MINISTRY OF EDUCATION

Biology

TEACHER MANUAL

YEAR 1 - BOOK 1

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

MINISTRY OF EDUCATION

REPUBLIC OF GHANA

Biology

Teacher Manual

Year One - Book One

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

BIOLOGY TEACHER MANUAL

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INTRODUCTION

The National Council for Curriculum and Assessment (NaCCA) has developed a new Senior High School (SHS), Senior High Technical School (SHTS) and Science, Technology, Engineering and Mathematics (STEM) Curriculum. It aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, competencies, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, further their education and enter the world of work.

This is the first time that Ghana has developed an SHS Curriculum which focuses on national values, attempting to educate a generation of Ghanaian youth who are proud of our country and can contribute effectively to its development.

This Teacher Manual for Biology covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively teach Year One of the new curriculum. It contains this information for the first 12 weeks of Year One, with the remaining 12 weeks contained within Book Two. Teachers are therefore to use this Teacher Manual to develop their weekly Learning Plans as required by Ghana Education Service.

Some of the key features of the new curriculum are set out below.

LEARNER-CENTRED CURRICULUM

The SHS, SHTS, and STEM curriculum places the learner at the center of teaching and learning by building on their existing life experiences, knowledge and understanding. Learners are actively involved in the knowledge-creation process, with the teacher acting as a facilitator. This involves using interactive and practical teaching and learning methods, as well as the learner's environment to make learning exciting and relatable. As an example, the new curriculum focuses on Ghanaian culture, Ghanaian history, and Ghanaian geography so that learners first understand their home and surroundings before extending their knowledge globally.

PROMOTING GHANAIAN VALUES

Shared Ghanaian values have been integrated into the curriculum to ensure that all young people understand what it means to be a responsible Ghanaian citizen. These values include truth, integrity, diversity, equity, self-directed learning, self-confidence, adaptability and resourcefulness, leadership and responsible citizenship.

Integrating 21st Century Skills and Competencies

The SHS, SHTS, and STEM curriculum integrates 21st Century skills and competencies. These are:

- **Foundational Knowledge:** Literacy, Numeracy, Scientific Literacy, Information Communication and Digital Literacy, Financial Literacy and Entrepreneurship, Cultural Identity, Civic Literacy and Global Citizenship
- **Competencies:** Critical Thinking and Problem Solving, Innovation and Creativity, Collaboration and Communication
- **Character Qualities:** Discipline and Integrity, Self-Directed Learning, Self-Confidence, Adaptability and Resourcefulness, Leadership and Responsible Citizenship

Balanced Approach to Assessment - not just Final External Examinations

The SHS, SHTS, and STEM curriculum promotes a balanced approach to assessment. It encourages varied and differentiated assessments such as project work, practical demonstration, performance assessment, skills-based assessment, class exercises, portfolios as well as end-of-term examinations and final external assessment examinations. Two levels of assessment are used. These are:

- Internal Assessment (30%) – Comprises formative (portfolios, performance and project work) and summative (end-of-term examinations) which will be recorded in a school-based transcript.
- External Assessment (70%) – Comprehensive summative assessment will be conducted by the West African Examinations Council (WAEC) through the WASSCE. The questions posed by WAEC will test critical thinking, communication and problem solving as well as knowledge, understanding and factual recall.

The split of external and internal assessment will remain at 70/30 as is currently the case. However, there will be far greater transparency and quality assurance of the 30% of marks which are school-based. This will be achieved through the introduction of a school-based transcript, setting out all marks which learners achieve from SHS 1 to SHS 3. This transcript will be presented to universities alongside the WASSCE certificate for tertiary admissions.

An Inclusive and Responsive Curriculum

The SHS, SHTS, and STEM curriculum ensures no learner is left behind, and this is achieved through the following:

- Addressing the needs of all learners, including those requiring additional support or with special needs. The SHS, SHTS, and STEM curriculum includes learners with disabilities by adapting teaching and learning materials into accessible formats through technology and other measures to meet the needs of learners with disabilities.
- Incorporating strategies and measures, such as differentiation and adaptative pedagogies ensuring equitable access to resources and opportunities for all learners.
- Challenging traditional gender, cultural, or social stereotypes and encouraging all learners to achieve their true potential.
- Making provision for the needs of gifted and talented learners in schools.

Social and Emotional Learning

Social and emotional learning skills have also been integrated into the curriculum to help learners to develop and acquire skills, attitudes, and knowledge essential for understanding and managing their emotions, building healthy relationships and making responsible decisions.

Philosophy and vision for each subject

Each subject now has its own philosophy and vision, which sets out why the subject is being taught and how it will contribute to national development. The Philosophy and Vision for Biology is:

Philosophy: **T**he next generation of scientists can be empowered through observation, curiosity, innovation, and exposure to practically related concepts and opportunities that leverage hands-on activities in a learner centred environment

Vision: Biology learners equipped with 21st Century Skills and Competencies to explore, understand, and apply creative and critical thinking processes in nature inspired-situations for the conservation and sustenance of life and the environment.

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SCOPE AND SEQUENCE

Biology Summary

S/N	STRAND	SUB-STRAND	YEAR 1			YEAR 2			YEAR 3		
			CS	LO	LI	CS	LO	LI	CS	LO	LI
1	Exploring Biology in Society	Biology as the Science of Life	4	4	5	1	1	2	-	-	-
		Biology and Entrepreneurship	1	1	3	1	1	2	1	1	4
2	Life in the Fundamental Unit	Cell structure and Functions	1	1	2	2	2	5	5	5	7
		Movement of substances in living organisms	1	1	3	1	1	1	-	-	-
3	Diversity of living things and their Environment	Living Organisms	3	3	3	3	4	6	1	1	2
		Ecology	5	5	7	1	1	2	2	2	4
		Diseases and infections	1	1	1	1	1	2	1	1	2
4	Systems of life	Mammalian Systems	1	1	2	1	1	2	1	1	4
		Plant Systems	1	1	3	1	1	2	1	1	4
Total			**18**	**18**	**29**	**12**	**13**	**24**	**13**	**13**	**29**

Overall Totals (SHS 1 – 3)

Content Standards	**41**
Learning Outcomes	**42**
Learning Indicators	**84**

SECTION 1:INTRODUCTION TO BIOLOGY, THE SCIENTIFIC METHOD, ORGANISMS AND MICROSCOPES

Strand: Exploring Biology in Society

Sub-Strand: Biology as the Science of Life

Content Standards:

1. Demonstrate knowledge and understanding of Biology, the various branches and fields of study and their benefits in everyday life.
2. Understand and apply the method through which biologists work to solve problems.
3. Demonstrate knowledge and understanding of symmetry, orientation, sectioning and biological drawing of specimens.
4. Demonstrate knowledge, skill and safety in the use of the microscope.

Learning Outcomes:

1. *Explain the importance of Biology and its branches and relate this to everyday life.*
2. *Solve everyday problems using the scientific method.*
3. *Apply knowledge of symmetry, orientation, and sectioning of various organisms in studying the structure of living things.*
4. *Explain the safe ways of using the light microscope and the functions of its parts.*

INTRODUCTION AND SECTION SUMMARY

Biology is a unit in the sciences that focuses on the study of living things and their inter-relationships within the environment. It has three major branches which are botany, zoology and microbiology. The learning of Biology is based on data obtained from research through empirical studies to solve everyday problems. All over the world, scientists, including biologists, solve problems identified in the environment by employing a special technique called the scientific method. To thoroughly understand how to use the scientific method to solve everyday problems, specific pedagogies and exemplars, key among which are collaborative learning strategies, inquiry and research-based learning, group learning and presentations, help learners acquire the necessary knowledge and skills required. In mixed-ability, gender-balanced groups, learners will be made to support one another by ensuring that learners of different levels (that is, those approaching proficiency (AP), those that are proficient (P), and those that are highly proficient (HP)) are mixed up in the various learner groups. With this approach, the highly proficient learners will provide support for the approaching proficient (AP) and the proficient (P) learners, so that each learner will improve considerably over the study period.

SUMMARY OF PEDAGOGICAL EXEMPLARS

This section aims to introduce learners to the foundation of Biology.

Several pedagogies are employed to ensure learners develop good social skills in addition to their scientific knowledge.

Mixed ability and gender-responsive groups are used to address content-proficiency and gender-related issues and help learners develop team spirit, tolerance and cooperation during group work. Research-based learning will also be used to help learners solve problems in their school environment and community as a whole.

Enquiry-based approaches also induce the spirit of curiosity, independent learning and critical thinking, much needed by the biology learners.

Experiential and differential learning is a strategy directly incorporated into the teaching and learning process to ensure learners gain sectioning and manipulative skills to handle and work with the microscope. These knowledge and skills acquired will be applied in various life situations.

Week 1

Learning Indicator: *Observe and discuss the importance of Biology, its various branches and their applications in everyday life.*

Theme or Focal Area 1: Importance of Biology

Biology is the branch of natural science that is concerned with the study of living things, their structure and function, and their interaction with the environment.

Biology is important in everyday activities such as food production, gardening, home hygiene, human and animal health, conservation of natural resources and plant health.

Use the photographs below to discuss the importance of Biology.

i. Bee keeping

ii. Salted fish/ 'Kobi'

iii. Degraded land

Learning Task 1

1. Describe what is meant by 'Biology', limit content expectation to the definition of Biology.
2. Describe at least four ways in which the knowledge of Biology is useful in everyday life. Extend content expectation to the discussion /explanation of how useful the knowledge of Biology is in the following areas of food production, gardening, home hygiene, human, animal and plant health, as well as conservation of natural resources.
3. Discuss the importance of Biology in the production of honey, dry fish/ 'Kobi', and bottled fruit juice. Extend content response to the importance of Biology in the following areas honey production, dry fish/'Kobi' and bottled juice.

Pedagogical Exemplars

Collaborative Learning: Learners in mixed ability, gender-balanced groups, observe pictures and videos of specimens relating to Biology (e.g., honey and dry tilapia) and share ideas with peers and accept feedback. Learners in mixed-ability groups learn from each other and provide emotional support to one another to achieve targets.

Talk-For Learning: learners in pairs discuss, analyse and share the contribution of biologists in the development of society; learners learn from each other and improve upon their communication skills.

Communication and Collaboration: Learners speak politely and clearly as they share ideas on the video and pictures they watched with their peers and accept constructive feedback from their peers. Critical Thinking and Problem-Solving Skills: learners analyse the work of the biologist in the development of products for human consumption.

Digital Literacy Skills: Learners use the internet to research the applications of the branches of biology in everyday life.

Cultural Identity and Global Citizenship: By researching the application of biology to address challenges within the community and the world at large, learners realise they are part of a global village.

Key Assessment -DoK

Level 1: What is Biology? Accept oral/written responses for different definitions of Biology.

Level 2: How is the knowledge of Biology applied in everyday life? Accept oral/written explanations for four ways the knowledge of Biology is applied in everyday life.

Level 3: Discuss the importance of Biology in the production of honey, dry fish/ 'Kobi' and bottled fruit juice. Accept oral/written discussion on the importance of Biology in honey, dry fish/'Kobi' and fruit juice production.

Level 4: Describe briefly how you will use the knowledge gained in Biology to reclaim degraded land. Accept oral/written responses for four ways a degraded land can be reclaimed using knowledge gained in Biology.

Theme or Focal Area 2: Discuss the Branches of Biology.

The major branches of Biology include the following:

Zoology- Is the branch of Biology that is concerned with the study of animals.

Botany- Is the branch of Biology that is concerned with the study of plants.

Microbiology- Is the branch of Biology that is concerned with the study of microscopic organisms.

Learning Task 2

1. Identify some other branches of Biology, limit content expectation to the identification of up to five branches of Biology.
2. Briefly describe what the branches identified entail. Extend content expectation to five branches of Biology not mentioned above.

