BIOLOGY SYLLABUS S4-S6

FOR ASSOCIATE NURSING PROGRAM

Kigali, 2024

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FOREWORD

The Ministry of Education, through the Rwanda Basic Education Board (REB) has initiated the Associate Nursing Program at the second cycle of secondary education. The underlying principle behind the introduction of this program is to ensure that the curriculum responds to the needs of the learners, the society, and the labour market.

Biology is one of subjects of Associate Nursing Program that emphasizes on equipping the learners with required knowledge, skills, and attitudes and values required for high-quality nursing care. This aligns with Rwanda Vision 2050, which focuses on improving the country's socio-economic status through health care.

It is only the healthy people who can significantly play a major role in this socio-economic transformation journey. Biology subject teach the theories, principles, and procedures on which the nursing practice depends.

I extend my sincere appreciation to all those involved in developing this syllabus, especially the Ministry of Health in collaboration with REB, who coordinated the entire process from start to the end. Feedback and suggestions for future revisions of this syllabus are welcome.

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1. GENERAL INTRODUCTION

1.1. Background to the introduction of the Associate Nursing Program in secondary schools

For a long time, nursing education around the world has taken different steps from the traditional apprenticeship, vocational, and hospital-based training model to a higher education academic model of teaching and learning (Gaberson & Oemann, 2010). This paradigm shift was driven by the increased demand of the professionalization of nursing, the changing illness patterns, and the expansion of the knowledge-based society requiring more improved and innovative education preparation of nursing professionals that is adapted to the context and specific health needs (Yam, 2004).

In Rwanda, the above-mentioned transformations in nursing education evolved overtime. Healthcare education in general started in 1933 with medical assistants "Assistants Médicaux" program, followed by the assistant midwives "Auxiliaires accoucheuses" in 1949 (Harelimana, et., 2015). From 1954 up to 1979, there was the program at secondary level "A2 and A3". From 1979 to 2004, the program of nursing education was exclusively "A2" secondary level (Kabgayi School of Nursing and Midwifery, 2013). Nurses were mostly prepared for hospitals and health centers, leaving out the community. This gap was later addressed by the introduction of the Community Health Workers (CHWs) in 1995 (MoH, 2012).

The Cabinet resolution of October 27th, 2004 phased out the A2 nursing program. A transition period was decided upon to move from nursing program A2 to Nursing Program A1 up to 2007. The purpose of this was to train more nursing professionals at a tertiary level in order to produce highly-qualified professionals, thus improving quality health care service delivery. However, gaps in providing basic nursing care at different levels were continually observed.

Fourteen years later after the closure of the A2 nursing, the Government of Rwanda decided to introduce the Associate Nursing Program, as provided by Article 58 of the Rwandan Law Determining Organisation of Education No 10/2021 of 16/02/2021 (MoE, 2021).

Therefore, the Associate Nursing Program is being introduced to provide the support needed in basic nursing care provision, with the capacity to progress in different advanced health care professions. This decision aims at meeting the current and contextual health needs that present high demand at different levels of the Rwanda healthcare system, particularly in the community.

Therefore, nursing is based on science. The sciences like general chemistry, general biology (Biology, microbiology, human anatomy, physiology and nutrition) physics and mathematics are required by this Associate Nursing Program as prerequisites for cornerstone preparing at earlier age of the future nurses.

1.2. Associate nurse leaver's profile

Upon completion of the Associate Nursing Program, the learner should have acquired knowledge, skills and attitudes to:

1. Provide support to individuals, families and communities when faced with unwelcome news and life changing diagnoses;
2. Provide health education within her/his scope of practice;
3. Demonstrate understanding of the determinants of health that affect individuals, families, groups and communities;
4. Demonstrate understanding of basic common health conditions affecting individuals of all age groups and their basic nursing care;
5. Assess individuals, families, groups and community needs and provide basic nursing care using evidence-based practice;
6. Collaborate effectively with multidisciplinary team members, clients and stakeholders in provision of basic nursing care;
7. Demonstrate values of responsibility, accountability, commitment and patriotism in serving the nation.
8. Ensure the privacy, dignity and safety of individuals is maintained at all times;
9. Provide support on basic care in reproductive, maternal, neonatal and child health.
10. Explain scientific phenomena using correct scientific terminologies;
11. Demonstrate knowledge and skills required to progress to higher learning education;
12. Express themselves fluently, and with confidence, in speaking and writing using correct vocabulary and grammar appropriately;
13. Perform experiments using a range of scientific and medical tools and equipment and draw appropriate conclusions;

14. Demonstrate ability to manage data (collect, recording, processing, analysis, synthesis, reporting) and take appropriate decision.

2. TEACHING AND LEARNING BIOLOGY

2.1. Rationale of teaching and learning Biology

Biology is the study of life and plays a crucial role in our everyday existence. Biology has many applications, both in the natural environment and in health and education. Studying biology develops an understanding of living systems and of how to apply learning in direct ways to maintain the health of humans, animals and plants. Biology enables us to understand the relationships between living organisms and what is beneficial and what is harmful. Technological advances in new areas, such as DNA and genetics, have made this varied discipline more exciting than ever.

2.1.1. Biology and society

Biology is one of the natural science subjects and is an important discipline that has contributed significantly to the global environment. Biologists are at the forefront of genetic engineering and health transformation and a number of major developments in these areas are due to the discoveries of biologists. The work of biologists has led to new technologies in the production of small scale and industrial products that are beneficial to man and the environment. Application of the knowledge of biology is evident in medicine, pharmacy, agriculture, fisheries and food processing industries. In particular, biology has played a role in the harmonisation of man's needs with the conservation of nature and the environment.

Biology plays a role in the Rwandan ambition to:

- Develop a competence-based society.
- Promote science and technology competitiveness in regional and global job markets.
- Address the issues of lack of appropriate skills in the Rwandan education system.

2.1.2. Biology and learners

Biology is a worthwhile subject because it prepares students for the real world of work through career pathways such as medicine, agriculture, pharmacy, food science, environmental studies and many others. Biology provides skills that guide the construction of theories and laws that help to explain natural phenomenon and manage man and the environment. It provides answers for the problems faced by our modern society by empowering students to be creative, innovative and to use independent approaches to solve problems in unfamiliar situations.

2.2. Competences

A competence is the ability to perform a particular task successfully, resulting from having gained an appropriate combination of knowledge, skills and attitudes. The national policy documents, based on the national aspirations, identify 'Basic Competences' alongside the 'Generic Competences' that will develop higher order thinking skills. Basic Competences are addressed in the stated **broad subject competences** and in objectives highlighted on a year basis and in each of the units of learning. The selection of types of learning activities must focus on how learners are able to demonstrate such competences throughout and at the end of the learning process. A Generic Competence is a competence that is not specific to a particular subject or situation. Generic Competences are transferrable and applicable to a range of subjects and situations including employment.

The generic competences that must be emphasized and reflected in the learning process are briefly described below and teachers will ensure that learners are exposed to tasks that help the learners acquire the skills.

2.2.1 Generic competences

Critical thinking and problem-solving skills: The acquisition of such skills will help learners think imaginatively and broadly to evaluate and find solutions to problems encountered in all situations.

Creativity and innovation: The acquisition of such skills will help learners take initiative and use imagination beyond the knowledge provided to generate new ideas and construct new concepts.

Research: This will help learners find answers to questions based on existing information and concepts and to explain phenomena based on findings from information gathered.

Communication in official languages: Teachers, irrespective of not being teachers of language, will ensure the proper use of the language of instruction by learners. This will help learners communicate clearly and confidently and convey ideas effectively through speaking and writing and use the correct language structure and relevant vocabulary.

Cooperation, inter personal management and life skills: This will help the learner to cooperate with others in a team in whatever tasks are assigned and to practice positive ethical moral values and respect for the rights, feelings and views of others. Learners will perform practical activities related to environmental conservation and protection. They will also advocate for personal, family and community health, hygiene and nutrition and respond creatively to the variety of challenges encountered in life.

Lifelong learning: The acquisition of such skills will help learners to keep updating their knowledge and skills with minimum external support and to cope with the evolution of advances in knowledge for personal fulfilment in areas that need improvement and development.

2.2.2. Broad biology syllabus competences

The syllabus competences listed below describe the educational purposes of a course based on this syllabus. It outlines the educational context in which the syllabus content should be viewed. These competences are the same for all learners and are not listed in order of priority. Some of these competences may be delivered by the use of suitable local, international or historical examples and applications, or through collaborative experimental work.

Learners should be able to:

1. Stimulate learners and create a sustained interest in Biology so that the study of the subject is enjoyable and satisfying.
2. Provide, through well-designed studies of experimental and practical biological science, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level. In particular, it should enable them to:

- Become confident citizens in a technological world, with an informed interest in scientific matters.
- Recognise the usefulness, and limitations, of scientific method and its application in other subjects and in everyday life.
- Be suitably prepared for studies in biological science beyond the Rwandan Advanced Level, in further or higher education, and for professional courses.

3. Develop abilities and skills that:
   - Are relevant to the study and practice of biological science.
   - Are useful in everyday life.
   - Encourage efficient and safe practice.
   - Encourage effective communication using universal scientific conventions.
   - Protect themselves against common illnesses and fatal diseases including HIV/AIDS and malaria.
4. Develop attitudes and values relevant to biological science such as:
   - A concern for accuracy and precision, objectivity, integrity, a spirit of enquiry, initiative, and inventiveness.
   - Advocate for personal, family and community health, hygiene and nutrition.
   - Peace and tolerance, justice, respect for others and for human rights, solidarity and democracy, patriotism, hard work, commitment, resilience and dignity.
5. Stimulate interest in, and care for, the local and global environment and help learners to understand the need for conservation.
6. Promote an awareness that:
   - Scientific theories and methods have developed, and continue to develop, as a result of groups and individuals working together, and that biological science overcomes national boundaries.

- The study and practice of biology is affected and limited by social, economic, technological, ethical and cultural factors.
- The applications of biological science may be both helpful and harmful to the individual and the community.
- Demonstrate awareness and concern for the environment, conservation and sustainability and act accordingly.
- The use of information technology is important for communication, as an aid to experiments and as a tool for interpreting experimental and theoretical results.

7. Use and experiment with a range of scientific and technological tools and equipment and draw appropriate conclusions.
8. Use ICT skills effectively to enhance learning and communication.

2.2.3. Biology and developing competences

These basic competences alongside the generic competences are stated in such way that will develop higher order thinking skills and will help subject learning and the application of what has been learnt in real life situations. Through experimentation, observations and presentation of information during the learning process, the learner develops not only deductive and inductive skills but also communication, critical thinking and problem-solving skills in trying to make inferences and conclusions.

The manipulation of numerical and other data, doing practical experiments and undertaking project assignments involves not only analytical and problem-solving skills, but also innovation, creativity and research. Group work and cooperative learning of Biology promote interpersonal relations and teamwork.

2. 3. Pedagogical approaches

Learners learn best when they are actively involved in the learning process through a high degree of participation, contribution and production.

At the same time, each learner is an individual with their own needs, pace of learning, experiences and abilities. Teaching strategies must therefore be varied but flexible within well-structured sequences of lessons. Learner-centred education does not mean that the

teacher no longer has responsibility for seeing that learning takes place.

2.3.1. Role of the learner

The activities of the learner are indicated against each learning unit and they all reflect appropriate engagement of the learner in the learning process.

The teaching and learning processes will be tailored towards creating a learner friendly environment based on the learner's capabilities, needs, experience and interests.

The learning activities will be organised in a way that encourages learners to construct knowledge either individually or in groups in an active and engaging way.

Learners work on one-unit competence at a time in the form of concrete units with specific learning outcomes broken down into knowledge, skills and attitude.

In practical lessons learners will work in groups where the availability of the apparatus will not permit working individually. They will also be encouraged to do simple project work individually.

2.3.2. Role of the teacher

The competence-based curriculum is about transforming learning and ensuring that learning is deep, enjoyable and habit- forming.

Teachers ought to shift from the traditional method of instruction to that of a facilitator in order to value the individual needs and expectations of learners.

The teacher must identify the needs of the learners, the nature of the learning to be done, and the means to shape the learning experiences accordingly.

A Teacher's role is to organise the learners, both in the classroom or outside, and engage them through participatory and interactive methods through the learning processes as either individuals, in pairs or in groups. This ensures that learning is personalised, active, participative, and co-operative.

The teacher will design and introduce tasks to the class to perform or for immediate discussion. The role of the teacher will be to guide the learners in constructing their own knowledge.

Learners are taught how to use textbooks and other resource materials in different ways for example to search for and make use of information in writing their own notes.

The teacher must select and develop appropriate materials such as teaching models, or charts, for the learners to use in their work.

In practical lessons, the teacher will first demonstrate the handling of the apparatus and the show the way the experiment should be carried out before exposing to the learners, as the task that can be dangerous if not performed correctly.

The teacher ought to demonstrate how to mix the reagents in the correct proportions before leaving the learners to do it on their own.

The teacher must devise remedial strategies, both in and outside the classroom, to address the issue of low achievers and those with learning difficulties. The teacher must ensure these learners keep pace with the rest of the group in acquiring the required competences.

2.3.3. Special needs education and inclusive approach

All Rwandans have the right to access education regardless of their different needs. The underpinnings of this provision would naturally hold that all citizens benefit from the same menu of educational programs. The possibility of this assumption is the focus of special needs education. The critical issue is that we have persons/ learners who are totally different in their ways of living and learning as opposed to the majority. The difference can either be emotional, physical, sensory and intellectual learning challenged traditionally known as mental retardation.

These learners equally have the right to benefit from the free and compulsory basic education in the nearby ordinary/mainstream

schools. Therefore, the schools' role is to enrol them and also set strategies to provide relevant education to them. The teacher therefore is requested to consider each learner's needs during teaching and learning process. Assessment strategies and conditions should also be standardised to the needs of these learners. Detailed guidance for each category of learners with special education needs is provided for in the guidance for teachers.

2.4. ASSESSMENT APPROACH

Assessment evaluates the teaching and learning methods through the collection and interpretation of evidence of individual learner's progress in learning and makes a judgment about the learner's achievements measured against a set of defined standards. Assessment is an integral part of the teaching learning processes. In the new competence-based curriculum assessment must also be competence-based. The learner is given a complex situation related to his/her everyday life and asked to try to overcome the situation by applying what he/she learned.

Assessment will be organised at the following levels: school-based assessment, district based examinations, national based assessment and examinations.

2.4.1. Types of assessment

a) Formative and continuous assessment (assessment for learning)

Continuous assessment involves formal and informal methods used by schools to check whether learning is taking place. When a teacher is planning his/her lesson, he/she should establish criteria for performance and behavioural changes at the beginning of a unit. At the of end of every unit, the teacher should ensure that all the learners have mastered the stated key unit competences based on the criteria stated before going to the next unit. The teacher will assess how well each learner masters both the subject content and the generic competences described in the syllabus. From this, the teacher will gain a picture of the all-round progress of the learner. The teacher will use one or a combination of the following: (a) observation (b) pen and paper (c) oral questioning and tests during or at the end of one or more learning units.

b) Summative assessment (assessment of learning)

When assessment is used to record a judgment of the competence or performance of the learner, it serves a summative purpose. Summative assessment gives a picture of a learner's competence or progress at any specific moment. The main purpose of summative assessment is to evaluate whether learning objectives have been achieved and to use the results for the ranking or grading of learners. The results of summative assessment are also used for deciding on progression, for selection into the next level of education and for certification. This assessment should have an integrative aspect whereby a student must be able to show mastery of all competences.

Summative assessment can be internally school based assessment or external assessment in the form of national examinations. School based summative assessment should take place once at the end of each term and once at the end of the year. School summative assessment average scores for each subject will be weighted and included in the final national examinations grade. School based assessment average grade will contribute a certain percentage as teachers gain more experience and confidence in assessment techniques. In the third year of the implementation of the new curriculum it will contribute 10% of the final grade, but will be progressively increased. Districts will be supported to continue their initiatives to organize a common test per class for all the schools to evaluate the performance and the achievement level of learners in each individual school. This is the comprehensive assessment that takes place at all levels of studies. This subject will be part of the External National Examination. External summative assessment will be done at the end of S6 and this will be for both theory and practical examination.

2.4.2. Record keeping

This is gathering facts and evidence from the assessment instruments and using them to judge the learner's performance by assigning an indicator against the set criteria or standard. Assessment procedures generate data in the form of scores which will be carefully recorded and stored in a portfolio. These scores will contribute to remedial actions and alternative instructional strategies. They will also be used to provide feedback to the learner and their parents to check learning progress and to provide advice, as well as be used in the final assessment of the learners.

This portfolio is a folder (or binder or even a digital collection) containing the learner's work as well as the learner's evaluation of the strengths and weaknesses of the work. Portfolios reflect not only work produced (such as papers and assignments), but also it is a record of the activities undertaken over time as part of student learning. The portfolio output (formative assessment) will

be considered only as enough for three years of the Advanced level. It will serve as a verification tool for each learner that he/she attended the whole learning before he/she undergoes the summative assessment for the subject.

2.4.3. Item writing in summative assessment

Before writing a question paper, a plan or specification of what is to be tested or examined must be created. This will show the units or topics to be tested on, the number of questions in each level of Bloom's taxonomy and the marks allocation for each question. In a competence-based curriculum, questions from higher levels of Bloom's taxonomy should be given more weight than those from the knowledge and comprehension level.

Before developing a question paper, the item writer must ensure that the test or examination questions are tailored towards competence-based assessment by doing the following:

- Identify topic areas to be tested on from the subject syllabus.
- Outline subject-matter content to be considered as the basis for the test.
- Identify learning outcomes to be measured by the test.
- Prepare a table of specifications.
- Ensure that the verbs used in the formulation of questions do not require memorisation or recall answers only but test for broad competences as stated in the syllabus.

2.4.4. Structure and format of the examination

There will be three papers in Biology subject at advanced level. Paper 1 measures knowledge and understanding, paper 2 measures skills from higher levels of Bloom's taxonomy and paper 3 will measure practical/experimental skills. Time will depend on the paper's items, weight of the paper and learner's special education needs.

Paper	Component	Weighting
Paper 1	The paper will measure both knowledge of the subject matter and acquisition of competences. The paper will assess the first two (low) levels of Bloom's taxonomy, which is Knowledge and understanding. (100marks)	30%
Paper 2	The paper will assess skills, it will consist questions from higher levels of Bloom's taxonomy (application, analysis, evaluation and synthesis). (100marks)	40%
Paper 3	Practical skills: This paper to measures practical/experimental skills (Observation, Recording & report writing, Manipulation, Measurement, Planning & designing) The experiments should be drawn from different topic areas of the syllabus. This paper requires candidates to carry out practical work in a set period of time. (100marks) drawn from different topic areas of the syllabus. This paper requires candidates to carry out practical work in a set period of time. (100marks)	30%

Assessment of Subject objectives (AO)

The assessment objectives listed below reflect those parts of the syllabus competences that will be assessed in the examination.

AO1: Knowledge with understanding

- Scientific vocabulary, terminology and conventions (including symbols, quantities and units).
- Scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety.
- Scientific quantities and their determination.

Candidates should be able to demonstrate knowledge and understanding of:

- Scientific phenomena, facts, laws, definitions, concepts and theories.
- Scientific and technological applications and their social, economic and environmental implications.
- The subject content defines the factual knowledge that candidates may be required to recall and explain.

Questions testing these assessment objectives will often begin with one of the following words: *define, state, name, describe, explain (using your knowledge and understanding) or outline.*

AO2: Handling information and solving problems

Candidates should be able to handle information and solve problems using, written, symbolic, graphical and numerical forms of presentation to:

- Locate, select, organise and present information from a variety of sources.
- Translate information from one form to another.
- Manipulate numerical and other data.
- Use information to identify patterns, report trends and draw conclusions.
- Give reasoned explanations for phenomena, patterns and relationships.
- Make predictions and hypothesises.
- Apply knowledge, including principles, to new situations.
- Demonstrate an awareness of the limitations of biological theories and models.
- Solve problems.

These assessment objectives cannot be precisely specified in the syllabus content because questions testing such skills may be based on information which is unfamiliar to the candidate. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, reasoned or deductive manner to a new situation.

Questions testing these assessment objectives will often begin with one of the following words: *discuss, predict, suggest, calculate, and explain (give reasoned explanations and explain the processes of using information and solving problems) or determine.*

AO3: Experimental skills and investigations

Candidates should be able to:

- Plan experiments and investigations.
- Collect, record and present observations, measurements and estimates
- Analyse and interpret data to reach conclusions.
- Evaluate methods and the quality of data and suggest possible improvements.

