urine containing urea, excess water and excess ions
8 explain dialysis and discuss its application in kidney machines
9 discuss the advantages and disadvantages of kidney transplants, compared with dialysis

12.0 Coordination and response

12.1 Hormones

1 describe a hormone as a chemical secreted by an endocrine gland, transported in the bloodstream and affecting a target organ

2 describe the chemical control of metabolic activity by adrenaline, stating its source, target organs and effects

3 discuss the use of chemicals in food production; auxins (growth regulation and ripening of fruits) and hormones (growth regulation)

12.2 Tropic responses

1 describe:
   (a) gravitropism as a response in which parts of a plant grows towards or away from gravity
   (b) phototropism as a response in which parts of a plant grow towards or away from the direction of the light source

2 investigate and explain:
   (a) negative and positive phototropism
   (b) negative and positive gravitropism

3 explain the chemical control of plant growth by auxins including gravitropism and phototropism in terms of auxins regulating differential growth

4 describe the use of synthetic plant hormones as weed killers

12.3 Nervous control in humans

1 describe the human nervous system in terms of:
   (a) the central nervous system consisting of the brain and spinal cord
   (b) the peripheral nervous system (PNS) consisting of the nerves outside of the brain and spinal cord

2 identify and state the functions of parts of the human central nervous system i.e. cerebral hemispheres, hypothalamus, pituitary gland, medulla, cerebellum and spinal cord

3 describe sense organs as groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals

4 identify in diagrams and images the component parts of the eye, limited to: cornea, iris, pupil, lens, retina, optic nerve and blind spot

5 describe the function of each part of the eye, limited to:
   (a) cornea – refracts light
   (b) iris – controls how much light enters the pupil
   (c) lens – focuses light on to the retina
   (d) retina – contains light receptors, some sensitive to light of different colours

(e) optic nerve – carries impulses to the brain

6 distinguish between rods and cones, in terms of function (limited to greater sensitivity of rods for night vision, and three different kinds of cones, absorbing light of different colours, for colour vision) and distribution in the retina of a human

7 explain the pupil reflex, limited to changes in light intensity and pupil diameter

8 explain the pupil reflex in terms of the antagonistic action of circular and radial muscles in the iris

9 explain accommodation to view near and distant objects in terms of the contraction and relaxation of the ciliary muscles, tension in the suspensory ligaments, shape of the lens and refraction of light

10 identify in diagrams and images the position of the fovea and state its function

11 identify motor, relay and sensory neurones from diagrams and images, and state their functions

12 describe the structure of a synapse, including the presence of vesicles containing neurotransmitter molecules, the synaptic gap and receptor proteins

13 describe the events at a synapse as:

(a) an impulse stimulates the release of neurotransmitter molecules from vesicles into the synaptic gap

(b) the neurotransmitter molecules diffuse across the gap

(c) neurotransmitter molecules bind with receptor proteins on the next neurone

(d) an impulse is then stimulated in the next neurone

14 state that synapses ensure that impulses travel in one direction only

15 describe effectors in terms of muscles (biceps and triceps) and glands

16 describe a simple reflex arc in terms of receptor, sensory neurone, relay neurone, motor neurone and effector (muscles and glands)

17 describe a reflex action as a means of automatically and rapidly integrating and coordinating stimuli with responses of effectors (muscles and glands)

18 distinguish between voluntary and involuntary actions

19 compare hormonal and nervous control systems in terms of speed and longevity of action

12.4 Homeostasis

1 describe homeostasis as the maintenance of a constant internal environment

2 identify in diagrams and images of the skin:
hairs, sweat glands, sweat ducts, temperature receptors, blood vessels, hair erector muscles, sensory neurones, and fatty tissue

3 describe the maintenance of a constant internal body temperature in mammals in terms of:

(a) insulation

(b) the role of temperature receptors

(c) sweating
(d) shivering
(e) vasodilation
(f) vasoconstriction

4 describe the control of the glucose concentration of the blood by the liver, and the roles of insulin and glucagon from the pancreas

5 describe sugar diabetes (Type 1 and 2) in relation to:
(a) the causes, signs and symptoms
(b) effects
(c) preventive measures
(d) control and treatment

12.5 Drugs

1 describe a drug as any substance taken into the body that modifies or affects chemical reactions in the body

2 describe the medicinal use of drugs (antibiotics and painkillers)

3 state that antibiotics kill bacteria but do not affect viruses

4 describe the short term and long term effects of alcohol, tobacco, cannabis (dagga), cocaine, heroin, and the dangers of their misuse

5 discuss the effects of performance-enhancing drugs in sports

SECTION III THE DEVELOPMENT OF THE ORGANISM AND THE CONTINUITY OF LIFE

All learners should be able to:

13.0 Reproduction

13.1 Asexual reproduction

1 describe asexual reproduction as the process resulting in the production of genetically identical offspring from one parent

2 describe asexual reproduction in:
- (a) bacteria
- (b) fungi (spore production)
- (c) potatoes (tuber formation)
- (d) sugar cane

3 discuss the advantages and disadvantages of asexual reproduction to the species