Pedagogical Exemplars

Inquiry-based Approach: In mixed-ability, all-inclusive groups, learners research from the internet, textbooks, scientific journals, and other related sources to find out the importance of the branches of Biology in everyday life and present their findings within a given time in a written report as feedback. Learners improve communication through group discussion. Learners develop forbearance and hence tolerate views from other peers.

Task-based: approach is used to encourage learners to search for different branches of biology and their application in everyday life from multiple sources such as textbooks, scientific journals and online searches and share their findings with colleagues.

Key Assessment -DoK

Level 1: Identify the various branches of Biology, accept responses for the identification of the three major branches of Biology and any five others.

Level 2: Describe everyday applications of three to five branches of Biology. Accept a page description of at least three branches of Biology and their applications in everyday life.

Level 2: Which branch of Biology is linked to the mode of transmission and treatment of diseases? Accept the identification of three branches of Biology linked to the mode of transmission and treatment of diseases.

Theme or Focal Area 3: Fields of Work Related to Biology

How is the concept of Biology applied in the following units/areas in the community?

1. Hospitals
2. Industries
3. Agricultural farms
4. Educational institutions
5. Markets
6. Homes

Learning Task 3

1. Discuss how Biology is related to at least five other fields of work, limit content expectation to the identification of other fields of work related to Biology.
2. Outline at least two branches of Biology associated with the production of tinned milk and describe how they are involved.
3. Give a hypothetical scenario where learners tease out other fields of Biology in addition to the main field identified. Example: A patient visits the doctor for a checkup on heart-related issues. Write out all the fields of work related to Biology from her visit to the hospital. Extend content expectation to deductions and teasing out other fields of work related to Biology in the hypothetical scenario.

Pedagogical Exemplars

Enquiry-Based Approach: In mixed-ability, all-inclusive groups, research from the internet, textbooks, scientific journals, and other related sources to find out other fields of study relating to Biology and their importance in everyday life and present their findings within a given period in a written report as feedback. Learners improve communication through group discussion, learners develop forbearance and hence tolerate views from other peers. In mixed-ability, gender-responsive groups guide learners to use digital tools to watch videos on different production units to identify fields of work related to Biology in areas that employ the use of knowledge and concepts in Biology. Using enquiry-based approaches encourage learners to explore their environment by taking a field trip around their school compound, identifying different units and how the units employ knowledge and concepts in Biology.

Key Assessment-DoK

Level 1: Identify five other fields of work related to Biology. Accept written/oral response for the identification of five fields of work related to Biology.

Level 2: Explain at least one way knowledge and concepts in Biology are applied in the following areas:

a. Hospitals
b. Industries
c. Agriculture farms

d. Homes

Accept written/oral explanations on how knowledge and concepts in Biology are applied in the following areas; Hospitals, Industries, Agriculture farms, and Homes.

Assessment Level 4: A student fell very sick and was sent to the hospital. He was diagnosed by the doctor with the following ailments: diarrhoea, blood in urine, stomach pain, ruptured tissues and a tumour in the brain. Identify the various fields of work related to Biology that makes the diagnosis possible. Accept oral/written responses from deductions made through critical thinking of the hypothetical scenario.

Week 2

Learning Indicator: *Solve Everyday Problems Using the Scientific Method.*

Theme or Focal Area 1: The Scientific Method

The Scientific Method and its Importance

The scientific method is an empirical method for investigating natural phenomena by formulating hypotheses and testing them through experimentation. The method has been widely used and modified by scientists over the centuries. As scientists, biologists also use the scientific method in solving problems. Biologists start investigations by making observations around them; that is, anything that draws the attention of the biologists. Observation leads to questioning or identification of a problem, and this will lead to further questions or inquiries. The biologist then sets to work to find answers to the problem using the steps or techniques involved in the scientific method.

The scientific method uses both inductive and deductive reasoning methods. Inductive thinking is when one makes a generalised conclusion from a specific observation or pattern. An example of inductive reasoning is when a biology student concludes that sunlight is necessary for plant growth because he or she observes that plants that receive light grow taller. Deductive reasoning is the kind that involves starting with a general principle and applying it to specific situations to predict and test the hypothesis. It moves from a broader idea and narrows to specific conclusions. An example is when the biology student predicts that the sheep give birth to young ones live, although he or she may not have observed this before but has learned that all mammals give birth to young ones live and knows that sheep are mammals.

Note: Inductive thinking is from specific to general, while deductive thinking is from general to specific.

Importance of the Scientific Method

1. It is a problem-solving tool that breaks down complex phenomena into simple components and hypothesis testing to find the root causes of a problem.
2. It provides a structured approach to inquiry so that the conclusion of research work is based on empirical evidence rather than personal belief.
3. The method should yield valid, reliable results that can be replicated by other scientists and researchers.
4. It encourages critical thinking, as researchers question assumptions, evaluate evidence and challenge existing theories.
5. It ensures innovation and progress by encouraging continuous refinement of theories and hypotheses and experimentation.

Learning Task 1

1. Explain the scientific method. Limit content to telling what the scientific method is about (learner not expected to mention and describe steps at this stage).
2. Examine the importance of using the scientific steps in solving problems. Learners are expected to discuss the important roles the scientific method plays in solving problems.

3. Briefly explain inductive reasoning and deductive reasoning as used by biologists in applying the scientific method to solve problems. Limit content to briefly defining and explaining inductive and deductive reasoning abilities,and how these approaches are used in the scientific method to solve practical problems in daily life.
4. Give examples of inductive reasoning and deductive reasoning methods in Biology. Each learner should give at least one example of each of the inductive and deductive thinking methods.

Key Assessment-DoK

Level 3: As a resource person from the Ministry of Agriculture, you have been invited to speak on the topic, "The use of biological principles in the harvesting and processing of fish". Elaborate on at least four basic principles used in the final processing of fish.

Level 3: A learner is provided with fingerlings and mature fish to cater for. Explain why these two should be kept in a different rather than the same aquarium.

Level 4: Identify and describe the essential features of a healthy aquarium, discussing the practices that would result in poor fish health.

Pedagogies and Exemplars

Consider the following activities:

Learners in mixed-ability, research-based learning, research to understand the basis on which the scientific method is built, and how it is employed in solving problems in the school environment and community at large. Learners learn to be team players in groups research activities and feel valued in contributing to lessons.

Learners in research group presentations, identify and explain some common problems in the environment, and the processes leading to the identification of these problems. By this, learners become critical thinkers and observers.

Learners employ individual-based learning methods to individually research, problem identification and try to independently identify some common problems. They develop individual learning capabilities.

Key Assessment – DoK

Level 1: By which technique do biologists and other scientists solve problems identified in their environment?

Learners are to give a simple answer, which is the scientific method.

Level 2: Explain why the biology learner should learn to use the scientific method in solving problems encountered in everyday life.

Each learner is expected to describe at least three important aspects of the scientific method and explain why the learner should use them in solving problems.

Level 3: Describe the two methods of thinking associated with the use of the scientific method and give one example of each.

Learners are to provide clear descriptions of inductive and deductive thinking and give at least an example for each.

Level 4: Create a typical scenario that uses inductive and deductive reasoning abilities and relate these to the scientific method.

Learners are free to think of hypothetical instances where inductive and deductive learning are applied and discuss this in the light of the scientific method.

Theme or Focal Area 2: Discuss the Steps or Techniques Used in the Scientific Method

There are several steps involved in using the scientific method, depending on how the biologist or scientist uses the method and the problem involved. The seven major steps are:

1. Identifying the problem by observation/questioning.

Just like other scientists, biologists identify problems by making observations around the environment and noting down their observations. They then begin to ask questions as to why these observations and patterns are made in nature. This then leads to problem identification. Thus, some tools and techniques employed in identifying problems include observation, problem-solving diagrams, problem-solving mind maps, problem-solving software, fishbone diagrams and flowcharts.

2. Reading around the problem to understand its nature; researching and looking for further information.

This is done by researching literature and related sources to have a clearer understanding of the problem and how to solve the problem. It involves the following:

a. Making a hypothesis: A hypothesis is an "educated guess'', or it is an assumption to a testable statement about the relationship between two or more variables. It is also defined as a proposed explanation for an observed phenomenon in nature.

b. Experimenting: Experimentation refers to the process or procedure carried out under controlled conditions to find an unknown effect or law, to test or establish a hypothesis, or to illustrate a known law.

c. Analysing data: This is done using tables, graphs and charts (e.g., cumulative frequency curves, bar charts, histograms, or pie charts) to put together and examine data to make meaning out of them.

d. Concluding/deduction: This is the final decision, judgment, or opinion that is formed after a scientific experiment or research.

e. Communication: Scientific communication refers to how ideas, methods, knowledge and findings in scientific exercise are made known to people in an accessible and helpful way.

Learning Task

1. Describe the processes that lead to problem identification by biologists. Limit content to mentioning and describing scientific skills and characters such as observation and curiosity or inquisitiveness which lead the learner to question and seek to find answers.
2. Explain the steps involved in the scientific method. Content should cover a list of the steps or techniques of the scientific method and their explanations.
3. Briefly explain the hypothesis and how to formulate this. The learner is expected to give a general explanation of the hypothesis (e.g., the explanation of the hypothesis as 'an educated guess') without its detailed description.

4. Use the scientific method to solve problems identified in everyday life. Limit content to identifying a common problem in everyday life (e.g. crop damage, water shortage, mosquito infestation) and describing how one can use the scientific method to find answers to these problems.

Pedagogies and exemplars

1. Use inquiry-based learning to put learners in mixed-ability, gender-balanced groups to gather more information about the scientific method and the steps or techniques it employs in solving problems.
2. Put learners in research-based learning groups to research and discuss the basis on which the scientific method is built, and how the steps it outlines are employed in solving problems in the school environment and community at large. Learners learn from one another as they gather information from different sources.
3. Learners in group presentations should indicate how they identify a problem (e.g., water pollution, sanitation or power outages.) and explain how the steps in the scientific method are used to find solutions to these problems. Learners learn teamwork and become problem-solving-oriented.
4. Each learner uses an individual learning technique to find a peculiar problem he or she faces and proposes how to mitigate this using the steps learned in the scientific method: Learners develop self-confidence through this method.

Key Assessment – DoK

Level 1: List the steps/techniques in the scientific method.

Limit content to mentioning at least three of the steps/techniques used in the scientific method to solve problems.

Level 2: describe with examples where possible, the steps or techniques involved in using the scientific method and the need for that step.

Provide a clear description of the scientific method and the reason why each of these steps is taken in solving problems.

Level 3: Sanitation is a major concern in Ghana. Using the scientific method, describe how you might solve the problem of sanitation in your locality.

Systematically, describe how you will solve sanitation problems in the light of each step of the scientific method, and the conclusions and recommendations you will make at the end of this exercise.

Level 4: Identify one major challenge in your locality and use the steps in the scientific method to solve this problem.

Consider any one common challenge in your community and use the techniques of the scientific method to propose how the problem could be solved permanently.

Week 3

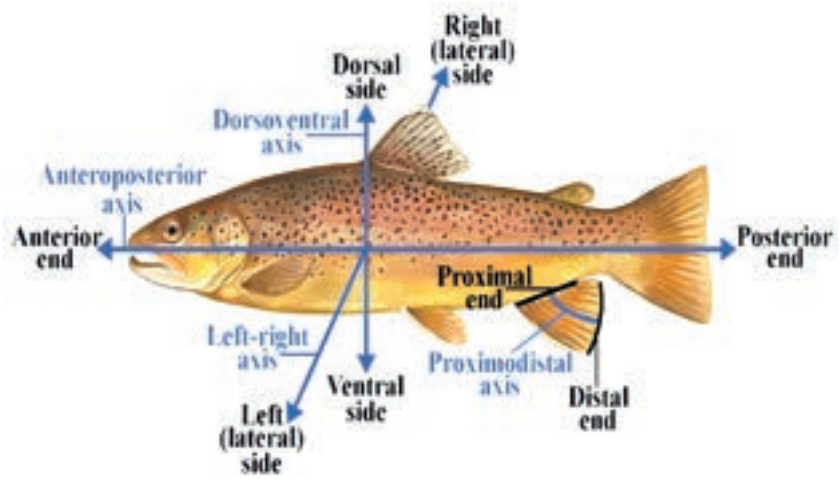
Learning Indicators:

1. *Observe and identify the various body orientations, symmetries and sections of different organisms.*
2. *Identify the parts of the microscope and state their functions.*
3. *Demonstrate the safe usage of the microscope to observe specimens.*

Theme or Focal Area 1: Explain the Following Terms as Applied in Symmetry, Orientation and Sectioning.