2.5. Reporting to parents

The wider range of learning in the new curriculum means that it is necessary to think again about how to share a learners' progress with their parents. A single mark is not sufficient to convey the different expectations of learning which are in the learning objectives. The most helpful method of reporting is to share what students are doing well and where they need to improve.

2.6. Resources

2.6.1. Material resources

Teaching and learning of Biology necessitates practical activities and experiments for better understanding of facts. The successful implementation of this curriculum requires a Biology laboratory, textbooks, charts and ICT tools like computers and projectors. However, there are some Biology concepts that cannot be easily explained and some experiments that cannot be done in our school laboratories due to their nature or safety reasons. Thus, the syllabus provides the opportunities to use ICT while studying to overcome concepts that cannot be well understood. The learners need to be confident and effective users of ICT.

These ICT opportunities include:

- gathering information from the internet, DVDs and CD-ROMs,
- gathering data using sensors linked to data –loggers or directly from the computers,
- using spreadsheets and other software to process data,
- using animations and simulations to visualise scientific data,
- using software to present ideas and information on paper and on screen

The list of basic materials and apparatus that a well-equipped Biology laboratory would contain is found in the appendix (**7a**). This list is not exhaustive other items may be required to allow for variety in the questions set.

2.6.2. Human resources

The effective implementation of this curriculum requires a joint collaboration of educators at all levels. Given the material requirements, teachers are expected to accomplish their noble role as stated above.

The following are detailed skills required for secondary school Biology teacher:

- Animated and engaging personality, patient and tolerant attitude, passion for sharing knowledge, excellent verbal and written communication abilities, creativity and diverse methodologies for imparting ideas and knowledge.
- Knowledge of educational software, programs for recording, grading, and evaluating students' work and progress.
- Ability to use a range of teaching tools for example, overhead projectors and other media-sharing devices. Proficiency with biology and lab experiment equipment, for example microscopes and slides.Proficient in Biology, able to motivate students and keep the classroom on task, a passion for life sciences and working with students, and proficient in the use and implementation of the latest technologies and tools.

3. SYLLABUS UNITS

3.1. Presentation of the structure of the syllabus

The subject of biology is taught and learned in upper secondary education as a core subject, i.e. in S4, S5 and S6 respectively. At every grade where it is taught, the syllabus of biology for upper secondary is structured in the following eight (8) topic areas: biodiversity and classification, ecology and conservation, organization and maintenance of life, reproduction, microbiology and biotechnology, health and disease, genetics and its applications, and selection and evolution. Topic areas are subdivided into sub-topic areas, and sub-topic areas are made up of 55 units: 20 in S4, 18 in S5 and 17 in S6. Each unit has the following common components:

- Each unit is aligned with the periods or number of lessons.
- Each unit has a key unit competence whose achievement is pursued by all teaching and learning activities undertaken by both the teacher and the learners.
- Each unit key competence is broken into three types of Learning Objectives as follows:

Type I: Learning Objectives relating to Knowledge and Understanding (Type I Learning Objectives are also known as Lower Order Thinking Skills or LOTS)

Type II and Type III: These Learning Objectives relate to the acquisition of Skills, Attitudes and Values (Type II and Type III Learning Objectives are also known as Higher Order Thinking Skills or HOTS). These Learning Objectives are actually considered to be the ones targeted by the present reviewed syllabus.

- Each unit has content that indicates the scope of coverage of what should be taught and learnt in line with stated Learning Objectives.

Each unit suggests learning activities that are expected to engage learners in an interactive learning process as much as possible (learner-centred and participatory approach).

- Finally, each unit is linked to other subjects, its Assessment criteria and the materials (or resources) that are expected to be used in the teaching and learning process.

3.2. Biology programme for S4

3.2.1. Key competences at the end of S4

- Explain how diversity is threatened by climate change and human activities.
- Apply the basic knowledge of classification to group living organisms into the three domains.
- Distinguish between the types of microscopy and their main uses.
- Describe the structure and function of cells in an organism.
- Describe different specialised plant and animal cells and adaptation of tissues.
- Use tests for biological molecules in a variety of contexts, such as identifying the contents of mixtures of molecules and following the activity of digestive enzymes.
- Explain the important roles of carbohydrates and lipids in the provision and storage of energy and for a variety of other functions.

- Describe how protein structure is related to function and the role of water as a special molecule with extraordinary properties that make life possible.
- Discuss the roles of minerals and vitamins in diet.
- Describe the mode of action and factors affecting enzymes and their importance for the existence of life.
- Explain the principles of gaseous exchange systems.
- Describe structures of gaseous exchange organs in plants.
- Account for the processes of growth and development in plants and animals.
- Explain and demonstrate modes of locomotion in protists, insects, fish, amphibians, birds and mammals.
- Describe the social factors that affect good health and apply knowledge gained in familiar and unfamiliar contexts.
- Account for various methods of asexual reproduction as means of increasing crop yield.
- Describe sexual reproduction in plants.
- Describe the structure and characteristics of viruses, bacteria, and fungal and non-fungal moulds.
- Explain the process of culturing microorganisms and the factors affecting their population growth.
- Explain the biotechnology involved in production of ethanol, biogas and bread making.

3.2.2. Biology units Table for S4

TOPIC AREA: BIODIVERSITY AND CLASSIFICATION		SUB-TOPIC AREA: BIODIVERSITY		
S4 Biology		**Unit 1: Introduction to biodiversity.**		**No. of periods:7**
Key Unit Competence: Explain how diversity is threatened by climate change and human activities.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Define the terms: species, ecosystem and niche. – Explain that biodiversity is considered at three different levels: • Variation in ecosystems or habitats. • The number of species and their relative abundance.	– Use suitable survey methods to assess the distribution and abundance of organisms in a local area. – Use Spearman's rank correlation and Pearson's linear correlation to analyse the relationships between the distribution and abundance ofspecies and abiotic or biotic factors.	- Acknowledge that Biodiversity is much more than a list of all the species in a particular area. - Recognise that the biodiversity of the Earth is threatened by human activities and climate change. - Appreciate that fieldwork is an important part of a biological education.	- Species. - Ecosystem. - Niche. - Biodiversity: • Variation in ecosystems or habitats. • Number of species and their relative abundance. • Genetic variation within each species. - Importance of random sampling in determining the biodiversity of an area. - Use of suitable methods, such as frame quadrats, line transects, and belt transects to assess the	- Use suitable methods, such as frame quadrats, line transects, belt transects, to assess the distribution and abundance of organisms in a local area. - Use Spearman's rank correlation and Pearson's linear correlation to analyse the relationships between the distribution and abundance of species and abiotic or biotic factors.

• Genetic variation within each species. – Explain the importance of random sampling in determining the biodiversity of an area.	– Apply Simpson's Index of Diversity. – Evaluate the effects of human population size, resource use, and technology on environmental quality. – Evaluate the consequences of loss of biodiversity. – Characterise the biotic and abiotic components that define Rwanda's ecosystems (e.g., freshwater, marine, and terrestrial).	– To appreciate diversity and find out how to analyse it.	distribution and abundance of organisms in a local area. – Spearman's rank correlation and Pearson's linear correlation to analyse the relationships between the distribution and abundance of species and abiotic or biotic factors. – Simpson's Index of Diversity (D) to calculate the biodiversity of a habitat, using the formula: $1-(\sum \left(\frac{n}{N}\right)^2)$ D=	- Apply Simpson's Index of Diversity (D) to calculate the biodiversity of a habitat, using the formula: D= $1-(\sum \left(\frac{n}{N}\right)^2)$ and state the significance of different values of D. – In groups, students evaluate the consequences of loss of biodiversity in either terrestrial or aquatic habitats. – Individually characterise the biotic and abiotic components that define Rwanda's ecosystems (e.g. freshwater, marine, and terrestrial).
Links to other subjects: *Geography: abiotic and biotic factors.*				
***Assessment criteria**: Learners clearly explain how the Earth's biodiversity is threatened by climate change and human activities.*				
***Materials:** Frame quadrats, long 50 m tape measures and rope or string, sweep nets, graph charts for populations, simulations and computer animations.*				

TOPIC AREA: BIODIVERSITY AND CLASSIFICATION		SUB-TOPIC AREA: CLASSIFICATION OF LIVING THINGS		
S4 Biology	**Unit 2:** Introduction to classification.			**No. of periods:21**
Key Unit Competence: Apply the basic knowledge of classification to group living organisms into the three domains.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the classification of species into the taxonomic hierarchy of domain, kingdom, phylum, class, order, family, genus and species. – Outline the characteristic features of the three domains Archaea, Bacteria and Eukarya. – Identify common bacterial diseases in plants and animals.	– Demonstrate the role of bacteria in the production of dairy products. – Demonstrate methods of preventing common bacterial diseases. – Design and apply a dichotomous key for a group of organisms.	– Support the concept that microorganisms can survive in hot springs.	– The taxonomic hierarchy: domain, kingdom, phylum, class, order, family, genus and species. – Three domains: archaea, bacteria and eukarya. Focus on structure, characteristics, types and economic importance. – Common bacterial diseases in plants and animals and methods of prevention.	– Use computer simulations and prepared slides to discuss characteristics, structure and economic importance of living organisms. – Use of illustrations to discuss types of bacteria.

– Outline the characteristic features of the kingdoms Protoctista, Fungi, Plantae and Animalia. – Explain why viruses are not included in the three domain classification. Outline how they are classified: limited to type of nucleic acid and whether these are single stranded or double stranded.	– Draw and label the structure of bacteria.		– Characteristic features of the kingdoms: Protoctista, Fungi, Plantae and Animalia – Classification of viruses. – Dichotomous keys.	– Carry out a field study trip to a site of production to study the economic importance of bacteria. – Learners observe collected organisms and construct dichotomous keys.
Links to other subjects: Agriculture: dairy processing.				
Assessment criteria: The basic knowledge of classification to group living organisms into the three domains.				
Materials: Computer aided study materials, prepared bacterial cultures, microscopes, incubator, fridge, and computer simulations.				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: CELL STRUCTURE	
S4 Biology	**Unit 3:** Microscopy.			**No. of periods:**14
Key Unit Competence: Distinguish between the types of microscopy and their principal uses.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the main features and functions of the components of a compound light microscope. – State that magnification is the increase in the apparent size of the object. – State that resolution is the ability of the microscope to show two objects as separate.	– Use of a microscope to determine the relationship between actual size of the specimen and the image. – Observe and draw biological specimens under a light microscope. – Manipulate a compound light microscope to observe prepared slides.	– Appreciate the importance of magnifying instruments in Biology. – Show perseverance when using light microscopes. – Pay attention when using a compound light microscope to avoid damage to the lenses, mirrors and slides.	– Compound light microscope. – Functioning of a compound light microscope. – Magnification and resolution of a compound light microscope. – Calculation of magnification. – Electron microscopes.	– Measure and calculate the magnification of different specimens provided. – Determine the actual size of specimens and micrographs given magnification or vice versa. – Observe microscopic organisms on prepared slides, draw and label the parts visible with a light microscope.

– State the advantage of using a light microscope. – State the principles and limitations of TEM (Transmitted Electron Microscopy). – State the advantages and disadvantages of using SEM (Scattered Electron Microscopy).	– Prepare temporary slides for observation under light microscopes using different objective lenses. – Calculate the approximate size of different biological structures using an appropriate unit of measurement. – Compare light and electron microscopes.	– Acknowledge the use of electron microscopes in modern science with reference to electron micrographs.	– Transmission electron microscopes (TEM) and scanning electron microscopes (SEM).	– Make temporary preparations of slides of epidermis of onions, young stems and roots for light microscopy by fixing, staining and mounting. Observe under low and high power. – Draw diagrams and label them. – Make a group presentation about the differences between a compound light microscopes and electron microscopes outlining the advantages of each.
Links to other subjects: Physics: optics. Mathematics: enlargement and measurements..				
Assessment criteria: Students can use a compound light microscope to observe biological specimens.				
Materials: Compound light microscopes, electro micrographs of prepared slides of microscopic specimens, stains, and cover slides				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: CELL STRUCTURE	
S4 Biology	**Unit 4:** Cell structure and specialization			**No. of periods:**14
Key Unit Competence: Describe the structure and function of cells in an organism.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Identify plant and animal cell structures visible under a light microscope. – State functions of cell structures as seen under an electron microscope. – Describe the nature of artefacts. – Discuss the importance of freeze fracturing for examining membrane structure.	– Prepare temporary slides for: *Wandering Jew*, in plants and cheek cells in animals. – Adopt the standard preparation procedure in slide preparation to avoid artefacts. – Observe and draw plant and animal cells under a light microscope.	– Appreciate the importance of a cell in an organism. – Show resilience and be aware of artefacts when preparing temporary slides. – Acknowledge the use of an electron microscope in modern science with reference to electron micrographs.	– Structure of plant and animal cell as seen under a light microscope. – Ultra structure of plant and animal cells. – Functions of organelles and their interrelationships. – Differences between ultra-structure of plant and animal cells. – Revealing the ultra-structure of cells. – Functions of cell membranes. – Fluid mosaic model of a cell membrane.	– Make temporary preparations of slides of leaves or stems of *Wandering Jew*, *Oxalis latifolia,* and cheek cells for microscopy by fixing, staining and mounting. Observe and draw under low and high power. – In groups, present the comparisons between prokaryotic and eukaryotic cells with reference to charts and diagrams. – Teacher guides learners to devise an experiment on estimating the size of a cell.

– Explain how cell organelles can be isolated by cell fractionation. – List the functions of cell membranes. – Describe the fluid mosaic structure of cell membranes. – Explain the role of the different components of a cell membrane. – Explain cell specialisation as the differentiation of a cell or process to do a particular function.	– Manipulate a compound light microscope to observe prepared slides of plant and animal cells. – Distinguish between ultra-structures of plant cells and animal cells. – Compare prokaryotic and eukaryotic cells. – Interpret charts and micrographs to relate the structure of specialised cells to their functions.	– Commit to an experiment until results are obtained. – Appreciate the importance of cell specialisation in multicellular organisms.	– Roles of different components of cell membranes. – Prokaryotic and eukaryotic cells. – Specialised animal cells limited to epithelial cells, blood cells, nerve cells, smooth muscle fibre, reproductive cells, animal pigment cells, flame cells, and nematocysts. – Specialised plant cells limited to palisade cells, parenchyma cells, guard cells and root hair cell.	– Students discuss the structure of plasma membranes using micrographs and animations and relate their components to their functions. – Using charts and micrographs, relate the structure of specialised cells to their functions.
Links to other subjects:				
Assessment criteria: Students can describe the structure and functioning of a cell.				
Materials: Compound light microscope, prepared slides, plant tissues, cheek cells, electro micrographs and charts, slides, stains, and mounting liquids for slide preparation.				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: HISTOLOGY	
S4 Biology	**Unit 5:** Diversity of specialize tissues			**No. of periods:14**
Key Unit Competence: Describe different specialize plant and animal cells and adaptation of tissues.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Define a tissue as a group of cells with similar structure working together for a particular function. – Name the main types of animal and plant tissues. – Define an organ as a structure made up of a group of tissues with related functions working together to perform bodily functions. – Explain how epithelial tissues have adapted to perform a diversity of functions in the body.	– Observe and draw plant and animal tissues under a light microscope. – Analyse and categorize tissues – Develop research spirit using internet to find out categories of tissues	– Acknowledge the relationship between levels of organization. – Recognize the efficiency shown by multicellular organisms to explore more modes of life that are not available to single celled organisms that show little or no specialization.	– Plant tissues: parenchyma tissues, xylem tissue, phloem tissue, sclerenchyma and collenchyma tissue. – Animal tissues: connective and skeletal tissue. – Functions and adaptations of epithelial tissues. – Levels of organisation: cell, tissue organ, and system. – Advantages and disadvantages of being unicellular.	– Using prepared slides and microscopes, observe, identify and draw plant and animal tissues. – Carry out research from the library or internet on categories of animal tissues. – In groups, discuss and present how epithelial tissues have adapted to their functions.

– State the advantages and disadvantages of being unicellular. – State the advantages of being multicellular.			– Advantages of the multicellular state of an organism.	
Links to other subjects:				
Assessment criteria: Students can describe the specialisation of plant and animal cells and adaptation of tissues.				
Materials: Staining reagents like iodine solution, acidified phloroglucinol, methylene blue, plant tissues, microscopes, slides, cheek cells, plastic ruler graduated in millimetres, and prepared slides of cells and tissues				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: TRANSPORT IN ANIMALS.	
S4 Biology	**Unit 6:** The Circulatory System.			**No. of periods:14**
Key Unit Competence: Relate the structures of the circulatory and lymphatic systems to their functions.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain the need for a transport system in animals. – Explain the advantages and disadvantages of different types of circulatory systems. – Describe the external and internal structure of a mammalian heart. – Explain how a heartbeat is initiated.	– Carry out an investigation on the effects of exercise on the pulse rate and blood pressure. – Distinguish between open and closed, single and double circulation with reference to insects, earthworm, fish and mammals.	– Appreciate the importance of the need for transport systems when animals become larger, more complex and more active, to supply nutrients to, and remove waste from, individual cells.	– The need for transport system in animals. – The blood circulatory system (advantages and disadvantages of open and closed, single and double circulatory systems) in insects, annelids, fish and mammals. – Internal and external structure of the mammalian heart. – Initiation of a heart beat. – Mammalian cardiac cycle. – Control of the heart rate:	– In pairs, investigate and state the effect of physical activity on the pulse rate and blood pressure. – Individually, describe the events that occur during a heartbeat. – Conduct dissections to indicate the major structures of the circulatory systems in insects and mammals. – Observe prepared slides of blood vessels using a microscope and make comparisons.

– Describe the main events of the cardiac cycle. – Explain the relationship between the structure and function of blood vessels. – Explain how blood circulation is controlled. – Describe the effects of exercise on respiration and on circulation. – Describe the process of blood clotting. – Recall the structure of haemoglobin and explain how haemoglobin transports oxygen.	– Recognise blood vessels from their structures using a light microscope. – Relate the structure of blood vessels to their functions. – Differentiate between blood, tissue fluid, and lymph. – Relate blood as a tissue to its functions. – Interpret oxygen. dissociation curves for haemoglobin and other respiratory pigments.	– Recognise possible risk factors as diet, stress, smoking, genetic predisposition, age and gender in relation to cardio vascular diseases.	• Nervous control. • Hormonal control: adrenalin and acetylcholine. • Other factors controlling heart rate: pH, carbon dioxide, temperature, and mineral ions. – Effect of drugs, physical activity and temperature on cardiac frequency. – Structure of blood vessels. – Blood and its functions. – Lymphatic system. – Carriage of respiratory gases by red blood cells. – Oxygen dissociation curve. – Common cardio vascular diseases.	– Use computer simulations to observe the initiation of a heart beat and the cardiac cycle. – Observe a blood smear and draw the structure of blood cells. – Observe and make plan diagrams of the structure of blood vessels. – Individually complete a flow chart for the pathway of blood through the heart. – Use illustrations, simulations and charts to discuss the carriage of respiratory gases and oxygen dissociation curves. – Use computer simulations to discuss the relationship between blood, tissue fluid and lymph.

– Explain how tissue fluid and lymphs are formed. – Describe the risk factors associated with cardiovascular diseases.				– In groups, research cardiovascular diseases and possible risk factors and present to the class.
Links to other subjects: Physics: blood pressure is linked to hydraulic pressure.				
Assessment criteria: Students can correctly relate the structures of the circulatory and lymphatic systems to their functions.				
Materials: Light microscope, prepared slides, charts and graphs of the cardiac cycle, micrographs for components of the circulatory cycle, sphygmomanometer and computer animations of the blood circulatory system.				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: SUPPORT AND LOCOMOTION	
S4 Biology	**Unit 7:** Skeletons, muscles and movement.			**No. of periods:14**
Key Unit Competence: Explain the structure of muscles in relation to movement.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the three main types of animal skeletons. – Discuss the functions of skeletons. – State and discuss the advantages and disadvantages of exoskeletons. – Describe the main types of mammalian muscles.	– Compare hydrostatic skeletons, exoskeletons and endoskeletons. – Relate the structure of a motor end plate to its function. – Interpret the ultrastructure of striated muscle with particular reference to the sarcomere structure.	– Adopt the practice of playing sport to develop healthy muscles and bones. – Appreciate the role of joints and muscles in bringing about movement.	– Types of animal skeletons: hydrostatic, exoskeleton and endoskeleton. – Types of muscles (cardiac, smooth and skeletal muscle). – Vertebrate joints and locomotion: structure of joints and types of joints (fibrous,cartilaginous, and synovial). – Ultrastructure and functioning of striated muscle. – The sliding filament theory of muscle contraction.	– Observe earthworms and insects to compare a hydrostatic skeleton and exoskeleton respectively. – Learners use prepared slides of the three types of muscles and compare their characteristics. – Learners dissect a frog/ toad heart and observe myogenic contraction. – Use prepared slides and micrographs to compare structures of cardiac, smooth and skeletal muscles.

