Biology

Upper Secondary

Syllabus

Papua New Guinea
Department of Education

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Contents

Secretary's message

This Biology syllabus is to be used by teachers of Biology to teach Upper Secondary students (Grades 11 and 12) throughout Papua New Guinea. This syllabus builds upon science concepts, skills and attitudes learnt in Lower Secondary and provides a sound foundation for further learning.

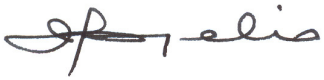
The Upper Secondary Biology Syllabus conforms to the National Education Plan's vision, which is that secondary education enables students to achieve their individual potential to lead productive lives as members of the local, national and international community. It provides opportunities for students to deepen their understanding of advanced biological knowledge. Students are prepared to deal with biological, moral and ethical issues brought about through local, national and international developments and changes.

Teachers of Biology play a pivotal role by being innovative, creative and keeping abreast of new information based on scientific research and technological changes. The challenge for teachers of Biology is to engage student learning in realistic contexts for increased and better understanding. Engaging in such learning helps students appreciate that humans are part of nature and continue to have a greater influence on the environment than any other species.

Through learning Biology, students identify patterns in nature and understand that all living organisms carry out similar processes to form the structures that make up their bodies. They also consider the impact of human activities, both on the organisms and ecosystems that constitute the biosphere and on individual human beings and human society in Papua New Guinea and the world. Applying an understanding of Biology helps students to appreciate culture, ethics, economics, power relationships and other factors that influence the pursuit of science and have significant impacts on the way people live. The study of Biology enables students to make informed decisions about modifying and interacting with nature.

This syllabus incorporates fundamental biology units that provide the foundation for higher learning in fields such as medicine and health, agriculture and the environment, and prepares students continuing on to further education at tertiary level and other professional courses. Besides providing students with the conceptual background in biology needed to meet the challenges of academic and professional courses, the syllabus also equips them to appreciate and apply basic biology knowledge in their lives and communities.

I commend and approve this syllabus as the official curriculum for Biology to be used in all schools with Grades 11 and 12 students throughout Papua New Guinea.



DR JOSEPH PAGELIO

Secretary for Education

Introduction

Biology is based on the curriculum principles from the National Curriculum Statement. It has been designed using learning outcomes that identify the knowledge, skills, attitudes and values that all students achieve or demonstrate by the end of Grade 12. It links to the national curriculum learning area Science and builds on the knowledge and skills students have learnt in Grades 9 and 10.

Through content knowledge, skills and values and building on students' prior learning, Biology offers a number of pathways to post-secondary study and the workforce. It has specialised and general applications in both areas.

Lower Secondary Science Strands	Lower Secondary Science Units	Upper Secondary Biology Grade 11 units	Upper Secondary Biology Grade 12 units
Life and Living Nature of Science Matter and Energy Earth and Space	Ecology Our Body Microbiology	Living Things Nutrition Transport Systems Respiration and Gas Exchange Response to Stimuli Reproduction	Ecology Population Genetics Evolution
Note: Strands 1, 3 and 4 have some relevance to Biology with regard to the nature of the units, interdependence and maintenance of natural processes			

Papua New Guinea harbours more than five per cent of the world's biodiversity within some of the world's most biologically diverse and rich ecosystems. These ecosystems are heavily depended upon by many ordinary people for basic needs. The rich resources of these ecosystems are threatened by an increasing trend in ecosystem destruction, caused by extractive activities and overuse of natural resources. The study of Biology reinforces students' understanding of variations amongst learners and their respect for diversity and helps them to appreciate that complex biological phenomena are also built on essentially simple processes.

Students and teachers of Biology have to be aware that all living things are protected and must not be harmed unnecessarily (as in dissection procedures). As well as the need to protect animals, students and teachers protect themselves from disease and while handling animals and microscopic organisms.

Biology is a specialised subject that requires a high level of cognitive competency. Having a high level of numeracy competency and a basic level of language skills would help students to learn and understand biological processes better.

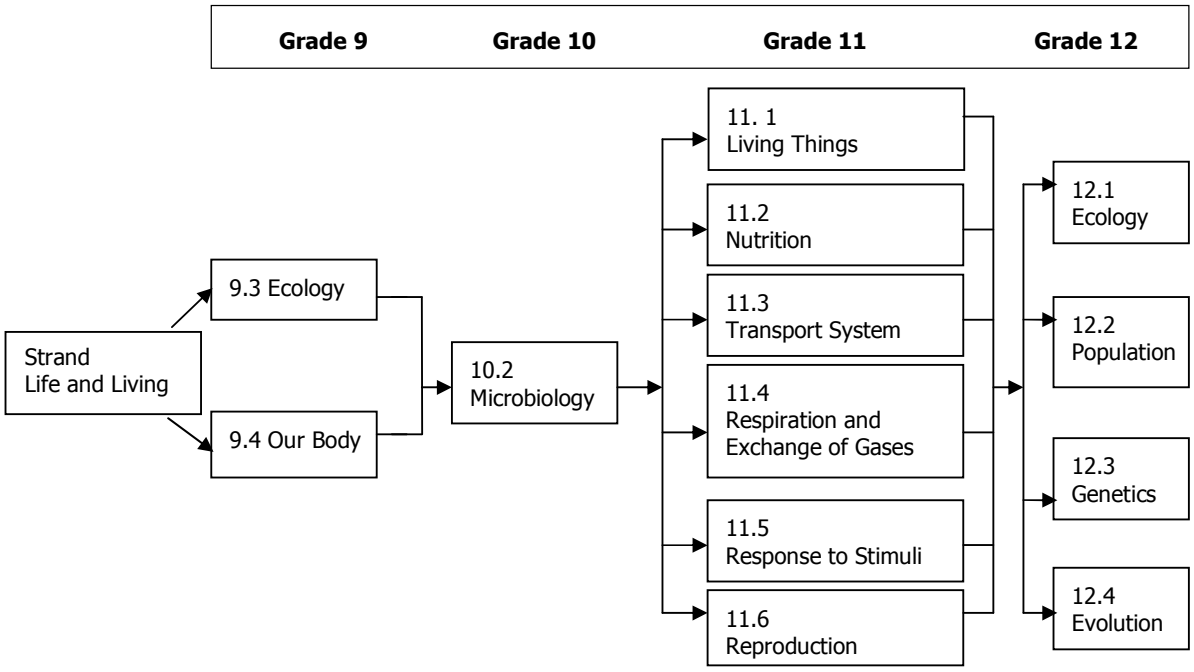
Assessment is an important component of teaching for learning and is integrated into the learning and teaching activities of Biology. Continuous assessment in Biology provides feedback to students and the teacher on students' progress towards achievement of the learning outcomes. It helps students improve their standards of achievement by knowing what they need to do well and where they need to improve. In Biology, teachers gather

