Republic of Namibia

MINISTRY OF EDUCATION, ARTS AND CULTURE

NAMIBIA SENIOR SECONDARY CERTIFICATE (NSSC)

BIOLOGY SYLLABUS

ADVANCED SUBSIDIARY LEVEL

SYLLABUS CODE: 8223

GRADE 12

FOR IMPLEMENTATION IN 2021
FOR FIRST EXAMINATION IN 2021

Ministry of Education, Arts and Culture
National Institute for Educational Development (NIED)
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Biology SyllabusAdvanced Subsidiary Level Grade 12

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1. INTRODUCTION

The Namibian Senior Secondary Certificate Advanced Subsidiary(NSSCAS) level syllabus is designed as a one-year course leading to examination after completion of the Namibia Senior Secondary Certificate Ordinary (NSSCO) level. The syllabus is designed to meet the requirements of the *National Curriculum for Basic Education*(NCBE) and has been approved by the National Examination, Assessment and Certification Board (NEACB).

The Namibia National Curriculum Guidelines, applicable at the stage of senior secondary education (Grades 10-12) and at equivalent stages of non-formal education, as a part of life-long learning, recognises the uniqueness of the learner and adheres to the philosophy of learner-centred education.

The Namibian National Curriculum Guidelines:

- recognise that learning involves developing values and attitudes as well as knowledge and skills;
- promote self-awareness and an understanding of the attitudes, values and beliefs of others in a multilingual and multicultural society;
- encourage respect for human rights and freedom of speech;
- provide insight and understanding of crucial global issues in a rapidly changing world which affect quality of life: the AIDS pandemic, global warming, environmental degradation, distribution of wealth, expanding and increasing conflicts, the technological explosion and increased connectivity;
- recognise that as information in its various forms becomes more accessible, learners need to develop higher cognitive skills of analysis, interpretation and evaluation to use information effectively;
- seek to challenge and to motivate learners to reach their full potential and to contribute positively to the environment, economy and society.

Thus the Namibia National Curriculum Guidelines should provide opportunities for developing essential skills across the various fields of study. Such skills cannot be developed in isolation and they may differ from context to context according to a field of study. The skills marked with an * are relevant to this syllabus.

The skills are:

- communication skills *
- numeracy skills *
- information skills *
- problem-solving skills *
- self-management and competitive skills *
- social and cooperative skills
- physical skills
- work and study skills *
- critical and creative thinking skills*

2. RATIONALE

This syllabus describes the intended learning and assessment for Biology in the NSSCAS phase. As a subject, Biology is within the natural science areas of learning in the curriculum, but has thematic links to other subjects across the curriculum.

The subject Biology places strong emphasis on the learners' understanding of the physical and environmental world around them at the local, regional and international levels.
It thus includes how societies use natural resources to satisfy their needs, and how the environment may be changed in ecologically sustainable ways. At this phase and in this subject area, the application of scientific knowledge and attitudes to health is of special relevance for the individual, the family, and society as a whole as well as the environment around us including the sustainability of our natural resources. Critical thinking, investigating phenomena, interpreting data, and applying knowledge to practical (experimental and investigative) skills and abilities are essential to understanding the value and limitations of natural scientific knowledge and methods, and their application to daily life. This requires advanced technology through the efficient and effective usage of equipment, materials and processes. Modern technology is required in order to assist our learners and society to solve problems through planning, design, realisation, and evaluation of activities and goals.

3. AIMS

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

Biology promotes the following aims in the curriculum to:

1. provide, through well designed in-depth studies of experimental and practical science, a worthwhile educational experience for all learners, 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:
    - become confident citizens in a technological world, to take or develop an informed interest in matters of scientific importance;
    - recognise the usefulness, and limitations, of scientific method and appreciate its applicability in other disciplines and in everyday life;
    - be suitably prepared for studies beyond the NSSCAS level in pure sciences, in applied sciences or in science-dependent vocational courses.

2. develop abilities and skills that
    - are relevant to the study and practice of Biology;
    - are useful in everyday life;
    - encourage efficient and safe practice;
    - encourage effective communication.

3. develop attitudes relevant to Biology such as
    - concern for accuracy and precision;
    - enquiry;
    - initiative;
    - integrity;
    - inventiveness;
    - objectivity.

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

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

4. ADDITIONAL INFORMATION

4.1 Guided learning hours

The NSSCAS level syllabuses are designed on the assumption that learners have about 180 guided learning hours per subject over the duration of one year, but this is for guidance only. The number of hours required to gain the qualification may vary according to local conditions and the learners' prior experience of the subject. The National Curriculum for Basic Education (NCBE) indicates that this subject will be taught for 9 periods of 40 minutes each per 7-day cycle.

4.2 Prior learning

It is recommended that learners who are beginning this course should have previously studied *Biology Ordinary* at Senior Secondary (NSS) level.

4.3 Progression

NSSCAS levels are general qualifications that enable learners to progress either directly to employment, or to proceed to further qualifications at Universities. Learners who are awarded grades *e to a* in NSSCAS are well prepared to enrol at leading universities (local, regional or abroad).

4.4 Grading and reporting

NSSCAS results are shown by one of the grades a, b, c, d or e indicating the standard achieved, grade a being the highest and grade e the lowest. 'Ungraded' indicates that the candidate has failed to reach the standard required for a pass at NSSCAS level.

4.5 Support materials and approved textbooks

NSSCAS syllabuses, question papers and examiner reports are sent to all schools. Assessment manuals in subjects, where applicable are sent to schools. Approved learning support materials are available on the Senior Secondary Textbook Catalogue for Schools. The Senior Secondary Textbook Catalogue is available on the institution's (NIED) website (http://www.nied.edu.na).

5. LEARNING CONTENT

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3.2 Nucleic acids and protein synthesis
3.2.1 Structure and replication of DNA
3.2.2 Protein synthesis

THEME 1: CLASSIFICATION OF LIVING ORGANISMS

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
1.1 Classification	• know how the hierarchical classification systems are used	• use and describe the binomial system of naming organisms • describe the use of a hierarchical classification system for living organisms • explain the concept of natural classification, based on homologous features and evolutionary relationships • construct dichotomous keys for the identification of locally occurring organisms • discuss the meaning of the term species, limited to the biological, morphological, ecological and behavioural concepts
1.2 Biodiversity	• know three levels of biodiversity, the importance of random sampling and assess their distribution and abundance of organisms in their locality	• define **ecosystem** and **niche** • explain that biodiversity can be assessed at differentlevels: - the number and range of different ecosystems and habitats - the number of species and their relative abundance - the genetic variation within each species • explain the importance of random sampling in determining the biodiversity of an area • use Simpson's Index of Diversity (D) to calculate the biodiversity of an area, and state the significance of different values of D (the formula for Simpson's Index of Diversity will be provided, as shown in the Mathematical requirements) (formula: $D = 1 - (\Sigma\frac{n}{N})^2$) • describe and usesuitable methods to assess the distribution and abundance of organisms in an area, limited to frame quadrats, line transects, belttransects and mark-release-recapture using the Lincoln index (as shown in the Mathematical requirements) • investigate the distribution and abundance of species in a local area,using the methods above/ suitable methods

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
1.3 Conservation	• realise the importance of maintaining biodiversity and know the actions required at local, national and global levels	• discuss the reasons for the need to maintain biodiversity • explain the importance of reducing the pollution of water ways with reference to bioaccumulation and eutrophication • outline the roles of zoos, botanic gardens, conserved areas (national parks and marine parks), 'frozen zoos' and seed banks, in the conservation of endangered species • explain why it may be necessary to limit the population of species, for example by culling or contraception, in order to reduce pressure of other species • explain, using examples, the importance of controlling alien species • describe how degraded habitats may be restored limited to local or regional examples • investigate the negative impact of rhino and elephant poaching on the tourism sector locally (Namibia) and regionally (South Africa and Botswana)