– Describe the ultrastructure of striated muscles with particular reference to the sarcomere structure. – Explain the sliding filament model of muscle contraction, including the roles of troponin, tropomyosin, calcium ions and ATP. – Explain the role of antagonistic muscles in a joint. – Describe the features of a synovial joint.	– Compare the structure of cardiac, smooth and skeletal muscle. – Distinguish between slow- twitch and fast- twitch fibres. – Demonstrate the structure and function of the sarcomere. – Demonstrate the laws of muscle contraction. – Illustrate the sliding filament model of muscular contraction. – Distinguish between temporal summation and muscle fibre recruitment.			– Use diagrams to discuss the structure of different types of joints. – In pairs, students observe others bicep muscles and write their observations (shortening and thickening of the antagonistic muscles). – Learners research the structure of the motor end plate using the internet or library. – Use of computer aided simulations to demonstrate the structure and functioning of the sarcomere during muscle contraction with reference to sliding filament theory. – Use of computer aided simulations to demonstrate the laws of muscle contraction (all or nothing, temporal summation and muscle fibre recruitment).

– Explain the function of a motor unit/ neuromuscular junction/motor end plate.				
Links to other subjects: Physics: joints are linked to levers.				
Assessment criteria: Learners can explain the structure of muscles in relation to movement.				
Materials: Illustrations, earthworms and computer aided study materials.				

TOPIC AREA: REPRODUCTION			SUB-TOPIC AREA: REPRODUCTION IN ANIMALS	
S4 Biology	**Unit 8:** Human reproduction.			**No. of periods:14**
Key Unit Competence: Explain the role of hormones in human reproduction, stages of pregnancy and foetal development.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the main events of the menstrual cycle. – Explain how hormones interact to regulate the menstrual cycle. – Describe how mammals mate. – Explain how a sperm enters and fertilises an ovum and how only one sperm fertilises an ovum.	– Distinguish between an oestrous and menstrual cycle. – Interpret graphs of physical and hormonal changes involved in the menstrual cycle. – Demonstrate the role of hormones to the changes in the ovary and uterus during the menstrual cycle. – Distinguish between a human embryo and foetus.	– Recognise the ethical implications of in-vitro fertilisation. – Show concern for the biological, social and ethical implications of the use of contraception. – Advocate for family planning methods as effective tools for controlling human population growth.	– The menstrual cycle in humans. – Copulation, fertilisation and foetal development. – Role of placenta in the development of an embryo. – Physiological changes in females during pregnancy. – Gestation period and birth. – Parental care. – Twins and multiple births. – Infertility and in-vitro fertilisation. – Family planning and contraceptive methods. – Causes and prevention of STIs and HIV.	– Using flow-charts, diagrams and information collected in advance (from the library or internet), learners interpret the activity of hormones in the maintenance of the menstrual cycle. – Watch a simulation of the stages that bring about the fertilisation and development of an embryo. – Using a diagram of the placenta, learners discuss its structure related to its functions.

				– Using models that show stages, learners discuss physiological, physical, and behavioural changes during pregnancy. – Using the internet or the library, learners research in-vitro fertilisation and present their findings to class. Learners then discuss the ethical implications. – Watch a movie or simulation on the stages of birth. – Learners brainstorm the social and economic consequences of barrenness and producing many children by a couple. Learners then suggest methods to cope with these issues.

– Outline the technique of in-vitro fertilisation (IVF). – Explain the physiological changes in females during pregnancy. – Define implantation. – Describe how a human embryo develops. – Describe the role of the extra embryonic membranes in pregnancy. – Explain how the placenta forms and discuss its functions. – Explain the gestation period and birth.		– Support people living with HIV.		– A guest speaker (doctor or nurse) gives a presentation to the learners on the different birth control methods available. Learners write up what they have learned.

– Describe the main stages of birth. – Discuss the significance of parental care in mammals. – Explain how twins and multiple births arise. – Describe the main types of birth control techniques. – Discuss the advantages and disadvantages of different birth control methods. – State the causes and ways of prevention of STIs and HIV.				– Learners research causes and prevention of STIs and HIV and present their findings in class.
Links to other subjects:				
Assessment criteria: Learners can explain the role of hormones in human reproduction and the stages of pregnancy and foetal development.				
Materials: Illustrations and computer aided study materials, prepared slides, microscopes, small animals (rat/rabbit/guinea pig), toad/frog, and cockroach/locust.				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: BIOLOGICAL MOLECULES	
S4 Biology	**Unit 9:** Testing for biological molecules			**No. of periods:14**
Key Unit Competence: Test for biological molecules in a variety of contexts, such as identifying the contents of mixtures of molecules and to follow the activity of digestive enzymes.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Write out procedures in the identification of biological molecules. – Explain the importance of the reagents used in the identification of biological molecules.	– Carry out tests for the identification of biological molecules. – Compare reducing and non-reducing sugars.	– Appreciate the importance of identification of food values in the food industry and in processing and packaging. – Show resilience making observations on colour changes during food tests.	– Test for reducing sugars, non- reducing sugars, starch, proteins and lipids. – Test for vitamin C (Ascorbic acid). – Semi-quantitative Benedict's test on a reducing sugar.	– Individually learners carry out tests for reducing sugars and non-reducing sugars and present results in table form. – In groups, carry out a test for starch. – Carry out an experiment for the identification of lipids using the emulsion test. – Carry out a chemical test for the identification of proteins using Biuret and Millon's reagent.

				– In a group, solve a problem by carrying out a semi-quantitative Benedict's test on a reducing sugar using standardised dilutions. Use the results (colour standards or time to first colour change) to estimate the concentration of reducing sugars. – In pairs, learners plan and conduct an experimental test different cooked and uncooked foods for the amount of ascorbic acid using dichlorophenol-indol-phenol (DCPIP)
Links to other subjects: Chemistry: macro molecules in organic.				
Assessment criteria: Students can use tests for biological molecules in a variety of contexts, such as identifying the contents of mixtures of molecules and following the activity of digestive enzymes.				
Materials: Test tubes, starch solution, egg albumen, vegetable oil, iodine in potassium iodide, sodium hydroxide, hydrochloric acid, Biuret reagent, ethanol, DCPIP, and pH meter/ indicator.				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE		SUB-TOPIC AREA: BIOLOGICAL MOLECULES		
S4 Biology	**Unit 10:** Carbohydrates and lipids.			**No. of periods: 14**
Key Unit Competence: Explain the important roles of carbohydrates and lipids in the provision and storage of energy and for a variety of other functions				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State the roles of carbohydrates and lipids. – Recall the elements that make up carbohydrates and lipids. – Explain the proportion of hydrogen in carbohydrates and lipids and relate this to the amount of energy released when oxidized.	– Demonstrate that phospholipids have a hydrophilic head and hydrophobic tails using a heterogeneous mixture made up of water and cooking oil.	– Appreciate the importance of carbohydrates and lipids in organisms. – Be aware of the other roles of lipids in the formation of soap and with carbohydrates and syrups in medicine.	– Ring forms of α-glucose and β-glucose. – Classes of monomers of the main biological molecules. – Formation and breakdown of glycosidic bonds. – Molecular structure and functions of polysaccharides (starch: amylose and amylopectin), glycogen and cellulose in living organisms.	– In pairs, discuss the reasons why carbohydrates are used to provide energy when fats produce twice as much for the same mass. – Find out why cells do not use fuel macro molecules directly and present the findings.

– Define the terms monomer, polymer, macromolecule, monosaccharide, disaccharide and polysaccharide. – Describe the ring forms of α-glucose and β-glucose structure. – Explain the formation of glycosidic bonds. – Describe the structure of phospholipids and relate to their functions in living organisms. – Describe the molecular structure and formation of triglycerides and phospholipids, and give their functions in living organisms.	– Interpret the charts and illustrations of molecular structure and the formation of maltose and triglycerides. – Demonstrate through a process of combustion that sugars and lipids are biological fuel – Differentiate between starch and cellulose		– Molecular structure and functions of triglycerides in living organisms. – Structure and functions of a phospholipid in living organisms.	– Observe charts of molecules of carbohydrates and lipids and identify monomers and bonds. Relate these to the roles they play in the life of an organism and present results. – In pairs learners carry out practical experiments to compare the bonding in maltose and sucrose – In groups, carry out a simple experiment or use a calorimeter to compare the enthalpy of combustion of 1g of glucose to that of lipid and critique the accuracy of the method.

Links to other subjects: Chemistry: condensation and hydrolysis. Physics: enthalpy.
Assessment criteria: Students can explain the important roles of carbohydrates and lipids in the provision and storage of energy and for a variety of other functions.
Materials: Charts for biological molecules, computer animations for formation and breakdown of complex biological molecules, reagents and sucrose for testing hydrolysis of sucrose, and equipment for examining the calorimetry of lipids and sugars.

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: BIOLOGICAL MOLECULES	
S4 Biology	**Unit 11:** Proteins and water			**No. of periods: 14**
Key Unit Competence: Describe how protein structure is related to function. To be able to describe the role of water as a special molecule with extraordinary properties that make life possible.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the structure of an amino acid and the formation and breakage of a peptide bond. – Describe the primary, secondary, tertiary and quaternary structure of proteins.	– Devise an experiment to investigate the effect of temperature, pH and chemicals on the structure of protein. – Relate the structure of globular and fibrous proteins to their functions.	– Appreciate the importance of globular and fibrous proteins in biological processes such as the transport of gases and providing support for tissues.	– The structure of an amino acid. – Formation and breakage of a peptide bond. – Structures of proteins (primary, secondary, tertiary and quaternary structures of proteins).	– Learners carry out research from the library or internet on formulae of amino acids. Show how they form the peptide bonds and model monomers using simple materials such as wires and plasticine or play dough balls to form amino acids, peptides and polypeptides

– Describe the molecular structure of haemoglobin as an example of a globular protein. Describe the functions with an emphasis on iron in the haemoglobin molecule. – Explain the effect of heat, pH and chemicals on protein structure. – Explain how hydrogen bonding occurs between water molecules and relate the properties of water to its roles in living organisms.	– Investigate the effect of lowering temperature on water. – Distinguish between collagen molecules and collagen fibres	– Express that protein structure is central to many aspects of biology, such as enzymes, antibodies and muscle contraction. – Acknowledge that water is a special molecule with extraordinary properties that make life possible on this planet.	– Fibrous and globular proteins. – Molecular structure of haemoglobin. – Denaturation of proteins. – Functions of proteins. – Water and its properties for life.	– Carry out an experiment to investigate the effect of temperature, pH and chemicals on the structure of protein. – Investigate the effect that a lowering temperature has on water. – Using the example of clotted blood or egg albumin, discuss the difference between fibrous and globular protein. – Carry out an experiment using cooking oil, water and detergents to study hydrophilic and hydrophobic effects on water.
Links to other subjects: Organic chemistry: chemistry of water and macromolecules.				
Assessment criteria: Learners can describe how protein structure is related to functions and the essential role of water in life.				
Materials: Egg albumen, clotted blood, sodium chloride, acidic solutions, Bunsen burner, water, cooking oil and detergents.				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE		SUB-TOPIC AREA: BIOLOGICAL MOLECULES		
S4 Biology	**Unit 12:** Vitamins and mineral salts.			**No. of periods:7**
Key Unit Competence: Discuss the roles of minerals and vitamins in diet				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State the mineral requirements for bodily functions. – Identify the symptoms of mineral and vitamin deficiency. – Outline the need for consumption of minerals and vitamins in small amounts.	– Organize a list of foods that are good sources of vitamins and mineral salts. – Recognize the signs and symptoms of scurvy, night blindness, goitre, and anaemia. – Differentiate between water soluble and lipid soluble vitamins.	– Appreciate the importance of a balanced diet in relation to health and economic prosperity. – Advocate for healthy feeding methods.	– Mineral nutrients in humans. – Classification of mineral nutrients – Sources, functions and deficiency symptoms of mineral nutrients in humans. – Vitamins and the classification of vitamins.	– In pairs, use tables of vitamin and mineral requirements, along with photographs of individuals with different deficiency diseases, to make a list of minerals and vitamins the individual may be lacking or having in excess.

	– Analyse one's eating habits and suggest improvements to make in order to prevent risks of vitamin or mineral deficiency or surplus. – Interpret photographs and computer aided material, to identify symptoms of scurvy, night blindness, goitre, and anaemia.		– – Sources, functions and symptoms of vitamin deficiency.	– In journal form, individually research the most evident dietary diseases in the community and suggest recommendations to improve the nutritional status. Present the results. – Using photographs or computer aided material learners brainstorm the observable symptoms of scurvy, night blindness, goitre, and anaemia.
Links to other subjects: Chemistry: transition and non-transition elements.				
Assessment criteria: Students can discuss the roles of minerals and vitamins in diet.				
Materials: Charts of vitamins and mineral requirements, graphs and tables for national nutritional information, and computer aided materials.				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: BIOLOGICAL MOLECULES	
S4 Biology	**Unit 13:** Enzymes			**No. of periods:14**
Key Unit Competence: Describe the mode of action and factors affecting enzymes and their importance for the existence of life.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Define the term enzyme. – Explain the criteria of naming enzymes.	– Investigate the progress of an enzyme- catalysed reaction by measuring rates of formation of products.	– Acknowledge that enzymes are essential in speeding up reactions that would be too slow to sustain life.	– Characteristics of enzymes – Criteria for naming enzymes. – . – Mode of action of enzymes. – Factors affecting enzyme action. – Importance of enzymes in living organisms.	– In pairs, learners carry out an experiment to show the effect of mylase on starch at different temperatures. – In groups, learners find out the effect of digestive enzymes on food substrate in different parts of the alimentary canal.

– State that enzymes function inside cells and outside cells. – Explain that enzymes are globular proteins that catalyse metabolic reactions. – Describe the mode of action of enzymes in terms of the lock and key and the induced fit hypotheses. – Explain factors affecting enzyme activity. – Define enzyme technology and its role in industry.	– Investigate the effects of temperature, pH, enzyme and substrate concentration, and inhibitors on enzyme activity. – Interpret graphs of the effects of reversible and irreversible inhibitors on the rate of enzyme activity. – Investigate the effect of immobilizing an enzyme in alginate as compared with its activity when free in solution.	– Appreciate the importance of planning and carrying out experiments under controlled conditions. – Understand the roles of enzymes in industry and medicine.	– Enzyme technology.	– Devise an experiment on the effect of temperature, pH and concentration of substrate on enzyme activities. – Solve a problem with graphs showing the determination rate of an enzyme catalysed reaction. – Learners carry out an investigation on the effect of immobilising an enzyme in alginate on its activity as compared with its activity when free in solution. – In groups, students use a computer or free hand to graphically plot the rate of an enzyme controlled reaction. – Learners investigate and present research on enzyme technology.

	– Use a computer to plot graphs of the rate of enzyme controlled reaction. Calculate Q10 of an enzyme controlled reaction. the rate of enzyme controlled reaction. Calculate Q10 of an enzyme controlled reaction.			
Links to other subjects: *Chemistry: rates of reactions.*				
Assessment criteria: *Students can describe the mode of action and factors affecting enzymes and their importance for the existence of life.*				
Materials: *Test tubes, amylase, starch,*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: GASEOUS EXCHANGE AND SMOKING	
S4 Biology	**Unit 14:** Principles of gas exchange systems.			**No. of periods: 7**
Key Unit Competence: To be able to explain the principles of gaseous exchange systems.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain the relationship between size and surface area to volume ratio. – Describe how different respiratory surfaces are modified to speed up the diffusion process.	– Observe prepared slides of gaseous exchange surfaces and identify their characteristics. – Dissect fish gillsand observe the surface area for gas exchange.	– Appreciate the evolution of gaseous exchange surfaces from simple to complex.	– Relationship between size and surface area to volume ratio. – Modifications of gaseous exchange surfaces to speed up diffusion. – Characteristics of gaseous exchange surfaces.	– Learners measure surface area to volume ratios of objects of various sizes and design. Learners then carry out an experiment to measure the diffusion rate into different sizes of gelatine tubes. – Research using the internet ortextbook material on modifications of gaseous exchange surfaces and report their findings.

– State the characteristics of gaseous exchange surfaces. – 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.	– Observe mammal's lungs and state their adaptation for gaseous exchange. – Use internet to make research and deduce the findings		– Smoking and related risks.	– Learners observe prepared slides of gaseous exchange surfaces of different organisms and identify common characteristics. – Learners dissect fish gills and observe the surface area for gas exchange. – Observe the lungs of a dissected mammal and identify their adaptations for gaseous exchange. – Learners observe photographs of healthy lungs to those affected by smoking and draw conclusions on risks related to smoking.
Links to other subjects: Mathematics: calculations of surface area.				
Assessment criteria: Learners can explain the principles of gaseous exchange systems.				
Materials: Illustrations, boxes of different sizes, rulers, microscopes and prepared slides, fish, gelatine, and lungs of mammals				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE		SUB-TOPIC AREA: GASEOUS EXCHANGE AND SMOKING		
S4 Biology	**Unit 15:** Gas exchange in plants			**No. of lessons: 7**
Key Unit Competence: Describe structures of gaseous exchange organs in plants.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the structure of stoma. – Explain the theories of opening and closure of stomata stating limitations of each. – Explain how stomata, lenticels and breathing roots are adapted to their function.	– Relate the differences between the structures of aquatic and terrestrial leaves to a habitat. – Draw and label a diagram of stoma as observed under a light microscope. – Compare gaseous exchange structures of aquatic and terrestrial plants.	– - Defend the relationship between structure and function in aquatic and terrestrial plants.	– Structure of stoma. – Theories used to explain the mechanism of opening and closure of stomata. – Structural adaptation and function of stomata, lenticels and breathing roots. – Comparison of gaseous exchange structures in terrestrial and aquatic plants. – Structural adaptation of leaves of aquatic and terrestrial plants to their habitats.	– Learners observe, draw and label structure of stoma as observed under a light microscope. – Learners research the theories used to explain the opening and closure of stomata and discuss their findings in class. – Learners observe prepared slides of T.S. of leaves of aquatic and terrestrial plants and discuss the differences.

Links to other subjects:
Assessment criteria: *Learners can describe structures of gaseous exchange organs in plants.*
Materials: *Microscopes, and prepared slides of T.S. of leaves.*

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: SUPPORT AND LOCOMOTION	
S4 Biology	**Unit 16:** Support and locomotion			**No. of periods:21**
Key Unit Competence: Explain and demonstrate modes of locomotion in protists, insects, fish, amphibians, birds and mammals.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain non-muscular movement in amoeba or paramecium. – Describe support and movement on land. – Describe skeletal modification in birds. – Explain how movements and support of fish are brought about in water.	– Observe locomotion of animals and identify reasons for their movement. – Demonstrate the arrangement ofmuscles in fish. – Dissect a fish to observe its swim bladder.	– Appreciate the need for locomotion in animals. – Recognize that the type of locomotion of animals depends on their habitat.	– Need for locomotion. – Non-muscular movements or movement without muscles: amoeboid, ciliated, flagella, and euglenoid. – Arrangement of muscles in fish. – Movement and support of fish in water: propulsion and stability. – Support and movement on land/muscular skeletal basis of locomotion. Propulsion of walking tetrapods (mammals), birds and annelids.	– Learners discuss reasons why animals move from one place to another. – Using a microscope, learners observe locomotion in *Amoeba* and *Paramecium* from a culture medium. – Observe the arrangement of muscles in fish (myotomes) to relate their structure to locomotion.

– Explain how support structures are related to the environment of the animal.	– Observe and explain the relationship between muscles, joints and musculo- skeletal attachments in fish, birds, amphibians and mammals. – Compare the flight of birds and insects. – Compare the jumping movement of grasshoppers and toads/frogs. – Develop research using internet through finding the relations between muscles, joints and musculo- skeletal		– Flight/movement through air by birds and insects. – Comparison of jumping movements of grasshoppers and toads.	– Observe external features (fins) and internal features (swim bladder) of a fish (tilapia) that enable locomotion of a fish in water. – Use models or computer aided simulations to observe the relationship between muscles, joints and musculo-skeletal attachments of the antagonistic muscles of fish, birds, frogs and rabbits. – Watch movies or simulations of the locomotion of different animals, such as a fish in water, a rabbit and lion on land, and insects and birds in the air.