Explain the following terms as applied in body orientation, symmetry and sectioning.

1. Body Orientations: This refers to the positioning or alignment of a specimen or its sections in a specific direction.

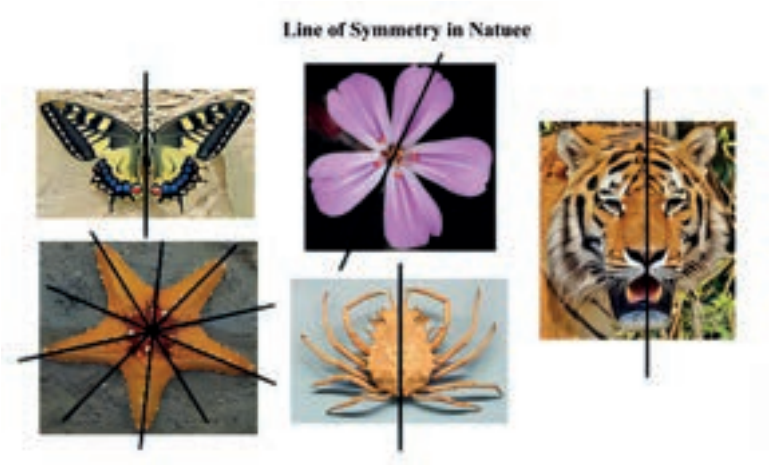


A diagram of a bony fish showing various views of body orientations

Types of Orientations:

Anterior: front or head region of a specimen.
Posterior: back or tail region of a specimen.
Lateral: sideways view/view from the side of a specimen.
Ventral: view from beneath/underside region.
Dorsal: view from above or the upper view.

2. Body Symmetry: Body Symmetry refers to the balanced arrangement and correspondence of body parts and structures on both sides of a central axis. Examples include the distribution of parts of a flower, seeds and fruits of plants and body parts such as limbs, eyes ears of animals. Symmetry is the fundamental characteristic observed in various organisms across different species. It is the quality of being made up of exactly similar parts facing each other around an axis.



A diagram showing radial and bilateral symmetry of different specimens.

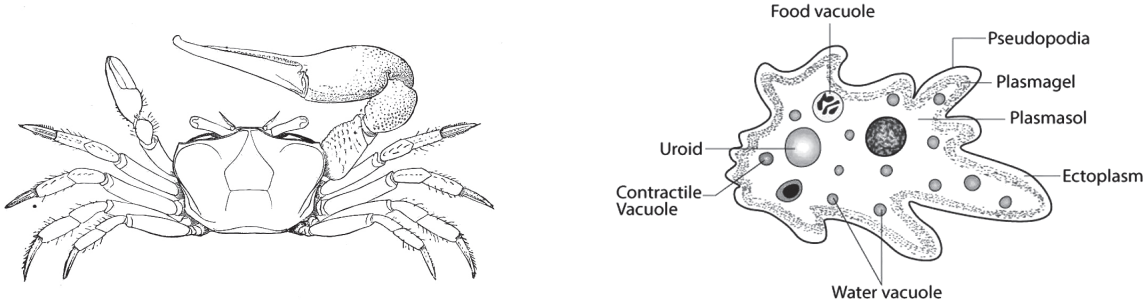
a. **Types of Symmetry**:

a. **Bilateral symmetry:** Organisms have an imaginary line cutting along only one plane to get mirror images. (Left and right halves identical to each other).

b. **Radial:** Organisms have an imaginary line cutting along two or more planes to get mirror images.

NB: Organisms without a line of symmetry are referred to as asymmetric

e.g. Fiddler crab and *Amoeba proteus*,



Diagrams of Fiddler crab and *Amoeba proteus* showing asymmetry

i. Sectioning: Sectioning is the process of cutting or slicing through a biological specimen to examine its internal structures.

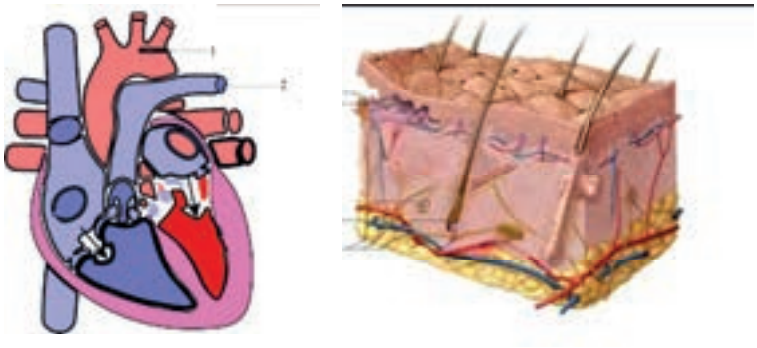
a. T**ypes of Sectioning**:

(i) Longitudinal Section: A cut that runs through the entire length of the specimen.

Diagrams of the longitudinal section of pawpaw and tomato fruit

(ii) Transverse Section: A cut across the whole of the specimen horizontally.

Diagram of the transverse section of the mammalian eye and an orange fruit



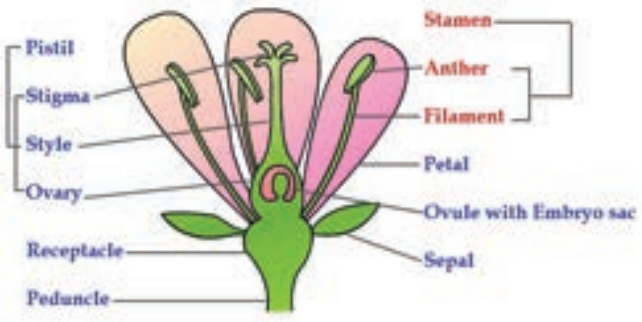
Diagrams of vertical sections of the mammalian skin and heart

4. Key features of biological drawings:

   Biological drawings should have the following features:

   a. A biological drawing must have an underlined heading or caption above or below the diagram.
   b. The drawing should cover at least two-thirds (2/3) of the space provided
   c. Guidelines should not carry arrowheads. They should be ruled with a straight edge. The guideline must point exactly to the label, not hanging or exceeding.
   d. The outline of drawings should be thin, firm and continuous. Avoid woolly and broken lines.
   e. Drawing must have magnification or scale
   f. A singular label should carry a singular guideline.
   g. Labelling should not be above or below guidelines but should be beside guidelines if space permits.
   h. It is advisable to use a sharp HB pencil when labelling, since this can be erased easily when mistakes are made.

A labelled diagram of the longitudinal section of a flower



Scale: Life size [__20 mm__]

Safety Note: Take great care if using sharp instruments for sectioning specimens.

Advice is to use plants rather than animals.

Learning Task

1. Identify the various orientations, symmetries and sections of different specimens. Accept identification of various symmetries, orientations and sections of different specimens.
2. Identify six of the key features of biological drawings.
3. Draw and label correctly natural orientations/views, symmetry and sections of different specimens. Accept biological drawings with at least five key rubrics.

Pedagogical Exemplars

Group project-based learning: In mixed ability, gender-responsive, task-based groups, ask each group to sample 5 to 10 biological specimens (e.g. fruits, flowers, and leaves of orange, *Crotalaria* and *Allamanda*, insects such as cockroaches, butterflies) from their environment.

NB: Safety measures must be observed while sampling and handling specimens.

Each group displays on a table and identifies each of the specimens collected. Learners are to select one specimen within the group for the group presentation on their key findings and accept feedback from their peers and teacher. In every group presentation, the teacher should ensure that all individuals, introverts and extroverts play a role in building confidence and team spirit.

Critical thinking and problem-solving: Learners think deeply to determine the lines of symmetries of organisms and their organs and make the right sections of specimens.

Observational and experiential learning: Learners in their groups critically observe and identify the orientations and symmetries of the collected specimens. Each group member draws and labels any one of the specimens collected.

Initiate talk for learning: Learners in mixed-ability groups discuss individual specimens drawn by each group member and critic the specimen drawing of each member. Here, learners improve on their communication and collaborative skills.

Communication and collaboration: Learners work together and discuss the orientation, symmetry and different types of sections of specimens.

Leadership and personal development: Learners gain leadership and personal development skills by assigning roles and responsibilities to each of the learners during the group activities.

Observational and experiential learning: Learners in their groups critically observe and identify the specimens given. Group members take turns to make different sections of the specimens collected. Each group member draws and labels any one of the specimens sectioned.

Key Assessment- DoK

Level 1: Give the view identified in the following orientations or positions of the body of an organism;

a. Head view
b. Tail view
c. Underside view
d. Backside view
e. Side view

Accept identification of at least any three correct views.

Level 2: Give four reasons why biologists need knowledge of body orientation symmetry and sectioning. Accept up to three correct reasons given.

Level 2: List between five to ten features of a good biological drawing or diagram.

Accept at least any five correct features of a good biological drawing.

Level 3: Draw the flowers of *Crotalaria* and *Allamanda*, and critically examine the differences in them concerning their lines of symmetry.

Accept any two distinctions concerning their lines of symmetry.

Level 3: Identify 10 - 15 living things from the school compound and state whether each is bilaterally or radially symmetrical, giving reasons for your answers.

Level 3: Name three living things that are asymmetrical and draw one of them.

Level 4: With your knowledge in orientation, explain the statement "No organism has a fixed or permanent orientation."

Accept posters/presentations of various natural orientations and views of some selected specimens collected.

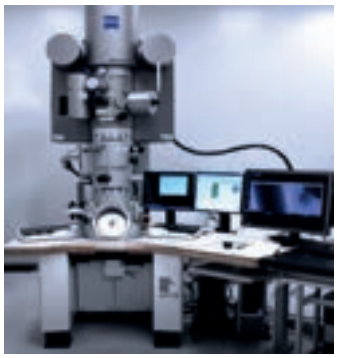
Theme or Focal Area 2: Identify Different Types of Microscopes and Describe the Parts and Functions of the Light Microscope.

The Microscope

The microscope is an instrument used in viewing or observing microscopic specimens like viruses, bacteria, cells and other living things not visible to the unaided eye.

There are two main types of microscop**es namely:**

The light microscope
Maximum magnification around 1,500x



The electron microscope
Maximum magnification around 1 million x.

Although in schools and colleges only around 400x

Parts of the Light Microscope;

(a) Eyepiece Lens: lens at the top that you look through to observe specimens. Magnification of the eyepiece lens is usually (x10 or x15) The eyepiece lens may be monocular (one lens) or binocular (two lenses).

(b) Tube: connects the eyepiece lens to the objective lenses.

(c) Objective lenses: together with the eyepiece lens, the objective lenses are used for viewing specimens. Magnification of the objective lenses ranges from (X4, X10, X40). The total

magnification of a specimen viewed is obtained by multiplying the magnifying power of the objective lens used by that of the eyepiece lens.

(d) Arm: part connecting the base to the eyepiece. It is held when carrying or tilting the light microscope.

(e) Revolving nose piece: holds or houses the three objective lenses. It is movable and rotated to select the desired objective lens. Always start with low power first.

(f) Coarse Adjustment knob: used for general focusing.

(g) Fine Adjustment Knob: used for fine-tuning, bringing specimen into sharp focus.

(h) Stage: firm platform on which specimen/slide is placed for viewing.