THEME 2: ORGANISATION AND MAINTENANCE OF THE ORGANISM		
TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
2.1 The microscope	• know and understand the principles of light and electron microscopy	• state and explain the principles of microscopy • explain and distinguish between resolution and magnification, with reference to light-and electron microscope • use an eyepiece graticule and stage micrometer scale to measure cells and be familiar with units (millimetre, micrometre and nanometre) • calculate actual sizes of specimens from drawings, photomicrographs and electron micrographs • calculate the linear magnifications of drawings, photomicrographs and electron micrographs
2.2 Cell structure	• know and understand the cellular nature of all living organisms and the difference between prokaryotic and eukaryotic cells and viruses	• identify and recognise the following parts of a eukaryotic cell and outline the functions of the: - cell surface membrane - nucleus, nuclear envelope and nucleolus - mitochondrion - ribosomes (80S in the cytoplasm and 70S in chloroplasts and mitochondria) - chloroplast - rough and smooth endoplasmic reticulum - Golgi body (Golgi apparatus or Golgi complex) - lysosomes - cell wall - centrioles - cilia - microvilli - plasmodesmata - large permanent vacuoles and - tonoplast

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.2 Cell structure (continued)	• know and understand the cellular nature of all living organisms and the difference between prokaryotic and eukaryotic cells and viruses (continued)	• describe and interpret the structure of plant and animal cells as seen with an electron microscope • draw and label low power plan diagrams of tissues and organs (including a transverse section of stems, roots and leaves) • compare the structure of a typical plant (palisade) and animal (liver) cells • make temporary slides (wet mounts) of plant and animal cells (for example: epidermal cells from a leaf or an onion, epithelial cells from the trachea of a sheep or human cheek cells) • make observations and drawings of cells as seen under a light microscope (including cells within transverse sections of stems,roots and leaves) • outline key structural features of typical prokaryotic cells as found in a typical bacterium (including: unicellular, 1–5μm diameter, peptidoglycan cell walls, naked circular DNA, 70S ribosomes, absence of double membrane-bound organelles) • compare and contrast the structure of prokaryotic cells with eukaryotic cells (no reference to mesosomes required) • state that ATP is produced in mitochondria and chloroplasts and outline its role in cells • state that all viruses are non-cellular and have a nucleic acid core (either DNA or RNA), a capsid made of protein, and some viruses have an outer envelope made of phospholipid

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.3 Cell membranes and transport		
2.3.1 Fluid mosaic membranes	• know and understand the structure and functions of cell surface membranes in relation to cell signalling	• describe the fluid mosaic model of membrane structure, including the components phospholipids, cholesterol, glycolipids, proteins and glycoproteins • outline the roles of the cell surface membrane • describe the roles in cell surface membranes of phospholipids, cholesterol, carrierproteins, channelproteins, cell surface receptors and cell surface antigens • outline the process of cell signalling involving the release of chemicals that combine with cell surface receptors on target cells, leading to specific responses
2.3.2 Movement of substances into and out of cells	• understand how substances enter and exit cells by a variety of mechanisms	• describe and explain the processes of diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis (no calculations involving water potential will be set) • investigate simple diffusion and osmosis using plant tissue and non-living materials, such as glucose solutions, Visking tubing and agar • calculate surface areas and volumes of simple shapes (e.g. cubes) to illustrate the principle that surface area to volume ratios decrease with increasing size • explain the movement of water between cells and solutionswith different water potentials and explain the different effect son plant cells (using the terms turgid, flaccid, plasmolysis) and animal cells (Movement of water should be described in terms of water potential. Knowledge of solute potential is not expected) • investigate the effects of immersing plant tissues in solutions of different water potential, using the results to estimate the water potential of the tissues

TOPIC		GENERAL OBJECTIVE *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.4	**Biological molecules**		
2.4.1	Carbohydrates and lipids	• know the structure and properties of biological molecules and understand the relationship between molecular structures and their functions	• define the terms monomer, polymer, macromolecule, monosaccharide, disaccharide and polysaccharide • describe and draw the ring forms of α-glucose and β-glucose • describe the formation of a glycosidic bond by condensation,with reference both to polysaccharides and to disaccharides, including sucrose • describe the breakage of glycosidic bonds in polysaccharides and disaccharides by hydrolysis, with reference to the non-reducing sugar test • describe the molecular structure of the polysaccharides starch (amylose and amylopectin) and glycogen and relate their structures to their functions in living organisms • describe the molecular structure of the polysaccharide cellulose and outline how the arrangement of cellulose molecules contributes to the function of plant cell walls • describe the molecular structure of a triglyceride with reference to the formation of ester bonds and relate the structure of triglycerides to their functions in living organisms • describe the structure of a phospholipid and relate the structure to the functions of phospholipids in living organisms • describe and carry out the Benedict's test for reducing sugars, the iodine test for starch and the emulsion test for lipids • describe and carry out a semi-quantitative Benedict's test on a reducing sugar solution by standardising the test and using the results (time to first colour change or comparison to colour standards) to estimate the concentration • describe and carry out a test to identify the presence of non-reducing sugars, using acid hydrolysis and Benedict's solution • carry out a semi-quantitative Benedict's test on a reducing sugar using dilution, standardising the test and using the results (colour standards or time to first colour change) to estimate the concentration

TOPIC	GENERAL OBJECTIVE *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.4.2 Proteins and water	• know the basic structure of protein molecules and understand how their structures relate to their functions • know the important roles of globular and fibrous proteins in biological processes • know the properties of the water molecule and the role of water in living organisms	• describe the structure of an amino acid and the formation and breakage of a peptide bond • explain the meaning of the terms primary structure, secondarystructure, tertiary structure and quaternary structure of proteins • describe the types of bonding (hydrogen,ionic, disulfide and hydrophobic interactions) that hold these molecules in shape • describe the molecular structure of haemoglobin as an example of a globular protein, and of collagen as an example of a fibrous protein and relate these structures to their functions (appreciate that the haemoglobin molecule is composed of two alpha (α) chains and two beta (β) chains, although when describing the chains the terms α-globin and β-globin may be used. There should be a distinction between collagen molecules and collagen fibres) • state the importance of iron in the haemoglobin molecule. • carry out biuret test to identify the content of solutions, food substances and biological specimens • explain that water is a polar molecule and explain how hydrogen bonding occurs between water molecules • relate the properties of water to its roles in living organisms (limited to solvent action, specific heat capacity and latent heat of vapourisation)
2.5. Enzymes		
2.5.1 Mode of action of enzymes	• know how the structure of enzymes relate to their function	• explain the nature of enzymes as globular proteins that catalyse metabolic reactions • state that enzymes function as intracellular and as extracellular enzymes • explain the mode of enzyme action in terms of an active site, enzyme-substrate complex, lowering of activation energy and enzyme specificity (the lock and key hypothesis and theinduced fit hypothesis should be included) • investigate the progress of an enzyme-catalysed reaction by measuring formation or rates offormation of products and by-products, (for example using catalase) or rates of disappearance of substrate (for example, using amylase)

TOPIC	GENERAL OBJECTIVE *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.5.2 Factors that affect enzyme action	• understand the importance of the factors that affect the rate of enzyme-catalysed reactions	• investigate and explain the factors that affect the rate of enzyme catalysed reactions - temperature, - pH (using buffer solutions) - enzyme concentration - substrate concentration - inhibitor concentration) • explain how the maximum rate of reaction (V_{max}) is used to derive the Michaelis-Menten constant (K_m) which is used to compare the affinity of different enzymes for their substrates • explain the effects of reversible inhibitors both competitive and non-competitive,on the enzyme activity • investigate and explain the effect of immobilising an enzyme in alginate on its activity as compared with its activity when free in solution
2.6 Transport in plants		
2.6.1 Structure of transport tissues	• know the structural components of xylem and phloem and relate these to their functions	• identify and label the various parts of the transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants, using an eyepiece graticule to show correct proportions • describe the structure of xylem vessel elements, phloem sieve tube elements and companion cells • relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions • draw and label from prepared slides the structure of xylem vessel elements, phloem sieve tube elements and companion cells (use a light microscope to recognise the structures)