				– Learners carry out research from the library or the internet to find out the similarity and difference between the flight of birds and insects.
Links to other subjects:				
Assessment criteria: *Learners can explain and demonstrate modes of locomotion in protists, insects, fish, amphibians, birds and mammals.*				
Materials: *Illustrations and computer aided study materials, model of human skeleton, fish, small mammal, chicken, and collections of video materials of animal locomotion.*				

TOPIC AREA: HEALTH AND DISEASE			SUB-TOPIC AREA: INFECTIOUS AND NON-INFECTIOUS DISEASES	
S4 Biology	**Unit 17:** Classification and patterns of disease			**No. of periods:7**
Key Unit Competence: Describe the social factors that affect good health and apply knowledge gained in familiar and unfamiliar contexts.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain what is meant by health and disease. – Identify different categories of disease and give an example of each. categories of disease and give an example of each.	– Analyse and interpret records from a given hospital to identify diseases as endemic, epidemic or pandemic.	– Appreciate the importance of germ theory of disease by showing that the death rate related to infections is greater than those caused by accidents.	– Theory of disease, germ theory. Focus on the following diseases: small pox, cholera, TB, malaria, typhus, tinea, scabies (or other skin parasites) and hook worm. These diseases should be studied in relation to the causative agent, sources of infection, methods of transmission, symptoms, prevention and control. – Reference to be made to the work of, Pasteur, Semelweiss, Leeuwenhock, Jenner, Cock, Ross, Gowland, Hopkins, etc.	– Learners discuss in groups, what they think are the causes of death using the story of Semelweiss' work. From the discussions they arrive at the germ theory of disease. - After the first activity, using the work of Pasteur learners debate or use drama to show whether a disease is caused by germs or not. This allows them to discover other causes of disease and to classify them.

– Explain the theory of the disease and the causes, sources, transmission, symptoms and controls of the disease. – Discuss how global patterns of disease are studied. – Explain the organisation and functioning of public health services in Rwanda.	– Apply knowledge gained to classify common diseases.		– Classification of disease. – Patterns of disease. – Health and community: criteria for good housing – Public health services: organisation and functions of local, state and international health services, food inspection, and the need for control of housing conditions, clean water, and hygiene.	– Learners analyse records from a given hospital to identify diseases identified as endemic, epidemic and pandemic.
Links to other subjects:				
Assessment criteria: Can describe the factors that affect good health.				
Materials: Charts/illustrations and computer aided materials.				

TOPIC AREA: MICROBIOLOGY AND BIOTECHNOLOGY			SUB-TOPIC AREA: MICROORGANISMS	
S4 Biology	**Unit 18:** Microbiology			**No. of periods:14**
Key Unit Competence: Describe the structure and characteristics of viruses, bacteria, fungal and non-fungal moulds.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the basic structure of viruses. – Explain how a retrovirus reproduces. – Identify theeffects of viruses (e.g. AIDS,influenza, measles, feline leukaemia, some human cancers) and prokaryotes (e.g., tuberculosis, bubonic plague, cholera) on organisms.	– Distinguish between the structure and function of viruses and prokaryotic organisms. – Relate the structures and functions (e.g. morphology, motility, reproduction and growth, metabolic diversity) of prokaryotes to their behaviour and identification.	– Appreciate the importance of microorganisms in life. – Recognise the diversity of microorganisms.	– Microbiology. – Structure and life cycle of viruses. – Viruses as living or non-living. – Archaebacteria. - Eubacteria. - E.coli and food poisoning. - Structure and lifecycle of E.coli. - Evolution of harmful strains.	– Learners in groups, discuss how viruses are different from living cells. – Discuss the nutrition of eubacteria. – Use photomicrographs and charts to describe the structure of different microorganisms. – Discuss the methods of reducing the risk of food poisoning by pathogenic bacteria.

– Describe how plant viruses can be transmitted. – Explain how and why archaebacteria are thought to have been the first forms of life. – Describe the main structural forms of eubacteria. – Describe the structure and Life cycle of Escherichia Coli. – Explain how harmless bacteria can be changed into potentially lethal ones. – Describe the main features of moulds. – Describe the structure of Mucor hyphae.	– Distinguish between the structure of Penicillium and Mucor.		– Sources of infection. – Fungal Moulds: Rhizopus and – Mucor. – Non-fungal moulds: water moulds, bacterial moulds, and cellular slim moulds. – Life cycle of Rhizopus. – Significance of moulds. – Moulds: – Penicillium and saccharomyces. – Penicillium and antibiotics. – Structure of Penicillium. – Saccharomyces. – Protozoa that cause disease: • Entamoeba hystolitica. • Plasmodium. • Trypanosoma.	– Learners interpret charts showing the life cycles of microorganisms. – Observe prepared slides of Entamoeba hystolitica Plasmodium and Trypanosoma to compare their structures. – Research in groups, the life cycle of pathogenic protozoa and present findings.

– Explain how Mucor and Rhizopus feed and reproduce. – Describe the structure of a yeast cell. – Explain how saccharomyces reproduce. – Describe the structure and life cycle of pathogenic protozoa limited to Entamoeba hystolitica, Plasmodium and Trypanosoma.				
Link to other subjects:				
Assessment criteria: *Students can clearly describe the structure and characteristics of viruses, bacteria, and fungal and non-fungal moulds.*				
Materials: *Prepared slides, computer simulations, and charts for bacterial, viral and fungal life cycles.*				

TOPIC AREA: MICROBIOLOGY AND BIOTECHNOLOGY			SUB-TOPIC AREA: MICROORGANISMS	
S4 Biology	**Unit 19:** Culturing microorganisms			**No. of periods:14**
Key Unit Competence: Explain the process of culturing microorganisms and the factors affecting their population growth.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– List and describe the roles of microorganisms and their requirements for growth. – Explain the role of environmental variables in culturing microorganisms. - Describe the different types of culture media.	– Draw and interpret the graph of the population growth of bacteria. – Carry out an experiment to stain bacteria for examination with a light microscope.	– Appreciate the importance of culturing microorganisms. – Show perseverance when inoculating a solid and liquid medium.	– Requirements for growth of microorganisms: • Essential nutrients limited to: source of carbon, nitrogen, growth factors, mineral salts, source of energy and water. • Environmental variables limited to: temperature, pH, oxygen concentration and ionic and osmotic balance.	– Draw and interpret the graph of the population growth of bacteria. – Carry out an experiment to stain bacteria for examination with a light microscope. – Interpret charts and illustrations for preparing culture media and the process of inoculating media.

– Describe the main features of aseptic techniques. – Explain how pure cultures of pure bacteria can be obtained. – Describe the methods of inoculation.	– Observe and compare the numbers of bacteria present in fresh and stale milk. – Distinguish between gram negative and gram positive bacteria. – Use sterile techniques to prepare agar plates to culture bacteria and fungi – Carry out research on why microorganisms are particularly suitable for industrial processes.	– Show concern for taking the basic precautions in the school laboratory when carrying out routine microbiological work.	– Culture media: solid and liquid, enrichment and selective, and indicator media. – Preparing the media. – Aseptic techniques. – Methods of inoculation. – Bacterial growth. – Measuring population growth of bacteria and fungi. – Staining bacteria. – Growing viruses.	– In groups, investigate the bacterial content of fresh and stale milk. – In pairs, culture fungi on a nutrient agar using sterile techniques. – Carry out research on why microorganisms are particularly suitable for industrial processes.
Links to other subjects:				
Assessment criteria: *Students can clearly explain the process of culturing microorganisms and the factors affecting their population growth.*				
Materials: *Sterile nutrient agar and plates, inoculating loops, Bunsen burner, fresh pasteurised milk, stale milk, incubator, aluminium foil, gram stain, counterstain (safranin), lugos iodine, staining rack, immersion oil and microscope, and charts for bacterial growth and processes of inoculation.*				

TOPIC AREA: MICROBIOLOGY AND BIOTECHNOLOGY			SUB-TOPIC AREA: BIOTECHNOLOGY	
S4 Biology	**Unit 20:** Biotechnology and its application.			**No. of periods:14**
Key Unit Competence: Explain the biotechnology involved in the production of ethanol, biogas and bread making.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State that bacteria are useful in biotechnology and genetic engineering due to their rapid reproduction rate and their ability to make complex molecules.	– Investigate and describe the use of pectinase in fruit juice production and lactase to produce – lactose-free milk.	– Show concern for the role of bacteria in genetic engineering. – Appreciate the role of anaerobic respiration in the production of ethanol and in yeast during bread-making.	– Role of bacteria in biotechnology and genetic engineering. – Why bacteria are useful in biotechnology and genetic engineering. – Immobilisation of enzymes. Focused on: use of pectinase in fruit juice production, lactase to produce lactose-free milk, and biological washing powders that contain enzymes and biosensors.	– Carry out research on the action of enzymes with reference to pectinase in fruit juice production and lactase to produce lactose-free milk. – Carry out an experiment on alcoholic fermentation using yeast. Alternatively, use charts and illustrations to describe an experiment on alcoholic fermentation using yeasts.

– Discuss why bacteria are useful in biotechnology and genetic engineering. Focus on: lack of ethical concerns over their manipulation and growth, genetic code shared with all other organisms, and presence of plasmids. – Describe the role of anaerobic respiration in yeast during bread-making.	– Compare leavened and unleavened bread. – Interpret and explain graphs showing how the pH and the concentration of penicillin in a culture changes over time when the pH is controlled and not controlled. – Apply the knowledge of bioreactors, using cow dung, agricultural waste and domestic waste to prepare and produce biogas.	– Defend the role played by antibiotics in treatment of bacterial diseases. – Appreciate the role of biogas production in reducing the environmental degradation.	– Application of enzyme technology. – Examples of industrial application of enzymes: brewing (beer and wines), baking, medicine, meat, cheese, and yoghurt) – Fermentation and fermenters and the production of penicillin. – Antibiotics: Antibiotic resistance and implications of antibiotic use. – Biogas production.	– Make a list of factors such as temperature and the amount of yeast and flour in dough that might affect the process of fermentation. Justify how each factor will affect the rate of fermentation. – Visit a nearby bakery and verify how bread is prepared. Write a short report on the raw materials and procedures used in making bread up to the final product. – Describe the role of anaerobic respiration in yeast during bread making. – In groups, interpret and explain graphs showing how the pH and the concentration of penicillin in a culture changes over time when the pH is controlled.

– Explain how fermenters are used in the production of penicillin. – Describe the role of the fungus Penicillium in the production of the antibiotic penicillin. – Describe the three stages of biogas production and the role of bioreactors in economically poor rural communities.				– Using diagrams or illustrations and visiting a biogas plants in your region, describe the stages of biogas production and its significance in your area (a simple biogas generator can also be made in schools).
Links to other subjects: *Chemistry: Applied Chemistry.*				
***Assessment criteria**: Learners can explain clearly the biotechnology involved in the production of ethanol, cheese, yogurt, antibiotics, biogas and bread making.*				
***Materials:** Online resources, CDs, simulations, diagrams, charts, micrographs, illustrations, cultured microorganisms, and materials to make biogas*				

3.3. Biology programme for S5

3.3.1. Key competences at the end of S 5:

- Explain complex relationships between organisms within their environment.
- Explain the physiological processes by which materials move in and out of cells and the significance of these processes in the life of organisms.
- Describe the structure of a chromosome and how DNA is folded in a chromosome.
- Explain the process of DNA replication and its significance to living organisms.
- Describe the stages of the cell cycle and explain the significance of cell and nuclear division in organisms.
- Explain the relationship of a gene to the sequence of nucleotides in DNA and describe the process of protein synthesis in eukaryotes.
- Describe the process of photosynthesis and explain the various environmental factors that influence the rate of photosynthesis.
- Describe the structure of the transport tissue in plants and the mechanisms by which substances are moved within the plant.
- Describe structures of gas exchange in different groups of animals.
- Describe the effects of tobacco smoking on the gas exchange system.
- Explain the general principles of homeostatic mechanisms.
- Explain the mechanism of the regulation of blood glucose levels.
- Explain the importance of thermoregulation and ways by which organisms regulate body temperature.
- Explain the different forms of behaviour and responses and their importance in the survival of organisms.
- Relate the structures of the human reproductive system to their functions and describe gamete formation.
- Describe the immune system and apply knowledge gained in familiar and unfamiliar contexts.
- Explain the role of genes in inheritance and genetic disorders.
- Describe the types, causes and effects of mutation in organisms.

3.3.2 Biology units Table for S5

TOPIC AREA: ECOLOGY AND CONSERVATION			SUB-TOPIC AREA: ENVIRONMENTAL BIOLOGY	
S5 Biology	**Unit 1:** Interdependence between organisms within their environment.			**No. of periods:14**
Key Unit Competence: To be able to explain complex relationships between organisms within their environment.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain the various interactions of organisms in nature. - State the significance of organisms' interactions in nature. - Explain the terms interspecific and intraspecific competition.	– Compare interspecific and intraspecific competition. – Interpret graphs for predator-prey relationships.	– Appreciate the relationships existing between organisms within their environment. – Recognise the role of saprophytes in mineral recycling.	– Interrelationships among organisms and their effects. – Inter and intraspecific relationships between organisms: • Competition. • Parasitism. • Predation. • Saprophytism. • Mutualism. • Mommensalism.	– Individually, classify examples of species interactions, e.g. competition, predation, parasitism, commensalism, and mutualism. – Compare interspecific and intraspecific competition and give examples in each case. – In groups, discuss and interpret the graphical illustrations for relationships between predators and prey.

– Describe the adaptations of predators to catch and kill prey and adaptations of prey to avoid predators.	– Classify examples of species interactions, e.g. competition, predation, parasitism, commensalism, and mutualism.		– Significance of organisms' interactions in nature.	– Observe predator-prey relationships in the environmentor from wildlife movies.
Link to other subjects: *Mathematics: graphs and data in tables for predator prey relationships.*				
Assessment criteria: *Students can clearly explain complex relationships between organisms within their environment.*				
Materials: *Ecological charts and graphs, audio visual data, computer aided material, and video-film materials (e.g. clips from YouTube).*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: MOVEMENT IN AND OUT OF THE CELL	
S5 Biology	**Unit 2:** Transport across the cell membrane.			**No. of periods:21**
Key Unit Competence: Explain the physiological processes by which materials move in and out of cells and the significance of these processes in the life of organisms				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– - Describe and explain the processes and significance of movement in and out of the cell mentioned in the content.	– Apply the knowledge of hypertonic environments in food preservation by salting. – Carry out an investigation on simple diffusion by using plant tissues and non-living materials.	– Appreciate the importance of movement of substances across cells. – Show concern when exposing living organisms to concentrated media.	– Diffusion and factors affecting the process of diffusion. – Significance of process of diffusion in organisms. – Osmosis and significance in organisms.	– Investigate simple diffusion using plant tissues, non-living materials such as glucose solutions and visking tubing – Calculate surface areas and volumes of simple shapes e.g. cube to illustrate the principle that the surface area to volume ratio decreases with increasing size.

– Recall that the increasing size of organisms is constrained by its ability to obtain resources through diffusion across the cell surface and its ability to move substances out of cells. – Explain the movement of water between cells and solutions with different water potentials and explain the effects on plant and animal cells.	– Research adaptations of plants and animals to salty habitats. – Interpret and present data in graphic and table form on the effects of varying concentrations of : e.g. sugar , salt on plant and animal tissues – Distinguish between endocytosis and exocytosis.		– Process of osmosis including: turgidity, plasmolysis, water potential, osmotic potential and wall pressure. – Osmosis in animal cells. – Active transport. – Process of active transport. – Factors affecting the process of active transport. – Significance of active transport in organisms. – Endocytosis: phagocytosis, pinocytosis, exocytosis.	– – In groups, investigate and present the effects of immersing plant tissue in solutions of different water potentials. Use the results to estimate the water potential of tissues. – Learners interpret data on movement of solvents and ions in and out of the cell in a table or graph form.
Links to other subjects: *Physics and chemistry: diffusion and concentrations.*				
Assessment criteria: *Students can clearly explain the physiological processes by which materials move in and out of cells and the importance of these processes in the life of organisms.*				
Materials: *Potato tubers, pawpaw petioles, unripe pawpaw fruits, filamentous algae, onion epidermis, slides and microscopes, visking tubing, knives, potassium permanganate, methylene blue, water, sucrose solutions of varying concentrations, and animal tissues e.g. blood smear of a frog.*				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: CELL DIVISION	
S5 Biology	**Unit 3:** Chromosomes and nucleic acids.			**No. of periods:14**
Key Unit Competence: Describe the structure of a chromosome and how DNA is folded into a chromosome.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the composition of chromosomes and the structure of nucleotides. – State how nucleotides pair. – Describe the structure of DNA and RNA. – Explain that the structure of the DNA molecule is described as a ladder twisted into a spiral.	– Use of complimentary base pairing to write the sequence for messenger RNA and the first DNA codes for three base codon. – Draw the structure of DNA (6-10 base pair sequence).	– Appreciate the importance of the presence of DNA in chromosomes. – Acknowledge the role of telomeres in preventing the loss of genes and its relation to the development of cancer.	– Composition of chromosomes. – Structure of nucleotides. – Structure of nucleic acids: DNA and RNA. – The Watson-Crick hypothesis of the nature of DNA. – Nature of genes. – Structure of a genetic code.	– In groups, use microscopic slides of prophase during mitosis to observe and draw a typical structure of a chromosome. – Using charts and diagrams compare DNA and RNA and then make a group presentation.

– Explain the Watson-Crick hypothesis of the nature of DNA. – Outline the significance of telomeres in permitting continued replication. – Describe the nature of genes. – Describe the structure of a genetic code	– Research on how Watson and Crick determined the nucleotide base pairing pattern. – Distinguish between RNA and DNA.			– Design and make group presentations about the structure of the DNA molecule and complimentary base pairing using plastic model shapes or homemade kits.
Links to other subjects: *Chemistry: hydrogen bonding.*				
Assessment criteria: *Students can describe the structure of a chromosome and how DNA is folded into a chromosome.*				
Materials: *Models of DNA, illustrations, computer simulations, suitable model materials, tooth picks, ribbons, electric wires, straws of different colours, and prepared slide on mitosis.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: CELL DIVISION	
S5 Biology	**Unit 4:** DNA replication.			**No. of periods:7**
Key Unit Competence: Explain the process of DNA replication and its significance to living organisms.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Determine how the structure of DNA enables it to reproduce itself accurately. – State semiconservative replication as a process by which DNA unzips and each new molecule of DNA (daughter DNA) contains one intact strand from the original DNA(parent DNA) and one newly synthesised strand.	– - Apply knowledge of complimentary base pairing in DNA to interpret Meselson and Stahl's experiment to test different hypothetical models for DNA replication using E.coli grown in a heavy nitrogen (15N) medium.	– Appreciate the importance of proper DNA replication. – Acknowledge improper DNA replication would result into genetic changes in the nucleus that would have both positive and negative effects on organisms. For example changes in the metabolism of cells, variation that can result into evolution and mutations that may lead to death.	– Mechanism of DNA replication. – Experimental evidence of DNA replication. – Semiconservative replication. – Enzymes involved in replication limited to: helicase, DNA binding proteins, DNA polymerase, and DNA ligase.	– In groups, discuss and present the process of replication of DNA. Use models, illustrations, charts and simulations stages. – In groups, analyse the rate of replication of bacterial DNA and eukaryotic DNA, discuss and present reasons for the shorter time taken by human DNA toreplicate.

– State the role of enzymes involved in replication of DNA. – List the ingredients used to make DNA in a test tube. – Describe how semi- conservative replication of DNA takes place. – State that conservative and dispersive replications are other hypothesis for DNA replication. – Explain the importance of DNA replication in organisms.				– Individually research and present other possibilities of replication e.g. the conservative and dispersive hypothesis of DNA replication.
Links to other subjects: *Chemistry: hydrogen bonding.*				
Assessment criteria: *Students can explain the process of DNA replication and its significance to living organisms.*				
Materials: *Computer animations, models and illustrations.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: CELL DIVISION	
S5 Biology	**Unit 5:** Cell and nuclear division.			**No. of periods: 14**
Key Unit Competence: Describe the stages of the cell cycle and explain the significance of cell and nuclear division in organisms				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– - Describe the main stages of the cell cycle including: interphase (growth and DNA replication), mitosis and cytokinesis. – Explain what is meant by homologous pairs of chromosomes. – Explain the meaning of the terms haploid and diploid.	– - Interpret data related to time for different cell cycles to identify tissues from which the cells came.	– Appreciate the importance of effective cell division. – Show concern to individuals with physical disabilities like Down's syndrome,	– Haploid and diploid conditions of the cell cycle. – Mitosis and role of mitosis in living organisms. – Meiosis and its role in living organisms and the significance of cell division limited to: spindle formation, synapsis, bivalents, chiasma formation and movement of chromosomes.	– - Devise an experiment to investigate how long onion root tip cells spend in each phase of the cell cycle and present your findings in table form showing the stages of mitosis.