(i) Clips: holds the specimen/slide in place.

(j) Aperture: this is a hole in the stage of the microscope, through which light is transmitted to the stage.

(k) Condenser: lenses that collect and focus light from the illuminator to the specimen on the stage.

(l) Illuminator: the source of light located below the condenser, is either a mirror or an electric bulb. If a mirror, an external light source is required. Not direct sun.

(m) Diaphragm: controls the amount of light entering/reaching the specimen.

NB: The diagram of the microscope below can be used by the teacher to re-enforce the identification of the various parts (especially in situations where the actual microscope is not readily available)

Learning Task

1 State the parts of the light microscope and their functions. Limit content expectation to the identification of various parts and relate each part of the light microscope to its functions.

2 Demonstrate at least five safe ways to use the light microscope to observe specimens. Extend content expectation to the correct handling of the microscope to observe specimens and make labelled drawings of what was observed.

Pedagogical Exemplars

Task-based group learning: In a mixed-ability, socially inclusive, task-based groups, learners examine the various parts of the microscope (with emphasis on the eyepiece lens, objective lens, stage,

clips, revolving nose piece, diaphragm, limb, base/foot). Mixed ability grouping ensures respect for every learner regardless of their social background.

Observational learning and talk for learning: Learners critically observe and examine each part of the microscope in relation to its function and share their observations in group discussions. Learners improve on the skill of oratory through group discussions and learn from one another.

Experiential learning approach: In mixed-ability, task-based groups, learners mount different types of slides provided on the stage of the microscope and observe the specimen on the slide.

Learner gains first-hand personal experience with the use of the microscope and can relate lessons to real-world situations.

Communication and collaboration: Learners talk among themselves, and collaborate, as they discuss the parts and functions of the microscope. Learners in mixed-ability groups exchange slides with different groups and examine other types of slides following the same procedure: draw the images obtained at sharp focus and gain support from each other as they work in groups to develop team spirit.

Personal development: Learners develop deep manipulative skills in demonstrating the use of the microscope and drawing the sharp images observed.

Differential learning approach: In their groups, learners mount different slides on the stage and observe and discuss the images formed; learner develops the skill of critical observation and inquisition.

Key Assessment- DoK

Level 1: Name two types of microscopes and state the maximum magnification of each.

Accept the names of the two types of microscopes and approx. correct magnification.

Level 2: Describe briefly how any four parts of the light microscope contributes to its effective functioning.

Accept the description of four correct parts of the light microscope and the role of each part mentioned.

Level 3: If available, manipulate the microscope to achieve sharp, bright images of the slides provided. Sketch and label what was observed.

Accept at least the coarse focus of the specimen under the light microscope and some of the specimens observed and drawn.

Theme or Focal Area 3: How to Care for a Light Microscope and Slides

Ways to care for the microscope include the following precautions and steps that are necessary for handling the light microscope to ensure its proper functioning and longevity.

a. Do not touch the glass parts of the lenses with your fingers. Use lens tissue to clean the lens.
b. Always carry the microscope with both hands with one hand supporting the base.
c. Microscope slides and slide covers are small and delicate. Always handle the slides with care, as they can easily be shattered or scratched.
d. Never drop slides or slide covers. Set them down only on clean countertops.
e. Cover when not in use.
f. Store in a clean, dry place.

g. If the microscope uses electricity or a battery as the source of light, the bulb must be allowed to cool down before packing.

h. Never use direct sunlight as a source of light for the mirror

i. The user manual must be kept for reference.

Types of Microscope Slide

Microscope slides are used to examine single-celled organisms and to look up close at very small parts of organisms. There are two types of prepared slides: Dry mounts and Wet mounts. Each type of preparation method is used for mounting different types of cells and tissues.

If the specimen for a wet mounting is particularly pale or translucent, it must be stained to ensure it is visible under the microscope. e.g. with iodine, eosin or methylene blue

Iodine and Methylene Blue are poisonous and should never be ingested. They will also stain skin (temporarily) and clothing (permanently), so wear clothes that you don't care about when handling the chemicals.

NB: The teacher should ensure each learner acquires the skills of preparation of temporary slides and can operate the light microscope, if available.

The general steps involved in the preparation of a wet mount include the following:

Gathering of Materials:

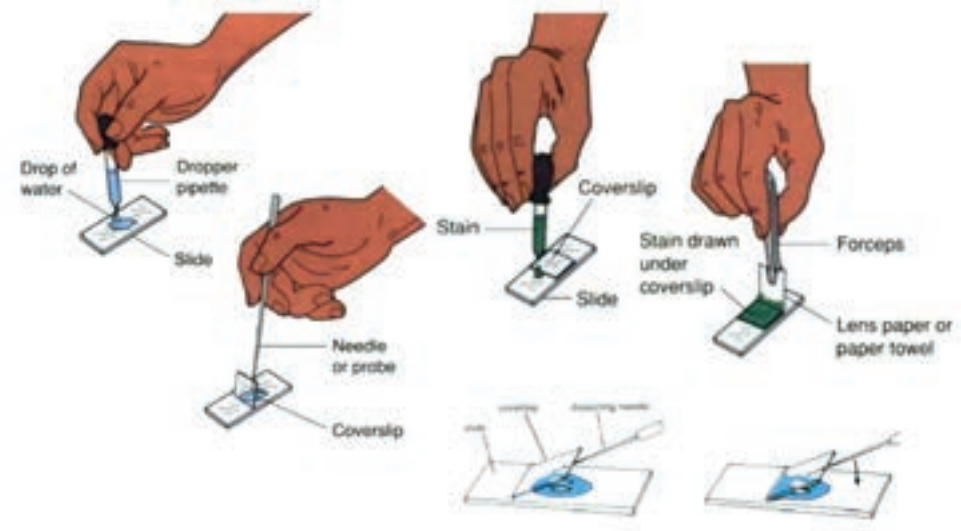
1. The following materials and procedures are needed for the preparation of a wet mount.
   a. Microscope + slides
   b. Coverslips
   c. Specimen with a drop of water or stain
   d. Staining dyes which can be used: iodine, eosin or methylene blue
   e. Dropper or pipette
   f. Razor blade or scalpel

2. Clean materials: Ensure that both the microscope slides and coverslips are clean and free from dust or debris. A lens paper or a soft cloth must be used to wipe them if necessary.

3. Preparation of Specimen: the specimen is placed on a microscope slide. If the specimen is in a liquid medium (like a drop of water containing microorganisms), a dropper or pipette is used to place a small amount onto the centre of the slide. If the specimen is solid (like a piece of onion epidermal tissue), a drop of water may be added to the specimen to help it adhere to the slide.
   a. Addition of cover slip: A cover slip is gently lowered onto the specimen at a slight angle to avoid trapping air bubbles. One edge of the cover slip is placed against the slide, and then slowly lower the rest of the cover slip over the specimen. This technique helps minimize the formation of air bubbles.
   b. Addition of dye or stain: A dye such as eosin or methylene blue may be added to specimens that are transparent to enhance contrast and visibility.
   c. Removal of excess liquid: A piece of blotting paper or tissue paper may be used to wick away any excess liquid around the edges of the coverslip. Extra care must be taken not to press too hard, as this can cause the coverslip to shift or break, and potentially damage the specimen.
   d. Sealing the edges: optionally, the edges of the coverslip can be sealed with a small amount of clear nail polish or commercial mounting medium. This helps prevent the specimen from drying out and keeps the coverslip in place during observation. This is for long-term use.
   e. Labelling of slide: It is good practice to label the wet mount with the type of specimen and any other relevant information. This helps to keep track of observations and findings.

f. Observation: The prepared wet mount is placed on the stage of the microscope and is carefully brought into focus using the rough objective lens first, then the fine adjustment knob to view the specimen clearly. The lowest magnification objective lens is used first, and then other more powerful lenses to suit. Take care the high-power lens does not touch the coverslip.

g. Cleaning up: After observing the specimen, the coverslip is carefully removed and the microscope slide is cleaned for future use. The specimen is properly disposed of according to laboratory protocols.



Learning Task (if microscopes are available in class)

1 Demonstrate at least five safe ways to use the light microscope to observe specimens.

2 Prepare a wet mount and observe under a light microscope.

Pedagogical Exemplars

Observational Learning and Talk for Learning: Learners critically observe and discuss safe ways of caring for each part of the light microscope. Learners improve on the skill of oratory through group discussions and learn from one another.

Experiential learning approach: In mixed-ability groups, learners prepare wet-mount and draw what was observed. The learner gains first-hand personal experience with the use of the microscope and can relate lessons to real-world situations.

Communication and collaboration: Learners talk among themselves, and collaborate, as they discuss the safe ways to use the light microscope. Learners in one group exchange their wet mounts with different groups and examine other types of slides following the same procedure. Labelled drawings of the images obtained at sharp focus were made.

Personal development: Learners develop deep manipulative skills in demonstrating the safe use of the light microscope.

Differential learning approach: Learners develop critical observation and inquisition skills as they prepare different wet mounts on the stage and discuss the images observed.

Key Assessment- DoK

Level 1: List four ways to care for the light microscope.

Accept any four ways to care for the light microscope.

Level 2: State with reasons, at least four safety precautions you should observe in handling the light microscope.

Accept at least two precautions.

Level 2: Describe how to prepare a wet mount to be observed under the light microscope.

Accept at least four stages in the preparation of wet mounts of specimens to be observed using the light microscope.

Level 3: Distinguish between a wet mount and a permanent slide.

Accept at least three distinctions between a wet mount and a permanent slide.

Additional Reading

- Biology GAST Textbook
- College Biology
- Online Resources.

References

- SHS Elective Biology Curriculum, Biology GAST Textbook, College Biology.

Section 1: Review

In the introductory section, we explored Biology's definition and its primary branches, along with various sub-branches. Emphasis was placed on Biology's relevance to daily life and its significance. Career opportunities in Biology were also explored. Subsequently, we delved into the scientific method, its components, and its application in solving everyday issues.

Then we studied body orientation, symmetry, sectioning of specimens, and biological drawing skills.

Finally, microscope types, parts, functions, safe usage, and slide preparation were discussed, along with distinctions between wet mount and permanent slides.

The aim is for learners to apply this knowledge to address real-world challenges, supporting both themselves and their communities.

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SECTION 2: FISH FARMING, PROCESSING AND CONSERVATION

Strand: **Exploring Biology in Society**

Sub-Strand: Biology and Entrepreneurship

Learning Outcome: *Apply the knowledge of basic concepts in Biology to improve productivity in fish farming*

Content Standard: Demonstrate knowledge of the application of biological concepts and their application to improve fish production

INTRODUCTION AND SECTION SUMMARY

Biology and entrepreneurship are two distinct areas brought together to enable learners to combine their biological knowledge with skills and knowledge in entrepreneurship. This combination of biology and entrepreneurship is expected to produce self-motivated, proactive and action-oriented learners to pursue an innovative product and service. Biology and entrepreneurship (bio-entrepreneurship) have a huge potential to develop new techniques in feed production, care for fingerlings and the creation of the right aquatic environment to increase fish production. Bio-entrepreneurship is frequently credited as a major driver of economic growth, spurring transformation, the creation of bigger and new markets, innovation and wealth creation.

At the end of this section, learners are expected to demonstrate knowledge of the application of biological concepts and their application to improve fish production. Additionally, learners are expected to identify the biological concepts that are used in the nursery and grow-out stages to improve fish production. Knowledge gained in this section is related to other subjects such as Business, Home Economics and Economics. Finally, learners are expected to be able to explain the use of biological principles in the harvesting and processing of fish to improve production.