evidence from students' work during the course of the term and use those continuous assessments to improve their teaching and students' learning.

The teaching program should also include formal summative assessment of learning to gauge students' level of achievement.

Biology is to be timetabled for 240–250 minutes per week in Grade 11 and Grade 12.

Overview of the study of Biology from Lower Secondary to Upper Secondary



Rationale

The technical assistance of qualified biologists, environmental managers and forestry and agricultural specialists is essential for sustainable management of our environment and resources, including biodiversity. Students' skills in problem solving, critical thinking, and working cooperatively in small groups are enhanced in the study of Biology. These skills enable students to explore various solutions to environmental and related problems.

Students also develop values and attributes such as flexibility, curiosity, critical reflection and respect for evidence, which help them to consider the issues and implications of having respect for the environment, both living and non-living. They can also recognise and understand the strengths and limitations of biological techniques and technologies in the field of science.

Humans are part of nature and continue to have a greater influence on the environment than any other species. By studying Biology, Papua New Guineans become scientifically literate and demonstrate a sound understanding of biological life processes, natural systems, interactions and balances, genetics and evolution.

The study of genetics and evolution is the basis for understanding some of earth's environmental, medical and agricultural problems and exploring ways of solving these. This knowledge helps students to recognise their responsibility to conserve, protect, maintain, and improve the quality of their environments for future generations.

Studying emerging biological knowledge and its relevance to individuals and societies encourages rational and specific attitudes to issues related to population, environment and development, and provides students with a foundation for sustainable living in their community, further education and the workforce. Students are able to make informed decisions to care for and protect their environment.

Through exploring the basic chemical constituents of living bodies, students understand the connections of biology to real-life problems, such as the use of biological discoveries or innovations in everyday life in the environment, nature, medicine and health and agriculture.

Students understand, through scientific investigations, the underlying principles that are common to animals and plants, as well as highlighting the relationships between biology and other areas of knowledge.

Aims

The study of Biology enables students to:

- think scientifically and apply biological knowledge and skills to make decisions about real problems and challenges in the context of their daily lives
- gain an appreciation of and respect for the natural world, its diversity, fragility and finite nature, especially when harvesting from the environment
- reflect on the underpinning biological principles and knowledge of living organisms and to be able to construct new knowledge for themselves through research and research-based information
- develop an understanding of the effects of human activities on living organisms, including the systems of the human body, for healthy living and maintaining healthy environment
- develop values and attributes that help them to consider issues and implications associated with biological techniques and technologies.

Strands

The study of Biology is described in the strand:

- 'Life and living'.

The 'Life and living' strand is about the diversity of living things and their interactions with each other and with the physical world. It considers the functions of various parts of living things and compares these in different ecosystems.

This strand considers the way in which living things adapt to environments and change. It examines ecological habitats, roles of plants in ecosystems, life processes, and social and biological issues surrounding the survival of species. The study of the interdependence of living things includes consideration of the relationship of organisms within ecosystems. It also explores the effects of human activity on these systems.

This strand provides students with an understanding of the interdependence of different life forms and the need to conserve the balance of nature.

Learning outcomes

The Biology learning outcomes identify the knowledge, skills, attitudes and values all students achieve or demonstrate at the end of Grade 12. The learning outcomes for Biology are listed below. Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions
7. analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions
8. demonstrate an understanding of traditional biological knowledge and practices and its relevance today

Note: While all ideas and concepts in Biology are linked, the table below indicates the connections that should be highlighted most.

Learning outcomes mapped against units

Learning outcomes	Unit									
	11.1	11.2	11.3	11.4	11.5	11.6	12.1	12.2	12.3	12.4
1. Demonstrate an understanding of fundamental principles and models of biology	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Demonstrate an understanding of plant and animal physiology	✓	✓	✓	✓	✓	✓	✓		✓	✓
3. Demonstrate an understanding of interactions between organisms and their environment	✓	✓		✓	✓	✓	✓	✓	✓	✓
4. Analyse and interpret data, graphics and other forms of information	✓	✓	✓	✓		✓	✓	✓	✓	✓
5. Undertake investigations using scientific methodologies to solve biological problems	✓	✓	✓		✓	✓	✓	✓		
6. Communicate biological investigation and findings in various ways using biological terms and conventions	✓	✓	✓		✓	✓	✓	✓		
7. Analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions			✓			✓	✓	✓	✓	✓
8. Demonstrate an understanding of traditional biological knowledge and practices and its relevance today	✓					✓	✓	✓	✓	✓