– Describe the process of mitosis and meiosis. – Outline the significance of mitosis in cell replacement and tissue repair by stem cells. – State that uncontrolled cell division can result in the formation of a tumour. – Define meiosis as reduction division in which the chromosome number is halved from diploid to haploid. – Explain the need for reduction prior to fertilisation in sexual reproduction.	– Apply knowledge of mitosis to predict which set of cells came from and which part of the plant and where other cells have come from. – Make a table showing the phases of the cell cycle mentioning one important event that occurs at each phase. – Compare mitosis and meiosis.		– Comparison of mitosis and meiosis.	– Examine prepared slides of dividing plant root tip and animal check cells and outline how dividing animal cells are different from dividing plant cells. – Carry out a research project to find out why cultured skin is grown in a medium of proteins similar to blood. Write a journal entry to summarise the research. – Identify the stages of meiosis by using micrographs and outline what is taking place at each stage.

– Outline the role of meiosis in gametogenesis in humans and in the formation of pollen grain and embryo sacs in flowering plants. – Explain how crossing over and random assortment of homologous chromosomes during meiosis and random fusion of gametes at fertilization leads to genetic variation including the expression of rare recessive alleles				
Links to other subjects: *Agriculture: polyploidy in breeding and cross breeding in crop and animal husbandry.*				
Assessment criteria: *Students can describe the stages of the cell cycle and explain the significance of cell and nuclear division in organisms.*				
Materials: *Micrographs, compound microscopes, computer animations, prepared slides on root tips and cheek cells, and computer aided learning materials.*				

Topic Area: Organisation and Maintenance of Life			Sub-topic Area: Protein Synthesis	
S5 Biology	**Unit 6:** Protein synthesis.			**No. of periods:14**
Key Unit Competence: Explain the relationship between a gene and the sequence of nucleotides in DNA and to describe the process of protein synthesis in eukaryotes.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State the features of a genetic code. – State that a gene is a sequence of nucleotides that form part of a DNA molecule that codes for a specific polypeptide.	– Construct a flow chart, in proper sequence, for the stages of transcription and translation. – Using the evidence, predict the effect of change in geneticcode on the structure of the protein manufactured during protein synthesis.	– Appreciate the importance of the genetic code in determining the structure of a protein. – Agree that the way DNA code for polypeptides is central to our understanding of how cells and organisms function.	– The genetic code. – Process of protein synthesis. – Transcription: formation of mRNA. – Translation: ribosomes and polysomes.	– Read and make a flow chart that shows protein synthesis. Put the steps of the process in separate boxes in the flow chart in the order in which they occur from production of mRNA to the final translation of the DNA code.

– Describe how the information in DNA is used during transcription and translation to construct polypeptides. – State the roles played by mRNA, tRNA and the ribosomes in the formation of the polypeptide. – State that ribosomes provide surface area for the attachment of mRNA during polypeptide synthesis. – State that polysomes consists of up to 50 ribosomes on the same mRNA strand and that they speed up polypeptide synthesis.	– Carry out research to find and understand better about protein synthesis and on genetic diseases	– Be aware that DNA is an extremely stable molecule that cells replicate with extreme accuracy to minimise possibilities of DNA mutations. – Appreciate the role of the genetic code in determining the characteristics of an individual.	– The role of DNA and RNA in protein synthesis. – Effects of alteration of nucleotide sequence.	– In groups, students research and present their findings in journal form on how genetic drugs can be used to stop the expression of genetic diseases with specific reference to how they may interfere with activities of nucleic acids in the nucleus and the cytoplasm of the cell. – Carryout an investigation or simulation on the effect of change in genetic code on the structure of the protein manufactured during protein synthesis.

– Describe the way in which the nucleotide sequence codes for the amino acid sequence with specific reference to HbA (normal) and HbS(sickle cell) alleles for β- globin poly peptides. – State that gene mutation is a change in the sequence of nucleotides that may result in an altered polypeptide.				– – Make a minilab report to demonstrate how gene mutations affect protein synthesis using a sequence of bases of one strand of an imaginary DNA molecule. – Work in groups to construct the model of protein synthesis.
Links to other subjects:				
Assessment criteria: *Students can explain the relationship between a gene and the sequence of nucleotides in DNA and describe the steps involved in protein synthesis in eukaryotes.*				
Materials: *Models, illustrations, computer animations and charts of DNA and RNA strands and amino acids.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: NUTRITION	
S5 Biology	**Unit 7:** Autotrophic nutrition.			**No. of periods:21**
Key Unit Competence: Describe the process of photosynthesis and explain the various environmental factors that influences the rate of photosynthesis.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State and explain the types of autotrophic nutrition. – Explain the roleof light in autotrophic nutrition. – State the pigments involved in light absorption. – Recall the structure of the leaf in relation to photosynthesis.	– Use their knowledge of plant cells and leaf structure from the section on cell structure while studying photosynthesis.	– Appreciate the importance of photosynthesis as an energy transfer process that produces complex organic compounds using light energy absorbed by chloroplast pigments.	– Types of autotrophic nutrition. – Structure of the chloroplast. – Adaptations for photosynthesis. – Absorption and action spectra. – Calvin cycle and the process of photosynthesis in C3 plants.	– In pairs, carry out tests for starch in terrestrial plants and for oxygen in aquatic plants. – Carry out investigations on the effects of changing light intensity, carbon dioxide and temperature on the rate of photosynthesis using whole plants, e.g. aquatic plants such as Elodea or using the floating leaf disc assay technique.

– State the sites and stages of photosynthesis in chloroplasts. – Describe the role of chloroplast pigments (chlorophyll a, chlorophyll b, carotene and xanthophylls) in light absorption in the grana. – Outline the three main stages of the Calvin cycle.	– Describe the relationship between the structure and function in the chloroplast, using diagrams and electron micrographs. – Interpret absorption and action spectra of chloroplast pigments. – Carry out an investigation of limiting factors. – Relate the anatomy and physiology of the leaves of C4 and CAM plants to high rates of carbon fixation and low rates of transpiration.	– Acknowledge that environmental factors influence the rate of photosynthesis and investigation shows how they can be managed in protected environments used in crop production.	– Other carbon dioxide fixation pathways (C4 CAM). – Rate of photosynthesis: limiting factors of photosynthesis. – Importance of autotrophic nutrition. – Tests for starch in terrestrial plants and for oxygen in aquatic plants	– Use chromatography to separate and identify chloroplast pigments and carry out an investigation to compare the chloroplast pigments in different plants. – Carry out an investigation to determine the effect of light intensity or light wavelength on the rate of photosynthesis using a redox indicator (e.g. DCPIP) and a suspension of chloroplasts (the Hill reaction) or by using a floating leaf disc assay

– Describe and outline the conversion of the Calvin cycle intermediates to carbohydrates, lipids and amino acids and their uses in the plant cell. – Explain the term limiting factor in relation to photosynthesis and the effects of the changes in the limiting factors on the rate of photosynthesis.	– Apply knowledge and understanding of limiting factors to increase crop yields in protected environments, such as glasshouses. – Investigate the effect of light intensity or light wavelength on the rate of photosynthesis. – Differentiate between C4, CAM and C3 plants during carbon dioxide fixation.			
Links to other subjects: *Physics: optics. Chemistry: redox reactions, endothermic and exothermic reactions.*				
Assessment criteria: *Students can describe the process of photosynthesis and explain the various environmental factors that influence the rate of photosynthesis.*				
Materials: *Aquatic plants e.g. Elodea, Redox indicator (e.g. DCPIP) and a suspension of chloroplasts from crushed green leaves, test tubes, light bulbs, colour filter, charts and illustrations of the Calvin cycle and cyclic and non-cyclic photophosphorylation, syringes, leaf materials, cork borers and light gels or colour filters.*				

Topic Area: Organisation and Maintenance of life.			Sub-topic Area: Transport in Organisms	
S5 Biology	**Unit 8: Transport in Plants.**			**No. of periods:14**
Key Unit Competence: Describe the structure of the transport tissues in plants and the mechanisms by which substances are moved within the plant.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Recall that plants have two transport tissues: xylem and phloem. – Explain the movement of water between plant cells, and between them and their environment, in terms of water potential. – Recall the term transpiration and understand that transpiration is an inevitable consequence of gas exchange in plants.	– Observe, draw and label, from prepared slides, plan diagrams of transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants to show tissues in correct proportion.	– Appreciate the importance of transport systems in plants. – Acknowledge that plants do not have systems for transporting oxygen and carbon dioxide. Instead these gases diffuse through air spaces within stems, roots and leaves.	– Need for a transport system. – Structure of transport tissues. – Transport mechanisms of plants: xylem sap and phloem sap. – Transpiration: water stress, adaptations of Xerophytes to reduce water loss by transpiration.	– Make annotated drawings, using prepared slides of cross-sections, to show transport structures in stem and roots and how leaves of xerophytes have adapted to reduce water loss by transpiration. – Experimentally, investigate and explain the factors that affect transpiration rates, using simple potometers, leaf impressions, epidermal peels, and grids for determining surface area.

– Explain how hydrogen bonding is involved with the movement of water in the xylem by cohesion- tension in transpiration pull and adhesion to cellulose cell walls. – State that assimilates, such as sucrose and amino acids, move between sources and sinks in phloem sieve tubes. – Explain how transport systems in plants move substances from where they are absorbed or produced to where they are stored or used. – Explain how sucrose is loaded into phloem sieve tubes by companion cells using proton pumping and the co- transporter mechanism in the cell surface membranes.	– Draw and label, from prepared slides, the cells in roots, stems and leaves using transverse and longitudinal sections. – Recognise, from prepared slides, using the light microscope to draw and label 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	– Show resilience when setting apparatus and making observations using microscopes and solutions of different concentration to ensure improved reliability – Show concern when selecting crop plants to reflect adaptations to environments e.g. where they grow well, and when under water or not under water stress.		– Discuss reasons for the fact that transpiration is an inevitable consequence of gas exchange in plants. – Investigate mass flow hypothesis in the translocation of phloem sap.

– Explain mass flows in phloem sap down a hydrostatic pressure gradient from source to sink	- Experimentally investigate and explain the factors that affect transpiration rate using simple potometers, leaf impressions, epidermal peels, and grids for determining surface area. - Make annotated drawings, using prepared slides of cross-sections, to show how leaves of xerophytes are adapted to reduce water loss by transpiration. - Carry out an investigation to demonstrate mass flow hypothesis.			

Links to other subjects: *Mathematics: graphs for variations of transpiration rates. Physics: pressure in fluids, vaporisation and heat capacity.*
Assessment criteria: *Students can describe the structure of the transport tissues in plants and the mechanisms by which substances are moved within a plant.*

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: GASEOUS EXCHANGE AND SMOKING	
S5 Biology	**Unit 9: Gas exchange in animals.**			**No. of periods:21**
Key Unit Competence: Describe structures of gas exchange in different groups of animals				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the tracheal system of insects and relate to its function. – Describe the structure of the gills in relation to function – Explain the significance of counter current flow in bony fish. – Describe the mode of gaseous exchange in amphibians. – Describe the structure of the human gas exchange system. – Describe the distribution of tissues within the trachea, bronchi, bronchioles and alveoli and relate each tissue to its function. Explain the mechanism of ventilation in humans.	– Dissect an insect, fish and a small mammal to study gaseous exchange organs. – Relate the structure of gas exchange – Analyze and interpret data from a spirometer. – Search and use data to calculate pulmonary ventilation and alveolar ventilation.	– Appreciate the similarities and differences in gas exchange surfaces of animals. – Appreciate the organs to function. – Differentiate between the gaseous exchange in bony fish and that in cartilaginous fish. – Interpret a graph of human lung volumes measured with a spirometer. – Calculate the volume of air in the lungs and in the alveoli.	– Gaseous exchanges in insects and fish. – Significance of counter current gaseous exchange in bony fish. – Gaseous exchange in amphibians. – Structure of human gas exchange system. – Functions of tissues within the gas exchange system. – Mechanism of ventilation (breathing). – Gas exchange in the alveoli. – Lung volume and capacities. – Use of spirometer to measure ventilation rate.	– Learners dissect an insect such as locust/cockroach to locate the tracheal system. – Learners examine the gills of a freshly killed bony fish and study the structure. Draw and label. – Observe fish in aquaria to monitor and sequence mouth and operculum movements during gas exchange. – Learners' research using the internet or textbooks and report to the class about counter flow and parallel flow.

– Explain the process of gas exchange in alveoli with emphasis on diffusion. – Describe the role of the brain in controlling gas exchange in humans. – Define terms related to the lung capacities (tidal, reserve volume, vital capacity, residual volume, and dead air space). – Describe how a spirometer can be used to measure vital capacity, tidal volume, breathing rates, and oxygen uptake.		role of the brain in controlling gas exchange.	– Nervous control of breathing.	– Observe a live frog or toad in a glass tank and discuss its gas exchange surfaces. – Use models, computer simulations and illustrations to discuss the structure and functioning of the human gas exchange system. – Design a model of the spirometer based on its main features. – Learners discuss the role of the brain in controling gas exchange. Use illustrations or computer aided materials. – Learners use illustrations of spirometer trace to define tidal volume, inspiratory reserve volume, expiratory reserve volume, vital capacity and residual volume.

				– Using data of lung volumes, learners calculate pulmonary ventilation (PV) and alveolar ventilation (AV).
Links to other subjects: *Mathematics: calculation of lung volumes.*				
Assessment criteria: *Learners can describe structures of respiratory organs in different groups of animals.*				
Materials: *Models, computer simulations and illustrations, live specimens of animals (locust/cockroach, tilapia, frog/toad, rat/rabbit), spirometer (or model of a spirometer), and spirometer traces for analysis.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: GASEOUS EXCHANGE AND SMOKING	
S5 Biology	**Unit 10: Smoking and related diseases.**			**No. of periods: 7**
Key Unit Competence: Describe the effects of tobacco smoking on the gas exchange system.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system. – Describe the signs and symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD).	– Interpret photographs to differentiate healthy lungs from infected lungs. – Interpret data linking cigarette smoking to disease and early death. – Observe and interpret research statistics linking to tobacco smoking.	– Evaluate the epidemiological and experimental evidence linking cigarette smoking to disease and early death. – Influence the campaign against cigarette smoking.	– Effects of tar and carcinogens in tobacco smoke on the gas exchange system. – Symptoms of lung cancer and chronic obstructive pulmonary diseases (COPD). – Effects of nicotine and carbon monoxide on the cardiovascular system. – Contribution of tobacco smoking to atherosclerosis and coronary heart disease.	– Learners boil tobacco in water to extract a solution which is allowed to cool. Learners then spray the solution on a plant infested with aphids and prove that tobacco contains poisonous substances that kill the aphids. Or using a video experiment to demonstrate how the quantity of tar from smoking is produced. – In groups, learners research from the internet or the library the effects of smoking on the gas exchange system and present their findings.

– Describe the effects of nicotine and carbon monoxide on the cardiovascular system. – Explain how tobacco smoking contributes to atherosclerosis and coronary heart disease.		– Evidence linking cigarette smoking to disease and early death.		– Learners observe and interpret research statistics linking tobacco smoking to disease.
Links to other subjects: *Chemistry: the poisonous nature of carbon monoxide is linked to carbon and its compounds.*				
Assessment criteria: *Learners can clearly describe the effects of tobacco smoking on the gas exchange system.*				
Materials: *Charts, cured tobacco leaves, computer simulations, and smoking machine or video clip.*				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: HOMEOSTASIS	
S5 Biology	**Unit 11:** General principles of homeostasis.			**No. of periods:** 7
Key Unit Competence: Explain general principles of homeostatic mechanisms.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	Attitudes and values		
– Explain the significance of a constant internal environment. – State the factors that must be kept constant in the internal environment of the body. – Discuss the role of the negative feedback mechanism. – Explain the feedback mechanism in relation to the endocrine and nervous system. – Identify the main internal and external causes of change in the internal environment.	– Relate organisms' ways of life to their environmental conditions. – Carryout research on homeostasis and deduce the findings.	– Appreciate the importance of maintaining a constant internal environment. – Appreciate the adaptations of animals to different environmental conditions in relation to homeostasis.	– Significance of constant internal environment. Factors that must be kept constant in the body: glucose, temperature, pH, water, ions, respiratory gases, and osmotic pressure of blood fluids. – Role of the negative feedback mechanism. – Feedback mechanisms related to the endocrine and nervous systems in homeostatic activities.	– Learners research from the library or internet the definition of homeostasis and factors that must be kept constant and present their findings in class. – In groups, learners use charts to discuss the mechanism of negative feedback and its role. – Learners are engaged in discussion of why there are diabetic people and people with high blood pressure, while others have no problems.

– Describe the formation, composition and movement of tissue fluid in relation to blood and lymphs.			– Causes of changes in the internal environment. – Formation, composition and movement of tissue fluid and its relationship to the blood and lymphs. – Adaptations of organisms to different environmental conditions.	– Learners work in groups to demonstrate how a fluid can leak through pores of a rubber tube as illustration of tissue fluid formation. – Learners are guided to make a field study on adaptations of different organisms to different environmental conditions.
Links to other subjects: *Physics: formation of tissue fluid is linked to fluid pressure.*				
Assessment criteria: *Students can clearly explain general principles of homeostatic mechanisms.*				
Materials: *Charts and computer aided materials and rubber tubes.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: HOMEOSTASIS	
S5 Biology	**Unit 12:** Regulation of glucose.			**No. of periods:**14
Key Unit Competence: Explain the mechanism of the regulation of blood glucose levels.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the role of hormones in sugar regulation. – Describe the detailed structure of a liver lobule and the Islet of Langerhans. – Explain the negative feedback mechanism in the process of blood glucose control. – Discuss the causes and effects of blood sugar imbalances in the body. – Describe the functions of the liver and pancreas in the regulation of glucose in the body.	– Test coloured water (simulated urine) for glucose. – Relate the structure of the liver and the pancreas to their functions. – Relate the microstructure of the liver and the pancreas to sugar regulation. – Make research using internet or articles on the role of adrenaline in the control of blood suger.	– Appreciate the importance of a controlled diet for diabetics. – Assist diabetics and people having hypertension in coping with their situation.	– Importance of glucose. – Role of the liver and the pancreas in glucose regulation. – Detailed structure of a liver lobule and the Islet of Langerhans. – Homeostatic control of blood glucose concentration by insulin and glucagon. – Interaction of glucose control mechanisms by other hormones. – Causes of blood sugar imbalances in the body. – Diabetes mellitus.	– Learners work in groups to discuss the process by which blood glucose level is controlled. Use illustrations and computer aided materials. – Learners research from the library or internet, negative feedback and causes and effects of blood sugar imbalances. Leaners present their findings to the class. – Using a microscope, learners observe prepared slides of liver tissue and pancreas tissue to study their structures and relate to the functions.

– Describe the three main stages of cell signalling in control of blood glucose by adrenaline as follows: • Hormone- receptor interaction at the cell surface. • Formation of cyclic AMP that bind to kinase protein. • An enzyme cascade involving activation of enzymes by phosphorylation to amplify the signal. – Explain the principles of the operation of dip sticks and biosensors for quantitative measurements of glucose in the blood and urine. – Explain how urine analysis is used in diagnosis with reference to glucose, protein and ketones.			– Monitoring of blood glucose levels. – Detection of glucose in urine.	– Carry out experiment to test for glucose in 'urine' samples. Coloured water may be used in place of real urine to avoid cases of infection. – Learners carry out research, from scientific articles or from the internet, on the role of adrenaline in the control of blood glucose level.
Links to other subjects:				
Assessment criteria: *Students can clearly explain the mechanism of the regulation of blood glucose levels.*				
Materials: *Charts/illustrations, computer aided study materials, microscopes and accessories.*				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: HOMEOSTASIS	
S5 Biology	**Unit 13:** Regulation of temperature.			**No. of periods:**14
Key Unit Competence: Explain the importance and ways by which organisms regulate body temperature.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain the importance of temperature regulation. – Describe the morphological, physiological and behavioural adaptations to temperature changes in the environment. – Describe the responses to cold and hot conditions by endothermic and ectothermic animals. – Explain the role of the brain and thermo receptors in temperature regulation.	– Interpret data related to the effects of temperature on animal behaviour. – Interpret and list the adaptive features shown by plants inhabiting extreme cold and hot environments. – Research using internet the role of brain in temperature regulation.	– - Acknowledge the importance of maintaining fairly constant temperatures for efficient metabolism.	– Importance of temperature regulation. – Morphological, physiological and behavioural adaptation to temperature changes in the environment. – Response to cold and hot conditions by endothermic and ectothermic animals. - The role of the brain: hypothalamus and thermo receptors in temperature regulation. - Effect of temperature conditions on animal behaviour.	– Learners carry out a simple experiment to show that enzymes require an optimum temperature and use the results to discuss why it is important to regulate body temperature. – In groups, learners observe photographs of animals, e.g. from the arctic regions and deserts, and record the observable features that enable them live in those conditions in relation to temperature changes. – Use computer aided materials or illustrations to describe the process of temperature regulation in endotherms and ectotherms.