The week covered by the section is:

1. **Week 4:**
   a) Fish farming management systems and practices.
   b) Harvesting, processing and marketability of fish.
   c) Discuss the various ways of fish stock management and conservation**.**

SUMMARY OF PEDAGOGICAL EXEMPLARS

This section requires learners to directly get involved in their learning. Learners should be offered the opportunity to get direct practical experience as they apply their learning and learn from their failures. Therefore, task-based learning, project-based learning, project-based and experiential learning approaches and analytical learning approaches should be employed to facilitate these concepts. In task-based learning for instance, learners should be placed in mixed-ability, all-inclusive groups, allowed to watch videos and documentaries on fish farming. Similarly, if project-based learning is successfully applied, learners will develop innovative skills and experience in fish farming and become self-initiators.

Additionally, project-based and experiential learning approaches should allow learners to apply suitable fish farming practices to feed and aerate the fishes in their holding facilities, while studying

their growth patterns and making notes on the changes. Finally, analytical learning approach should encourage learners to collate results obtained from the project, analyse and discuss the findings. Learners will develop communication and collaboration skills as they watch, discuss and share ideas on the various techniques employed in fish production.

All learners, irrespective of their learning abilities, should be encouraged to participate fully in hands-on activities and presentation of findings. However, considerations and accommodations should be made for the different groups including learners with special educational needs (SEN).

ASSESSMENT SUMMARY

Every classroom is made up of learners with different abilities and different learning styles. Hence, the assessments should largely cover levels 1, 2, 3 and 4 of the depth of knowledge (DoK). The concepts under this section require learners to demonstrate conceptual understanding, including their real-life applications. Again, the teacher should employ a variety of formative assessment (assessment "as" and "for") strategies such as brainwriting, oral/written presentations, pair-tasks, reports, and home tasks, to gather information about learners' progress and give prompt feedback to them. Specifically, teacher should conduct the following assessments and record the performances of learners for continuous assessment records and grading;

For example, through:

1. Multiple choice questions (MCQ), making sure content validity is attained.

   e.g. MCQ: All the following tools are used to increase fish production **except**
   A. an aerator machine
   B. algae scrubbers
   C. a pair of scissors
   D. a weighing scale.

2. Class exercises (including individual worksheets) after each lesson
3. Homework
4. Practical group activities

Week 4

Learning Indicators:

1. *Identify the biological practices and tools that are used in the nursery and grow-out stages to improve fish production*
2. *Explain the use of biological principles in the harvesting and processing of fish to improve production*
3. *Identify the biological practices and principles that are used in the management and sustainable exploitation of wild stocks to improve fish production.*

Theme or Focal Area 1: Biological Practices and Tools Used in the Nursery and Out-grow Stages in Fish Farming.

1. Some biological practices employed in the nursery stage in fish farming to include:
   a. acquisition of fingerlings with best quality and health.
   b. routine checking of water quality and level to maintain an optimal environment for growth
   c. regular supply of essential feed and other inputs such as aeration and drugs when necessary
   d. weaning of fry from natural feed to formulated feed
   e. record keeping on all practices.

2. Some biological practices employed in the out-grow stage include the following:
   a. Stocking
   b. Feeding
   c. Water quality management
   d. Disease prevention and management
   e. Monitoring and record keeping
   f. Good harvesting and processing practices

3. Functions of tools and equipment used in nursery and grow-out stages to improve fish production:
   a. Nets: Used for harvesting and transferring fish between ponds. They are also used for removing debris from ponds, and used in making hapas or cages.
   b. Graders: They are used to sort fish by their sizes in order to manage stock densities and optimise growth.
   c. Fish counters: They are used to count fish during harvesting and management practices.
   c. Water quality test kits: for testing water quality such as pH, dissolved oxygen, ammonia, nitrite and nitrate levels.
   d. Water pump: for pumping water in and out of the pond.
   e. Pond liners: used to prevent water seepage and to facilitate proper water management in the fishponds. Also used to prevent contamination by ground water.
   f. Aeration machine: used to increase oxygen levels in the water.
   g. Filtration systems: used to remove solid waste and organic matter from the fishpond thereby increasing water quality.
   h. Algae scrubbers: used to scrub/remove excess algae from pond in order to prevent algal blooms and maintain water quality for healthy fish.
   i. Weighing Scale: used to weigh fish accurately, and to monitor growth rate

Water pumping machine

Fishing net

Algae scrubber

Fish counter

Learning Task

1. Name at least three tools required in nursery and grow-out stages to improve fish production.
2. State one function of each of the tools mentioned above. NB: Limit content expectation to identification and discussion of no more than three tools used in harvesting fish.

Pedagogical Exemplars

The teacher should consider the following activities: using think-pair-share, assist learners to identify and discuss the functions of at least three tools and equipment used in harvesting fish.

Using task-based learning**,** place learners in mixed-ability, all-inclusive groups, to watch videos and documentaries on fish farming or embark on field trips to fish rearing and research centres. Confident learners provide internal support to struggling colleagues. Teacher provides individual support to learners with specific learning needs.

Key Assessment- DoK Levels

Level 1: List some tools that are required in nursery and grow-out stages to improve fish production. Accept at least two tools used in harvesting fish.

Level 2: Describe the function of at least two tools for harvesting fish.

Accept description of the functions of at least two tools used in harvesting fish.

Theme or Focal Area 2: Harvesting, Processing and Marketing Fish

What key considerations are needed to decide on harvesting?

1. When the fish have attained the right size to give maximum profit in the market
2. When the prevailing market opportunities (like Christmas and Easter) offer highest profit

Identify three pieces of equipment used in harvesting fish in a pond/aquaculture farm:

The methods and equipment for harvesting fish in their holding facilities depend on the size of the pond, the type of harvest and the purpose of the harvest. They include the following:

1. Hook and line
2. Traps
3. Nets (Gillnets, Seine net, and Sweep net.)

Discuss some methods of processing and preserving fish:

Some methods of processing and preserving fish include the following:

a. Deep-frying in oil for immediate consumption.

b. Preserving in ice to keep them fresh for the market.

c. Processing (sun-dried, salted or smoked); and at higher industrial levels, may be filleted and chilled for supermarkets or export.

d. Whenever possible, it is best to present fish for sale in their freshest form. Live fish are in the freshest state.

Learning Task

1. List at least two methods of harvesting fish in their natural habitat. Limit content expectation to listing of two methods of harvesting fish in their natural habitat.
2. Describe at least two techniques used in harvesting fish in their holding facilities. Encourage learners with in-depth knowledge on the techniques of harvesting fish to orally explain the various techniques to less experienced learners. Extend content expectation to describing at least two techniques used in harvesting in their holding facilities.
3. Explain at least three ways of processing and preserving fish, highlighting the biological principles involved in each case. Extend content expectation to describing at least three ways of processing and preserving fish, highlighting the biological principles involved in each case.
4. Individually, think critically about how to increase the market value of fish and share your ideas within the group and with the whole class.

Pedagogical Exemplars

Using project-based and experiential learning approaches: learners should be placed in mixed-ability groups and guided to apply suitable fish farming practices to feed and aerate the holding facilities of fish, while studying their growth patterns and making notes on the changes.

In groups, learners list at least two methods of harvesting fish in their habitats. Struggling learners should be supported where necessary.

Using think-ink-pair-share strategy: learners should describe at least two techniques used in harvesting fish in their holding facilities.

Using the television talk show strategy: learners explain at least three ways of processing and preserving fish, highlighting the biological processes involved in each case.

Teacher scaffolds help for learners with learning difficulties. Using an enrichment exercise, challenge talented learners to build an aquarium using materials given to them.

Learners develop the skill of critical thinking and observation, and develop independent thinking. Learners develop the ability of working and supporting one another in a teamwork.

Key Assessment-DoK

Level 3: As a resource person from the Ministry of Agriculture, you have been invited to speak on the topic, "The use of biological principles in the harvesting and processing of fish". Elaborate on at least four basic principles used in the final processing of fish.

Level 3: A learner is provided with fingerlings and mature fish to cater for. Explain why these two should be kept in different aquaria/ponds.

Level 4: Describe the essential features of a healthy aquarium, describing three bad practices that would result in poor fish health.

Level 4: On a trip to two different fishing centres, A and B, a learner observed that the fingerlings and mature fish produced at Centre A grew larger and healthier than those from Centre B. Describe the factors that could lead to these two different scenarios.

Level 4: In harvesting fish to be processed and exported to another country, the following practices were carried out by the harvesters:

a. Increasing fish feed two weeks before harvesting
b. Starving the fish on the day of harvesting
c. Draining the pond
d. Removing scales
e. Removing the intestines
f. Freezing the fish.

Suggest how and/or why each of these processes was carried out.

Accept an explanation of at least three ways of processing and preserving fish, highlighting the biological processes involved in each case.

Theme or Focal Area 3: The Various Ways of Fish Stock Management and Conservation

Discuss management practices of fish populations in their habitats under the following headings:

a. In freshwater bodies such as rivers, lakes, ponds and springs.

b. In brackish-water bodies such as lagoons and restricted estuaries

c. In marine habitats such as mudflats, mangroves, coral reefs, oyster beds, and kelp forests

Artificial habitats include the following:

a. Aquaculture facilities where fish are raised for commercial purposes

b. Re-circulating aquaculture system (RAS). This is where water is continuously filtered and reused to raise fish in a controlled environment

c. Artificial reefs: these are made from materials such as concrete and steel which are used under water to provide a suitable habitat for fish and other marine organisms.

Some management practices of fish populations in their natural habitats include the following:

a. Keeping accurate and current data on the fish populations.

b. Regulating commercial fishing activities to avoid overfishing.

c. Enforcing enacted laws to protect fish populations.

d. Desilting and removal of weeds must be done periodically to ensure easy movement of fish and adequate penetration of sunlight to the bottom of the water body. This will ensure increased primary productivity and high dissolved oxygen concentrations, necessary for fish growth and health.

e. Regular control of harvesting should be carried out to avoid overpopulation, cannibalism and disease outbreaks.

f. Practising aquaculture to reduce over-dependency on wild fish stock.

Learning Task

1. Name at least two water bodies where fish populations can be found. Limit content expectation by accepting two water bodies and their corresponding examples where fish populations can be found.

2. Describe four management practices of fish populations in their natural habitats. Extend content expectation to describing four management practices of fish populations in their natural habitats and explain why such management practices should be encouraged

Pedagogical Exemplars

Using think-pair-share: Ask learners to name at least two water bodies and their corresponding examples where fish populations can be found. Teachers should recognise the distinct needs of learners and provide appropriate learning support.

Using the doughnut-sharing strategy: learners describe at least four management practices of fish populations in their habitats, and state why such management practices should be encouraged.

Using an analytical learning approach: Learners in mixed-ability groups, collate results obtained from the project of rearing fingerlings in an aquarium tank, and analyse and discuss the findings in-

class presentations. As learners work in groups, they provide emotional and psychological support to one another to obtain the required results. Learners will subsequently develop analytical skills.

Key Assessment

DoK Levels

Level 3: Describe some practices that should be promoted or discouraged in sustainable fish farming.

Level 3: Explain the significance of biological practices and principles in the sustainable management and conservation of fish. Accept oral or written explanations on at least two biological practices used in fish conservation.

Level 4: Alidu and Dede carried out practices that included the removal of natural predators of fish and preventing algal blooms, to increase the productivity of their school's fishpond. Explain the relevance of these practices in aquaculture and give the biological terminology of these processes. Accept posters/presentations on explanations of at least four management practices of fish populations in their natural habitats and why such management practices should be encouraged.

Section 2 Review

In this section, learners have learned about the biological practices and tools used in the nursery and grow-out stages in fish farming, and the functions of tools and equipment used in nursery and grow-out stages to improve fish production. Additionally, learners learned about key aspects of harvesting, processing and marketing of fish. Finally, the various ways of stock management and conservation were also discussed.

Knowledge and skills acquired would assist learners to possibly develop and manage their fish farms to boost fish production in Ghana. The knowledge and skills acquired will again help learners to engage in further studies, and prepare them for adult life and the world of work.