TOPIC	GENERAL OBJECTIVE *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.6.2 Mechanisms of transport in plants	• understand mass flow in relation to the movement of xylem and phloem sap	• explain that transpiration involves the evaporation of water from the internal surfaces of leaves followed by diffusion of water vapour to the atmosphere • describe,in terms of water potential, the movement of water: - between plant cells - between the plant and its environment (no calculations involving water potential will be set) • investigate experimentally and explain the factors that affect transpiration rate using simple potometer, epidermal peels and grids for determining surface area • explain how hydrogen bonding of water molecules is involved with movement in the xylem by cohesion-tension in transpiration pull and adhesion to cellulose cell walls • describe the pathways and explain the mechanisms by which water and mineral ions are transported from soil to xylem and from roots to leaves (include reference to the symplastic pathway, apoplastic pathway and Casparian strip) • make annotated drawings of transverse sections of leaves from xerophytic plants to explain how they are adapted to reduce water loss by transpiration • state how assimilates, such as sucrose and amino acids, move between sources (e.g. leaves and storage organs) and sinks, (e.g. buds, flowers, fruits, roots and storage organs) in phloem sieve tubes • explain how sucrose is loaded into phloem sieve tubes by companion cells using proton pumping and the co-transporter mechanism in their cell surface membranes • explain mass flow in phloem sap down a hydrostatic pressure gradient from source to sink

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.7 Transport in animals (mammals)		
2.7.1 Mammalian circulatory system	• know the structure and function of the mammalian circulatory system and the components of blood	• state that the mammalian circulatory system is a closed double circulation consisting of a heart, blood vessels and blood • observe and make plan diagrams of the structure of arteries and veins, using prepared microscope slides and be able to recognise these vessels using the light microscope or from photomicrographs • explain the relationship between the structure and function of arteries, veins and capillaries • recognise and draw the structure of red blood cells, monocytes, neutrophils and lymphocytes using prepared slides, photomicrographs and electron micrographs • state the functions of tissue fluid and describe the formation of tissue fluid in a capillary network • state and explain the differences between blood, tissue fluid and lymph • describe the role of red blood cells in carrying oxygen and carbon dioxide with reference to the role of: - haemoglobin - carbonic anhydrase - the formation of haemoglobinic acid - the formation of carbamino-haemoglobin (details of the chloride shift are not required) • describe how carbon monoxide binds with haemoglobin to form carboxyhaemoglob in reducing the affinity of haemoglobin for oxygen • describe the role of plasma in the transport of carbon dioxide • describe and explain the oxygen dissociation curve of adult haemoglobin • explain the importance of the oxygen dissociation curve at partial pressures of oxygen in the lungs and in respiring tissues • describe the Bohr shift and explain the importance of the Bohr shift • describe and explain the significance of the increase in the red blood cell count of humans at high altitude

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.7.2 Mammalian heart	• know the structure and functions of the heart	• describe the external and internal structure of the mammalian heart • observe and make plan diagrams of the structure of the external and internal structure of the mammalian heart • explain the differences in the thickness of the walls of the: - atria and ventricles - left ventricle and right ventricle • describe the cardiac cycle (including blood pressure changes during systole and diastole)and the opening and closing of valves • interpret graphs showing the changes in blood pressure during the cardiac cycle • explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkyne tissue, but not to nervous and hormonal control)
2.8 Disease		
2.8.1 Infectious disease	• understand the biology of pathogens and know the mode of their transmission	• define the term disease and explain the difference between an infectious disease and a non-infectious disease (limited to sickle cell anaemia and lung cancer) • state the name and type of pathogen that causes each of the following diseases: - cholera – caused by the bacterium *Vibrio cholerae* - malaria – caused by the protoctists*Plasmodium falciparum, Plasmodium malariae, Plasmodium ovale*and *Plasmodium vivax* - tuberculosis (TB) – caused by the bacteria *Mycobacterium tuberculosis* and *Mycobacterium bovis* - HIV/AIDS – caused by the human immunodeficiency virus (HIV) - measles - caused by*Morbillivirus* • explain how cholera, malaria, TB and HIV/AIDS are transmitted • discuss the biological, social and economic factors that need to be considered in the prevention and control of cholera, measles, malaria, TB and HIV/AIDS (a detailed study of the life cycle of the malarial parasite is not required) • discuss the factors that influence the global patterns of distribution of malaria

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.8.2 Antibiotics	• know that penicillin is used to control bacterial infections and know the consequences of antibiotic resistance	• describe how penicillin acts on bacteria and why antibiotics do not affect viruses and eukaryotic cells • outline how bacteria become resistant to antibiotics with reference to mutation and selection • discuss the consequences of antibiotic resistance and the steps that can be taken to reduce its impact
2.9 The immune system		
2.9.1 The response of the immune system to pathogens	• understand the roles of the cells and molecules of the immune system and their functions in protecting the body against infectious diseases	• describe the mode of action of phagocytes (macrophages and neutrophils) • describe the sequence of events that occurs during a primary immune response with reference to the roles of: - macrophages - B-lymphocytes, including plasma cells - T-lymphocytes, limited to T-helper cells and T-killer cells • explain what is meant by an antigen and state the difference between self antigens and non-self antigens • explain the role of memory cells in the secondary immune response and in long-term immunity
2.9.2 Antibodies and vaccination	• recognise the role of antibodies and vaccination in the prevention of infectious diseases	• relate the molecular structure of antibodies to their functions(see 2.4.2) • outline the hybridoma method for the production of monoclonal antibodies • outline the use of monoclonal antibodies in the diagnosis of disease and in the treatment of disease • describe the differences between active and passive immunity and between natural and artificial immunity • explain that vaccines contain antigens that stimulate immune responses to provide long-term immunity • explain how vaccination programmes can help to control the spread of infectious diseases

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.10 Human gas exchange and smoking		
2.10.1 The gas exchange system	• know the gross structure of the gas exchange system and understand the function of various parts	• describe the gross structure of the human gas exchange system • investigate and observe the gross structure of lungs and associated organs of a sheep or other mammal (dissect) • describe the distribution in the gas exchange system of cartilage, ciliated epithelium, smooth muscle, capillaries and squamous epithelium of alveoli • recognise cartilage, ciliated epithelium, smooth muscle, capillaries and squamous epithelium of alveoli in microscope slides, photomicrographs and electron micrographs • recognise trachea, bronchi, bronchioles and alveoli in microscope slides, photomicrographs and electron micrographs and make plan diagrams of transverse sections of the walls of the trachea and bronchus • describe the functions of ciliated epithelial cells, goblet cells and mucous glands in maintaining the health of the gas exchange system • describe the functions in the gas exchange system of cartilage, smooth muscle, elastic fibres and squamous epithelium • describe the process of gas exchange between air in the alveoli and the bloodin the capillaries
2.10.2 Smoking and its impact on the gas exchange and circulatory system	• understand the impact of smoking on one's health	• describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system with reference to lung cancer and chronic obstructive pulmonary disease (COPD) • describe the short-term effects of nicotine and carbon monoxide on the cardiovascular system • conduct a survey, possibly with the use of a questionnaire, on the incidence of hay fever and/ or asthma

THEME 3: DEVELOPMENT OF THE ORGANISM AND THE CONTINUITY OF LIFE			
TOPIC		**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
3.1	**Mitotic cell cycle**		
3.1.1	Replication and division of nuclei and cells	• acknowledge the significance of the cell cycle and replication in the uniformity of daughter cells	• describe the structure of a chromosome, limited to DNA, histone proteins, chromatids, centromere and telomeres • explain the importance of mitosis in the production of genetically identical cells, growth, cell replacement, repair of tissues and asexual reproduction • observe and draw the mitotic stages visible in temporary root tip squash preparations and in prepared slides of root tips of species such as those of *Vicia faba* and *Allium* cepa • outline the mitotic cell cycle, including interphase (growth in G1 and G2 phases and DNA replication in S phase), mitosis and cytokinesis • outline the significance of telomeres in permitting continued replication and preventing the loss of genes • outline the role of stem cells in cell replacement and tissue repair by mitosis • explain how uncontrolled cell division can result in the formation of a tumour
3.1.2	Chromosome behaviour in mitosis	• know the events that occur during mitosis/cell cycle	• describe, with the aid of photomicrographs and diagrams, the behaviour of chromosomes in plant and animal cells during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell surface membrane and the spindle(names of the main stages of mitosis, prophase, metaphase, anaphase and telophase, are expected) • interpret photomicrographs, diagrams and microscope slides of mitosis and identify the main stages of mitosis