Unit sequence and structure

Grade 11 units	Grade 12 units
11.1 Living Things *5–6 weeks* • Living cells • Linnean system of classification **11.2 Nutrition** *8–10 weeks* • Autotrophic nutrition • Heterotrophic nutrition **11.3 Transport Systems** *6–8 weeks* • Transport systems in plants • Transport systems in animals **11.4 Respiration and Gas Exchange** *4–6 weeks* • Gas exchange surfaces • Respiration **11.5 Response to Stimuli** *6–8 weeks* • Tropism in plants • Nervous system • Endocrine system **11.6 Reproduction** *6–8 weeks* • Reproduction and fertilisation • Secondary sexual characteristics • Family planning methods • Sexually transmitted infections	**12.1 Ecology** *8–10 weeks* • Biomes and habitats • Interactions • Human impacts on the environment **12.2 Population** *4–6 weeks* • Population sampling • Human population growth **12.3 Genetics** *8–10 weeks* • Inheritance • Genes and chromosomes • Variations • Biotechnological techniques **12.4 Evolution** *6–8 weeks* • Theories of evolution • Evidence of evolution • Mechanisms of evolution

Grade 11 units

11.1 Living Things

5–6 weeks

Context

Did you know that there are millions of plant and animal species in the world? And did you know that Papua New Guinea has about 20 000 species of vascular plants, over 200 species of mammals and 750 species of birds? How are scientists able to organise such vast numbers of species into an orderly manner? What kind of system do they use? Would you know if there are some forms or methods of grouping or naming organisms in your local area? If you don't, would you like to find out?

Knowledge

In this unit, students discover the vast number of plant and animal species, realising the need for a common classification system. Students use investigative procedures to find out traditional classification systems, leading to the Linnean classification system where every living thing has a double name in Latin ('binomial nomenclature'). Students learn that under this system organisms are divided into groups, the largest being the 'kingdom'.

Students have prior knowledge about cells from Grade 8, strand 2 'Living things', sub-strand 'Nature of living things', and experience in using microscopes. Combining this knowledge and experience, students prepare wet mounts to manipulate the microscope to view differences between plant and animal cells.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions
8. demonstrate an understanding of traditional biological knowledge and practices and its relevance today.

To achieve these outcomes, students:

- compare and contrast traditional biological classification and Linnean classification systems

- design and conduct investigations on cell structure and functions
- manipulate microscopes to observe cells.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Living cells

- parts of a compound microscope
- structure and functions of cell organelles such as:
  - mitochondria, nucleus, endoplasmic reticulum, ribosomes, golgi body, vacuole, cell membrane, nuclear membrane, cell wall, chloroplast, nucleolus
- types of animal cells such as nerve, muscle, skin, brain, reproductive cells, blood
- experiments to investigate living cells

Linnean system of classification

- researching traditional biological classification systems
- binomial nomenclature and the Linnean system of classification
- using set criteria to classify given organisms into categories (kingdom, phyla, class, order, family, genus, species)
- the five kingdoms: monera, protista, fungi, animals and plants
- simple use of dichotomous keys for identification of unknown organisms

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- appreciation of and respect for traditional knowledge and the great diversity of organisms

Process skills

- manipulation of microscopes
- observation and classification of organisms
- calculation of cell magnification

General skills

- communication of results

Laboratory and practical work

1. Collect plant and animal specimens and identify them.
2. Construct simple dichotomous keys and use these to identify unknown organisms.
3. Prepare a wet mount and observe different types of plant and animal cells such as onion cells and cheek cells.

11.2 Nutrition

8–10 weeks

Context

Have you ever wondered about how plants manufacture food? Or which plant structure makes food by photosynthesis? Do you know if animals benefit from these products made by plants? Or, what do the digestive systems of herbivores and carnivores look like?

Knowledge

Students have prior knowledge about how plants and animals feed through the Upper Primary sub-strand, 'Nature of living things'. This extends briefly into the Lower Secondary strand, 'Life and living'. The unit provides students with an understanding of autotrophic and heterotrophic nutrition through investigating how plants and animals feed. In other laboratory work, students explore factors that determine rates of chemical reactions, such as photosynthesis and respiration.

The unit begins with experimenting in photosynthesis through different factors such as light, carbon dioxide, chlorophyll and oxygen in autotrophic nutrition. This extends into leaf adaptations and physiology. Students also take an investigative approach when studying heterotrophic nutrition through food and enzyme tests and looking at digestive systems. This further leads to the study of the liver, pancreas and kidneys and their functions. The students use drawings and illustrations to show these organs.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions.

To achieve these outcomes, students:

- investigate and explain leaf physiology and factors enhancing photosynthesis
- describe and explain the structure and function of the human digestive system and its associated organs.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Autotrophic nutrition

Leaf physiology

- leaf arrangement on plants for maximum light absorption
- leaf adaptations for photosynthesis

Process and products of photosynthesis

- the process or stages of photosynthesis
- experiments to test for photosynthesis: light, carbon dioxide, chlorophyll and oxygen
- balanced word and chemical equations for photosynthesis
- use and storage of photosynthetic products such as oxygen and glucose in respiration

Rate of photosynthesis

- factors that affect the rate of photosynthesis
- experiments to identify limiting factors that inhibit photosynthesis
- the role of stomata

Heterotrophic nutrition

Food test

- chemical composition of certain foods (experiments)

Digestion

- digestive systems of different animals: herbivore, carnivore, human
- functions of mouth, stomach, ileum, pancreas and colon in digestion
- investigations of the rate of enzymic reaction and predictions on its effect in chemical digestion; metabolism (catabolism and anabolism)
- assimilation of amino acids, fatty acids and glycerol, and glucose

The liver

- function of the liver in:
  - regulation of blood sugar level
  - production of bile
  - storage of vitamins
  - deamination
  - detoxication
- diseases of the liver

The kidney

- the function of the kidney in ultra filtration, water balance, osmoregulation, homeostasis and selective reabsorption

- the common parts of a kidney (medulla, cortex and pelvis)
- diseases of the kidneys

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- promoting a healthy lifestyle through proper diet
- appreciation of the role of plants in food and oxygen production

Process skills

- experimenting with and measuring rates of transpiration, enzymic reactions and photosynthesis
- investigating the nutritional value of food samples

Laboratory work

1. Carry out experiments to demonstrate if chlorophyll, light and carbon dioxide are necessary for photosynthesis.
2. Simple test to find out if oxygen is produced during photosynthesis.
3. Food test for starch, sugar, protein, fats.
4. Determine chemical composition of certain foods.
5. Investigate the rate of enzymic reactions and make predictions on its effect in chemical digestion.