13.2 Sexual reproduction

1 describe sexual reproduction as a process involving the fusion of the nuclei of two gametes (one male and one female) to form a zygote and the production of offspring that are genetically different from each other

2 describe fertilisation as the fusion of the nuclei of gametes

3 state that nuclei of gametes are haploid and that the nucleus of a zygote is diploid

4 discuss the advantages and disadvantages of sexual reproduction to the species

13.2.1 Sexual reproduction in plants

1 identify in diagrams and images, and draw the parts of a dicotyledonous flower (e.g. hibiscus) and a monocotyledonous flower (e.g. grass):
sepals, petals, stamens, filaments, anthers, carpels, style, stigma, ovary and ovules

2 state the functions of parts of the dicotyledonous and monocotyledonous flowers

3 identify in diagrams and images, and describe the anthers and stigmas of a wind-pollinated flower

4 describe pollination as the transfer of pollen grains from the anther to the stigma

5 state that fertilisation occurs when a pollen nucleus fuses with a nucleus in an ovule

6 describe self-pollination as the transfer of pollen grains from the anther of a flower to the stigma of the same flower or a different flower on the same plant

7 describe cross-pollination as the transfer of pollen grains from the anther of a flower to the stigma of a flower on a different plant of the same species

8 discuss the potential effects of self-pollination and cross-pollination on a population, in terms of variation, capacity to respond to changes in the environment and reliance on pollinators

9 compare the structural adaptations of insect-pollinated and wind-pollinated flowers
10 describe:
(a) the growth of the pollen tube and its entry into the ovule followed by fertilisation
(b) the formation of seed and fruit
11 identify in diagrams and images the parts of a non-endospermic seed
12 state the functions of parts a non-endospermic seed
13 describe dispersal as a means of moving fruits or seeds away from the parent plant
14 describe the structural adaptations of seeds/fruit for wind, animal and explosive dispersal
15 investigate and describe the environmental conditions affecting germination limited to the requirement for: suitable temperature, oxygen and water
16 describe the role of enzymes in seed germination

13.2.2 Sexual reproduction in humans

1 identify on diagrams and state the functions of the following parts of the human male reproductive systems: testes, scrotum, sperm ducts, prostate gland, seminal vesicle, urethra and penis
2 identify on diagrams and state the functions of the following parts of the female reproductive system: ovaries, oviducts, uterus, cervix and vagina
explain the adaptive features of sperm, limited to: flagellum, mitochondria and enzymes in the acrosome
3 explain the adaptive features of egg cells, limited to: energy stores and the jelly coat that changes at fertilisation
4 describe the differences between the sperm and ovum in terms of: size, structure, motility and numbers
5 describe the roles of testosterone and oestrogen (sex hormones) in the development and regulation of secondary sexual characteristics at puberty
6 describe the menstrual cycle in terms of the physical changes in the ovaries and in the lining of the uterus
7 describe the sites of production of oestrogen and progesterone in the menstrual cycle and in pregnancy
8 explain the role of hormones in controlling the menstrual cycle and pregnancy, limited to FSH (follicle stimulating hormone), LH (luteinising hormone) progesterone and oestrogen
9 describe fertilisation as the fusion of the nuclei from a male gamete (sperm) and a female gamete (egg cell)
10 state that in early development, the zygote forms an embryo which is a ball of cells that implants into the lining of the uterus

11	describe the development of the foetus in terms of: the placenta, maternal and foetal blood supplies and exchange of materials, amniotic sac and amniotic fluid
12	identify on diagrams and state the functions of the following in the development of the fetus: umbilical cord, placenta, amniotic sac and amniotic fluid
13	describe the function of the placenta and umbilical cord in relation to the exchange of dissolved nutrients, gases and excretory products between the blood of the mother and the blood of the fetus
14	describe antenatal care in terms of dietary requirements (calcium, iron, folic acid, carbohydrates and proteins) and maintaining good health in relation to alcohol intake and smoking
15	describe the main stages of birth (labour, delivery and after birth)
16	describe the advantages and disadvantages of breast-feeding compared with bottle-feeding
13.3 Methods of birth control	
1	name and describe the following methods of birth control: (a) natural (abstinence, rhythm, withdrawal) (b) chemical (spermicides, contraceptive pills, injectables, hormonal implant) (c) mechanical (intrauterine device, condom and femidom) (d) surgical (vasectomy and tubal ligation)
2	discuss: (a) the social aspects of artificial insemination (gamete donation and surrogacy) (b) the use of hormones in fertility drugs
13.4 HIV and sexually transmissible infections (STIs)	
1	state the causative agent for gonorrhoea
2	describe the symptoms, signs, effects and treatment of gonorrhoea
3	state the causative agent for Acquired Immuno Deficiency Syndrome (AIDS) as Human Immunodeficiency Virus (HIV)
4	describe the methods of transmission of HIV, and the ways in which it can be prevented from spreading, such as early testing for everyone, use of condoms, anti-retroviral drugs.
5	outline how HIV affects the immune system
6	discuss the control and treatment of HIV/AIDS such as male circumcision and prevention of mother to child transmission (PMTCT)