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
3.2 Nucleic acids and protein synthesis		
3.2.1 Structure and replication of DNA	• know the structure of nucleic acids and understand their role in the storage of genetic information and how that information is used in the synthesis of proteins	• describe the structure of nucleotides, including the phosphorylated nucleotide ATP (structural formulae are not required) • state that adenine and guanine are purines with a double ring structure, and that cytosine, thymine and uracil are pyrimidines with a single ring structure (structural formulae for bases are not required) • describe the structure of RNA and DNA and explain the importance of base pairing and the different hydrogen bonding between bases • describe the semi-conservative replication of DNA during S phase • design and make a model of DNA to illustrate the semi-conservative replication of DNA during interphase
3.2.2 Protein synthesis	• understand the genetic code and how DNA codes for polypeptides	• state that a polypeptide is coded for by a gene and that a gene is a sequence of nucleotides that forms part of a DNA molecule • state the features of the genetic code • describe how the information in DNA is used during transcription and translation to construct polypeptides, including the role of messenger RNA (mRNA), transfer RNA (tRNA) and the ribosomes • state that a gene mutation is a change in the sequence of nucleotides that may result in an altered polypeptide • explain that a gene mutation occurs by substitution or deletion or insertion of base pairs in DNA and outline how each of these types of mutation may affect the polypeptide produced • describe the way in which the nucleotide sequence codes for the amino acid sequence in a polypeptide with reference to the nucleotide sequence for Hb^A(normal) and Hb^S(sickle cell) alleles of the gene for the β-globin polypeptide • design and make a model of RNA to contrast it with the DNA model

6. ASSESSMENT OBJECTIVES

The assessment will include, wherever appropriate, personal, social, environmental, economic and technological applications of Biology in modern society. Learners are required to demonstrate the assessment objectives in the context of the content and skills prescribed. Within each of the Assessment Objectives the assessment must take account of the learners' ability to communicate clearly and logically and apply conventions where appropriate.

The three Assessment Objectives in Biology are:

A Knowledge with understanding

B Handling information and solving problems

C Practical (experimental and investigative) skills and abilities

The following is a description of each Assessment Objective:

A Knowledge with understanding

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

A1. scientific phenomena, facts, laws, definitions, concepts and theories;

A2. scientific vocabulary, terminology and conventions, (including symbols, quantities, units);

A3. scientific instruments and apparatus, including techniques of operation and aspects of safety;

A4. scientific quantities and their determination;

A5. scientific and technological applications with their social, economic and environmental implications.

The Learning Content defines the factual content that learners may be required to recall and explain. Questions testing these objectives will often begin with one of the following command words or phrases: define, name, list, indicate, give examples, state, describe, compare, explain, distinguish, outline and give reasons.

B 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:

B1. locate, select, organise and present information from a variety of sources;

B2. translate information from one form to another;

B3. manipulate numerical and other data;

B4. use information to identify patterns, report trends and draw inferences;

B5. present reasoned explanations for phenomena, patterns and relationships;

B6. make predictions and hypotheses and solve problems

B7. apply knowledge, including principles, to new situations

B8 demonstrate an awareness of the limitations of biological theories and models

These skills cannot be precisely specified in the Learning Content, because questions testing such skills are often based on information that is unfamiliar to the learner. In answering such questions, learners are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner to a novel situation. *Questions testing these objectives will often begin with one of the following command words or phrases: discuss, deduce, compare and discuss, find, estimate, interpret, evaluate, sketch, predict, identify, relate, suggest and calculate or determine.*

C PRACTICAL (experimental and investigative) SKILLS AND ABILITIES

Learners should be able to:

- C1. Follow a sequence of instructions,using appropriate techniques, handling apparatus and materials competently and having due regard for safety;
- C2. make and record estimates, observations and measurements accurately;
- C3. handle and process experimental observations and data, including dealing with anomalous or inconsistent results;
- C4. apply scientific knowledge and understanding to make interpretations and to draw appropriate conclusions from practical observations and data;
- C5. plan, design and carry out investigations (based on concepts familiar to learners) and suggest modifications in the light of experience

7. SCHEME OF ASSESSMENT

All learners should be entered for **Papers 1, 2 and 3**, which are compulsory papers.

Paper	Description of paper and types of questions	Duration of paper	Marks
Paper 1: Theory: Multiple choice questions	This paper consists of forty multiple-choice items of the four-choice type. The questions will be based on content described as specific objectives and will test abilities in assessment objectives A and B. Candidates will answer all questions. Candidates will answer on an answer sheet.	1 hour	40
Paper 2: Theory: Structured questions	This paper will consist of compulsory short-answer, structured and free-response questionsa variable number of questions, of variable mark value.The questions will test skills and abilities in Assessment Objectives A and B. Learners will answer all questions on the question paper [booklet].	1 hour 15 minutes	60
Paper 3: Advanced Practical Skills	This paper requires learners to carry out practical work in timed conditions. Learners will be expected to collect, record and analyse data so that they can answer questions related to the activity. The paper will consist of two experiments drawn from different areas of Biology. Learners will answer all questions. Learners will answer on the question paper. These questions may be based on the practical work in this syllabus with which the learner is familiar. They may also include practical exercises unfamiliar to the learner, but if this is the case then sufficient explanation and instruction will be given to enable the learner to use knowledge of practical work in other areas to complete the task satisfactorily. Centres are expected to have standard laboratory facilities available for all of their learners.	2 hours	40
		TOTAL	**140**

Weighting of papers

The assessment will be based on the end of year national examination.

All learners will be entered for Papers 1, 2 and 3 as specified below. Learners will be graded from a to e, depending on their abilities and achievements. Paper 1 and 2 will constitute 77% of the final assessment while Paper 3 will constitute 23%.

Weighting of papers	
Paper 1	29%
Paper 2	42%
Paper 3 (Advanced Practical Skills)	29%

The Specification Grid in section 8 gives a general idea of how marks are allocated to assessment objectives in the different components. However, the balance on each paper may vary slightly.

8. SPECIFICATION GRID

The approximate weightings allocated to each of the assessment objectives across the papers are summarised below.

Assessment Objective	**Weighting across all components**	**Paper 1(marks)**	**Paper 2 (marks)**	**Paper 3 (marks)**
A Knowledge with understanding	40% (not more than 20% recall)	20	30	0
B Handling information, application and solving problems	40%	20	30	0
C Practical (experimental and investigative) skills and abilities	20%	0	0	40
		40 marks	**60 marks**	**40 marks**

Teachers should note that there is a greater weighting of 60 per cent for skills (including handling information, solving problems, experimental skills and investigations) compared to 40 per cent for knowledge and understanding. Teachers should make sure that their **schemes of work** and the **sequence of learning activities** reflect this balance so that the aims of the syllabus are met and the candidates are suitably prepared for the assessment

9. GRADE DESCRIPTIONS

The scheme of assessment is intended to encourage positive achievement by all learners. Grade descriptions are therefore provided for judgmental Grades a, c and e to give a general indication of the standards of achievement expected of learners awarded particular grades. The description must be interpreted in relation to the content specified by the Biology syllabus, but are not designed to define that content. The Grade awarded will depend, in practice, upon the extent to which the learner has met the assessment objectives overall.

*At **Grade a** the learner is expected to:*

- show mastery of curriculum content;
- demonstrate the ability to interpret relatively complex data with precision;
- demonstrate the ability to discuss biological topics with depth and breadth of understanding, bringing together ideas from various areas of the curriculum and from the learner's own experience;
- communicate with clarity, by means of words, diagrams and other forms of presentation;
- be able to link his or her theoretical and practical studies in biology with applications relating to society and to the environment;
- show a clear understanding of scientific method, and be able to design, carry out and evaluate experiments with confidence and competence.

*At **Grade c** the learner is expected to:*

- show reasonable mastery of curriculum content;
- demonstrate the ability to interpret relatively simple data with precision;
- demonstrate the ability to discuss biological topics, with some success at bringing together ideas from different areas of the curriculum and the learner's experience;
- communicate effectively, by words, diagrams and other forms of presentation;
- show some ability to link his or her biological studies with applications relating to society and the environment;
- show a reasonable understanding of scientific method, and be able to design, carry out and evaluate experiments with reasonable confidence and competence.