– Describe the different processes in which plants minimise overheating.	– Design and investigate the effect of temperature.		– Temperature control in plants.	– Using internet or textbook material, learners research the role of the brain and thermo receptors in temperature regulation and present their findings. – Design and carry out a project to investigate the effect of temperature conditions on animal behaviour. – In pairs interpret and list the adaptive features shown by plants inhabiting extreme cold and hot environments
Links to other subjects: *Physics: heat.*				
Assessment criteria: *Students can clearly explain the importance and ways by which organisms regulate body temperature.*				
Materials: *Charts and graphs for temperature regulation in different animals, and computer aided materials.*				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: RESPONSE AND COORDINATION IN ORGANISMS	
S5 Biology	**Unit 14:** Behaviour and response in mammals.			**No. of periods:** 14
Key Unit Competence: Explain the different forms of behaviour and responses and their importance in the survival of organisms.				
Learning Objectives			Content	Learning Activities
Knowledge and understanding	Skills	Attitudes and values		
– State the different types of behaviour. – Recall that the nervous system is responsible for coordinating behaviour. – Explain the different types of behaviour in terms of stimulus, receptor, nerves and effectors. – Explain how types of behaviour result from sequential responses. – Give examples of imprinting and understand its significance.	– Apply knowledge of reflex actions to describe the components of a reflex arc and explain the different reflex behaviours. – Distinguish between simple reflex actions and a fixed action pattern. – Analyse the forms of conditioning.	– Appreciate the importance of animal welfare. – Value the causes and effects of bird and other animal migration. – Show concern for the behaviour of animals in societies. – Acknowledge the need for a territory by some animals for their continued survival.	– Behaviour: simple responses. – Learning: habituation and imprinting. – Conditioning and latent learning. – Social behaviour. – Courtship, territoriality and dominance hierarchies. – Behavioural rhythms and biological clocks. – Animal migration.	– Discuss how taxes and kineses can orient animals to favourable places. – Learners discuss the contribution of innate behaviour and learned behaviour to an animal's. - Discuss the significance of latent learning. – Research the different forms of communities that exhibit territorial behaviour.

– Explain the value of habituation. – Define the terms: conditioning, habituation, survival, courtship behaviour and migration. – Discuss the advantages and disadvantages to organisms living in societies. – Describe how birds and mammals maintain their territory. – Explain the significance of behavioural rhythms. – Discuss the advantages of bird migration.	– Analyse the contribution of innate behaviour and learned behaviour to an animal's overall behaviour and survival. – Distinguish between classical and operant conditioning. – Analyse the significance of latent learning. – Relate learning and response to survival in the environment. – Distinguish between migration and dispersion.	– Show concern for the importance of conditioned reflex in relation to survival.		– Make a group presentation about the interpretations of Pavlov's experiment. – Research and discuss the advantages of bird migration.
Link to other subjects: *Geography: graph statistics for seasons during migration and climate change.*				
Assessment criteria: *Students can clearly explain the different forms of behaviour and responses and their importance to the survival of organisms.*				
Materials: *Online sources, charts and diagrams for animal behaviour and migration.*				

TOPIC AREA: HEALTH AND DISEASE			SUB-TOPIC AREA: IMMUNITY	
S5 Biology	**Unit 15:** Immune system, vaccination and antibiotics.			No. of periods:14
Key Unit Competence: Describe the immune system and apply knowledge gained in familiar and unfamiliar contexts.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State the origin and describe the mode of action of phagocytes. – Describe the modes of action of B-lymphocytes and T-lymphocytes. – Explain the meaning of the term immune response, making reference to the terms antigen, self and non-self. – Explain the role of memory cells in long-term immunity. – Distinguish between active and passive, natural and artificial immunity and explain how vaccination can control disease.	– Recognise phagocytes and lymphocytes under a light microscope. – Relate the molecular structure of antibodies to their functions. – Interpret the differences between cellular responses and humoral responses.	– Support and promote national immunisation days. – Support and have sympathy for asthmatic patients.	– Origin and mode of action of phagocytes. – Immune responses. – Types of immunity. – Allergy as an immune response. – Asthma and hay fever. – Antibiotics.	– Learners study the prepared slides of blood smear and observe, draw and describe the structures seen. Learners should focus on phagocytes and lymphocytes. – Interpret charts for humoral and cellular responses to show the relationship between the two forms of response.

– Explain the role of antibodies in allergies. – Distinguish between generalised and localised allergic reactions. – Discuss causes, symptoms and treatment of asthma and hay fever. – Discuss the reasons why vaccination programs have eradicated smallpox but not measles, TB, malaria or cholera. – Define antibiotic as a substance produced by one microorganism that is capable of destroying or inhibiting the growth of another microorganism. – Explain how antibiotics work. – Explain the reasons for antibiotic resistance.	– Carry out research and be able to present findings on the reasons for antibiotic resistance in the treatments of infections.			– Learners compare data showing statistics of cases of smallpox, measles, malaria and tuberculosis over centuries and discuss why vaccination has not eradicated some of these diseases. – Learners carry out research and present their findings on the reasons for antibiotic resistance in the treatment of bacterial infections.
Links to other subjects:				
Assessment criteria: *Learners can describe the immune system and apply knowledge gained in familiar and unfamiliar contexts.*				
Materials: *Microscopes, prepared slides of white blood cells, and statistics on disease occurrence.*				

TOPIC AREA: REPRODUCTION			SUB-TOPIC AREA: REPRODUCTION IN ANIMALS	
S5 Biology	**Unit 16:** Human reproductive system and gametogenesis.			**No. of periods:**14
Key Unit Competence: Relate the structures of the human reproductive system to their functions and describe gamete formation.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the structure of human male and female reproductive systems. – State where female and male gametes are produced. – Describe the histology of mammalian ovary and testis.	– Relate the histology of the testis and ovary to their functions. – Analyse and interpret chart diagrams of spermatogenesis and oogenesis. – Prepare slides well to study the structure of gametes.	– Appreciate the significance of the process of gametogenesis at puberty as a key characteristic of sexual maturity. – Acknowledge the relevance of meiosis during gametogenesis as an essential tool in maintaining the diploid condition after fertilisation.	– Reproduction in humans. – Male and female reproductive systems. – Gametogenesis: spermatogenesis and oogenesis.	– In pairs, learners dissect and identify structures of the reproductive system of male and female small mammals. – Learners use prepared slides or micrographs to study the histology of the testis and ovaries. – Prepare or use prepared slides to study the structure of gametes.

– Outline gametogenesis in a male and a female human as a process involving mitosis, growth, meiosis and maturation. – Explain how spermatozoa are produced. – Explain how oocytes are produced. – Explain the significance of gametogenesis.	– Research about gametes and their formation and deduce their findings.			– Learners analyse and interpret chart diagrams of spermatogenesis and oogenesis to find out their similarities and differences. – Learners discuss the significance of gametogenesis in terms of the haploid nature of gametes.
Links to other subjects:				
Assessment criteria: *Learners can clearly relate the structures of the human reproductive system to their functions and describe gamete formation.*				
Materials: *Illustrations and computer aided study materials, prepared slides of testis and ovarian tissue, sperm and egg, microscopes, and small mammals (rat/rabbit/guinea pig).*				

TOPIC AREA: GENETICS AND ITS APPLICATIONS			SUB-TOPIC AREA: GENETICS	
S5 Biology	**Unit 17:** Genetics.			**No. of periods:21**
Key Unit Competence: Explain the role of genes in inheritance and how genetic disorders occur.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain the terms gene, locus, allele, dominant, recessive, co- dominant, linkage, test cross, F1 and F2, phenotype, genotype, homozygous and heterozygous. – Explain how to conduct a test cross. – Explain why monohybrid ratios of 1:2:1 occur. – Describe an example of inheritance involving multiple alleles. – Explain the effect of lethal genes on phenotype ratios. – Give a genetic explanation of Mendelian dihybrid inheritance.	– Analyse various patterns of inheritance. – Use genetic diagrams to solve problems involving monohybrid and dihybrid crosses, including those involving autosomal linkage, sex linkage, and codominance, multiple alleles and gene interactions. (The term epistasis does not need to be used: knowledge of the expected ratio for various types of epistasis is not required. The focus is on problem solving).	– Appreciate the roles of genes in determining the phenotype and patterns of inheritance.	– Concept of inheritance. – Definition of genetic terms. – Mendel's laws of inheritance: monohybrid inheritance, independent assortment and segregation. – Co-dominance, multiple alleles and lethal alleles. – Dihybrid inheritance. – Linkage and crossing over. – Sex determination. – Sex linkage. – Genetic disorders.	– Learners, in groups, use genetic diagrams provided to solve problems involving monohybrid and dihybrid crosses, including those involving autosomal linkage, sex linkage, co- dominance, multiple alleles and gene interactions. The focus is on problem solving. – In groups, use genetic diagrams to solve problems involving test crosses with the help of a chi- squared test to test the significance of differences between observed and expected results (the formula for the chi- squared test will be provided.). (See mathematical requirements).

– Explain the use of test crosses to determine unknown genotypes in studies of dihybrid inheritance. – Explain the significance of recombination. – Explain how sex is determined in humans and the role of sex related Y genes in determining sex. – Describe how non-disjunction can affect the distribution of sex chromosomes in gametes and offspring. – Explain why linked genesdo not show independent assortment. – Explain how crossover values can be used to make a chromosome map.	– Use the complete and accurate format to show a genetic cross and the results of a simple monohybrid cross. – Use genetic diagrams to solve problems involving test crosses. – Use the chi-squared test to test the significance of the differences between observed and expected results (the formula for the chi- squared test will be provided.). (See mathematical requirements) – Demonstrate monohybrid and dihybrid inheritance. – Interpret Pedigree charts.			– Learners, using genetic crosses provided on the chart, calculate the phenotype and genotype ratios involving monohybrid and dihybrid crosses. – Discuss the effect of lethal genes on phenotype ratios. – Using uniform money coins, and beads/seed learners demonstrate monohybrid and dihybrid inheritance. – Use the provided pedigree chart showing the transmission of haemophilia to calculate the ratio of normal carriers haemophiliac and make presentation.
Links to other subjects: *Mathematical requirement: ratios in mathematics.*				
***Assessment criteria**: Students can clearly explain how genes are passed on from one generation to another and how genetic disorders occur.*				
***Materials:** Online resources, CDs, simulations, diagrams, charts, micrographs, pedigree charts, illustrations, different plant seeds (e.g. beans and peas), animals, and money coins.*				

TOPIC AREA: GENETICS AND ITS APPLICATIONS			SUB-TOPIC AREA: GENETICS	
S5 Biology	**Unit 18:** Mutations.			**No. of periods:**7
Key Unit Competence: Describe the types, causes and effects of mutation in organisms.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Define mutation. – Describe types of mutation and causes of mutations. – Explain the significance of mutations. – Explain that gene mutation occurs by substitution, deletion, inversion and insertion of base pairs in DNA. Outline how such mutations may affect the phenotype. – Explain that the environment may affect the phenotype.	– Make a chart illustrating and summarising different kinds of gene and chromosomal mutations. – Distinguish between gene and chromosomal mutation. – Use a thin clay log composed of different colours to represent different chromosomes.	– Appreciate that mutations can bring about change in the genetic constitution of an organism and that these may or may not result in evolution.	– Mutations. – Types of mutations: gene and chromosomal mutation. – Differences between gene and chromosomal mutations. – Causes of mutation: chance, radiation, and chemical. – Effect of mutations on the phenotype. – Effect of environment on the phenotype. – Significance of mutations.	– In groups, discuss differences between gene and chromosomal mutation and one possible effect on an organism. – Learners manipulate a thin clay log composed of different colours to represent different genes in order to show how an inversion can occur. – Use computer simulations to discuss the types and significance of mutations.

– Outline the effects of mutant alleles on the phenotype in the following human conditions: albinism, sickle cell anaemia, haemophilia and Huntington's disease. – Explain the relationship between genes, enzymes and phenotypes with respect to the gene for tyrosinase involved in the production of melanin. – Explain how a change in the base sequence of the gene for haemoglobin results in abnormal haemoglobin and sickle-shaped red blood cells.	– Manipulate the clay to show how an inversion can occur. – Use internet to search simulations of mutations and deduce the findings.			– In groups, use charts and illustrations to show how sickle cell anaemia is inherited and outline the features of the offspring with or without sickle cell anaemia.
Links to other subjects: *Agriculture: genetics and variation.*				
***Assessment criteria**: Students can clearly describe the types, causes and effects of mutation in organisms.*				
***Materials:** Online resources, CDs, computer simulations, diagrams, charts, micrographs, clay logs, and illustrations.*				

3.4. Biology programme for S6

3.4.1. Key competences at the end of S6

- Describe the factors affecting population size and the importance of natural resources.
- Describe the different components of an ecosystem, biogeochemical cycles and how energy flows in an ecosystem.
- Evaluate the effects of human population size, resource use, and technology on environmental quality.
- Relate the structures of the circulatory and lymphatic systems to their functions.
- Describe the structure and importance of ATP, and outline the roles of the coenzymes NAD, FAD and coenzyme A during cellular respiration.
- Describe the process of cellular respiration.
- Explain the principles of excretion and osmoregulation.
- Explain the general principles of reception and response in animals.
- Describe the structure of neurones and explain the mechanisms of impulse transmission.
- Identify the location and function of endocrine glands in the body.
- Explain the structure of muscles in relation to movement.
- Explain the role of hormones in human reproduction, stages of pregnancy and foetal development.
- Explain the principles of gene technology.
- Evaluate how gene technology is applied in areas of medicine, forensic science and agriculture.
- Explain variation and mutation as a source of biodiversity.
- Explain the role of artificial and natural selection in production of varieties of animals and plants with increased economic importance.

- Analyse the relevance of theories of evolution and explain the process of speciation.

3.4.2. Biology units Table for S6

TOPIC AREA: ECOLOGY AND CONSERVATION			SUB-TOPIC AREA: ENVIRONMENTAL BIOLOGY	
S6 Biology	**Unit 1:** Population and natural resources.			**No. of periods:**14
Key Unit Competence: Describe the factors affecting population size and the importance of natural resources.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State and define population characteristics. – Explain factors that affect population density. – Explain population growth patterns. – Explain the terms renewable and non-renewable resources. – Explain how environmental resistance affects the balance of nature.	– Demonstrate methods used in estimating populations by using quadrats and line transects. – Research how the human population has grown over the past 250 years. – Compare statistics on the population age- sex structure of developing and developed countries.	– Support that human population explosion impacts negatively on the environment. – Recognise that some resources are renewable and others are non-renewable and that effective use of these resources is of great value – Justify the practice of family planning as a tool for reducing population explosion.	– Population characteristics: density, age structure, growth pattern, birth and death rates. – Population density: dependent and independent factors. – Methods or techniques of measuring and estimating population density. – Population growth patterns.	– Learners practically estimate populations using quadrats and line transects. – Learners use the capture-recapture method and the Lincoln index to estimate population sizes. – Use illustrations and videos to discuss population growth patterns of organisms. – Learners discuss how the human population has grown over the past 250 years.

– Explain the importance of natural resources in growth of the Rwandan economy and methods of conservation.	– Analyse the costs and benefits of managing renewable and non-renewable resources.		– Environmental resistance (density dependent factors that affect the balance of nature). – Natural resources (renewable and non-renewable). – Importance of natural resources and methods of conserving natural resources.	– Learners compare statistics on the population age-sex structure of developing and developed countries and discuss the implications to resource use. – Discuss how environmental resistance affects the balance of nature. – In pairs, undertake a research project on the importance of natural resources in the growth of the Rwandan economy and methods of conservation.
Links to other subjects: *Economics and geography: use of natural resources in relation to population.*				
Assessment criteria: *Students can clearly describe the factors affecting population size and the importance of natural resources.*				
Materials: *Quadrates, pegs, strings/ropes, specimen bottles, markers, and computer aided simulations of population growth and statistics on human populations in different countries.*				

TOPIC AREA: ECOLOGY AND CONSERVATION		SUB-TOPIC AREA: ENVIRONMENTAL BIOLOGY		
S6 Biology	**Unit 2:** Concept of ecosystem.			**No. of periods:14**
Key Unit Competence: Describe the different components of an ecosystem, biogeochemical cycles and how energy flows in an ecosystem.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe an ecosystem. – State the types and properties of an ecosystem. – Describe the main components of an ecosystem. – Explain the ecological factors influencing the life of organisms in an ecosystem. – Define the terms: populations, communities, ecosystems, biomes, niche and biosphere. – Describe feeding relationships in an ecosystem.	– Distinguish between individuals, populations, communities, ecosystems, biomes, and the biosphere. – Analyse the relationship between organisms (e.g. producers, consumers, and decomposers) and their trophic levels.	– Appreciate the existence of different components of an ecosystem and their roles in the life of organisms. – Beware of the effect of bioaccumulations at different trophic levels.	– Ecosystem. – Types of ecosystems: terrestrial, aquatic and their properties: – Feeding relationships. – Cycling of materials. – **Succession.** – Ecological factors influencing the life of organisms: – **Biotic and abiotic**. – **Edaphic factors**.	– In groups analyse the relationship between organisms (e.g., producers, consumers, and decomposers) and their trophic levels. – Individually interpret energy flow diagrams and charts. – In groups, compare gross primary, net primary production, and secondary production. – Distinguish between primary and secondary succession in biotic communities.

– Describe a food chain and a food web. – Explain the relative merits of pyramids of numbers, biomass and energy. – Explain what is meant by trophic. efficiency. – Explain energy flow and the recycling of nutrients in an ecosystem. – Describe biogeochemical cycles. – Identify processes, components, and roles of organisms in the hydrologic, carbon and nitrogen cycles.	– Distinguish between abiotic and biotic factors. – Interpret energy flow diagrams. – Compare gross primary, net primary production and secondary production. – Distinguish between primary and secondary succession in biotic communities.	– Recognize the source and transfer of energy in an ecosystem.	– Energy flow in ecosystems: – **Food chains.** – **Food webs.** – **Ecological pyramids** – Bioaccumulation/ biological magnification. – Efficiency of production. – Biogeochemical cycles: nitrogen, carbon and water.	– Discuss the relative merits of pyramids of numbers, biomass and energy. – Discuss the processes, components, and the roles of organisms in the hydrologic, carbon and nitrogen cycles.
Links to other subjects: *Geography: water cycle and drainage.*				
Assessment criteria: *Can properly describe the different components of an ecosystem, biogeochemical cycles and how energy flows in an ecosystem.*				
Materials: *Specimen bottles, computer aided learning materials, charts and illustrations of biogeochemical cycles, food chains and food webs, and energy flow charts.*				

TOPIC AREA: ECOLOGY AND CONSERVATION			SUB-TOPIC AREA: APPLIED ECOLOGY	
S6 Biology	**Unit 3:** Effects of human activities on ecosystems.			**No. of periods:14**
Key Unit Competence: Evaluate the effects of human population size, resource use and technology on environmental quality.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain how modern technology has resulted in increased food production in terms of agricultural machinery, chemical fertilisers, insecticides, herbicides, and selective breeding. – Explain the negative impacts to an ecosystem of large scale monoculture of crop plants. – Explain the reasons for habitat destruction (agriculture and extraction of natural resources).	– Assess the negative impacts to an ecosystem of intensive livestock production. – Conduct shows and dramas on wildlife conservation. – Research the effects of the excessive use of fertilisers on the environment. – Assess the different methods of the conservation of nature.	– Appreciate the balance between society, environment and the economy. – Recognize that extinction is a natural part of the evolution of life on earth but has taken place in an unprecedented rate, mainly as a result of human activities. – Support the Rwandan government policy of protecting the environment.	– Impact of human activities on ecosystems. – Agriculture: modern technology to increase food supply, negative impacts of large-scale monoculture and livestock on ecosystems. – Fishing. – Deforestation: habitat destruction. – Mining. – Industrialisation. – Pollution:	– In groups, discuss the negative impacts of techniques used by farmers to increase their yield. – Learners make a trip to polluted sites and assess the impact of industrial sewage and fertiliser application on nearby land to wetlands and water bodies. – Learners research the mandate of the Rwanda Environmental Management Authority (REMA).