14.0 Inheritance

14.1 Chromosomes

1 state that chromosome are made of DNA, which contains genetic information in the form of genes
2 define a gene as a section of DNA, which codes for the formation of a protein, controlling a specific characteristic of the organism
3 define an allele as an alternative form of a gene
4 describe a haploid nucleus as one containing a single set of unpaired chromosomes e.g. in sperm and ovum
5 describe a diploid nucleus as one containing pairs of chromosomes e.g. in somatic (body) cells
6 state that in a diploid cell, there is a pair of each type of chromosome and in a human diploid cell there are 23 pairs
7 describe the structure of DNA with reference to double strand, nucleotides and pairing of the bases (A with T and C with G)

14.2 Mitosis

1 describe mitosis simply, in terms of the exact duplication of chromosomes resulting in identical daughter nuclei (details of stages are **not** required)

14.3 Meiosis

1 describe the production of gametes by meiosis simply, in terms of halving of chromosome number leading to variation (details of stages are **not** required)

14.4 Monohybrid inheritance

1 describe inheritance as the transmission of genetic information from generation to generation, leading to continuity of, and variation within, the species
2 describe genotype as the genetic make-up of an organism
3 describe phenotype as the characteristics visible in an organism controlled by the genotype and the environment
4 describe homozygous as having a pair of identical alleles of a particular gene
5 describe heterozygous as having a pair of dissimilar alleles of a particular gene
6 describe a dominant allele as an allele that always shows in the phenotype if it is present in the genotype
7 describe a recessive allele as an allele that only has an effect on the phenotype when there is no dominant allele of the gene present in the genotype
8 interpret pedigree diagrams for the inheritance of a given characteristic
9 use genetic diagrams to predict the results of monohybrid crosses and calculate phenotypic ratios, limited to 1:1 and 3:1 ratios
10 use Punnett squares in crosses which result in more than one genotype to work out and show the possible different genotypes

11	explain how to use a test cross to identify an unknown genotype
12	describe the inheritance of sex in humans with reference to X and Y chromosomes
13	describe codominance as a situation in which both alleles in heterozygous organisms contribute to the phenotype
14	explain the inheritance of ABO blood groups: phenotypes are A, B, AB and O blood groups and alleles are I^A, I^B and I^o
15	describe a sex linked characteristic as a feature in which the gene responsible is located on a sex chromosome and that this makes it more common in one sex than in the other
16	describe red-green colour blindness and haemophilia as examples of sex linkage
17	use genetic diagrams to predict the results of monohybrid crosses involving codominance or sex linkage and calculate phenotypic ratios, limited to 1:1, 3:1 and 1:2:1
15.0	**Variation and Selection**
15.1	**Variation**
1	define variation as observable differences within a species
2	describe continuous and discontinuous variation as influenced by the environment and genes, illustrated by examples such as height, body mass and blood groups in humans; seed shape and colour in peas
3	describe mutation as a spontaneous change in a gene or a chromosome using albinism and Down's syndrome as examples
4	state that mutation is the way in which new alleles are formed leading to variation within species
5	state that ionising radiation and some chemicals increase the rate of mutation
6	state that mutation, meiosis, random mating and random fertilisation are sources of genetic variation in population
7	describe cancer in relation to the causes, preventive measures and treatment using cervical and prostate cancer as examples
8	describe sickle cell anaemia, and explain its incidence in relation to that of malaria
9	describe how variation and competition leads to differential survival of, and reproduction by, those organisms best fitted to the environment
15.2	**Selection**
1	describe the role of artificial selection in relation to the production of varieties of animals and plants with increased economic importance
2	describe natural selection with reference to: (a) genetic variation within populations (b) production of many offspring

(c) struggle for survival, including competition for resources
(d) a greater chance of reproduction by individuals that are better adapted to the environment than others
(e) these individuals pass on their alleles to the next generation

3 describe adaptation as the process, resulting from natural selection, by which populations become more suited to their environment over many generations

4 describe the development of strains of antibiotic resistant bacteria such as Multiple Drug Resistant (MDR) tuberculosis as an example of evolution by natural selection

5 describe the importance of completing the full course of antibiotics medication

6 describe selective breeding with reference to:
(a) selection by humans of individuals with desirable features
(b) crossing these individuals to produce the next generation
(c) selection of offspring showing the desirable features

7 outline how selective breeding by artificial selection is carried out over many generations to improve crop plants and domesticated animals and apply this to given contexts

8 compare natural and artificial selection

16.0 Biotechnology and Genetic modification

16.1 Biotechnology

1 describe biotechnology

2 describe the role of enzymes and their uses in biological washing products and in the food industry with reference to the extraction of fruit juices

3 describe the use of microorganisms and fermenters to manufacture enzymes for use in biological washing powders

4 investigate and describe the use of biological washing powders that contain enzymes

5 describe how fermenters can be used for the large-scale production of useful products by bacteria and fungi, including insulin and penicillin

6 describe and explain the conditions that need to be controlled in a fermenter, including: temperature, pH, oxygen, nutrient supply and waste products