11.3 Transport Systems

6–8 weeks

Context

Have you ever wondered how food, water and oxygen get circulated in an animal? Or what medium is responsible for carrying these? Do you sometimes wonder about how water absorbed in plant roots gets to the shoots? Or how food produced in a plant's leaves are taken to other parts of the plant?

Knowledge

In this unit, students explore the various ways in which blood, oxygen and dissolved materials are distributed in animals. It further enhances students' understanding of the movement of food and water in plants. The unit also enables students to identify lifestyle diseases related to the human circulatory system and the measures taken to prevent these.

The unit begins by exploring transport systems in plants by investigating food, water and salt uptake through the xylem and phloem vessels. It further explores the circulatory and lymphatic systems, their functions and structures and the effect of their malfunctions, through experiments and investigations.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
4. analyse and interpret data, graphics and other forms of information
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions
7. analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions.

To achieve the learning outcomes, students:

- investigate and explain the structure and functions of transport systems in larger organisms
- research and present findings on causes and prevention of heart and blood-related diseases
- compare statistics on past and current heart-related problems and make inferences to human lifestyles
- carry out experiments on transport in vascular bundles
- investigate the rate of water uptake in different conditions

- explore the differences in water loss from a range of leaf surfaces
- observe blood circulation in live tadpoles
- dissect a small live mammal or cane toad to observe the functioning heart.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Transport systems in plants

Vascular bundle

- functions of transport systems in terms of food and water
- structure and function of phloem and xylem vessels in plants:
  - phloem cells include companion cells, sieve plates, sieve tubes
  - xylem includes tracheid, lignified cells, xylem vessels

Uptake of water and salts

- processes of osmosis, diffusion and transpiration (simple experiments)

Transport systems in animals

Circulatory system

- function and structure of blood cells: red and white cells, platelets and plasma
- structure of blood vessels: arteries, veins and capillaries
- action of valves in pulmonary and systematic circulation
- relationship between capillaries, cells and lymphatics
- blood groups and transfusion

Lymphatic system

- the human lymphatic system: lymph, lymph nodes, spleen, thymus
- constituents of the lymph
- causes of swollen lymphatic glands

Diseases of the heart and circulatory system

- causes of malfunctions such as clotting and blocking of vessels; for example, heart attack, leukaemia, hypertension, stroke, haemophilia
- comparison of statistics on past and current heart-related problems and inferences to human lifestyles

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- promoting healthy lifestyles through proper diets
- being sceptical and inquisitive about foods and related diseases

Process skills

- prediction and experimenting in relation to process of osmosis
- measurement of pulse rates
- manipulation of microscopes and observation of blood flow in tadpoles
- investigation and research on diseases related to transport systems

Laboratory work

1. Carry out experiments to demonstrate water uptake through xylem vessels.
2. Measure pulses and calculate average heart rate.
3. Observing flow of blood in tadpole tails.
4. Dissect and observe mammalian heart.

11.4 Respiration and Gas Exchange

4–6 weeks

Context

Do you ever stop to think about where your energy comes from? Or where plants and animals get their energy from? Do frogs breathe in the same way as mammals do? Or do earthworms and insects have lungs to breathe like birds? Of course, all organisms respire and exchange gases for survival. However, do they all do this in the same way?

Knowledge

In this unit students learn about the different types of respiration and what is involved in each type. It builds on the Lower Secondary unit, 'Our Body', and particularly focuses on the gas exchange surfaces. The unit also enables students to understand the characteristics of gas exchange surfaces and how these factors influence exchange of gases.

The unit begins with an exploration of gas exchange surfaces, using cubes of various sizes as models of organisms, to investigate the surface area to volume ratio. Students compute numbers of stomata on leaves to determine the gas exchange surface. Students also investigate various factors influencing respiration.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse, interpret data, graphics and other forms of information.

To achieve the learning outcomes, students:

- describe specialised gas exchange surfaces in various organisms
- investigate and explain cellular respirations
- use cubes as models of organisms and investigate the surface area to volume ratio of increasingly large cubes
- observe organs of gas exchange in amoeba, earthworm, insect, fish and mammal
- make a simple computation of the numbers of stomata for a field of view (or per millimetre—optional) on the upper and lower epidermis
- study the graph of daily concentration of carbon dioxide in plants and explain the changes in carbon dioxide concentration.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Gas exchange surfaces

- definition of surface area to volume ratio
- characteristics of gas exchange surfaces:
  - large surface area to volume ratio
  - thin
  - moist
  - near a transport system
- using labelled diagrams to discuss gas exchange surfaces in:
  - amoeba
  - earthworm
  - insect
  - fish
  - amphibian
  - mammal
  - plants (roots, bark, leaves)
- the need for specialised gas exchange organs in larger organisms, using surface area to volume ratio

Respiration

- aerobic and anaerobic respiration
- balanced word and symbol equations for aerobic and anaerobic respiration
- respiration in the mitochondria of all cells: energy transfer with ATP
- respiration and photosynthesis in green plants, in:
  - dim light
  - darkness
  - bright light
- experiments on anaerobic respiration in yeast (fermentation), carbon dioxide from germinating seeds, and use of oxygen during respiration (aerobic)

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- developing self-awareness on the importance of respiratory system

Process skills

- measuring surface area to volume ratio using model cubes
- hypothesising and investigating aerobic and anaerobic respirations

Laboratory and practical work

1. Observe smeared leaf surface to estimate numbers of stomata on the upper and lower epidermis.
2. Carry out experiments using different-sized cubes to explain how the surface area to volume ratio affects the rate of movement of substances into and out of cells.
3. Observe earthworms to identify characteristics of gas exchange surfaces.
4. Devise experiments on aerobic and anaerobic respiration.