*At **Grade e** the learner is expected to:*

- show a limited mastery of curriculum content;
- demonstrate the ability to interpret simple data with reasonable precision;
- demonstrate some ability to discuss biological topics;
- communicate effectively, by words, diagrams and other forms of presentation;
- show some ability to link his or her biological studies with applications relating to society and the environment;
- show a reasonable understanding of scientific method and be able to design, carry out and evaluate simple experiments with some confidence and competence.

10. GLOSSARY OF TERMS USED IN SCIENCE PAPERS

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

Define (the term(s)...).	is intended literally. Only a formal statement or equivalent paraphrase is required
What do you understand by/What is meant by (the term(s)...)	normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
State	implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.
List	requires a number of points with no elaboration. If a specific number of points is requested, this number should not be exceeded.
Explain	may imply reasoning or some reference to theory, depending on the context.It is another way of asking candidates to give reasons for. The candidate needs to make sure that the examiner is told why something happens.
Give a reason/ give reasons	this is another way of asking candidates to explain why something happens.
Describe	requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. For particular phenomena, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. In other contexts, **describe and give an account of**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 in a similar way to **state and explain**.***Describe a process***meansgive a step-by-step description of what happens during the process.
Discuss	requires candidates to give a critical account of the points involved in the topic.
Outline	implies brevity, i.e. restricting the answer to giving essentials.
Deduce	follow the guidance for predict, but a supporting statement is also required. For example, reference to a law, a principle or the necessary reasoning should be included in the answer.
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.
Comment	is intended as an open-ended instruction, inviting candidates to recall or infer points ofinterest relevant to the context of the question, taking account of the number of marks available.

Suggest	*Suggest*: may imply that there is no single correct answer (for example, in biology, there are a number of factors that might limit the rate of photosynthesis in a plant in a glasshouse). *Suggest*: may also imply that the candidate must apply their general knowledge and understanding of biology to a 'novel' situation, one that may not formally be 'in the syllabus'. Many data-response and problem-solving questions are of this type.
Find	is a general term that may variously be interpreted as calculate, measure, determine, etc.
Calculate	is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.The candidate should give suitable units where possible.
Measure	implies that the quantity concerned can be directly obtained from a suitable measuringinstrument, e.g. length, using a rule, or angle, using a protractor.The candidate should give suitable units where possible.
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. It may also be used when the candidate must carry out a procedure to find a numerical answer.
Estimate	implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make any necessary simplifying assumptions about points of principle and about the values of quantities not otherwise included in the question.
Show	make an algebraic deduction to prove a given equation. The candidate must state clearly the terms being used.
Sketch	when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. In diagrams, sketch implies that a simple, freehand drawing is acceptable though care should be taken over proportions and the clear exposition of important details.
Construct	is often used in relation to chemical equations where a candidate is expected to write a balanced equation, not by factual recall but by analogy or by using information in the question.
Compare	requires candidates to provide both the similarities and differences between things orconcepts.
Recognise	identify facts, characteristics or concepts that are relevant and/or appropriate to understanding a situation, event, process or phenomenon. Classify: group things based on common characteristics.
Classify	requires candidates to group things based on common characteristics.

In all questions, the number of marks is shown on the examination paper and candidates should use this as a guide to how much detail to give. When describing a process, the candidate should use the number of marks to decide how many steps to include. When explaining why something happens, the candidate should use the number of marks to decide how many reasons to give, or how much detail to give for each reason

ANNEXE A: Practical assessment (investigative skills and abilities)

Teachers should ensure that learners practise experimental skills throughout their course of study. As a guide, learners should spend at least 20 per cent of their time doing practical work individually or in small groups. This 20 per cent does not include the time spent observing teacher demonstrations of experiments and simulations.

The practical work that learners do during their course should aim to:

- provide learning opportunities so that they develop the skills they need to carry out experimental andinvestigative work
- reinforce their learning of the theoretical subject content of the syllabus
- instil an understanding of the interplay of experiment and theory in scientific method
- be enjoyable, contributing to the motivation of learners.

Learners' experimental skills will only be assessed in Paper 3. The questions may be based on biology not included in the syllabus content, but learners' will be assessed on their practical skills rather than their knowledge of theory. Where appropriate, learners' will be told exactly what to do and how to do it.

Examples of unfamiliar contexts might include:

- following instructions to set up and use unfamiliar equipment
- making microscopic observations, drawings and magnification calculations from unfamiliar structures or specimens
- following instructions to use unfamiliar biochemical procedures

It is accordingly important that an assessment of a student's knowledge and understanding of Biology should contain a component relating to practical work and experimental skills as identified by Assessment Objective C. Although there are differing circumstances such as the availability of resources. Only a formal Advanced Practical Skills (Paper 3) will be offered for examination of this syllabus.

A1. Paper 3 Advanced Practical Skills

Paper 3 will be a timetabled, laboratory-based practical paper focusing on the following investigational skills:

- manipulation, measurement and observations
- presentation of data and observations
- analysis, conclusions and evaluation

Questions may be based on the suggested practical work as well as on work that may be unfamiliar but for which full instructions will be provided.

For example, learners may be asked to carry out exercises involving:

- simple physiological experiments, e.g. tests for food sustances and use of hydrogen-carbonate indicator and litmus and Universal Indicator paper;
- making clear line drawings of specimens provided, an indication of magnification of the drawing and labelling as required;
- the making of a temporary slide and subsequent examination under a microscope;
- the interpretation of an electron micrograph;
- simple arithmetical calculations

Each paper:

- has two questions
- requires learners to carry out an investigation or investigations. They may be asked to:
  - make decisions on techniques
  - collect quantitative or qualitative data
  - present the data or observations as tables, charts, graphs and other appropriate means
  - make appropriate analyses, including making calculations
  - make conclusions
  - suggest improvements to the procedure or modifications for extending the investigation
- requires learners to carry out one activity using a light microscope. They may be asked to
  - prepare slides
  - make observations of specimens
  - present their observations appropriately
  - make appropriate analyses, including measurements and calculations
  - make deductions and conclusions from the observations
- requires the Centre to provide microscopes for half of the candidates at a time so half the candidates should start on the investigation while the others start with access to the light microscope
- includes questions set in different areas of NSSCAS Biology, and may include material from unfamiliar contexts. Where unfamiliar material or techniques are required, full instructions will be given.

Learners will be expected to show evidence of skills in the handling of familiar and unfamiliar biological material. Where unfamiliar materials or techniques are required, full instructions will be given.

No dissection of materials of animal origin will be required in Paper 3. However, the use of dissection, interactive videos or similar will continue to be a useful aid to teaching, e.g. when the heart is being studied.

A2. Mark scheme for Paper 3

Skill	Total marks	Strands	Marks
Manipulation of apparatus, measurementand observation (MMO)	16	Making decisions about measurements or observations	8
		Successfully collecting data and observations	8
Presentation of data and observations (PDO)	12	Recording data and observations 4	4
		Displaying calculations and reasoning 2	2
		Data or observations layout 6	6
Analysis, conclusions and evaluation (ACE)	12	Interpreting data or observations and identifying sources of error	6
		Drawing conclusions	3
		Suggesting improvements to a procedure or modifications to extend investigation	3

A3. Expectations for each mark category (Paper 3)

The table provide expectations for each category:

A3.1 Manipulation of apparatus, measurement and observation (MMO)

Within an investigation, candidates should use the skills, knowledge and understanding of NSSCAS level Biology syllabus to:	
Making observations about measurements or observation	• Identify the independent and dependent variables. • Decide how the independent variable should be changed within a suitable range to provide accurate results. Candidates should: – decide the range to use for an independent variable and decide how to change its values, including: o concentration (using proportional dilution or serial dilution) o temperature (selected from above freezing to 100°C) o pH (using buffers) o moving air (using a fan) o humidity (using a plastic bag or calcium hydroxide) – decide the number of values at which measurements are recorded (a minimum of 5 measurements, replicates or more measurements around a specific value) – decide on the spacing of the values, for example, if more measurements are needed around a specific value – decide intervals including concentration, temperature or pH – decide the number of replicates at each value – decide how to identify the presence of a biological molecule and estimate its quantity by standardising the appropriate test • Describe an appropriate control which removes the effect of the independent variable (including replacing a solution with the same volume of water or denaturing an enzyme by boiling) and variables to standardise. • Decide which variables to standardise because they may change the results if the variable changes during the investigation and decide how to standardise each variable to provide accurate results. These include: - volume (must be suitable for apparatus) - concentration - temperature - pH - biological material (for example same species; age; storage conditions; time of year; mass) - humidity (using a plastic bag or calcium hydroxide) - apparatus