7 describe the use of microorganisms in the food industry, with reference to yoghurt, bread and brewing

16.2 Genetic Modification
1 describe genetic modification as changing the genetic material of an organism by removing, changing or inserting individual genes
2 outline the process of genetic modification using bacterial production of a human protein as an example, limited to: (a) isolation of the DNA making up a human gene using restriction enzymes, forming sticky ends (b) cutting of bacterial plasmid DNA with the same restriction enzymes, forming complementary sticky ends (c) insertion of human DNA into bacterial plasmid DNA using DNA ligase to form a recombinant plasmid (d) insertion of recombinant plasmids into bacteria (specific details are not required) (e) multiplication of bacteria containing recombinant plasmids (f) expression in bacteria of the human gene to make the human protein
3 explain why bacteria are used in genetic modification limited to: (a) their rapid reproduction rate and their ability to make complex molecules (b) few ethical concerns over their manipulation and growth (c) the presence of plasmids
4 discuss potential advantages and disadvantages of genetic engineering with reference to genetically modified organisms (GMOs)

SECTION IV BIODIVERSITY AND ECOSYSTEMS	
All learners should be able to:	
17.0 Biodiversity	
1	describe biodiversity as the number of different species that live in an area
2	discuss the importance of biodiversity such as medicinal purposes and ecological roles
3	discuss threats to biodiversity (habitat change, alien invasive species, unsustainable resource extraction, wild fires, climate change and soil erosion).
18. 0 Ecosystems	
18.1 Energy flow	
1	state that the Sun is the principal source of energy input to biological systems
2	describe the flow of energy through living organisms, including light energy from the Sun and chemical energy in organisms, and its eventual transfer to the environment
18.2 Food chains and food webs	
1	describe a food chain as showing the transfer of energy from one organism to the next, beginning with a producer
2	construct and interpret simple food chains
3	describe a food web as a network of interconnected food chains and interpret food webs
4	describe a producer as an organism that makes its own organic nutrients, usually using energy from sunlight, through photosynthesis
5	describe a consumer as an organism that gets its energy by feeding on other organisms
6	state that consumers may be classed as primary, secondary, tertiary and quaternary according to their position in a food chain
7	describe a herbivore as an animal that gets its energy by eating plants
8	describe a carnivore as an animal that gets its energy by eating other animals
9	describe a decomposer as an organism that gets its energy by breaking down dead or waste organic material
10	use food chains and food webs to describe the impact humans have through overharvesting of food species and through introducing foreign species to a habitat
11	draw, describe and interpret pyramids of numbers, pyramids of biomass and pyramids of energy
12	discuss the advantages of using a pyramid of biomass rather than a pyramid of numbers to represent a food chain
13	describe a habitat as the place where an organism lives, feeds and breeds
14	describe an environment as all conditions in the surroundings of an organism that may affect it
15	describe an ecosystem as a community of interdependent organisms and their environment

16 describe a trophic level as the position of an organism in a food chain, food web or ecological pyramid

17 identify the following as the trophic levels in food webs, food chains and ecological pyramids: producers, primary consumers, secondary consumers, tertiary consumers and quaternary consumers

18 discuss the advantages of using a pyramid of energy rather than pyramids of numbers or biomass to represent a food chain

19 explain why the transfer of energy from one trophic level to another is often not efficient

20 explain, in terms of energy loss, why food chains usually have fewer than five trophic levels
explain why it is more energy efficient for humans to eat crop plants than to eat livestock that have been fed on crop plants

18.3 Nutrient cycles

1 describe the carbon cycle, limited to:
photosynthesis, respiration, feeding, decomposition, formation of fossil fuels and combustion

2 discuss the effects of the combustion of fossil fuels and deforestation on the balance between oxygen and carbon dioxide and the implications on global warming

3 describe the nitrogen cycle with reference to: decomposition of plant and animal protein to ammonium ions, nitrification, nitrogen fixation by lightning and bacteria, absorption of nitrate ions by plants, production of amino acids and proteins, feeding and digestion of proteins, deamination and denitrification

4 state the roles of microorganisms in the nitrogen cycle, limited to: decomposition, nitrification, nitrogen fixation and denitrification (generic names of individual bacteria, e.g. Rhizobium, are not required)

19.0 Pollution

1 describe pollution as a build-up of substances such as chemicals, which damage the environment, due to human activities

2 describe the effects of:
(a) water pollution by untreated sewage and excess fertiliser
(b) air pollution by sulfur dioxide and oxides of nitrogen
(c) pollution due to pesticides and herbicides
(d) nuclear fall-out

3 discuss the causes and apparent effects on the environment of acid rain, and the measures that might be taken to reduce its incidence

4 explain the process of eutrophication of water, limited to:
(a) increased availability of nitrate and other ions
(b) increased growth of producers
(c) increased decomposition after death of producers

(d) increased aerobic respiration by decomposers
(e) reduction in dissolved oxygen
(f) death of organisms requiring dissolved oxygen in water