– Explain the undesirable effects of habitat destruction. – Explain the sources and effects of the pollution of air, water and land. – Explain the causes and effects of acid rain, eutrophication of water and non-biodegradable plastics. – Explain the main methods of the conservation of resources. – Describe an example of conservation in action.	– Carry out a research project on recycling sewage. – Carry out research on the African species endangered by human activity. – Evaluate the reasons for conserving wildlife. – Demonstrate ways of reducing pollution and protecting the environment. – Organise clubs focused on environmental and wildlife protection. – Suggest ways in which one could take positive action to help conserve biological resources.	– Translate regulations designed to prevent over fishing into action.	* Air pollution, sources and effects of main air pollutants (greenhouse effect and acid rain). – **Water pollution (eutrophication).** – **Bio indicators of pollution.** – **Control of pollution.** – **Ways of reducing:** – **Pollution.** – Poaching. – Forest fires. – Biological conservation – conservation methods	– Learners perform role plays to appreciate the view points of various stakeholders and parties in balancing conservation and agriculture. Learners to investigate potential solutions. – Discuss the contribution deforestation may make to flooding and desertification. – In journal form, learners conduct a survey of a nearby site that is suffering from degradation and then implement protection measures. – Research project on recycling sewage. – Carry out research on the endangered species in Africa as a result of human activity.

				– Discuss ways in which one could take positive action to help conserve biological resources.
Links to other subjects: *Chemistry: causes of acid rain..*				
Assessment criteria: *Evaluate the effects of human population size, resource use, and technology on environmental quality.*				
Materials: *Illustrations, photographs, videos, and computer aided study materials.*				

Topic Area: Organisation and Maintenance of Life			Sub-topic Area: Energy and Respiration	
S6 Biology	**Unit 4:** Energy from respiration.			**No. of periods:7**
Key Unit Competence: Describe the structure and importance of ATP and outline the roles of the coenzymes NAD, FAD and coenzyme A during cellular respiration.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Discuss the need for energy in living organisms, as illustrated by anabolic reactions, active transport, and the movement and maintenance of body temperature. – Describe the structure of ATP as a phosphorylated nucleotide formed by condensation reaction. – Explain that ATP is synthesised in substrate-linked reactions in glycolysis and in the Krebs cycle. (tri-carboxylic acid (TCA) cycle)	– Design simple experiments using respirometers to determine the RQ of germinating seeds or small invertebrates e.g. woodlice. – Calculate RQ values from the equations of respiration of different substrates.	– Appreciate the importance of energy in the life of organisms. – Acknowledge the role of ATP as the energy currency of the cell.	– The need for energy by organisms. – Structure of ATP. – Synthesis and breakdown of ATP. – The roles of coenzymes (NAD, FAD and coenzyme A) in respiration. – Respiratory substrates and their relative energy values. – Measurement of respiration and respiratory quotients by using respirometers.	– Learners read and then discuss in groups the need for energy in living organisms. – Learners research from the internet or library, the structure and roles of ATP and present their findings. – Using provided learning resources, learners discuss ways by which ATP molecules are synthesised. – Using provided learning resources, learners discuss in groups, the roles of the coenzymes NAD, FAD and coenzyme A in respiration.

– Outline the roles of the coenzymes NAD, FAD and coenzyme A in respiration. – Explain that the synthesis of ATP is associated with the electron transport chain on the membrane of the mitochondrion and chloroplast. – Explain the relative energy value of carbohydrate, lipid and protein as respiratory substrate and explain why lipids are particularly energy-rich. – Define the term respiratory quotient (RQ) as the ratio of the volume of CO_2 evolved to the volume of O_2 uptake during aerobic respiration.	– Interpret graphs for varying RQ values during seed germination.			– Use simple combustion experiments with calorimeter to determine the relative energy values of different food substances. – Learners carry out an investigation showing the respiratory rate of germinating seeds or woodlice using respirometers. – In groups, learners use simple respiration equations to calculate values of the respiratory quotient. – Individually, interpret graphs for varying RQ values during seed germination.
Links to other subjects: *Mathematics: RQ. Physics and chemistry: ATP is synthesised during the exothermic processes..*				
Assessment criteria: *Learners can describe the structure and importance of ATP, and outline the roles of the coenzymes NAD, FAD and coenzyme A during cellular respiration.*				
Materials: *Seeds, insects (woodlice), and respirometers.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: ENERGY AND RESPIRATION.	
S6 Biology	**Unit 5:** Cellular respiration.			**No. of periods: 21**
Key Unit Competence: Describe the process of cellular respiration.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Outline the four stages in aerobic respiration (glycolysis, link reaction, TCA cycle and oxidative phosphorylation) and state where eachoccurs in the eukaryotic cells. – Explain that when oxygen is available pyruvate is converted into acetyl coenzyme A, which then combines with oxaloacetate (4C) to form citrate (6C).	– Carry out investigations to determine the effect of factors such as temperature and substrate concentration on the rate of respiration of yeast. – Carry out simple investigations, using simple respirometers, to measure the effect of temperature on the respiration rate of germinating seeds or small invertebrates.	– Acknowledge the need for energy in food molecules and how it is made available for organisms to do biological work.	– Aerobic respiration. – Glycolysis. – The link reaction. – TCA cycle. – Oxidative phosphorylation. – Efficiency of aerobic and anaerobic respiration. – Factors which affect the rate of respiration. – Use of other substrates in respiration.	– Learners discuss the four stages of aerobic respiration using illustrations. – Using computer simulations and suitable illustrations, learners work in groups to study the process of glycolysis and link reactions. Learners then present to the class. – Learners work in groups to draw charts summarizing the essential reactions of the TCA cycle, showing the link with NAD and FAD. Learners then present their charts to class.

– Explain that reactions in the TCA cycle involve decarboxylation and dehydrogenation and the reduction of NAD and FAD. – Outline the process of oxidative phosphorylation including the role of oxygen (details of the carriers are not required). – Describe the relationship between the structure and function of the mitochondrion. – Explain the production of a small yield of ATP from anaerobic respiration in yeast and mammalian muscle tissue, including the concept of oxygen debt.	– Compare the theoretical ATP yield during aerobic and anaerobic respiration. – Perform experiments using spirometer. – Carry out research on why anaerobic respiration produces a small yield of ATP.			– Learners discuss the process of oxidative phosphorylation using computer aided learning materials or illustrations. – Observe a micrograph or diagram of mitochondrion and relate the structure with its function. – Use the internet or library resources to research why rice is able to grow with its roots submerged in water. – Perform investigations to determine the effect of temperature and substrate concentration on the rate of respiration. – Carry out simple experiments with spirometers to measure the effect of temperature on the respiration rate of geminating seeds or small vertebrates. – Research why anaerobic respiration produces a small yield of ATP and present the findings.

– Explain how other substrates are involved in glycolysis and the TCA cycle.				
Links to other subjects: *Chemistry: the physiology of respiration is linked to redox reactions.*				
Assessment criteria: *Learners can describe the process of cellular respiration.*				
Materials: *Charts, respirometers, computer simulations, and germinating seeds or small vertebrates such as woodlice.*				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: HOMEOSTASIS	
S6 Biology	**Unit 6:** Excretion and osmoregulation.			**No. of periods:21**
Key Unit Competence: Explain the principles of excretion and osmoregulation.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the structure and role of excretory organs in mammals. – Describe the detailed structure of the nephron with its associated blood vessels. – Describe and outline the ornithine cycle and its role in the conversion of ammonia to urea. – Describe how the process of ultrafiltration and selective reabsorption are involved in the formation of urine in the nephron.	– Dissect, display, draw and label the urinary system of a toad, rat/rabbit etc. – Interpret the ornithine cycle diagram with reference to urine formation. – Relate adaptations of different organisms to their habitat in terms of osmoregulation.	– Support the use of dialysis machine or kidney transplants in solving problems associated with kidney failure. – Appreciate the adaptation of organisms to different habitats in relation to osmoregulation.	– Structure and functions of excretory organs in mammals: kidney, liver and skin. – Structure and the functions of the nephron. – Formation of urea and urine. – Role of the hypothalamus, pituitary gland, adrenal gland and nephron in varying the osmotic pressure of blood. – Kidney transplants and dialysis machines.	– Learners carry out research on the structure and the function of the kidney, liver and skin. Learners to focus on the excretory functions. – Learners dissect a rabbit kidney to study its structure. – Learners use models and charts to describe the structure of a nephron with its associated blood vessels.

– Describe the use of dialysis in kidney machines. – Describe how kidney transplants are performed. – Describe the role of hypothalamus, posterior pituitary, ADH and collecting ducts in osmoregulation. – Explain the principles of osmoregulation in organisms living in marine, freshwater and terrestrial habitats. – Explain dialysis in terms of salt balance, the maintenance of glucose concentration and the removal of urea. – Explain why plants do not have specialised excretory organs.	– Compare the advantages and disadvantages of kidney transplants with dialysis machines.		– Excretion and osmoregulation in other organisms – protoctista, insects, fish, amphibians and birds. – Principles of osmoregulation in marine, freshwater and terrestrial organisms. – Excretion in plants.	– Learners carry out research on the osmoregulation of marine animals, fresh water animals and terrestrial animals to show their difference in terms of excretory organs and nitrogenous waste products. – Learners analyse the generalised flow chart of osmoregulation and identify the role of the Hypothalamus, Pituitary, ADH and collecting duct. A dialysis technician or nurse speaks to learners who take notes on the use, effectiveness, and importance of the machine. – Learners write-up what they learned.

– State the excretory products of plants and how they are eliminated.				
Links to other subjects:				
Assessment criteria: *Can explain the principles of excretion and osmoregulation.*				
Materials: *Charts/illustrations and computer aided materials, prepared slides, microscopes, dissecting sets and boards, animals for dissection, and models and simulations of kidney function.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: RESPONSE AND COORDINATION IN ORGANISMS	
S6 Biology	**Unit 7: General principles of reception and response in animals.**			**No. of periods:14**
Key Unit Competence: Explain the general principles of reception and response in animals.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain the necessity of responding to internal and external changes in the environment. – Describe the main types of sensory receptors. – Discuss the main functions of a sensory system. – Explain the significance of sensory adaptation. – Describe the structure of the human eye. – Describe the structure of the retina. – Explain how rods transduce light energy into nerve impulses.	– Observe the structure of the skin, retina, cochlea and vestibular apparatus from prepared slides or micrographs and relate them to their functions. – Interpret graphs on sensory adaptation in response to a constant stimulus. – Relate the number of retinal cells to sensitivity and visual acuity.	– Recognise the role of sense organs in the perception of different stimuli. – Appreciate the role of sensory adaptation in protecting the sense organs from overload with unnecessary or irrelevant information.	– Importance of responses to the internal and external environment. – Types of sensory receptors and stimuli. – Components of the sensory system: transduction, transmission and processing. – Sensory adaptation. – Structure and functioning of the eye and the ear. – Location of taste buds on the tongue and sensory cells in the skin.	– Learners demonstrate their ability to perceive various stimuli: smooth/loud sounds, dim/bright lights, cold/warm items, perfume, and water/brine. Learners then discuss the types of stimuli. – Using the 3D model of the sense organs, learners discuss the structure of these organs. – Learners dissect the eye of a mammal and identify the three layers of the eyeball.

– Explain how retinal convergence improves sensitivity. – Explain how the cones achieve visual acuity. – -Explain how cone cells produce colour vision. – -Discuss the significance of binocular vision. – -Describe the structure of the human ear and the functions of its main parts. – -Describe the process of hearing and balance. – Locate the taste buds on the tongue and sensory cells in the skin.				– Learners research from the internet or textbooks the location of taste buds on the human tongue. – Learners individually investigate the relative location of rods and cones in the retina by focusing at objects in dim light. – Learners carry out experiments on reverse colour sense by cones. – Use computer animations to discuss the process of light perception, hearing and balance. – Interpret graphs of sensory adaptation when sensory cells lose their responsiveness.
Links to other subjects: *Physics: image formation and sound waves.*				
Assessment criteria: *Learners can explain clearly the general principles of reception and response in animals.*				
Materials: *Illustrations and computer aided study materials, models of eyes, ears and skin, and reverse colour cards or websites.*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: RESPONSE AND COORDINATION IN ORGANISMS	
S6 Biology	**Unit 8:** Nervous coordination.			**No. of periods:14**
Key Unit Competence: Describe the structure of neurones and explain the mechanisms of impulse transmission.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the arrangement of neurons in a reflex arc. – Describe the structure neurones. – Explain how a resting potential is maintained. – Explain how an action potential is generated. – Explain how a nerve impulse is propagated along a neurone. – Explain the factors affecting the speed of impulse transmission. – Describe the properties of a nerve impulse limited to: saltatory conduction, all or nothing law, and refractory period.	– Relate the structure of a cholinergic synapse to its functions. – Interpret graphs for all or nothing law and refractory period. – Investigate the nature of a nerve impulse in a nerve tissue of a frog.	– Appreciate the importance of a coordinated behaviour in organisms. – Show concern about the need to have reflexes as rapid responses.	– Control and co-ordination in mammals. – Structure and functions of neurons. – Generation of nerve impulses (resting and action potential). – Transmission of a nerve impulse: – **Propagation of a nerve impulse.** – **Transmission in a myelinated fibre/ saltatory conduction.** – **All or nothing law** – **The refractory period.**	– Discuss reasons for having reflexes as responses in the body. – In groups, learners describe and explain the transmission of an action potential in a myelinated neurone. - Investigate knee jerk, pupil and the blinking reflexes. - Use charts and computer simulations to observe the structure and mode of impulse transmissions.

– Describe the functions of neurones in a reflex arc. – Explain how information passes across a synapse from one neurone to another or from a neurone to its effector. – Outline the roles of synapses. – Describe the roles of neuromuscular junctions, transverse system tubules and sarcoplasmic reticulum in stimulating contraction in striated muscle.			– Functions of sensory, relay and motor neurones in a reflex arc. – Structure and function of a cholinergic synapse. – Roles of synapses in the nervous system.	– Demonstrate electric activity in the nerve of a frog. – Learners carry out project work for the simulation of the transmission of nerve impulses along the axon and across the synapse.
Links to other subjects: *Physics: electric current.*				
Assessment criteria: *Students can correctly describe the structure of neurones and explain the mechanisms of impulse transmission.*				
Materials: *Computer simulations, charts and diagrams of nerve cells, impulse transmission, reflex arc, frog, dissection set, nerve muscle.*				
junction slide, and microscope.				

TOPIC AREA: ORGANIZATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: RESPONSE AND COORDINATION IN ORGANISMS	
S6 Biology	**Unit 9:** Hormonal coordination in animals.			**No. of periods:14**
Key Unit Competence: Identify the location and function of endocrine glands in the body.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Define hormones. – Explain why hormonal balance is necessary for coordinating the functions in the body. – Describe the principle of the negative feedback mechanism by which hormones produce their effects on target cells.	– Compare and contrast the actions of the endocrine and nervous systems. – Draw and interpret the flow chart of negative feedback mechanisms.	– Appreciate the role of hormones in the growth and development of organisms.	– Structure and function of the endocrine system in humans: location of endocrine glands and functions of their secretions. – Principles of the negative feedback mechanism of hormonal action. – Necessity of hormonal balances. – Effects of hormonal imbalance: diabetes, goitre, dwarfism and gigantism. – Comparison of hormonal and nervous systems.	– Learners use illustrations to identify and name the endocrine glands in human body. – Learners discuss the hormones secreted by each gland and their functions. – Learners discuss picture/ photographs or movies showing gigantism and dwarfism with reference to hormonal disorders. – Learners research the necessity of hormone balance and the effects of imbalance and write a report.

– Describe the structure and function of the endocrine system. – Explain the effects of hormonal imbalances.				– – Learners use computer simulations to study and analyse the principles of the negative feedback mechanism of hormonal action. – In groups, learners discuss the similarities and differences between the structure and functioning of nervous and hormonal systems.
Links to other subjects: *Physics: diffusion.*				
Assessment criteria: *Learners can identify the location and function of endocrine glands in the body.*				
Materials: *Illustrations and computer aided study materials, and charts for locating endocrine glands in the human body*				

TOPIC AREA: ORGANISATION AND MAINTENANCE OF LIFE			SUB-TOPIC AREA: RESPONSE AND COORDINATION IN ORGANISMS	
S6 Biology	**Unit 10:** Growth and development in plants and animals			**No. of periods:14**
Key Unit Competence: Account for the processes of growth and development in plants and animals.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe dormancy as a state of inactivity to absolute minimum due to the morphological and physiological state of a plant structure. – Explain how dormancy is maintained and broken. – State the conditions required for germination. – Outline the role of enzymes in the process of germination. – State types of plant growth hormones and their functions. – Identify the hypocotyl and coleoptile in a germinating seed.	– Observe structures of endospermic and non-endospermic seeds. – Demonstrate how fruit and seed dispersal takes place. – Demonstrate hypogeal and epigeal germination. – Carry out an investigation to distinguish between primary and secondary growth.	– Appreciate the importance of fruit and seed dormancy and germination in the life cycle of plants. – Appreciate the demands of the terrestrial environment to the adaptation of amphibians	– Fruit, seed and bud dormancy. – Types and stages of germination. – Primary and secondary growth. – Determination of growth. – Phytohormones. – Plant movements. – Photoperiodism in plants. – Metamorphosis and growth patterns in insects and amphibians.	– Cut and compare longitudinal sections of endospermic and non-endospermic seeds. – Cut monocot and dicot stems, shoots and meristems of woody trees to compare primary and secondary growth. – Carry out a research project on the phototropism and geotropism. – Investigate primary growth in a seedling. – Investigate the effect of temperature on development of frog eggs. – Learners collect varieties of fruits and seeds and bring them to class and investigate how far they travel when dropped from a height.

– Describe the stages and types of germination. – State that a meristem is a growing point of the plant and the main meristematic regions of a tree. – Describe current views about photoperiodic control of flowering. - Describe the process of metamorphosis in arthropods and amphibians.	– Carry out an experiment on the development of eggs at different temperatures. – Distinguish the various stages of development in frogs. – Analyse complete and incomplete metamorphosis. – Compare growth patterns in arthropods and vertebrates.			– In pairs, make a hypothesis about what other environmental factors would affect the development of frog eggs and present it for evaluation. – Discus reasons why complete metamorphosis may have greater adaptive value for an insect than incomplete metamorphosis. – Interpret data and graphs for growth patterns in arthropods, vertebrates and plants.
Link to other subjects:				
Assessment criteria: *Students can correctly explain the reasons for the changes in growth and development in insects, plants and amphibians during their life cycle.*				
Materials: *Thermometer, binocular microscope, frog eggs, flash light, refrigerator, charts for growth patterns, thread, ink, germinating seeds, and a timer.*				

TOPIC AREA: REPRODUCTION			SUB-TOPIC AREA: REPRODUCTION IN PLANTS	
S6 Biology	**Unit 11:** Asexual Reproduction in Plants			**No. of periods:7**
Key Unit Competence: Account for various methods of asexual reproduction as means of increasing crop yield.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Describe the various methods of asexual reproduction: fragmentation, budding, and spore formation. – Discuss the advantages and disadvantages of asexual reproduction. – Describe the characteristics of vegetative reproductive parts in a flowering plant.	– Differentiate between asexual and sexual reproduction. – Demonstrate asexual reproduction mechanisms in lower organisms. – Apply principles of artificial propagation in growing varieties of plants that are economically important. – Apply the know how to produce economically important plants.	– Appreciate the use of artificial propagation in increasing crop yields.	– Asexual and sexual reproduction. – Methods of asexual reproduction. – Advantages and disadvantages of asexual reproduction. – Vegetative and artificial propagation in flowering plants. – Application of artificial propagation in growing improved varieties of plants.	– Discuss asexual reproduction in lower organisms and higher plants, outlining advantages and disadvantages. – Learners observe asexual reproduction in lower organisms and write reports as an out-of-class activity. – Learners examine prepared slides on asexual reproduction in lower organisms. – Learners carry out vegetative propagation of at least two plant species by stem cutting suckers or layering (cassava, Banana, hibiscus). – Field study on natural and artificial propagation methods.