SECTION 3: CELL BIOLOGY

Strand: **Life in the Fundamental Unit**

Sub-strand: Cell Structure and Function

Learning Outcome: *Describe the various processes involved in the movement of substances in and out of the cell, and the factors affecting them.*

Content Standard: Demonstrate an understanding of the processes by which substances move across the cell membrane.

INTRODUCTION AND SECTION SUMMARY

Cell biology is a branch of biology that studies the structure and function of cells. Cells were discovered by a British scientist, Robert Hooke in 1665. He observed cells in a cork slice under his self-designed microscope and noticed honeycomb like compartments. He called them cells. Cells are the basic building blocks of all living things. Some organisms are composed of only one cell, others of many millions of cells. The human body is composed of trillions of cells. They provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions. Cells come in discrete and easily recognizable packages. That's because all cells are surrounded by a delicate envelope called the cell membrane, or plasma membrane, which serves as a clear boundary between the cell's internal and external environments.

At the end of this section, learners are expected to demonstrate understanding of processes by which substances move across the cell membrane.

SUMMARY OF PEDAGOGICAL EXEMPLARS

This section requires learners to be placed at the centre of the teaching and process. This is because knowledge exists within the context of every learner. Hence, learners are to be guided or supported to develop their own knowledge consistent with what is acceptable by the scientific community. Therefore, individual-based learning differentiated project-based learning, talk for learning (TFL), case-based consultative learning and group project-based learning should be used to facilitate the concepts in this section. In individual-based learning for instance, learners in mixed-ability, gender balanced groups revise previous lessons on cell organelles and cell structure with regards to their nature and functions from JHS lessons on cells and each group discusses further for whole class open discussions. To employ differentiated project-based learning, learners should form mixed ability groups and each group is assigned to examine in detail the cell theory and 3 to 5 organelles with respect to their shapes, structures and functions and prepare brief discussion notes for 10 minutes presentation each in the next lesson and teacher provides feedback for each presentation

In talk-for learning, learners should be placed in mixed-ability groups to revise lessons on movement of substances in and out of the cell (diffusion and osmosis). Besides, learners in mixed-ability groups should brainstorm under teacher's guide to discuss the cell membrane. Teacher then introduces lessons on the cell membrane with regards to its structure, component and functions. Similarly, case-based consultative learning should be applied where the teacher guides learners in groups to consult and discuss among themselves the structure and components of the cell membrane linking them to the fluid mosaic model using diagrams and pictures. And finally, in group project-based learning strategy, learners in groups prepare charts and annotated diagrams on the structure and components

of the cell membrane linking them to the fluid mosaic theory. Each learner in their groupings presents and discusses their work with the whole class.

All learners, irrespective of their learning ability should be encouraged to participate fully in hands-on activities and presentation of findings. However, considerations and accommodation should be made for the different groups including learners with special educational needs (SEN).

ASSESSMENT SUMMARY

Every classroom is made up of learners with different abilities and different learning styles. Therefore, the assessments should cover Levels 1, 2, 3 and 4 of the depth of knowledge (DoK). The concepts under this section require learners to demonstrate conceptual understanding, including their real-life applications. Again, the teacher should employ a variety of formative assessment (assessment "as" and "for") strategies such as brainstorming, oral/written presentations, pair-tasks, reports, home tasks, etc. to gather information about learners' progress and give prompt feedback to them. Specifically, teacher should conduct the following assessments and record the performances of learners for continuous assessment records and grading;

a) Multiple choice questions (mcq), making sure content validity is attained.

b) Class exercises (including individual worksheets) after each lesson

c) Homework

d) Practical group activities

Week 5

Learning Indicator(s):

1. *Discuss the factors that affect the movement of substances across the cell membrane*
2. *Discuss the effect of the movement of substances across the cell membrane*

Theme 1: Introduction to the Cell Membrane

Cells are full of membranes and are surrounded by a membrane called the cell membrane or plasma membrane. Many organelles such as chloroplasts, mitochondria, endoplasmic reticulum and the nucleus itself are bounded by or composed of one or two membranes. Membranes are exceedingly thin and are primarily made of **phospholipids** and **proteins**. The lipids form two layers of molecules which are mobile. The proteins are found scattered as a mosaic in and on the lipid layers, and they too can move around the membrane.

For this reason, the membrane is described as a **fluid-mosaic**. Membranes keep their shape because of the hydrophobic and hydrophilic nature of their lipid molecules. One end of the molecule is repelled by water (hydrophobic) and the other is attracted to water (hydrophilic). As a consequence of their fluidity, they can often recover from minor physical damage. Lipids also allow small molecules such as water molecules to pass through unaided. The surface area of cells or organelles can be increased by the folding of membranes.

Because they are composed of proteins and lipids, membranes are easily damaged by heat, acids and by fat solvents such as alcohol. This can be demonstrated in the classroom using cells which have a coloured sap such as beetroot or red cabbage. When the membrane of these cells is damaged by heat, acid or alcohol the coloured sap leaks out into the surrounding water.

Membrane proteins have many functions:

(a) There are enzymes present in membranes for many chemical reactions which take place on the surface of the membranes. E.g. stages in protein synthesis, respiration and photosynthesis.

(b) There are receptor sites for hormones which then influence the activity of the cell.

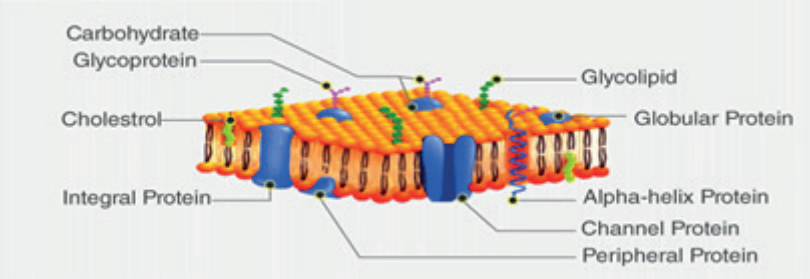
(c) There are proteins which act as a skeleton for the membrane to give it shape and to allow it to move. For example, the membrane moves during phagocytosis and when cilia waft to and fro.

(d) There are proteins which actively transport materials across the membrane using chemical energy obtained from the cell in the form of Adenosine Triphosphate (ATP).

(e) There are proteins which form pores in the membrane through which substances can pass.

Because cells are full of hundreds of different enzymes and millions of molecules which react every second, it is important that the internal environment of the cell is kept as constant as possible. In this respect the outer cell/plasma membrane plays a very important function by regulating what enters and leaves the cell. It allows some substances to pass through unaided, while others are transported actively and some substances are entirely prevented from passing through. For this reason, membranes are said to be **selectively permeable**.

Below is a diagram of a section of cell membrane showing the phospholipid bilayer in orange.



Scale: The membrane is around 5 to 10 nanometres thick, and a nanometre is one billionth of a metre. [10^{-9} m]

Learning Task

(a) Name the outermost envelope-like structure which surrounds the cell.

(b) Identify three cell organelles that are bounded by <u>two</u> membranes

(c) Mention at least three key structural features of the cell membrane and state the role they play in the structure and function of the membrane

(d) Name at least three key structural features of the cell membrane and describing why the model of the membrane is described as a 'fluid mosaic'.

Pedagogical Exemplars

Teacher should consider the following activities;

Individual-Based Learning: In individual-based learning for instance, learners in mixed-ability, gender balanced groups revise previous lessons on cell organelles and cell structure with regards to their nature and functions from JHS lessons on cells.

Differentiated Project-based Learning: to employ differentiated project-based learning, guide learners to form mixed ability groups, and each group should be assigned to examine in detail, the cell theory and up to five organelles with respect to their shapes, structures and functions, and prepare brief discussion notes for 10 minutes presentation each in the next lesson. The teacher must provide feedback for each presentation.

Talk-For-Learning (TFL): In a talk-for-learning strategy, learners should be placed in mixed-ability groups to revise lessons on movement of substances in and out of the cell by diffusion and osmosis. Learners in mixed-ability groups should brainstorm under the teacher's guide to discuss the cell membrane, its structure and function.

Key Assessment- DoK

Level 1: Identify at least two characteristics of the cell membrane.

Level 3: Describe with an illustration the structure of the cell membrane and state the key features in relation to the movement of substances in and out of cells

Level 4: Explain why it is important that the cell cytoplasm is kept in homeostasis.

Theme 2: Movement of Substances in and out of the Cell thorough the Cell Membrane

Diffusion and Osmosis: Atoms and molecules of gases and liquids have the ability to move about at random. As a result, they tend to spread themselves from areas of high concentration to areas of low concentration. This process is called diffusion. Osmosis is the term used to describe the diffusion of water across a membrane from a weak solution (high proportion of water molecules) to a strong solution (low proportion of water molecules). A solution which is weaker than another solution is said to be hypotonic to the other stronger solution. The stronger solution is hypertonic to the weaker solution. Solutions of the same strength are said to be isotonic.

Because all cells are surrounded by a membrane, water can diffuse into and out of cells with ease. Animal cells and plant cells behave differently however, because animal cells do not have a strong supportive porous cell wall surrounding them. The table shows what can happen to animal and plant cells when placed in water solutions of different strengths.

	Hypotonic solution (very little or no salt)	*Hypertonic solution (salty)*
Animal cells	Burst	shrink
Plant cells	become turgid (firm)	become flaccid (limp)

Plasmolysis

Plant cell walls are composed principally of cellulose fibres which allow free passage of molecules through the gaps between them. These walls give strength and structure to the plant cell, which animal cells do not have.

If plant cells are placed in very strong solutions, much water leaves the cell. In fact, the cytoplasm and vacuole shrink so much that the cell membrane can be pulled away from the cell wall. The cell is then said to be plasmolysed. This can be shown with pieces of potato or red onion placed in a range of salt solutions and in fresh water. The cells and tissues can then be examined after an hour's immersion.

All cells rely on the process of diffusion to absorb and secrete materials. However, diffusion on its own is not sufficient to transport all substances. There are many other ways cells can move substances across membranes.

Sometimes substances have to be moved against the way in which they would move naturally by diffusion. i.e. against the concentration gradient. This requires energy which is supplied by the cell. The process is called active transport, and specialised proteins in cell membranes act as carriers, moving molecules from one side of the membrane to the other using the chemical energy of a compound called Adenosine Tri-phosphate (ATP).

Exocytosis and Endocytosis

Another way of moving substances across a membrane is for the membrane to flow round the substance and form a tiny sac or vesicle as it is called. If the vesicle is formed inside the cell, then releases its contents to the exterior the process is called exocytosis. The import of materials in the opposite direction is called endocytosis. Phagocytosis is an example of a form of endocytosis on a large scale, where whole bacteria are surrounded by white blood cells and ingested.

Functions of the cell membrane

a. The cell/plasma membrane functions as a physical barrier between the external environment and the cytoplasm or the contents of cell organelles.

b. The cell membrane is selectively permeable and therefore only allows the movement of selected molecules in and out of the cell.

c. It functions by facilitating communication and signalling between the cells.

d. The plasma membrane plays a vital role in anchoring the cytoskeleton to provide shape and structure to the cell.

Learning Task

a. Why is the cell membrane described as a semi-permeable or selectively permeable membrane?

b. Describe at least three functions of the cell membrane.

Pedagogical Exemplars

Teacher should Consider the activity below;

Case-Based Consultative Learning: case-based consultative learning should be applied where the teacher guides learners in groups to consult and discuss among themselves the structure and components of the cell membrane, linking them to the fluid mosaic model using diagrams and pictures.

Group Project-Based Learning: similarly, in group project-based learning strategy, learners should be placed in groups to prepare charts and annotated diagrams on the structure and components of the cell membrane, linking them to the fluid mosaic theory. Each learner in their groups presents and discusses their work with the whole class.

Key Assessment-DoK

Level 1: State three ways by which substances can move in and out of cells.

Level 2: Describe four functions of membrane proteins.

Level 3: Explain why plant cells and animal cells behave differently when placed in fresh water.