20.0 Conservation

1 describe a sustainable resource as one which is produced as rapidly as it is removed from the environment so that it does not run out
2 explain the need to conserve non-renewable resources, limited to fossil fuels
3 explain why organisms become endangered or extinct, including: climate change, habitat destruction, hunting, overharvesting, pollution and introduced species
4 describe how endangered species can be conserved, limited to:
(a) monitoring and protecting species and habitats
(b) education
(c) captive breeding programmes
(d) seed banks
5 explain how forests can be conserved using: education, protected areas, quotas and replanting
6 explain how fish stocks can be conserved using: education, closed seasons, protected areas controlled net types and mesh size, quotas and monitoring
7 describe the reasons for conservation programmes, limited to:
(a) maintaining or increasing biodiversity
(b) reducing extinction
(c) protecting vulnerable ecosystems
(d) maintaining ecosystem functions, limited to nutrient cycling and resource provision,
(e) including food, drugs, fuel and genes
8 describe the use of artificial insemination (AI) and in vitro fertilisation (IVF) in captive breeding programmes
9 explain the risks to a species if its population size decreases, reducing genetic variation (knowledge of genetic drift is not required)
10 state that products can be re-used, reduced, or recycled, limited to plastic

GRADE DESCRIPTIONS

The scheme of assessment is intended to encourage positive achievement by all candidates. Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The grade awarded will depend on the extent to which the candidate has met the assessment objectives overall and may conceal weakness in one aspect of the examination that is balanced by above-average performance on some other.

Grade A	Candidate must show mastery of the curriculum
	A candidate should be able to: • relate facts to principles and theories and vice versa; • state why particular techniques are preferred for a procedure or operation; • select and collate information from a number of sources and present it in a clear logical form; • solve problems in situations which may involve a wide range of variables; • process data from a number of sources to identify any patterns or trends; • generate a hypothesis to explain facts, or find facts to support an hypothesis.
Grade C	Candidate must show a high level of competence in the curriculum.
	A candidate should be able to: • link facts to situations not specified in the syllabus; • describe the correct procedure(s) for a multi-stage operation; • select a range of information from a given source and present it in a clear logical form; • identify patterns or trends in given information; • solve problems involving more than one step, but with a limited range of variables; • generate a hypothesis to explain a given set of facts or data.
Grade G	Candidate must show competence in the curriculum.
	A candidate should be able to: • recall facts contained in the syllabus • indicate the correct procedure for a single operation • select and present a single piece of information from a given source • solve a problem involving one step, or more than one step if structured help is given • identify a pattern or trend where only a minor manipulation of data is needed • recognise which of two given hypotheses explains a set of facts or data

APPENDIX 1: ASSESSMENT CRITERIA FOR PRACTICALS

Practical Assessment

Scientific subjects are, by their nature, experimental. It is, accordingly, important that an assessment of a learner's knowledge and understanding of Biology should contain a component relating to practical work and experimental skills (as identified by Assessment Objective C). In order to accommodate, within EGCSE, differing circumstances - such as the availability of resources - two alternative means of assessing Assessment Objective C are provided, namely, a formal practical test and a written alternative to practical paper, as outlined in the scheme of assessment.

The Practical Test and Alternative to Practical:

- require the same experimental skills to be developed and learned
- require an understanding of the same experimental contexts
- test the same assessment objective, AOC.

Candidates are expected to be familiar with and may be asked questions on the following experimental contexts:

- simple quantitative experiments, including the measurement of:
  - volumes of gases and liquids
  - masses
  - temperatures
  - times
  - lengths
- diffusion
- osmosis
- food tests
- rates of enzyme-catalysed reactions, including judging end-points, e.g. colour changes
- pH and the use of hydrogencarbonate indicator, litmus and universal indicator
- photosynthesis (rate and limiting factors)
- transpiration
- heart rate and breathing rate
- respiration
- tropic responses
- observation and dissection of seeds and flowers
- germination
- continuous and discontinuous variation
- use methods of sampling that are representative and avoid bias, e.g. consideration of sample size and simple random sampling
- observe, record and measure images of familiar and unfamiliar biological specimens
- make clear line drawings of biological specimens, calculating the magnification or actual size and adding labels as required
- collect quantitative or qualitative data
- use simple apparatus in situations where the method may not be familiar to the candidate.

Candidates may be required to do the following:

1. **demonstrate knowledge of how to select and safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate):**
   1 identify apparatus from diagrams or descriptions
   2 draw, complete or label diagrams of apparatus and biological specimens
   3 use, or explain the use of, common techniques, apparatus and materials
   4 select the most appropriate apparatus or method for the task and justify the choice made
   5 describe food tests
   6 describe how the pH of a solution or substance can be tested
   7 describe and explain hazards and safety precautions
   8 describe and explain techniques used to ensure the accuracy of observations and data
2. **plan experiments and investigations:**
   1 identify the independent variable and dependent variable
   2 describe how and explain why variables should be kept constant
   3 suggest an appropriate number and range of values for the independent variable
   4 suggest the most appropriate apparatus or technique and justify the choice made
   5 describe experimental procedures, including a suitable control experiment
   6 identify risks and suggest safety precautions
   7 describe how to record the results of an experiment
   8 describe how to process the results of an experiment to form a conclusion or to evaluate a prediction
   9 make reasoned predictions of expected results
3. **make and record observations, measurements and estimates:**
   1 take readings from apparatus (analogue and digital) or from diagrams of apparatus with appropriate precision
   2 take sufficient observations or measurements, including repeats and replicates where appropriate
   3 record qualitative observations from food and other tests
   4 record observations and measurements systematically, for example in a suitable table, to an appropriate degree of precision and using appropriate units
4. **interpret and evaluate experimental observations and data:**
   1 process data, including for use in further calculations or for graph plotting, using a calculator as appropriate present data graphically
   2 analyse and interpret observations and data, including data presented graphically
   3 use interpolation and extrapolation graphically to determine a gradient or intercept
   4 form conclusions justified by reference to observations and data and with appropriate explanation
   5 evaluate the quality of observations and data, identifying any anomalous results and taking appropriate action
5. **evaluate methods and suggest possible improvements:**
   1 evaluate experimental arrangements, methods and techniques, including the use of a control
   2 identify sources of error
   3 suggest possible improvements to the apparatus, experimental arrangements, methods and techniques
   4 suggest modifications to the procedure to improve validity and reliability of experiments.

Apparatus, materials and reagents

These lists give items candidates should be familiar with using, whether they are taking the Practical Test or the Alternative to Practical Test.

These items should be available for use in the Practical Test. These lists are not exhaustive and we may also require other items to be sourced for specific exams. The Confidential Instructions we send before the Practical Test will give the detailed requirements for the exam.

Every effort is made to limit the resources required by centres and so minimise the costs. Experiments will be designed around basic apparatus and materials which should be available in most school laboratories or are easily obtainable.

Hazard codes are used where relevant and in accordance with information provided by CLEAPSS (www.cleapss.org.uk). Candidates should be familiar with the meanings of these codes and terms but will **not** be assessed on them.

C	corrosive	**MH**	moderate hazard
HH	health hazard	**T**	acutely toxic
F	flammable	**O**	oxidising
N	hazardous to the aquatic environment		

The attention of centres is drawn to any national regulations relating to safety, first aid and disposal of chemicals. ‘Hazard Data Sheets’ should be available from your chemical supplier.

Candidates must be provided with appropriate safety equipment, such as suitable eye protection and gloves, during practical work.

The Confidential Instructions will indicate which hazard symbols are applicable for the materials required for each Practical Test exam.

List of chemicals, reagents and indicators

The list below is not intended to be comprehensive but shows the types of chemicals, reagents and indicators that candidates should be familiar with.

- **[MH] [N]** Benedict’s solution – suitable for reducing sugar test
- **[C] [MH]** biuret reagent or potassium hydroxide and copper sulfate solution - suitable for biuret test for proteins
- **[F] [MH] [HH]** ethanol – suitable for emulsion test for lipids
- **[N]** iodine in potassium iodide solution (iodine solution) – suitable for starch test
- DCPIP (2,6-dichlorophenol-indophenol)
- albumin
- ascorbic acid (vitamin C)
- carbohydrates (starch, glucose, sucrose (Analar, AR))
- lipids
- dilute acid e.g hydrochloric acid

- dilute alkali e.g **[C]** sodium hydroxide, **[C] [MH]** potassium hydroxide
- distilled or deionised water
- **[HH]** enzymes (e.g. amylase, protease, lipase)
- plant sources of catalase, e.g. sweet potatoes, celery, potatoes
- **[MH]** hydrogen peroxide solution
- yeast, dried
- indicators (universal indicator solution with chart, universal indicator paper with chart, hydrogencarbonate indicator, litmus solution red and blue litmus paper)
- **[MH]** limewater
- **[HH]** methylene blue dye
- petroleum jelly (Vaseline® or similar)
- sodium chloride
- sodium hydrogencarbonate (sodium bicarbonate)
- technical agar

List of apparatus

Other materials may be required for examinations.

- balance to measure up to 500 g, with precision of at least 0.1 g
- beakers (various sizes, 100 cm^3, 250 cm^3 and 400 cm^3)
- bungs to fit standard test-tubes and large test-tubes
- bungs with delivery tubes to fit standard test-tubes and large test-tubes
- Bunsen burners
- clamp (retort) stands and bosses
- clear plastic tubing to fit syringe nozzle
- capillary tubing
- cork borers
- filter funnels
- filter paper
- forceps (blunt)
- hand lenses (at least ×6 magnification)
- heat-proof mats (bench mats)
- lamps for photosynthesis experiments
- means of cutting biological materials (e.g. scalpels, single-edged razor blade or sharp knives)
- means of writing on glassware (e.g. wax pencils or water-resistant markers)
- measuring cylinders (e.g. 10, 25 and 100 cm^3)
- mortars and pestles
- mounted needles or seekers or long pins with large heads
- paper towels
- partially permeable membrane (e.g. Visking or dialysis tubing, 14 mm width with a pore diameter of approximately 2.5 nm)
- Pasteur or dropping pipette
- Petri dishes, plastic or glass, 9 cm diameter
- rulers, graduated in mm, ideally clear plastic
- scalpel
- scissors
- spatulas
- spotting tiles (dimple tiles) with at least 12 wells