11.5 Response to Stimuli

6–8 weeks

Context

Sensitivity is one of the characteristics of all living organisms. The effects of sensitivity are easy to observe in animals; but what about plants? How do they respond to stimuli? If they do respond, does the whole plant respond or certain parts only? Or how about the time when you touched a very hot pot and very quickly removed your hands? What causes you to respond so quickly? These are just a few examples of sensitivity in action in animals.

Knowledge

Students begin by investigating and discussing plant tropisms and the external factors that cause them. Plant hormones and how they influence plant tropisms are considered. Sensitivity in animals is studied under coordination, which looks at the way all organs and systems of the body are made to work efficiently together. The unit looks at the components and functions of the nervous system and the endocrine system, and how these systems work together to bring about coordination.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions.

To achieve the learning outcomes, students:

- investigate and describe the external factors that act as stimuli on plants
- develop an understanding of coordination and regulation in living organisms
- research and describe reproductive hormones and their functions: follicle stimulating hormone, luteinising hormone, oestrogen, progesterone, testosterone
- investigate and explain voluntary and involuntary reflexes.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Tropism in plants

- plant hormones (IAA, auxins) and their functions
- phototropism, geotropism and hydrotropism
- other types of tropism such as thigmotropism

Nervous system

- central and peripheral nervous systems:
  - receptors and effectors
- types of nerve cells:
  - motor
  - sensory
  - multipolar neurons
- structure of nerve cells
- voluntary and involuntary reflexes:
  - knee jerk
  - blinking

Endocrine system

Endocrine systems and their functions

- position of endocrine glands in human body
- components of endocrine system
  (1) ductless (endocrine) glands:
  - pituitary glands:
    follicle stimulating hormone (FSH), luteinising hormone (LH) and their functions
    other hormones such as ADH, growth hormones, TSH and their functions
  - thyroid glands: thyroxine
  - pancreas: insulin; glucagon
  - adrenal: adrenalin
  - ovaries: oestrogen; progesterone
  - testis: testosterone

Differences between endocrine and nervous systems

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- develop awareness of the importance of plant tropism
- appreciation of and respect for the nervous and endocrine systems

Process skills

- measurement of growth in root or shoot coleoptiles
- hypothesising about and investigation of plant tropisms
- observation and interpretation of reflex actions such as the knee jerk

Laboratory work

1. Experiments to investigate responses of plants to light, gravity and water stimuli in the environment.
2. Set up controlled experiments to investigate the effect of:
   - thyroxin on the metamorphosis of tadpoles
   - gibberellic acid on the growth of dwarf plants.
3. Conduct simple experiments to show that stimuli are received by receptors and that responses are made by effectors.

11.6 Reproduction

6–8 weeks

Context

Have you ever stopped to think about sexual and asexual reproduction in both plants and animals? In the continuation of life, which method would have more advantages for a group of organisms and why? How do different organisms, apart from humans, multiply? What are the new developments related to 'test-tube babies' or multiple births? Is it better to have smaller families or large ones? Do you think a possible cure is near for HIV and AIDS? How could we eliminate or reduce this problem?

Knowledge

Students have been introduced to patterns of reproduction in living things and reproductive structures. In this unit, students extend their knowledge into reproductive processes like fertilisation, implantations and embryonic developments. Students explore and present all family planning methods and review the main sexually transmitted diseases.

Beginning with sexual and asexual reproduction in plants and animals, students learn to recognise male and female reproductive structures, preferably from a small dissected mammal. Functions of related structures lead students to additional information on sex hormones, pregnancy and embryonic development. Students study data collection and presentation on sexually transmitted diseases through tables and graphs from local health centres. Special consideration is given to HIV and AIDS research, prevention and methods of transmission.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions
7. analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions
8. demonstrate an understanding of traditional biological knowledge and practices and its relevance today.

To achieve the learning outcomes, students:

- describe and explain the differences between asexual and sexual reproduction in organisms
- investigate and explain the development and functions of the reproductive system and its related diseases
- research statistical data and do presentation on STIs and HIV and AIDS.
- compare and contrast causes, symptoms, transmission and prevention of STIs (sexually transmitted infections)
- demonstrate knowledge of disorders of the reproductive systems
- use pictures, posters and models to discuss the human reproductive system, conception, internal and external fertilisation
- identify a plant or animal and investigate its method of reproduction.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Reproduction and fertilisation

Asexual and sexual reproduction in plants and animals

- asexual (vegetative propagation) reproduction:
  - cell division: mitosis
- sexual reproduction:
  - formation and fusion of gametes (conception)
  - cell division: meiosis

Fertilisation

- fertilisation (implantation, multiple births, in-vitro fertilisation)
- embryonic development (stages of pregnancy)

Secondary sexual characteristics

- sex hormones in the menstrual cycle:
  - interpreting graphs of levels of hormones in a menstrual cycle

Family planning methods

- traditional family planning or contraceptive methods
- natural family planning or contraceptive methods:
  - abstinence
  - withdrawal
  - ovulation
- artificial family planning or contraceptive methods:
  - sterilisation (tubal ligation and vasectomy)
  - contraceptive pill
  - condoms (male and female)
  - IUD (inter-uterine device)