Section 3: Review

In this section learners have learnt about the features of the cell (plasma) membranes which are found bounding many organelles and the cell itself. They learned about the 'fluid mosaic' model of the membrane structure, the compounds from which it is composed and how substances are moved in and out of the cell by diffusion, osmosis, active transport, endocytosis and exocytosis.

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SECTION 4: ORGANISMS

Strand: **Diversity of Living Things and Their Environment**

Sub-strand: Ecology

Content Standard:

1. Demonstrate knowledge and understanding of the use of biological keys in identifying living organisms.
2. Demonstrate understanding of the principles of classification of organisms.
3. Demonstrate knowledge and understanding of the life processes of living things.

Learning Outcomes:

1. *Apply the knowledge of biological keys to identify living things.*
2. *Apply the principles of classification to group living things.*
3. *Describe the life processes and economic importance of lower organisms.*

INTRODUCTION AND SECTION SUMMARY

The diversity of living things is vast, comprising a wide array of organisms including microscopic life forms from bacteria to macro-organisms such as trees, elephants and whales. Good knowledge and understanding in this area is required to ensure the protection, conservation and sustainable exploitation of ecosystems within the biosphere. Biological keys are essential tools in identifying and classifying these organisms, based on their characteristics.

Classifying organisms allows biologists to study these fundamental life forms to delve deeper into the intricacies of complex life forms. Carolus Linnaeus introduced the binomial system of naming in the 18th century, and this system gives every organism two-term Latin or Greek names, which are the genus and species names. e.g. *Homo sapiens* These names provide a universal means by which biologists communicate about living things in an attempt to understand all life forms.

The weeks covered by this section are:

Weeks 6: Constructing and using simple keys to identify organisms, leading to a study of the classification of organisms.

Week 7: The classification of organisms

Week 8: Discuss the life processes and economic importance of a selection of plants and animals found in Ghana.

SUMMARY OF PEDAGOGICAL EXEMPLARS

A variety of pedagogies are introduced to ensure that learners of all levels are fully involved in lessons. Among the pedagogies used are experiential learning techniques, project-based approach, group learning, talk for learning, and digital literacy learning approaches that will assist the learner to fully understand and appreciate lessons in the construction and use of keys, classification and its application to Biology and everyday life activities. Other exemplars are field trips to observe biodiversity, and hands-on exploration of populations and communities of living things. Pedagogical exemplars were carefully selected to take into account the interest of learners with special education

needs, so that these groups of students do not feel different and discriminated by other learners, and to encourage the essential 21st century skills and competencies required to transform the learner into a global citizen.

ASSESSMENT SUMMARY

Assessments in lessons of classification are mainly in formative oral questions and responses, quizzes, concept maps, and observation checklists to guide learner understanding and progress. Assessment on classification has been prepared to accommodate all levels of learners, including the approaching proficiency (AP), proficient (P) and highly proficient (HP). For P and HP learners, more complex assessments such as projects, scientific writings and presentations, and experiential design tasks, have been utilised to deepen understanding, critical and analytical thinking skills. Additionally, learners with special education needs (SEN) are catered for through the use of several educational strategies such as time-extension and differentiated learning. This is to be achieved through extended time, simplified instructions, and less complex alternative formats for assessments to support the SEN learner in demonstrating his or her knowledge and skills in classification effectively. Thus, assessment in the lessons has been formed to be GESI responsive, to suit the learning needs of all learners, and to make the biology learner appreciate fully the lessons taught about classification of organisms. With these diverse assessment modes, all learners are assured of showcasing their understanding in the concept of classification and its application in Biology and everyday life.

Week 6

Learning Indicator: *Identify living Organisms Using Biological Keys.*

Theme or Focal Area 1: Biological keys, how to make them and how to use them.

An example of a simple paired-statement key

The following is a simple key to identify six common invertebrates.

1
- No legs ---------- go to 2
- Legs ---------- go to 3

2
- Shell ---------- Snail
- No shell ---------- Slug

3
- Six legs ---------- go to 4
- More than six legs ---------- go to 5

4
- Wings ---------- Bee
- No wings ---------- Springtail

5
- Eight legs ---------- Spider
- Many pairs of legs ---------- Millipede

Why keys are important?

We can identify unfamiliar organisms in the field using a key. The advantage of using a key is that it requires careful observation of an organism to check whether a particular feature is present or absent. As a result, we become more familiar with the organisms we have identified.

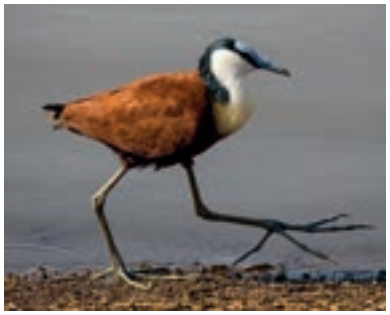
We should also be able to construct keys to enable other users to use these keys to identify organisms. The ability to construct a key is an important skill, testing knowledge, understanding and problem-solving skills.

For example, a key could be constructed to identify six birds native to Ghana shown below, using the colour of their feathers, the length of their legs, and the length of their tails.

African Green Pigeon

Abyssinian Roller

Afep Pigeon



African Jacana

Black-crowned Tchagra

Yellow-fronted Tinkerbird

1
- Long tail ---------- 2
- Short tail ---------- 3

2
- Brown feathers and black bar on head ---------- Black-crowned Tchagra
- Forked tail and bright blue breast feathers -------- Abyssinian Roller

3
- Green feathers---------- African Green Pigeon
- Feathers not green ---------- 4

4
- Legs as long as body with four long toes --------- African Jacana
- Legs shorter than body ---------- 5

5
- Small bird with yellow breast feathers ---------- Yellow-fronted Tinkerbird
- Large bird with dark blue/grey feathers all over -- Afep pigeon

As well as being useful for identifying organisms and describing their features, keys can be used to help us understand the classification of animals and plants.

The following key enables you to identify the main groups of plants present in the world + fungi, (Fungi are not really plants in the true sense)

Some examples are given in brackets after each group.

1
- No leaves, stems or roots ---------- 2
- Leaves, stems and roots ---------- 3

2
- Photosynthetic ----------Algae (seaweed)
- Non-photosynthetic ---------- Fungi (toadstools and mushrooms)

3
- No seeds ---------- 4
- Seeds ----------5

4
- Roots and stem with vascular tissue ----- Ferns
- Simple single leaf or leaves only --------- Mosses and Liverworts

5
- Naked seeds in a cone ---------- Conifers (pine and fir trees)
- Covered seeds, and flowers ---------- 6

6
- One seed leaf ---------- Monocots (grasses)
- Two seed leaves ---------- Dicots (broad-leaved plants)

Learning Task:

1. Practise constructing a key for some common items: e.g. Coin, Pin, Button, Rubber/Eraser, Paperclip, Rubber band, Cork
2. Collect some leaves from different plants in the school grounds and construct a key to identify them by their shape and colour.
3. Collect some pictures of common farm animals found in Ghana and construct a key to identify them.
4. Construct a key to identify a group of pupils in your class, using visible features only. e.g. type of hair, gender, left or right-handed, how they fold their arms: left over right, or right over left; ear lobes or no ear lobes; can they roll their tongues into a tube? Don't use clothes as an indicator, because they change from day to day.

Note that these examples all consist of paired statements. That need not be the case.

You can have more than two statements if you wish, as in (3) below

The key below outlines the main groups of animals in the world;

1
- Backbone---------- 2
- No backbone ---------- 5

2
- Fur or hair ---------- Mammals
- No fur or hair ---------- 3

3
- Scales ---------- 4
- Feathers ---------- Birds

4
- Naked skin with no covering ---------- Amphibians (e.g. toads and frogs)
- Wet/slimy scales ---------- Fish

5
- Dry scales ---------- Reptiles
- This leads to all Invertebrates (animals without a backbone), a group consisting of a vast number of different animals.

In the following week, we will look at the principles of classification of animals and plants.

Week 7

Learning Indicator: *Explain how lower organisms are classified into their taxonomic groups.*

Theme or Focal Area 1: Explain How Simple or Lower Organisms are Classified into their Taxonomic Groups

Background of classification in lower organisms

The scientific classification of living things, called taxonomy, dates back to ancient civilisations such as those of the Greeks (as done by Aristotle) and Roman eras. They classified living things based on their observable characteristics. However, it was not until the 18th century that the Swedish botanist and physician, Carolus Linnaeus (Carl Linnaeus) developed a more comprehensive system of classification. He introduced a hierarchical classification, thereby organising into groups called taxa (singular is called taxon) based on their shared characteristics. He put organisms into seven taxa, starting from kingdom, a broader and more general group, and ending on species (specific epithet), which is made up of closely related organisms. He also introduced the binomial nomenclature, a system that gives two names to an organism, the genus name and the species name. His system laid the foundation of modern classification. Linnaeus is considered as the father of modern classification. Simple (lower) organisms, like other living things, are classified using a variety of characteristics. Examples of lower living things are prokaryotes (bacteria) and protoctists such as the *Amoeba*, *Euglena* and *Spirogyra*. They also include fungi and some simple plants and animal forms.

Factors Used in Classification of Simple/Lower Organisms:

1. **Morphology** – This involves physical characteristics or features such as shape, size, colour and structure of the organism.
2. **Physiology** – this is when living things are grouped based on the functions and processes (such as metabolism, reproduction, growth and response to stimuli) occurring within them.
3. **Genetic information** – This is when living things are classified based on the differences and similarities in their DNA and gene composition. This offers a more accurate and detailed classification of living things.
4. **Ecological information** – This is the grouping of organisms based on their ecological roles such as their habitat, behaviour and interactions with other living things.
5. **Evolutionary relationships** – This involves classification where closely related organisms are grouped based on a common ancestry.

Forms of Classification

1. **Hierarchical Classification** – this is when living things are classified based on nested orders from a broader group to a smaller and specific group. This is the most common type of classification and was used by Linnaeus in classification. Thus, the modern hierarchical taxa from broader groups to the more accurate group are Domain, Kingdom, Phylum/Division, Class, Order, Family, Genus and Species (use the mnemonics, *Dear King Philip Came Over for Good Soul* Or *Do Kindly Please Choose One for Goodness Sake).*
2. **Cladistics** – This type of classification is based on evolutionary relationships and puts organisms into groups based on shared characteristics, regardless of traditional taxonomic ranks.
3. **Phylogenetic Classification** – This refers to the use of molecular data to reconstruct evolutionary relationships between organisms

4. Numerical Classification – This refers to the use of quantitative data such as measurements and statistical analysis to classify organisms based on their similarities.

Natural And Artificial Classification

Natural classification is based on natural relationships among living organisms. These natural relationships include their evolutionary history and shared characteristics.

Artificial Classification is based on arbitrary standards chosen for convenience and is often based on easily observable features.

Differences between Natural and Artificial Classification

Feature	Natural Classification	Artificial Classification
1. Bases of classification	Based on natural relationships such as shared characteristics	Arbitrary criteria by chosen by humans
2. Criteria for classification	Considers overall similarities and evolutionary history.	Considers specific easily observable features chosen
3. Flexibility	Flexible as more information about the organism becomes available	Less flexible and may not reflect true relationships among living things.
4. Purpose	Aims to understand natural relationships and diversity of life.	Often used for practical purposes such as identification.

Processes Involved in Classifying Organisms

1. Observation and collection of data on the characteristics of organisms (e.g. genetic, morphological and behavioural data).
2. Comparing the observed characteristics among different organisms to identify patterns (similarities and differences).
3. Sort or group organisms based on shared characteristics to form an initial classification.
4. Arrange groups into hierarchical orders from broad to specific.
5. Validate classifications through further analysis (e.g. through DNA analysis and comparative anatomy) to ensure accuracy.
6. Document scheme of classification (e.g. description of taxa and criteria of classification).
7. Periodic review and revision of classification based on discoveries and evidence.