- stop-clocks or stop-watch, reading to 1 s or better or timer showing seconds
- syringes (various sizes, 1 cm^3, 2 cm^3 or 3 cm^3, 5 cm^3, 10 cm^3)
- stirring (glass) rods
- suitable eye protection
- test-tubes – standard (125 mm × 15 mm) including some that are heat resistant
- test-tubes – large (150 mm × 25 mm) including some that are heat resistant
- test-tube racks and test-tube holders
- thermometers, –10°C to +110°C, with 1°C graduations
- tripods and gauzes
- water-resistant marker pens (for labelling glassware)
- wash bottles
- white paper or white card
- white tiles or other suitable cutting surfaces

APPENDIX 2: TERMINOLOGY, UNITS, SYMBOLS AND NOMENCLANTURE

Candidates are expected to be familiar with the nomenclature used in the syllabus. The syllabus and question papers conform with accepted international practice.

Decimal markers
In accordance with current international practic, decimal markers in examination papers will be a single dot on the line. Candidates are expected to follow this convention in their answers.

Numbers
Numbers from 1000 to 9999 will be printed without commas or spaces. Numbers greater than or equal to 10 000 will be printed without commas. A space will be left between each group of three digits, e.g. 4 256 789.

Variables
Independent variables are the variables that are changed in a scientific experiment by the scientist. Changing an independent variable may cause a change in the dependent variable.
Dependent variables are the variables that are observed or measured in a scientific experiment. Dependent variables may change based on changes made to the independent variables.

Units
To avoid any confusion concerning the symbol for litre, the equivalent quantity, the cubic decimetre (dm^3) will be used in place of *l* or litre.
In practical work, candidates will be expected to use SI units or, where appropriate, units approved for use with the SI (e.g. minute). Units will be indicated in the singular not in the plural, e.g., 28 kg.

(a) Units commonly used in Biology are listed below.
N.B. Care should be taken in the use of *mass* and *weight.*
In most biological contexts, the term mass is correct, e.g., dry mass, biomass.

Quantity	*Name of unit*	*Symbol for unit*
length	kilometre	km
	metre	m
	centimetre	cm
	millimetre	mm
	micrometre	µm
mass	tonne (1000 kg)	(no symbol)
	kilogram	kg
	gram	g
	milligram	mg
	microgram	µg
temperature	degree celsius	ºC
time	year	Y
	day	D
	hour	H
	minute	min
	second	s
amount of substance	mole	mol

(b) Derived units are listed below.

energy	kilojoule joule (calorie is obsolete)	kJ J

(c) Recommended units for area, volume and density are listed below.

area	hectare = 104 m^2 square metre	ha m^2
	square decimetre square centimetre square millimetre	dm^2 cm^2 mm^2
volume	cubic kilometre	km^3
	cubic metre cubic decimetre (preferred to litre)	m^3 dm^3
	cubic centimetre	cm^3 (not ml)
	cubic millimetre	mm^3
density	kilogram per cubic metre	kg / m^3
	gram per cubic centimetre	g / cm^3

APPENDIX 3: MATHEMATICAL REQUIREMENTS

Calculators may be used in all parts of the Assessment.

Candidates should be able to:

Number

1. add, subtract, multiply and divide;
2. understand and use decimals, fractions, ratios and reciprocals;
3. calculate and use averages, percentage and percentage change
4. express answers to an appropriate or given number of significant figures
5. express answers to an appropriate or given number of decimal places
6. round answers appropriately
7. recognise and use standard notation;
8. use direct and inverse proportion;
9. use positive, whole number indices;
10. draw charts and graphs from given data;
11. interpret charts and graphs;
12. select suitable scales and axes for graphs;
13. make approximate evaluations of numerical expressions;
14. recognise and use the relationship between length, surface area and volume and their units
15. use usual mathematical instruments e.g. ruler, compasses, protractor;
16. understand the meaning of radius, diameter, square, rectangle.

Algebra

17. recognise and use direct and inverse proportion;
18. solve simple algebraic equations for any one term when the other terms are known
19. substitute physical quantities into a formula

Geometry and measurements

20. convert between units, including cm3 and dm3, mg, g and kg, μm, mm, cm and m
21. understand the meaning of angle, curve, circle, radius, diameter, circumference, square, rectangle and diagonal
22. recall and use equations for the area of a rectangle, the area of a triangle and the area of a circle

23. recall and use equations for the volume of a rectangular block and the volume of a cylinder
24. use a ruler, compasses, protractor
25. make estimates of numbers, quantities and lengths
26. understand surface area and use surface area : volume ratio
27. use scale diagrams
28. select and use the most appropriate units for recording data and the results of calculations

Graphs, charts and statistics

29. draw charts and graphs from data
30. interpret line graphs, bar charts, pie charts and histograms with equal intervals
31. interpolate and extrapolate from data
32. determine the gradient and intercept of a graph, including units where appropriate
33. select suitable scales and axes for graphs
34. recognise direct and inverse proportionality from a graph
35. calculate the mean and range of a set of values
36. use simple probability

APPENDIX 4: PRESENTATION OF DATA

Taking and recording readings

1. Data should be recorded so as to reflect the precision of the measuring instrument, i.e. the smallest difference that can reliably be detected on the measuring instrument scale should be reflected by the number of decimal places given in the measurement.
2. A measurement or calculated quantity must be accompanied by a correct unit, where appropriate.
3. Each column of a table should be headed with the observation or physical quantity and the unit where appropriate, e.g. time / s. The solidus (/) is to be used for separating the quantity and the unit in tables, graphs and charts.
4. Units should not be included with data in the body of a table.
5. Data should be recorded to the appropriate number of significant figures.