- cervical cap

Sexually transmitted infections

- the causes, symptoms, transmission and prevention of STIs such as gonorrhoea, syphilis, HIV and AIDS, donovaniasis, chlamydia, genital herpes
- the causes, symptoms, transmission and prevention of HIV and AIDS
- disorders of the reproductive system:
  - male (impotence, prostate cancer, undescended testes, infertility)
  - female (infertility, breast cancer, cervical and ovarian cancer)

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- having appreciation and knowledge of the reproductive system
- having respect for the body
- being open-minded about sexual education

Process skills

- research and presentation of statistical information on sexually transmitted infections

Laboratory activities

1. Examine root tips for evidence of cell division: mitosis.
2. Carry out flower dissection of a dicotyledon plant.

Grade 12 units

12.1 Ecology

8–10 weeks

Context

Do you know that Papua New Guinea's ecosystems are some of the most diverse in the world? That Papua New Guinea's ecosystems range from coral reefs to high montane grasslands? Did you know that Papua New Guinea's forests are ranked third in the world?

Knowledge

This unit enables students to describe the different biomes and habitats of the world through research and case studies on terrestrial and aquatic environments. It further enhances students' understanding of the interrelationships that exist in a natural environment, through in-depth discussion of food chains, food webs and natural cycles. Students have the opportunity to design and undertake investigations, using scientific methodologies, to identify and solve environmental problems.

Students first identify the different biomes of the world and factors influencing the availability of plant and animal life and how these are adapted to survive in these conditions. They then discuss the interrelationships between plants and animals through feeding relationships and nutrient cycles.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions
7. analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions
8. demonstrate an understanding of traditional biological knowledge and practices and its relevance today.

To achieve the learning outcomes, students:

- state and describe common abiotic and biotic factors of major biomes

- explain and analyse the relationships between environmental factors, adaptations and distribution of living things
- evaluate human impacts on natural environment and analyse procedures for minimising and managing these impacts
- investigate various local classification systems in nature and compare these to the Linnean system
- compare and contrast traditional environmental management practices with current practices
- research and present findings on:
  - management practices in fisheries and forestry
  - carbon trade
  - sustainable practices in relation to development.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Biomes and habitats

- definitions of ‘species’, ‘population’, ‘community’, ‘habitat’ and ‘niche’
- polar, temperate and tropical climatic regions of the biosphere
- major types of biomes: tundra, desert, forests, wetlands and grasslands
- factors influencing plant and animal life:
  - climate (rainfall, temperature and relative humidity)
  - soil (composition, water retention and drainage, pH, mineral content and decomposition)
  - topography (the effects of altitude, inclines and contours)

Terrestrial environments

- tundra, desert, tropical rainforest and grassland:
  - biotic and abiotic factors
  - types of adaptations (behavioural, morphological and physiological)

Aquatic environments

- freshwater, marine, estuaries, mangroves and wet lands:
  - biotic and abiotic factors
  - types of adaptations (behavioural, morphological and physiological):adaptations of organisms in terms of buoyancy, gas exchange, osmoregulation, reproduction, streamlining, locomotion

Interactions

Feeding relationships

- defining food chains and food webs: examples from various biomes
- trophic levels: energy source, energy flow and transformation along a food chain
- the effect of biomagnification and eutrophication on a food chain

- pyramid of biomass, numbers and energy for any community

Natural cycles

- carbon, nitrogen, oxygen and water cycles
- examples of natural and artificial succession in the local area

Human impacts on the environment

Environmental issues

- environmental issues that have impacts on the environment, such as mining, logging, monocultural farming, overfishing, use of plastics, chemical wastes (such as from mines)

Sustainable management

- traditional environmental management practices
- current environmental practices
- biological management practices in fisheries and forestry:
  - carbon trade
  - sustainable management practices in relation to development

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- respecting the environment, caring about environment and nature issues
- appreciating and conserving traditional environmental knowledge

Process skills

- investigation and observation of soil test results
- research of biomes, habitat factors, management practices
- manipulation of weather instruments

Laboratory work

1. Investigate soil composition, water retention and drainage, pH and porosity of a range of soil types.
2. Observe and record the effects of osmosis on cells using visking or dialysis tubing.

Field trip or excursion such as

1. Observe and investigate aquatic or terrestrial environments in the school area; for example, pond, freshwater or seawater, mangrove, wildlife park, forested area, grassland.
2. Visit old gardens, forested areas, mangrove or any habitat types to observe feeding relationships.
3. Excursion to a logged, mined or destroyed area to identify damage caused and its impacts on the environment.

12.2 Population

4–6 weeks

Context

Imagine carrying out a census for plants and animals! If that were possible, how could you count all the grasses in your school playing field? Or how about getting ants to stand still for a moment so you can take a head count? Or further still, would you go among the fierce hungry sharks to count them? Having some kind of indication of the total population of organisms can help us to better manage their environments.

Knowledge

Students are already aware of the huge number of organisms and the problems associated with counting them. In this unit students can investigate different sampling methods and decide on the best one for any organism of study. The effects of various birth, death, immigration and emigration rates on population, as well as factors that limit population growth, are looked at. This leads to considering human population and the relationship between world population growth and the decrease in the Earth's resources. Students become more aware of problems associated with population increase and better able to make informed decisions later in life; for example, when planning what number of children to have.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
5. undertake investigations using scientific methodologies to solve biological problems
6. communicate biological investigation and findings in various ways using biological terms and conventions
7. analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions
8. demonstrate an understanding of traditional biological knowledge and practices and its relevance today.