	• Decide and describe how the dependent variable should be measured to obtain accurate and precise results. Candidates should: - use a variety of techniques to measure dependent variables, including release of gases; absorption of gases; change in colour (using an indicator for change in pH); time (to a colour change when testing for biological molecules); counting (e.g. cells showing degrees of plasmolysis) - decide on the frequency of measurement (e.g. measurements to determine the initial rate of a reaction should be taken as quickly as possible after the reaction starts) - decide how long to allow for taking measurements to determine a rate of reaction, time for a colour change or time for a reaction to reach an end-point - decide whether to repeat or replicate readings in order to identify anomalous results or to provide a more accurate estimate - decide an appropriate number of significant figures for measurements or clear descriptions of observations - decide how to measure an area using a grid, counting those areas covering half or more of a grid square as one whole square and not counting those areas less than half a square.
Successfully collecting data and observations	• follow instructions or diagrams for a range of techniques to collect results • assess the risk of a procedure as low, medium or high considering the hazards of solutions and reagents and the procedure • take readings using a range of apparatus to obtain accurate data or observations with the expected pattern of results - Quantitative results o measure all results to an appropriate number of significant figures, using a range of apparatus which includes temperature changes with time; distance with time; time for a colour change; angle of bend; volumes of gases or solutions o measure using counting: tally counts, e.g. to count bubbles in a minute; grids for surface area; numbers of cells - Qualitative results from observations of colour changes, using clear descriptions, for example: o blue' or 'orange' or 'purple' with use of 'pale' or 'dark' for fine discrimination o a number scale 1 to 5 for intensity of colour with a key o a suitable symbol such as number of + or √ to represent cloudiness or intensity of colour (a key should always be given).

When using a light microscope and photomicrographs, candidates should use skills, knowledge and understanding of the NSSCAS level Biology syllabus to:	
Making decisions about measurements or observations	• set up a light microscope to view and observe specimens, in order to make either plan diagrams to show tissue distribution or to draw cells to include only the observable features • draw the distribution of different tissues in plant and animal specimens and label the drawings appropriately • correctly identify cells and label the structures of cells • stain and make a slide of cells • calibrate an eyepiece graticule using a stage micrometer • obtain actual sizes of tissues or cells using a calibrated eyepiece graticule, by measuring the tissues or cells to obtain a mean measurement, using the correct units for microscopy (μm) • estimate the number of cells or cell organelles in a whole slide or field of view using a sample or using a grid.
Successfully collecting data and observations	• observations by drawing the distribution of tissues in a specimen, as plan diagrams, with no cells drawn and correct proportions of layers of tissues • observations by drawing the observable features of cells in a specimen showing: - the correct shapes - the thicknesses of cell walls (which are drawn with two lines or with three lines for two touching cell walls) - the relative sizes (using an (uncalibrated) eyepiece graticule scale) - observable cell contents only • correct measurements of tissue layers or cells, including - using a calibrated eyepiece graticule - using scale bars - appropriate magnification • correct observations from specimens, including numbers of cells or cell organelles, using sampling or a grid or tally counts or numbers of stained to non-stained cells • similarities and differences between two specimens using only their observable features.

A3.2 Presentation of data and observations (PDO)

Within each investigation candidates should be able to:	
Record data and observations	• Record only the raw data (unprocessed results) as quantitative data and qualitative observations in a fully ruled table with no units in the body of the table Learners should: – prepare a table with a heading for the independent variable in the left column or top row with appropriate units and a heading for the dependent variable with units – record quantitative data to the same number of significant figures dependent on the measuring instrument used – record qualitative observations using clear descriptions • Record calculated values (processed results) selecting whether to include these with raw results or in a separate table.
Displaying calculations and reasoning	• show calculations clearly showing all the steps in the calculation and their reasoning • use the correct number of significant figures for calculated quantities. This should be the same number of significant figures as (or one more than) the measured quantity of least accuracy.
Data or observations layout	• select whether data should be shown as a graph or chart and then present the graph or chart clearly and accurately Learners should draw a graph or chart with: - axes with the independent variable on the x-axis, clearly labelled (to match the relevant table heading) with units where appropriate and the dependent variable (to match the relevant table heading) on the y-axis labelled with units, where appropriate - a scale where both axes should use most or all of the grid available and allow the graph to be read easily to half a 2mm square, such as 1, 2, or 5 units to a maximum of 20 mm - all points plotted accurately. Points should be drawn with a sharp pencil, as a small cross or a small dot in a circle. The intersection of the cross or centre of the dot should be exactly on the required point • for a graph (based on data provided) the plotted points should be connected with a clear, sharp and unbroken - line of best fit - smooth curve - set of ruled straight lines to join the points The graph should not be extrapolated unless this can be assumed from the data - all bars should be plotted accurately with the horizontal lines as a thin ruled line - for a chart (based on the data provided) bars should be separated for discrete or categorical data and joined for continuous data. Lines should be clear, sharp and unbroken and bars unshaded and clearly labelled

When using a light microscope and photomicrographs, candidates should use skills, knowledge and understanding of the NSSCAS Level Biology syllabus to:	
Recording data and observations	– record the fine details of the specimen including drawing of detailed shapes of layers or outlines of specimens in plan diagrams and drawing of the shape and position of observable cell organelles in cells.
Displaying calculations and reasoning	Candidates should be able to show calculations, clearly show all the steps in their calculation, including: - the calibration of the eyepiece graticule • the actual size (using an eyepiece graticule or magnification scale bar) - the linear magnification - the total number, e.g. stomata per unit of area (for example field of view) - the mean measurement of length or number - determining ratios - using the correct number of significant figures for calculated quantities
Data or observations layout	– make drawings, using a sharp pencil, to give finely drawn lines. Drawings should: - have clear, sharp, unbroken lines - be unshaded - use most of the available space to show all the features observed in the specimen – organise comparative observations, showing differences and/or similarities, of specimens of biological material.

A3.3 Analysis (interpretation of data or observations), conclusions and evaluation (ACE)

Within each investigation candidates should use skills, knowledge and understanding of the NSSCAS Level syllabus to:	
Interpreting data and observations and identifying sources of error	– calculate the correct answer with the correct number of significant figures using quantitative results or data provided. – find an unknown value by using co-ordinates or intercepts with axes on a graph or extrapolation where the data allows – estimate the concentration of unknown solutions from qualitative results – identify the contents of unknown solutions using biological molecule tests – identify anomalous results and remove them before beginning calculations, e.g. when calculating means – describe patterns and trends using the data provided in tables and graphs – identify systematic or random errors from using apparatus in an investigation and understand that systematic errors do not affect the trend in results whereas a random error, for example, due to variability of biological material, may affect the trend and accuracy – identify the significant sources of error in a particular investigation as any variable that may change during the recording of results so making the results less accurate Note: Contamination is not considered a significant source of error since washing correctly should remove contamination – estimate quantitatively, by calculating the actual error or percentage error (where a particular measurement is given) to evaluate the uncertainty in quantitative measurements and evaluate the confidence in the accuracy of results (how close they are to the true value) – evaluate the effect of the standardisation of variables on the general trend or pattern and therefore the confidence with which conclusions might be made.
Draw conclusions	• Make conclusions: – to predict a trend from provided information or results – from the patterns and trends in data – on whether investigational data support a given hypothesis – from results, including estimating an unknown concentration using known concentrations • Make scientific explanations, using skills, knowledge and understanding of the NSSAS Level Biology syllabus, of: – data collected – observations – calculated values – described conclusions – information provided in unfamiliar contexts.