Links to other subjects: *Agriculture: crop yield methods are used to improve the economy.*

Assessment criteria: *Learners can account for various methods of asexual reproduction as means of increasing crop yield.*

Materials: *Illustrations and computer aided materials.*

TOPIC AREA: REPRODUCTION			SUB-TOPIC AREA: REPRODUCTION IN PLANTS	
S6 Biology	**Unit 12:** Sexual Reproduction in Plants			**No. of periods:14**
Key Unit Competence: Describe sexual reproduction in plants.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain the meaning of the term alternation of generations. – Discuss the significance of alternation of generations. – Describe the types and structure of flowers. – Describe pollination and fertilisation in flowering plants. – Explain the events that take place in a flower after fertilisation. – Describe the types and structure of seeds and fruits. – Discuss modes of dispersal of fruits and seeds.	– Observe and draw pollen grains. – Draw and interpret floral formulae and diagrams. – Relate floral structures to the mode of pollination. – Draw and label structures of fruits and seeds. – Make a research using internet and deduce the findings.	– Appreciate the role of pollinating agents in flowering plants.	– Alternation of generations in bryophytes and pteridophytes. – Types and structure of flowers. – Pollination and double fertilisation in flowering plants. – Events in a flower after fertilisation. – Structure and types of seeds and fruits. – Fruit and seed dispersal with their adaptation.	– Learners carry out a project to study alternation of generations in mosses and ferns. Learners use a mixture of first hand observations of living specimens and information from textbooks and the internet. – Learners examine the structures of flowers, inflorescences, fruits and seeds using hand lenses and a light microscope. – Carry out research from the library and internet on the process of double fertilisation in angiosperms. – Carry out project research on the dispersal of seeds and fruits, through first hand observation and collection linked to information from secondary sources.

Links to other subjects: *Agriculture: crop yield methods are used to improve the economy.*
Assessment criteria: *Learners can describe sexual reproduction in lower organisms and plants.*
Materials: *Illustrations and computer aided study materials, prepared slides, microscopes, flowers, hand lens, dissection sets, inflorescences (guinea grass/maize, sunflower/black jack/banana, Tridax, Bougainvillea, Lantana camara), flowers (Hibiscus, morning glory/sweet potato, Cassia, pea/bean family), fruits & seeds, and examples of bryophytes*

TOPIC AREA: GENETICS AND ITS APPLICATIONS			SUB-TOPIC AREA: GENE TECHNOLOGY	
S6 Biology	**Unit 13**: Principles of gene technology.			**No. of periods:21**
Key Unit Competence: Explain the principles of gene technology.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Define the term recombinant DNA. – Explain that genetic engineering involves the extraction of genes from one organism or the synthesis of genes, in order to place them in another organism (of the same or another species) such that the receiving organism expresses the gene product. – Describe the properties of plasmids that allow them to be used in gene cloning.	– Interpret illustrations of the isolation and transfer of genes using plasmids in transgenic organisms (bacteria, plant or an animal). – Sequence the processes involved in the extraction and transfer of genes from one organism to another.	– Appreciate that the easy transfer of some plastids from one species of bacteria to another may carry genes for antibiotic resistance. – Acknowledge that advances in genetic engineering have enabled manipulation of genes to our advantage.	– Recombinant DNA. – Gene manipulation (transfer of genes from one organism to another). – Properties of plasmids. – Principles of Polymerase Chain Reaction (PCR) in cloning and amplifying DNA. – Gel electrophoresis. – Roles of enzymes in genetic engineering. – Use of microarrays in the analysis of genomes and in detecting mRNA.	– Interpret a chart on the transfer of DNA from a eukaryotic cell to a bacterial cell using a plasmid. – Using diagrams, learners show how a transgenic organism and a clone are produced. – In groups, students discuss how biotechnologists might transform harmless bacteria to pathogenic forms in the course of their studies.

– Explain the use of genes in fluorescent or easily stained substances as markers in gene technology. – Describe the principles of the Polymerase – Chain Reaction (PCR) to clone and amplify DNA (the role of Taq polymerase should be emphasised). – Describe and explain how gel electrophoresis is used to analyse proteins and nucleic acids, and to distinguish between the alleles of a gene (limited to the separation of polypeptides and the separation of DNA fragments cut with restriction endonucleases).	– Interpret charts of the Polymerase Chain Reaction (PCR). – Relate the mechanism of DNA replication to PCR and the amount of DNA produced in a given period of time.			– Using computer animations students observe the gel electrophoresis used to analyse proteins and nucleic acids to distinguish between alleles of a gene. (Alternatively, visit a local university, health centre or forensic lab) – In groups, learners discuss the mechanisms of artificial DNA synthesis. – Research non-biological methods of gene transfer.

– Explain the roles of restriction endonucleases, reverse transcriptase and ligases in genetic engineering. – - Explain and outline, how microarrays are used in the analysis of genomes and in detecting mRNA in studies of gene expression.				
Links to other subjects:				
***Assessment criteria**: Students can clearly explain the principles of gene technology.*				
***Materials:** Online resources, CDs, computer simulations, diagrams, charts, micrographs, and illustrations.*				

TOPIC AREA: GENETICS AND ITS APPLICATIONS			SUB-TOPIC AREA: GENE TECHNOLOGY	
S6 Biology	**Unit 14:** Applications of gene technology.			**No. of periods:14**
Key Unit Competence: Evaluate how gene technology is applied in areas of medicine, forensic science and agriculture.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Define the term bioinformatics. – Outline the role of bioinformatics following the sequencing of genomes, such as those of humans and parasites, e.g. Plasmodium. (Details of the methods of DNA sequencing are not required). – Explain the advantages of producing human proteins by recombinant DNA techniques. (Reference should be made to some suitable examples, such as insulin, factor VIII for the treatment of haemophilia and adenosine deaminase for treating severe combined immunodeficiency (SCID)).	– Interpret a chart on the stages involved in the production of insulin by bacteria. – Analyse the application of gene technology in agricultural modernisation. – Research the benefits, hazards and implications of gene technology.	– Appreciate the application of gene technology in medicine, and forensic science such as the detection of crimes e.g. rape, murder, and paternity disputes. – Appreciate the application of gene technology in agriculture through the improvement of crop varieties and animal breeds.	– Bioinformatics. – Production of human proteins by recombinant DNA technology. – Genetic technology applied to medicine: genetic screening and treatment of genetic diseases by gene therapy. – Genetically modified organisms in agriculture. – Significance of genetic engineering in improving the quality and yield of crop plants and livestock.	– In groups, discuss the role of bioinformatics in the sequencing of genomes. – Discuss the social and ethical considerations of using gene testing and gene therapy in medicine. – Using the internet, students read articles, journals, and publications on the research underway in agriculture e.g. improvement of crop varieties and animal breeds.

– Outline the advantages of screening for genetic conditions. (Reference may be made to tests for specific genes such as those for breast cancer, BRCA1 and BRCA2, and genes for haemophilia, sickle cell anaemia, Huntington's disease and cystic fibrosis). – Outline how genetic diseases can be treated with gene therapy and discuss the challenges in choosing appropriate vectors, such as: viruses, liposomes and naked DNA, (Reference may be made to SCID, inherited eye diseases and cystic fibrosis). – Explain the significance of genetic engineering in improving the quality and yield of crop plants and livestock in solving the demand for food in the world e.g. Bt maize, vitamin A enhanced rice (Golden rice TM) and GM salmon.			– Ethical and social implications of using genetically modified organisms (GMOs) in food production.	– Students visit an agricultural centre or research stations available in the area and find out how gene technology is applied in the modernisation of agriculture. Focus on the following crops varieties: maize, cassava, Irish potatoes, beans, tomatoes, oranges, mangoes, and avocado. Focus on the following animals: poultry, cattle, goats, sheep, and pigs). – Discuss the ethical and social implications of using genetically modified organisms (GMOs) in food production. – Research the benefits, hazards and implications of gene technology and DNA fingerprinting.

– Outline the way in which the production of crops such as maize, cotton, tobacco and rape seed oil may be increased by using varieties that are genetically modified for herbicide resistance and insect resistance. – Explain the ethical and social implications of using genetically modified organisms (GMOs) in food production.				
Links to other subjects: *Agriculture: improvement of crops and animal breeds..*				
Assessment criteria: *To be able to evaluate how gene technology is applied in the areas of medicine, forensic science and agriculture.*				
Materials: *Online resources, CDs, simulations, graphs, and tables.*				

TOPIC AREA: SELECTION AND EVOLUTION			SUB-TOPIC AREA: VARIATION	
S6 Biology	**Unit 15:** Variation.			**No. of periods:14**
Key Unit Competence: Explain variation and mutation as a source of biodiversity.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain population traits and types of variation. – Describe the differences between continuous and discontinuous variation. – Describe the causes of variation. – Explain the genetic basis of continuous (many additive genes control characteristics) and discontinuous variation.	– Interpret graphs of variations in blood groups and height. – Construct genetic diagrams to show how sickle cell anaemia is inherited. – Use a t-test to compare the variation of two different populations (see mathematical requirements for the syllabus).	– Appreciate the significance of genetic variation in selection. – Express that discontinuous variation results in a limited number of phenotypes with no intermediates e.g. tongue rolling. – - Justify the effect of the environment on the phenotype of plants and animals.	– Variation. – Types of variation: continuous (quantitative) and discontinuous (qualitative). – Causes of variation: genetic and environmental factors.	– Observe natural populations and identify various types of variation. – Collect measurements from populations of organisms in two varying sites and use t-tests to distinguish whether or not these are likely to represent two distinct populations. – Classify the variations as continuous and discontinuous. – Independently, use data in tables on continuous and discontinuous variations among organisms (height and blood groups) to draw and interpret graphs.

– Explain, with, examples, how the environment may affect the phenotype of plants and animals. – Explain why genetic variation is important in selection.				– In pairs, discuss the effect of the environment on the phenotype of organisms.
Links to other subjects: *Mathematics: statistics.*				
Assessment criteria: *Students can clearly explain variation and mutation as a source of biodiversity.*				
Materials: *Online resources, CDs, simulations, graphs, tables for statistical tests and equipment for collecting and measuring organisms in two situations/sites.*				

TOPIC AREA: SELECTION AND EVOLUTION			SUB-TOPIC AREA: SELECTION	
S6 Biology	**Unit 16:** Artificial and natural selection.			**No. of periods:14**
Key Unit Competence: Explain the role of artificial and natural selection in the production of varieties of animals and plants with increased economic importance.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– Explain that natural selection occurs as populations have the capacity to produce many offspring that compete for resources. In the struggle for "existence" only the individuals that are best adapted survive to breed and pass on their alleles to the next generation. – Explain, with examples, how environmental factors can act as either stabilising, disruptive and directional forces of natural selection.	– Interpret graphs on how fur length affects the number of individuals at different temperatures. – Use the Hardy–Weinberg principle to calculate allele, genotype and phenotype frequencies in populations. – Differentiate between natural and artificial selection.	– Appreciate that the environment has considerable influence on the expression of features that show continuous (or Quantitative) variation. – Appreciate the importance of selective breeding (artificial selection) to improve features in ornamental plants, crop plants, domesticated animals and livestock.	– Natural selection with specific examples: antibiotic resistance in bacteria, pesticide resistance in insects and mammals and industrial melanism. – Role of over production and variation in natural selection. – Environmental factors as forces of natural selection (selection pressure, stabilising selection, directional selection and disruptive selection). – Artificial selection (selective breeding). – Inbreeding and out breeding (selective breeding in cattle)	– In groups, construct and interpret graphs on how temperature affects fur length in a population of a particular mammal. – Use computer simulations or videos to discuss how selection, founder effect and genetic drift may affect allele frequencies in a population. – Learners in groups use the Hardy–Weinberg principle to calculate allele, genotype and phenotype frequencies in populations using given data. – Learners undertake a field study or visit nearby farms, demonstration centres, and agriculture research stations to deduce advantages of selective breeding in comparison with natural selection.

– Explain how selection, the founder effect and genetic drift may affect allele frequencies in populations. – Explain how a change in allele frequency in a population can be used to measure evolution. – Describe how selective breeding (artificial selection) has been used to improve the milk yield of dairy cattle. – Outline the following examples of crop improvement by selective breeding: – **The introduction of disease resistant varieties of wheat, tomatoes, Irish potatoes, and rice.**				- In groups, discuss the various methods of crop improvement. - Individually, carry out project work on selective breeding of varieties of crops (e.g. maize, tomatoes, cabbages etc.) at home or school gardens from planting to harvesting and produce a report for the seasons or years.

– **Inbreeding and hybridization to produce vigorous, uniform varieties of maize.**				
Links to other subjects: *Agriculture: crop and livestock improvement.*				
Assessment criteria: *Students can explain clearly the role of artificial and natural selection in the production of varieties of animals and plants with increased economic importance.*				
Materials: *Online resource, CDs, simulations, green houses, drawn graphs, illustrations, and various crop varieties and animals breeds.*				

TOPIC AREA: SELECTION AND EVOLUTION			SUB-TOPIC AREA: EVOLUTION	
S6 Biology	**Unit 17:** Evolution and speciation.			**No. of periods:14**
Key Unit Competence: Analyse the relevance of theories of evolution and explain the process of speciation.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and understanding	**Skills**	**Attitudes and values**		
– State the general theory of evolution that organisms have changed over time. – Discuss the molecular evidence that reveals similarities between closely related organisms with reference to mitochondrial DNA and protein sequence data. – Explain the causes of present day evolution. – Explain the role of pre-zygotic and post-zygotic isolating mechanisms in the evolution of new species.	– Observe and interpret mitochondrial, DNA and protein sequence data and investigate the similarities of closely related organisms. – Relate diagrams of Darwin's finches to the mechanism of evolution. – Research evidence for evolution.	– Acknowledge that over the years the theories of evolution have undergone modifications as more evidence is collected. – - Appreciate that over prolonged periods of time, some species have remained virtually unchanged, while others have changed significantly and many others have become extinct.	– Theories of evolution (Lamarck, Darwin, Neo-Darwinism and creation theory). – Molecular evidence of evolution. – Causes of evolution limited to: – **Competition changes in the environment.** – **Sexual reproduction.** – **Mutations.** – **Gene recombination.** – **Industrialisation.** – **Effect of drugs or chemical resistance.** – **Artificial selection.**	– Using data of mitochondrial DNA and protein sequences learners investigate the similarities of closely related organisms. – Learners undertake research, using the library or internet, to show evidence of evolution. – Interpret pictures of – evolution of Lamarck's theory of evolution of giraffes and Darwin's finches.

– Explain how speciation may occur as aresult of geographical separation (allopatric speciation), and ecological and behavioural separation (sympatric speciation). – Explain why organisms become extinct, with reference to climate change, competition, habitat loss and killing by humans. – Explain large- scale extinctions in earth's history.			– Speciation (allopatric and sympatric speciation) – Role of natural selection and artificial selection in speciation. – Mechanisms of speciation: – **Continental drift** – **Migration.** – **Adaptive radiation.** – **Divergent and convergent evolution.** – **Isolation i.e. ecological, reproductive and genetic.** – **Extinction**	– Research animals and plants that have become extinct in Rwanda and what measures are currently in place to overcome that extinction. Make a report on the findings.
Links to other subjects: *Physical geography: Continental drift.*				
Assessment criteria: *Students can clearly explain theories of evolution.*				
Materials: *Online resources, CDs, simulations, maps, diagrams, and charts.*				

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4. APPENDIX

4.1. List of laboratory materials and equipments

This is a list of basic materials and apparatus that a well-equipped biology laboratory would contain. These items are regularly used laboratory experiments, field visits and in Paper 3 examination. The list is not exhaustive. Other items may be required to allow for variety in the questions set.

In accordance with the COSHH (Control of Substances Hazardous to Health) Regulations, operative in Rwanda, a hazard appraisal of the list has been carried out.

The following codes have been used where relevant. C = corrosive substance, F = highly flammable substance, H = harmful or irritating substance, O = oxidising substance, and T = toxic substance.

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.
- A means of heating – Bunsen burners or similar (candidates 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 cm3).
- White tiles or other suitable surfaces on which to cut.
- Spotting tile or similar with space for 12 separate drops.
- Glass slides and cover slips.
- Conical flasks.
- Clamp (retort) stands and bosses.
- Visking (dialysis) tubing or suitable alternative.
- Capillary tubing.
- Soda glass tubing.
- Paper towelling or tissue.
- Cotton wool.
- Solid glass rods.
- Spatulas.
- Black paper/aluminium foil.
- Means of writing on glassware (water-resistant markers).

- Hand lenses (not less than x6, preferably x8).
- Forceps.
- Scissors.
- Mounted needles.
- Cutting implement, such as solid-edged razor blade/knife/scalpel.
- Rulers in mm (ideally clear plastic).
- Mortars and pestles.
- Safety spectacles or other 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 cover slips.
- 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/timer showing seconds.
- Simple respirometer – can be 'homemade'.
- Pipe cleaners/other suitable aid to demonstrate mitosis and meiosis.
- Culture bottles, autoclave.

- Inoculating loops/wires.
- Tape for sealing dishes.
- Cultures of live yoghurt.
- Appropriate cultures of microorganisms, such as Escherichia coli, Bacillus subtilis.

Stocks of:

- [H] – Iodine in potassium iodide solution.
- [H] – Benedict's solution.
- [C] – Biuret reagent/potassium hydroxide and copper sulfate solution.
- [F] – Ethanol (for fats test).
- [F] – Methylated spirit (for extraction of chlorophyll).
- Sucrose (use Analar (AR) for non-reducing sugar test. Some types of table sugar contain reducing sugars.).
- Glucose.
- Starch.
- Albumen (or egg white).
- [C] – Potassium hydroxide.
- [C] – Sodium hydroxide.
- Sodium chloride.
- [H] – Dilute hydrochloric acid.
- Hydrogencarbonate indicator (with air pump to equilibrate to atmospheric carbon dioxide).
- Sodium bicarbonate/sodium hydrogencarbonate.

- [H] – Limewater.
- [H] – Hydrogen peroxide.
- Distilled/deionised water.
- Universal Indicator paper and chart.
- Litmus solution and red and blue litmus paper.
- Eosin/red ink.
- [F] – Thymolphthalein indicator.
- [H] – Bromothymol blue.
- [H] – Methylene blue.
- Vaseline/petroleum jelly (or similar).
- DCPIP (dichlorophenol-indophenol).
- Ascorbic acid (vitamin C).
- Diastix for testing glucose concentration.
- Albustix or another appropriate test strip for testing protein.
- [H] – 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. [H] – copper sulfate – hydrated).
- Stains for preparing slides to show mitosis, e.g. acetic carmine, toluidine blue.

- [H] – Feulgen stain (Schiff's reagent).
- Nutrient broth, nutrient agar and technical agar (Note: technical agar is suitable for making agar blocks).
- Appropriate disinfectants.
- Solvents for chromatography of chloroplast pigments.
- Aquatic plants for photosynthesis investigations, e.g. Elodea, Cabomba.

Apparatus for field work:

- Beating tray ('homemade').
- Pooter ('homemade').
- Sweeping net (muslin).
- Plankton net and dip net (if aquatic environment is being sampled).
- Pitfall trap/jam jar with suitable cover to prevent water entry.
- Trays for hand sorting.
- Frame quadrats, open or gridded.
- Tape measures.

Slides: For A Level

- 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, xerophytes 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).
- Meiosis.
- TS anther, TS ovule.
- Pollen.
- VS maize fruit.
- TS kidney.
- TS spinal cord.

Examples of organisms representing the three kingdoms: Protoctista (e.g. Amoeba, Euglena or locally available equivalents); Prokaryotae (e.g. bacterial smear, cyanobacteria); Fungi (e.g. yeast, penicillium).

5. WEEKLY TIME ALLOCATION FOR ASSOCIATE NURSING PROGRAM

No	Subjects	Weight	WEEKLY TIME ALLOCATION		
			S4	S5	S6
1	Fundamentals of Nursing *	11	7	7	7
2	Biology*	11	7	7	7
3	Chemistry*	11	7	7	7
4	Mathematics*	5	3	3	3
5	Physics*	10	6	6	6
6	Ethics and professional code of conduct	1	1	1	0
7	Medical Pathology *	2	0	3	1
8	Surgical Pathology*	1	0	1	1
9	Pharmacology*	4	3	2	2
10	Maternal and Child health*	7	4	4	4
11	Individual learning	5	3	1	5
12	Clinical attachment*	13	6	7	10
13	Kinyarwanda	3	2	2	0
14	English*	6	4	4	4
15	French	2	1	1	1
16	Entrepreneurship	2	2	1	0
17	Citizenship	2	2	1	0
18	ICT	2	1	1	1
19	Sports/ Clubs	2	1	1	1

Total periods / week	100	60	60	60
Total number of contact/years		2340	2340	2340
Total number of contact hours/year (39 weeks)		1560	1560	1560

*= Examinable Subjects