To achieve these learning outcomes, students:

- investigate and describe environmental factors affecting population growth and distribution
- interpret, analyse and make predictions using population graphs
- use sampling methods to estimate population distribution

- interpret prey–predator graphs that show slight population fluctuations, with the stability of populations being maintained by normal regulatory processes
- debate for and against the use of birth control methods in Papua New Guinea
- choose a sampling method to estimate population of an organism in the local area
- use Papua New Guinean population data from the last 10 years to construct graphs and make predictions on current population trends
- research and present findings on the impacts of human population on species endangerment and make recommendations to address these issues.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Population sampling

- use sampling methods listed below to estimate population within a given area (aquatic or terrestrial):
  - quadrant frame
  - capture–recapture technique for sampling animal population
  - line of transect
- pyramid of biomass for any community
- effects of birth, death, immigration and emigration rates on population of organisms
- prey–predator graph showing population fluctuations
- factors that limit population growth (limiting factors) such as food availability, predators, natural disasters and diseases

Human population growth

- exponential growth of population for the last 20 years in Papua New Guinea
- reasons for population explosion:
  - high birth rate and low mortality rate
  - better medical facilities and treatment
  - improved diet and lifestyle
- relationship between world population growth rates and availability of resources with emphasis on Papua New Guinea and the Pacific region
- impact of increased population in terms of species endangerment

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- appreciation and awareness of impacts of overpopulation

- open-mindedness to sensitive population issues
- respect for and appreciation of opinions on populations

Process skills

- investigation
- sampling
- estimation
- interpretation of graphs

Practical work

1. Conduct experiments to estimate population of plants using the quadrant frame method.
2. Investigate the total estimated population of a selected species of animal using the capture–recapture method.
3. Construct a transect in the field and observe the biotic components along the transect and/or measure the abiotic factors.
4. Conduct an experiment to identify and classify hidden organisms amongst leaf litter.

12.3 Genetics

8–10 weeks

Context

Have you ever wondered why you look like your father and talk like your mother, or wondered why some people behave like their grandparents? Have you questioned why flowers are red, white, pink or yellow? Believe it or not, some tall parents have short children and vice versa.

Nowadays, highlanders talk about 'san kopi' and Tolais talk about 'didiman cacao'. How can you explain that to ordinary village people or even students? In the quest to meet the growing demands of humans as the population continues to grow, scientists have taken advantage of genetics to come up with improved varieties of plants and animals.

Knowledge

The study of genetics exposes students to some possible answers to such questions. At this level, students are, for the first time, learning genetics and inheritance. Students learn that the detailed information about themselves as individuals is contained in each nucleus of each and every body cell. Students can investigate and predict possible characteristics of known genotypes.

The unit begins with the study of how genetics came to being. The initial experiments done on plant characteristics are studied in detail and students learn the important terms in genetics. Different types of genetic crosses form the bulk of the unit to help students to understand genetics. Students study, in detail, the gene and chromosomes as the basis of genetic materials. Studying variation and biotechnological techniques helps students understand how scientists use genetics to modify both plants and animals.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
7. analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions
8. demonstrate an understanding of traditional biological knowledge and practices and its relevance today.

To achieve theses outcomes, students:

- identify and explain species variation and inheritance

- analyse and describe the evidence for molecular basis of heredity and patterns of inheritance
- plot graphs of height, weight, blood type, ear lobes, left or right-handedness
- describe the purpose of gene cloning, transgenesis and DNA
- demonstrate an understanding of profiling.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Inheritance

- definition and explanation of the terms:
  - inheritance
  - genotype
  - phenotype
  - gene
  - genome
  - allele
- Mendelian experiments:
  - monohybrid and dihybrid crosses
  - dominant and recessive genes
  - recessive test or back cross
  - homozygous, heterozygous genotypes
  - F_1 and F_2 phenotypic ratios
  - Mendel's phenotypic ratios
  - Mendel's law of segregation and independent assortment
  - incomplete dominance (ABO blood groups)and co-dominance

Genes and chromosomes

- the structure and role of chromosomes in organisms in relation to:
  - chromosome numbers (haploid and diploid)
  - chromosomes and genes
- process of DNA replication
- mechanisms for maintaining cell chromosome numbers during growth (mitosis) and reproduction (meiosis)
- structure and function of nucleic acid (DNA and RNA)
- protein synthesis:
  - the roles of proteins in cells
  - relating the DNA sequence of a gene to the amino acids sequence of a protein
  - the steps of transcription and translation in protein synthesis
  - interpreting diagrams of protein structure and synthesis

Variations

- differentiate between acquired and inherited characteristics in relation to continuous and discontinuous variations

Biotechnological techniques

- manipulation of DNA by molecular biology techniques
- tissue culturing techniques
- principles used in the use of restriction enzymes, DNA ligation and polymerase chain reaction

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- appreciation of continuity of life, new developments in the field of genetics, and variation among organisms

Process skills

- observation, classification, research and presentation
- construction of biological models (DNA)
- experimenting and data collection

Laboratory and practical work

1. Construct models of meiosis and mitosis using plasticine.
2. Conduct an experiment to measure continuous variation in a population; draw and interpret graphs of weight or height.
3. Measure and draw graphical representations of discontinuous variation such as blood type, ear lobes, tongue rolling.
4. Demonstrate, by means of models, that DNA is a double helix structure composed of nucleotide units.

12.4 Evolution

6–8 weeks

Context

Did you know that all organisms were believed to have evolved from pre-existing life forms? Or that all life forms had one common ancestor? Did you know that these beliefs formed the theory of evolution? Comparison of ancient fossil records shows that organisms have changed. Do you know what caused these changes?

Knowledge

Students entering Upper Secondary have prior knowledge about fossils from the Upper Primary strand, 'Earth and beyond'. This unit begins with the theory of evolution. Students compare several theories and sets of evidence supporting processes of evolution.

The study of Lamarck's and Darwin's theories enables students to make informed and comprehensive judgements about natural selection. Students enhance their knowledge about evidence of evolution and mechanisms of evolution, based on recent findings such as the evolution of the modern horse and Darwin's finches.