Suggesting improvements or modifications to extend an investigation	• Suggest improvements to a procedure that will increase the accuracy of the procedure for the investigation or accuracy of the observations including how to: - standardise relevant variables - use a measurement method for the dependent variable which is more accurate - collect more data by taking replicate measurements to obtain a mean • Suggest how to modify or extend the investigation to answer a new question or change the independent variable and describe such modifications clearly in words or diagrams, including how to: - change a different independent variable - standardise all other variables including a previously used independent variable - use an improved method to obtain accurate and precise results for the dependent variable.
When using a light microscope and photomicrographs, candidates should use skills, knowledge and understanding of the NSSCAS Level Biology syllabus to:	
Interpreting data or observations and identifying sources of error	• Calculate the correct answer with the correct number of significant figures, using quantitative results or provided data including: - the calibration of the eyepiece graticule scale - the actual size of a specimen (using a calibrated eyepiece graticule, a magnification or a scale bar) - the magnification of a specimen - the number in a field of view, e.g. number of stomata per unit of area • Compare observable features of specimens of biological material including similarities and differences between microscopic slides of specimens and photomicrographs of specimens.
Drawing conclusions	• Use the skills, knowledge and understanding acquired from the NSSAS Level Biology syllabus make scientific explanations of: - observations of specimens - calculated values - how a specimen is adapted for a particular habitat.
Suggesting improvements to a procedure or modifications to extend an investigation	• Suggest improvements to a procedure that will increase the accuracy of the observations that can be made, to include how to: - use a measurement method which uses smaller intervals to improve accuracy and precision - collect more data by taking replicate results to obtain a mean.

A4: INVIGILATOR'S REPORT FORM FOR PAPER 3
Republic of Namibia
NAMIBIA SENIOR SECONDARY CERTIFICATE
ADVANCED SUBSIDIARY LEVEL BIOLOGY **XXXX / 3**

PAPER 3 Advanced Practical Skills

Question Paper & Examination Security Declaration
Region..... Date.....
Centre Number..... Centre Name.....
Principal (full name, print).....
Head of Examination Centre (full name, print).....

Hereby it is certified that this examination was conducted under appropriate measures and conditions as stipulated in the 'Rules & Regulations for the NSSC Examinations'.

Attached are the following details;

1 Subjects Teacher's Results

*Please submit details of the readings obtained in **Question 1** and **Question 2** on a spare copy of the question paper clearly marked '**Subject Teacher's Results'** and showing the Centre Number.*

*It is essential that each packet of candidates' scripts contains a copy of the applicable '**Subject Teacher's Results'** as the candidates' work cannot be assessed accurately without such information.*

2 The Candidate Numbers of candidates attending each session were:
Please write them in their sitting order

First session	Second session	Third session

3 The supervisor is required to give details of any difficulties experienced by particular candidates, giving Candidates' Names and Numbers. This should include any reference to:

- any general difficulties encountered in making preparation
- difficulties due to faulty apparatus or materials
- accident to apparatus or materials
- assistance with respect to colour-blindness

Other cases of hardship, e.g. illness, temporary disability, should be reported directly to DNEA through the regional offices on the normal ' Application for Special Consideration' forms.

Report on any difficulties experienced by candidates.

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Principal's Signature & Date.....
Head of Examination Centre's Signature & Date:.....
Subject Teacher's Full Name:.....
Subject Teacher's Signature & Date:.....
Supervisor's Signature & Date:.....

ANNEXE B: Apparatus that is used regularly for Paper 3

The apparatus required for Paper 3 will vary from paper to paper. The Confidential Instructions will include a complete list of apparatus and materials required for each question during a particular examination. Supervisors should follow the Confidential Instructions very carefully in preparation of the required material. Some examination questions may require unusual items or equipment.
Microscopes provided for learners' use in Paper 3 must be fitted with:

- eyepiece lens, ×10 (equal to 16 mm)
- low-power objective lens, ×10 (equal to 16 mm)
- high-power objective lens, ×40 (equal to 4 mm)
- eyepiece graticule fitted within the eyepiece and visible in focus at the same time as the specimen.

To avoid confusion, only the lenses specified above should be fitted in the microscopes to be used in the examination. Any objective lenses which are not ×10 or ×40 should be removed or replaced.

For the examination, Centres should provide eyepiece graticules as standard. However, DNEA/Regional office will supply stage micrometer scales for the examination as needed. Learners will be allowed to use the microscope for a maximum of one hour.

Laboratory equipment
This is a list of basic materials and apparatus that should be in a biology laboratory. The list is not exhaustive. Other items may be required as variety of questions may require different equipment.

The following codes indicate the Substances that are Hazardous to Health and to be used with caution.

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

General:

- test-tubes and large test-tubes (boiling tubes) – some test-tubes should be heat resistant
- test-tube holders or similar means of holding tubes
- test-tube racks or similar places in which to stand tubes
- bungs to fit test-tubes / boiling tubes
- bungs with delivery tube to fit test-tubes / boiling tubes
- specimen tubes with corks
- means of heating – Bunsen burners or similar (learners should be familiar with setting up and maintaining a water-bath)
- thermometers
- measuring cylinders
- means of measuring small volumes, such as syringes (various sizes)
- plastic tubing or rubber tubing to fit syringes
- teat pipettes (plastic or glass)
- beakers (various sizes)
- tripod stands and gauzes
- filter funnels and filter paper
- Petri dishes (plastic) or shallow containers to hold small volumes (e.g. 20 cm^3)
- white tiles or other suitable surfaces on which to cut
- spotting tile or similar with space for 12 separate drops
- glass slides and coverslips
- conical flasks
- clamp (retort) stands and bosses
- Visking (dialysis) tubing, e.g. 14 mm width with a pore diameter of approximately 2.5 nm, or suitable alternative
- capillary tubing
- soda glass tubing
- paper towels
- cotton wool
- solid glass rods
- spatulas
- black paper /aluminium foil
- means of writing on glassware (water-resistant markers)
- hand lenses (not less than ×6, preferably ×8)
- forceps
- scissors
- mounted needles
- cutting implement, such as single-edged razor blade / knife / scalpel
- rulers in mm (ideally clear plastic)
- mortars and pestles
- suitable eye protection
- microscope and lamp/inbuilt illumination with high-power and low-power objective lenses (1 each or 1 between 2)
- eyepiece graticules and stage micrometer scales
- microscope slides and glass coverslips
- haemocytometers
- bench lamp with flexible arm
- balance (to 0.1 g)
- water-baths (thermostatically controlled) or means to supply hot water
- cork borers
- stop-clock or timer showing seconds
- pipe cleaners / other suitable aid to demonstrate mitosis

Stocks of:

- [**N**] – iodine in potassium iodide solution
- [**MH**] [**N**] – Benedict's solution
- [**C**] [**MH**] – biuret reagent/potassium hydroxide and copper sulfate solution
- [**F**] **[MH**] **[HH**] – ethanol (for fats test)
- sucrose (use Analar (AR) for non-reducing sugar test. Some types of table sugar contain reducing sugars.)
- glucose
- starch
- albumen (or egg white)
- **[C**] **[MH**] – potassium hydroxide
- **[C**] – sodium hydroxide
- sodium chloride
- dilute hydrochloric acid
- sodium hydrogencarbonate
- **[MH**] – hydrogen peroxide
- distilled / deionised water
- Universal Indicator paper and chart
- litmus solution and red and blue litmus paper
- **[MH**] – eosin/red ink
- [**HH**] – methylene blue
- Vaseline / petroleum jelly (or similar)
- diastix for testing glucose concentration
- albustix or another appropriate test strip for testing protein
- [**HH**] – enzymes: amylase, trypsin (or bacterial protease)
- materials for preparing immobilised enzymes: calcium chloride, sodium alginate
- plant sources of catalase, e.g. sweet potatoes, mung beans, potatoes
- wheat, barley or similar as a source of starch
- non-competitive enzyme inhibitor (e.g. **[MH**] [**N**] – copper sulfate – hydrated)
- stains for preparing slides to show mitosis, e.g. acetic carmine, toluidine blue
- [HH] – Feulgen stain (Schiff's reagent)
- technical agar (note: technical agar is suitable for making agar blocks)

Slides:

The following prepared slides are important for NSSCAS Biology:

- mitosis
- TS stem, TS root and TS leaf of, for example, dicotyledonous mesophyte (such as Ligustrum or Prunus or local equivalent), maize, rice, sorghum, wheat, xerophyte leaves
- LS stem, LS root to show xylem vessel elements and sieve tube elements and companion cells
- TS trachea, TS bronchus, TS bronchioles
- TS lungs to show alveoli
- TS artery, TS vein
- blood smear
- animal and plant cells; Protoctists (e.g. Amoeba, Euglena or local equivalents, for example from a culture made with water and hay to stimulate single cell organisms)

Safety in the laboratory

Responsibility for safety matters rests with Centres. Attention is drawn to the Lab Manual of the MoEAC.