Graphs

6. The column headings of a correctly headed table can be directly transferred to the axes of a constructed graph.
7. A graph should be drawn with a sharp pencil.
8. Each axis should be labelled with the observation or physical quantity and the unit where appropriate, e.g. time / s.
9. Unless instructed otherwise, the independent variable should be plotted on the *x*-axis (horizontal axis) and the dependent variable plotted on the *y*-axis (vertical axis).
10. Unless instructed otherwise, the scales for the axes should allow more than half of the graph grid to be used in both directions, and be based on sensible ratios, e.g. 2 cm on the graph grid representing 1, 2 or 5 units of the variable. The axes do not have to include (0, 0).
11. Points on the graph should be clearly marked as crosses (×) or encircled dots (⊙) of appropriate size.
12. Each data point should be plotted to an accuracy of one half of one of the smallest squares on the grid.
13. A best-fit line (trend line) should be a single, thin, smooth straight line or curve. The line does not need to coincide exactly with any of the points; where there is scatter evident in the data, examiners would expect a roughly even distribution of points either side of the line over its entire length. Points that are clearly anomalous should be ignored when drawing the best-fit line.
14. A best-fit line or curve should only be drawn if there is good reason to believe that the intermediate values can be predicted.
15. Candidates should be able to take readings from the graph by extrapolation or interpolation and indicate on the graph how they determined the reading.
16. Data values should be read from a graph to an accuracy of one half of the smallest square on the grid.

Drawings

17. Drawings should be drawn using a sharp pencil to give fine lines that are clear and unbroken.
18. Drawings should use most of the available space and show all the features observed in the specimen, with no shading or use of colour.
19. Label lines should be drawn with a ruler and touch the object or feature labelled.

Charts

20. Pie charts are generally used to show percentage or proportionality.
21. Bar charts should be drawn for categorical or discrete data. They should be made up of bars of equal width that do not touch.
22. Histograms should be drawn for continuous data. They should have bars that touch.

APPENDIX 5: GLOSSARY OF TERMS

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 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.

In all questions, the number of marks allocated is shown on the examination paper, and should be used as a guide by candidates to how much detail to give or time to spend in answering. In describing a process, the mark allocation should guide the candidate about how many steps to include. In explaining why something happens, it guides the candidate on how many reasons to give, or how much detail to give for each reason.

CALCULATE	Used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.
COMPARE	identify/comment on similarities and/or differences
DEDUCE	Used in a similar way to “Predict” except that some supporting statement is required (e.g., reference to a law, principle, or the necessary reasoning is to be included in the answer).
DEFINE	(the term(s) ...) is intended literally, only a formal statement or equivalent paraphrase being required.
DESCRIBE	Requires the candidate 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. In other contexts, describe should be interpreted more generally (i.e., the candidate has greater discretion about the nature and the organisation of the material to be included in the answer). “Describe and explain” may be coupled, as may “State and explain”.
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 (e.g., resistance, the formula of an ionic compound).
ESTIMATE	Implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
EXPLAIN	May imply reasoning or some reference to theory, depending on the context.
EVALUATE	judge or calculate the quality, importance, amount, or value of something
FIND	Is a general term that may variously be interpreted as “Calculate”, “Measure”, “Determine”, etc.

GIVE	produce an answer from a given source or recall/memory
IDENTIFY	name/select/recognise
INVESTIGATE	Investigate in the syllabus implies that the learners will have planned the experiment themselves before carrying it out, and as a result will be able to use hypotheses to make predictions and so explain the experimental plan, as well as the issues included above.
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.
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).
NAME	to state or simply specify a word(s) of a known specific feature
OUTLINE	Implies brevity (i.e., restricting the answer to giving essentials).
PERFORM	Perform an experiment in the syllabus implies that the learners will gain great benefit from carrying out such an experiment themselves, and as a result will be able to recall and explain the procedures and the associated science knowledge and understanding, demonstrate how to handle and interpret data from the experiment, and draw conclusions.
PLAN	A detailed step by step procedure followed to test a hypothesis or to arrive at a conclusion
PREDICT	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 in an earlier part of the question. Predict also implies a concise answer with no supporting statement required.
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). In diagrams, sketch implies that simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.
STATE	Implies a concise answer with little or no supporting argument (e.g., a numerical answer that can readily be obtained 'by inspection').
SUGGEST	Used in two main contexts (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').

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