Learning outcomes

Students can:

1. demonstrate an understanding of fundamental principles and models of biology
2. demonstrate an understanding of plant and animal physiology
3. demonstrate an understanding of interactions between organisms and their environment
4. analyse and interpret data, graphics and other forms of information
7. analyse and evaluate past and present biology-related developments and their impacts on human beings and environment and be able to make informed and ethical decisions
8. demonstrate an understanding of traditional biological knowledge and practices and its relevance today.

To achieve these outcomes, students:

- define and explain evolution and its mechanisms
- analyse and evaluate theories and evidence of evolution
- describe different types of genes and chromosome mutation
- discuss and describe the acquisition of mutation through mutagens, somatic and inherited mutations
- investigate the causes of changes in the gene pool through microevolution and macroevolution.

Content

Students acquire knowledge and skills through the learning and teaching of this content.

Theories of evolution

- Darwin's theory of natural selection and Lamarck's theory
- modern developments of Darwin's theory

Evidence of evolution

- fossil evidence
- comparative anatomy (convergent and divergent)
- comparative embryology
- comparative biochemistry

Mechanisms of evolution

- evolutionary agents: non-random mating, mutation
- genetic drift
- gene flow
- natural selection
- geographical isolation
- hybridisation

Attitudes, values and skills

Specific skills and attitudes practised in and gained through this unit:

Attitudes and values

- being sceptical and questioning
- being open-minded
- appreciating traditional myths about how life began

Process skills

- investigation
- research and presentation

Laboratory and practical work

1. Investigate forelimbs of various vertebrates, such as frogs, birds, bats, and lizards, using specimens. Observe, analyse and compare structure of vertebrate forelimbs and fossils.
2. Construct a model of two different vertebrate forelimbs (use colours to identify similar bones in each limb) using Styrofoam, cardboard, modelling clay, paints, wire and glue.
3. Perform an investigation to model natural selection.
4. Collect, observe and analyse samples of fossilised rocks as a project or fieldwork.

Assessment components, weightings and tasks

The internal assessment mark for Biology is to be based on the Grade 11–12 syllabus only. Final assessment should be based on a range and balance of assessment instruments. One task may be used to assess several components. The components, weightings and tasks for Grade 11 and 12 units are detailed below.

Components, weightings and tasks for Grade 11

Component	Weighting	Tasks
Written tests	150	These may include multiple-choice items, short answers and extended responses, statistical interpretation, graphical skills, calculations. These can utilise contemporary or hypothetical situations
Practical tests on basic skills	100	Testing students' abilities, short practical techniques, scientific reports, models and assignments
Practical investigative skills	50	Practical work competency, conduct investigations, experiments, observing experiments, making inferences, presentation and communication
Marks	**300**	

Components, weightings and tasks for Grade 12

Component	Weighting	Tasks
Written tests	150	These may include multiple-choice items, short answers and extended responses, statistical interpretation, graphical skills, calculations. These can utilise contemporary or hypothetical situations
Practical tests on basic skills	100	Testing students' abilities, short practical techniques, scientific reports, models and assignments
Practical investigative skills	50	Practical work competency, conduct investigations, experiments, observing experiments, making inferences, presentation and communication
Marks	**300**	

Assessment, examinations and certification

The assessment and reporting practices described here are detailed further in the *National Assessment and Reporting Policy for Papua New Guinea* (2003) and in other support materials produced by the Department of Education.

Assessment

The main purpose of assessment is to improve student learning.

Assessment needs to be *for* learning as well as *of* learning. It is used to evaluate and improve learning and teaching, report achievement and provide feedback to students on their progress.

Assessment measures students' achievement of learning outcomes as described in the syllabus. It is the ongoing process of identifying, gathering and interpreting information about students' achievement of the learning outcomes.

Learning and teaching using an outcomes approach requires teachers to plan their teaching and assess learner performance in relation to outcomes, using criteria derived from those outcomes. Assessment involves focusing less on whether a learner has 'passed' or 'failed' and more on what outcomes a learner has achieved and in which areas further support is required.

Assessment in Biology

A student's achievement in Biology at the end of Grade 12 will be assessed against the learning outcomes. Assessment of student progress towards achieving these learning outcomes is cumulative throughout Grades 11 and 12.

It is important that teachers plan the learning and teaching sequence so that there is a balanced spread of assessment during the year. Some tasks, such as investigations or case studies, can be designed so that they are completed over a period of time rather than at the end of the unit. Other tasks can be done immediately the relevant section of the unit or topic has been covered.

Assessment for certification

A student's overall achievement in Biology will be both internally and externally assessed. The final mark awarded to each student will be a combination of the internal assessment mark provided by the school and the examination mark.

Internal assessment

Internal assessment provides a measure of a student's achievement based on a wider range of syllabus content and outcomes than may be covered by the external examination alone.

For Biology the internal assessment marks will provide a summation of each student's achievements in Grades 11 and 12. The assessment tasks used to determine the internal assessment mark must comply with the components, weightings and types of tasks specified in the tables on page 36. A variety of tasks gives students the opportunity to demonstrate all the learning outcomes in different ways to improve the validity and reliability of the assessment.

All schools must meet the requirements for internal assessment as specified in the Grade 12 *Assessment, Examination and Certification Handbook.*

External examination

The external examination provides a measure of student achievement of those aspects of the learning outcomes that can be reliably measured in an examination setting. Questions for the external examination in Biology will be developed using the outcomes, knowledge and skills in the syllabus.

Recording

All schools must meet the requirements for maintaining and submitting student records as specified in the Grade 12 *Assessment, Examination and Certification Handbook.*

Certification

Candidates will be awarded the national certificate only if they meet all requirements for internal and external assessment. Eligibility rules for the award of certificates are specified in the Grade 12 *Assessment, Examination and Certification Handbook.*