ANNEXEC: Mathematical requirements

Calculators may be used in all parts of the examination.

Learners should be able to:

- add, subtract, multiply and divide;
- understand averages, decimals, fractions, percentages, ratios and reciprocals;
- recognise and use standard notation;
- use direct and inverse proportion;
- use positive, whole number indices;
- draw charts and graphs from given data;
- interpret charts and graphs;
- select suitable scales and axes for graphs;
- make approximate evaluations of numerical expressions;
- recognise and use the relationship between length, surface area and volume and their units on metric scales;
- use usual mathematical instruments (ruler, compasses);
- understand the meaning of radius, diameter, square, rectangle.
  - recognise and use expressions in decimal and standard form
  - use a calculator for addition, subtraction, multiplication and division, finding the arithmetical mean and to find and use x, x^2, $\log_{10}x$ and $\sqrt{x}$
  - understand and use the symbols <, >, , ≈, /, ∞, Σ
  - understand and use the prefixes: giga (G), mega (M), kilo (k), milli (m), micro (μ), and nano (n)
  - calculate magnifications and actual sizes
  - take account of accuracy in numerical work and handle calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified
  - make estimations of the results of calculations (without using a calculator)
  - use a spreadsheet program for collating, analysing and presenting data
  - recognise and use ratios
  - calculate percentages and percentage changes
  - express errors in experimental work as percentage errors
  - calculate areas of triangles, circumferences and areas of circles and rectangles, surface areas and volumes of cylinders and rectangular blocks
  - translate information between graphical, numerical, and algebraic forms
  - construct and interpret frequency distributions and diagrams, such as pie charts, bar charts and histograms
  - understand when information should be presented in the form of a bar chart, histogram or line graph
  - select appropriate variables and scales for graph plotting using standard 2 mm square graph paper
  - recognise when it is appropriate to join the points on a graph with straight ruled lines and when it is appropriate to use a line (straight or curved) of best fit
  - calculate the rate of change from a line on a graph
  - draw and use the slope of a tangent to a curve as a means to obtain the rate of change
  - use Simpson's Index of Diversity (D) to calculate the biodiversity of a habitat, using the formula $D = 1 - (\Sigma\frac{n}{N})^2$ and state the significance of different values of D

ANNEXED: Terminology, units, symbols and presentation of data for biology

These terms will be used by Principal Examiners during the setting of papers. Learners should be made aware of the terminology during teaching and practical work.

1. Numbers

The decimal point will be placed on the line, e.g. 52.35.
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 whole numbers, e.g. 4 256 789.

2. Units

The International System of units will be used (SI units). Units will be indicated in the singular not in the plural, e.g. 28 kg.

(a) **SI 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
	micro-metre	µm
mass	tonne (1000 kg)	(no symbol)
	kilogram	kg
	gram	g
	milligram	mg
	microgram	g
time	year	y
	day	d
	hour	h
	minute	min
	second	s (not sec)
amount of substance	mole	mol
energy	**kilojoules**	**kJ**
(calorie is obsolete)	**joule**	**J**

(b) Derived SI units are listed below

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

area	hectare = 10^4 m2	ha
	square metre	m^2
	square decimetre	dm^2
	square centimetre	cm^2
	square millimetre	mm^2
volume	cubic kilometre	km^3
	cubic metre	m^3
	cubic decimetre (preferred to	dm^3
litre		
	litre	dm^3 (**not l**)
	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}

3. Presentation of data

(a) Tables

(i) Each column of a table will be headed with the physical quantity and the appropriate unit, e.g. time/s.

There are three acceptable methods of stating units, e.g. metre per second or m per s or m s-1.

(ii) The column headings of the table can then be directly transferred to the axes of a constructed graph.

(b) Graphs

(i) The independent variable should be plotted on the x-axis (horizontal axis) and the dependent variable plotted on the y-axis (vertical).

(ii) Each axis will be labelled with the physical quantity and the appropriate unit, e.g. time/s.

(iii) The graph is the whole diagrammatic presentation. It may have one or several curves plotted on it.

(iv) Curves and lines joining points on the graph should be referred to as 'curves'.

(v) Points on the curve should be clearly marked as crosses (×) or encircled dots (⊙). If a further curve is included, vertical crosses (+) may be used to mark the points.

(c) Pie Charts

These should be drawn with the sectors in rank order, largest first, beginning at 'noon' and proceeding clockwise. Pie charts should preferably contain no more than six sectors.

(d) Bar Charts

These are drawn when one of the variable is not numerical, e.g. percentage of vitamin C in different fruits. They should be made up of narrow blocks of equal width that do not touch.

(e) Column Graphs

These are drawn when plotting frequency graphs from discrete data, e.g. frequency of occurrence of leaves with different numbers of prickles or pods with different numbers of seeds. They should be made up of narrow blocks of equal width that do not touch.

(f) Histograms

These are drawn when plotting frequency graphs with continuous data, e.g. frequency of occurrence of leaves of different lengths. The blocks should be drawn in order of increasing or decreasing magnitude and they should be touching.

4. Taxonomy

Taxonomy is the study of the principles of the organisation of taxa into hierarchies. There are seven levels of taxon – kingdom, phylum, class, order, family, genus and species. These may be used when teaching the concept and use of a classificatory system, the variety of organisms, and the binomial system. The following should apply:

(a) Five Kingdoms are now recognised as

Prokaryotes (Prokaryotae), including bacteria and blue-green bacteria

Protoctists (Protoctista), including green, red and brown algae and protozoans

Fungi (Fungi)

plants(Plantae)

animals(Animalia)

The viruses cannot be fitted into this classificatory system.

(b) The binomial system of naming gives each organism a two-word name. The first word is the generic name and the second word is the trivial name, e.g. *Homo sapiens*. The trivial name should never by used by itself.

(c) Generic and trivial names are distinguished from the rest of the text either by underlining (when written or typed) or by setting in italics (in print).

(d) The generic name always takes an initial capital letter. It can be accepted as a shorthand for the species name where the intent is obvious, e.g. *Plasmodium*, and in these circumstances can stand alone.

(e) The common name should **not** normally be written with an initial capital letter, e.g. cat and dog. The exception is Man, where it is the common name for a species where the two sexes are distinguished by the terms man and woman.

(f) A species is not easy to define, but an acceptable general definition is as follows.

'A group of organisms capable of interbreeding and producing fertile offspring.'

5. Genetics

(a) The terms gene and allele are not synonymous.

A gene is a specific length of DNA occupying a position called a locus. A specific function can be assigned to each gene. An allele is one of two or more different forms of a gene.

(b) A standard form of presenting genetic crosses should be adopted. Thefollowing symbols should be used:
P designates the cross of pure-breeding (homozygous) individuals
F1 designates the offspring of homozygous parents
F2 designates the offspring produced by crossing F1 parents.

(c) The format for the course of a genetic cross should be labelled:
parental phenotypes
parental genotypes
gametes
offspring genotypes
offspring phenotypes, etc.

(d) The gene should be designated by a letter or letters so that upper and lower case versions are easily distinguishable, e.g. B and b.
The upper case letter indicates the dominant allele and the lower case letter indicates the recessive allele.

(e) The symbols for the genotypes of gametes should be circled to indicate the discrete nature of each gamete.

(f) Some form of checkerboard should be used to demonstrate genotypes that can result from random fusion of gametes. Learners should understand that genotypes are only possible combinations and that only a very large number of offspring can result in all combinations being achieved in the predicted ratio.

.(g) The term incomplete dominance should be discontinued and in the particular case where alleles are equally dominant it should be called co-dominance. Thus co-dominance should be used where the influence of both alleles is shown in the phenotype, e.g. the AB blood group in humans.

6. Terminology

(a) Wherever possible, English terms should be used in preference to Latin or Greek terms, e.g. the term red blood cell should be used and not erythrocyte.

(b) Generalised terms should be stated in English, e.g. small intestine.

(c) Where no suitable English terms exist, latinised terms are unavoidable and will need to be used, e.g. atrium, bronchus, villi.

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