Importance Of Classifying Organisms

1. It provides a systematic way to organise the huge diversity of life.
2. It allows easy communication about organisms among biologists.
3. It allows the identification of endangered species and ecosystems for the conservation of biodiversity.
4. Taxonomy offers a broader understanding of interactions among living things and energy transmission among them through food chains and webs.
5. It allows biologists to predict the characteristic traits, behaviour and ecological interactions of organisms.

Learning Task

1. Discuss the background of classification, linking it to simple living organisms, and the factors that are considered in classifying them. Limit content expectation to discussing the background of classification briefly before Linnaeus and listing at least three factors used in the process.
2. Discuss the various forms of classification among living things. Content should cover brief discussions on at least three forms of classification and how these are done.
3. Examine the differences between natural and artificial classification of simple living things. Limit content to listing and describing at least three basic differences between natural and artificial forms of classification.
4. Analyse the steps to be taken to classify a newly discovered simple living organism, hence discuss why it is necessary to classify living things. Limit content to discussing the major steps that taxonomists follow to classify and name newly discovered species.

Pedagogies Exemplars

Consider The Following Activities:

Using experiential learning put learners in mixed-ability, gender-balanced groups to embark on tours around the school community to observe and collect data on some simple living things (e.g. lower plants and common invertebrates). This offers learners the direct experience of basic taxonomic processes.

Use research-based learning to put learners in mixed-ability groups to research from textbooks and available sources (e.g. audio and video documentaries) to understand the basis of classifying lower living things into various taxa. Research exercises keep all learners focused on participating in learning, as there are differentiated roles.

Use project-based learning groups to assign learners into mixed-ability groups, give each group a project exercise on simple living things and their classification, and ask them to submit these for feedback to be provided. This strategy ensures that every learner has a significant role to play and, hence feels important in the lesson.

Key Assessment/DoK Levels

Level 1: Identify the key factors required in creating a system for the identification and classification of simple living things.

Accept a list of at least three key factors required for identifying and classifying simple living things.

Level 2: Explain why you think it is important that a biology learner should have a good basis in classifying living things.

Accept an explanation of why learners should have a good foundational understanding of taxonomy.

Level 3: discuss the strengths and limitations of natural and artificial classification.

Accept discussion on the advantages and disadvantages of natural and artificial classifications, using factors such as the bases of classification, criteria of classification and flexibility.

Level 4: Collect samples (10-20 specimens) from your school community and group them under their various taxa as far as possible, assigning reasons as to why a particular organism is placed in a specific group. Accept project up to at least specimens and their identification and classification, including reasons for their classification.

Theme or Focal Area 2: Describe the Various Major Ranks or Taxa in Hierarchical Classification

The major ranks/taxa/groups used in the hierarchical system of Classification, from the largest to the smallest taxon are: **Domain, Kingdom, Phylum, Class, Order, Family, Genus and Species.**

1. Domain and Kingdom: Organisms are first categorized into one of the three domains: Bacteria, Archaea, or Eukarya. Lower organisms typically fall under the Eukarya domain. Then, they are grouped into one of the major kingdoms, such as Protista, Fungi, Plantae, or Animalia.
2. Phylum (Division for plants): Each kingdom is further divided into phyla or divisions (for plants) based on major evolutionary differences. For example, the Animalia kingdom includes phyla like Arthropoda (insects, spiders) and Chordata (vertebrates).
3. Class and Order: Within each phylum or division, organisms are grouped into classes and orders based on more specific characteristics. For example, in the Animal Kingdom, cockroaches are insects that belong to the order Blattodea.
4. Family and Genus: The next taxonomic levels are family and genus. Families group together related genera. Genus is a more specific category that includes species that are closely related to each other. For instance, the genus *Panthera* includes species like lions, tigers, and leopards.
5. Species: The smallest and most specific taxonomic group is species. Species consists of individuals that can interbreed and produce fertile offspring. For example, the species name for cashew is ***Anacardium occidentale***.

Classify *Amoeba Proteus* as An Example of Single-Celled Organism

- Domain: Eukarya (It has cells with nuclei)
- Kingdom: Protista (It is a unicellular eukaryote)
- Phylum: Amoebozoa (Organism that moves by internal cytoplasmic flow)
- Class: Tubulinea (It is a tubular *Amoeba*)
- Order: Euamoebida (It is a type of tubulinea)
- Family: Amoebidae (It is a type of *Amoeba*)
- Genus: *Amoeba* (It belongs to the genus *Amoeba*)
- Species: *Amoeba proteus* (The specific species name)

Characteristics of Taxa

1. Organisms with shared characteristics are placed in the same taxa.
2. Numbers decrease down the taxon whilst shared characteristics increase down it.
3. Organisms put at the species group can interbreed to produce fertile offspring.
4. The introduction of binomial nomenclature at the genus and species level ensures uniformity in classification.

Learning Task

1. Describe the 8 taxa/ranks in modern classification with examples of common organisms. Limit content expectation to naming and describing the 8 taxa of modern classification and use particular organisms to show how they are grouped from the largest to the lowest taxa.
2. Explain how you will classify a named species of simple organism into its taxa. Limit content expectation to understanding how simple living things are assigned the various taxa from the largest to the smallest.

Pedagogical Exemplars

Use experiential learning method to embark on a tour around the community to observe and collect some common, harmless organisms: Learners obtain hands-on practical lessons through experiential learning to understand lessons better.

Use inquiry-based learning groups to research from textbooks and at the library and other research centres to obtain good insights into hierarchical classification and the various taxa within it. This learning strategy makes the learner ambitious inquirer.

Use project-based learning to assign learners in to collect and identify some common simple organisms that are easily assessable. Project-based learning ensures that all learners are involved in at least one aspect of the project.

Key Assessment – DoK

Level 1: Define the term taxon, as related to classification in living things, and give examples of some taxa and animals that belong to them.

Accept the definition of taxon as used in the classification of living things and give some examples of taxa.

Level 2: Describe the eight taxa identified in hierarchical classification.

Accept a list of the eight modern groups of classification by levels and describe each group.

Level 3: Discuss the concept of taxa and show how this makes classification of lower organisms convenient to the biologists.

Accept the explanation of taxa and how this process makes it easier for biologists to work among living things.

Level 4: Design a flowchart of the hierarchies in classification and select one common example to identify each of the eight taxa it belongs.

Accept an annotated diagram of the various steps involved in classification and how specific organisms are put under these groups.

Theme or Focal Area 3: Identify Key Features of the Binomial Nomenclature

Binomial Nomenclature

Organisms are given a unique scientific name using the binomial nomenclature, which combines the genus name and the species name. For example, humans are *Homo sapiens*, where "Homo" is the genus and "sapiens" is the species. This system was introduced and used by Carolus Linnaeus (Carl Linnaeus) in the 18th century. The two-part names are represented in italics when in text or printed material and are underlined separately when hand-written. The generic name begins with a capital letter, followed by the species name (species epithet), which begins with a small letter. In some cases, the organism may have been domesticated. In such instances, the organism is usually given a three-part name. The first name is the genus, the second is the species, while the last is the sub-species name. In texts and writing, the same rules are applied. The genus name begins with a capital letter, while the species and sub-species names begin with small letters. One important usage of binomial nomenclature is that it allows biologists to communicate smoothly about organisms with limited or no barrier in communication.

Some common examples of organisms and their binomial names are provided below.

Some Important Animals in Ghana/Africa and Their Binomial Nomenclatures

Common name	Genus name	Species name	Sub-species name
Chicken	*Gallus*	*Gallus*	*domestica*
Goat	*Capra*	*aegagrus*	*hircus*
Sheep	*Ovis*	*aries*	--------
Dog	*Cannis*	*Lupus*	*familiaris*
Rhesus monkey	*Macaca*	*mulatta*	--------
Human	*Homo*	*Sapiens*	--------

Some Important Crops Grown in Ghana and Their Nomenclatures

Common name	Genus name	Species name
Cassava/Manioc	*Manihot*	*esculenta*
Maize	*Zea*	*mays*
Rice	*Oryza*	*sativa*
Shea butter	*Vitellaria*	*paradoxa*
Cocoa	*Theobroma*	*cacao*

Factors That Influence Binomial Names Assigned to Species

1. Scientific accuracy; for example, the binomial of the giant panda was changed from the raccoon family to the bear family (thus, based on genetic evidence.
2. Consistency and clarity in communication; this allows biologists from different regions and specialties to communicate effectively.
3. International acceptance; for example, the gray wolf is internationally accepted as *Cannis lupus*.
4. Cultural and historical norms and origin of species; for example, the Ethiopian bamboo is named as *Oxytenanthera abyssinica*, reflecting the historical name of Ethiopia (that is Abyssinia).
5. Taxonomic revision; for example, the discovery of a new species of flowering plant, Ethiopian/ African pepper) in the rainforests of Ghana led to the adoption of the binomial name, *Xylopia aethiopica* to reflect its status as a distinctive species.
6. Formal nomenclature rules; for example, the binomial name for the lion, *Pantera leo*, follows the rules in the International Code of Zoological Nomenclature.

Significance Of Binomial Nomenclature.

1. Taxonomic ranks ensure organisms with shared characteristics are placed on the right taxa.
2. Numbers decrease down the taxon whilst shared characteristics increase.
3. Binomial nomenclature ensures uniformity in naming and identifying living things amongst biologists the world over.

Learning Task

1. Explain binomial nomenclature in taxonomy and give some common examples. Limit content to explaining the term binomial nomenclature and give the binomial names of at least three common living things.
2. Explain why some nomenclatures are two termed names but others may be three.Limit content to explaining the concept of sub-species, resulting in some species bearing trinomial names due to their sub-species names.
3. Discuss the factors that affect binomial names assigned to living things.Limit content to discussing at least three factors to consider when giving binomial names to living things.
4. Describe the process leading to the discovery of some recently discovered living things and `describe how they were classified and named binomially. Limit content to discussing the naming of at least one new species discovered within the past five years.

Pedagogies Exemplars

Consider The Following Pedagogical Exemplars:

In experiential learning groups, learners in mixed-ability, gender-balanced groups embark on tours around the school community and lab exercises to observe and collect specimens. Learners become well acquainted through hands-on- learning activities.

In research-based learning groups, learners research from textbooks and available sources (e.g. audio and video documentaries) to find and understand the binomial nomenclatures of these organisms. Through research learning groups, learners develop the spirit of cooperation and become team players.

Using individual-based learning method, ask learners to individually collect at least 3 specimens and find out their binomial names and why they were given those names. When learners take up individualised research, they become independent and focused.

Where possible, use individual presentations to allow learners to present and share their findings to boost public speech and confidence.

Key Assessment – DoK Levels

Level 1: Explain the term binomial nomenclature.

Accept a brief explanation of binomial nomenclature and how organism are assigned this name.

Level 2: Discuss the factors that affect the assigning of binomial names to new species, and give example in each case.

Accept learners giving and explaining at least three factors that could influence how binomial names are provided to living things.

Level 3: As a taxonomist, why will you prefer to use the binomial names of living things in your study, and not their common names?

Accept discussion of the advantages and implications of binomial names over common names.

Week 8

Learning Indicator: *Discuss the life processes and economic importance of the micro-organisms: Amoeba, Euglena and Spirogyra*

Theme or Focal Area 1: Discuss the life processes and Economic Importance of *Amoeba proteus*

Life Processes in *A. proteus* includes the following:

1. **Nutrition**: *Amoeba* is a heterotrophic organism, meaning it feeds on other organisms. It captures food, such as bacteria and other small particles, by surrounding them with its pseudopods (false feet) and forming a food vacuole. The food is then digested and absorbed within the cell.
2. **Respiration**: *Amoeba* undergoes cellular respiration to produce energy by breaking down food molecules and using oxygen.
3. **Reproduction**: *Amoeba* reproduces asexually through a process called binary fission, where the cell divides into two identical daughter cells.
4. **Excretion**: Waste products are eliminated from the cell through the cell membrane.
5. **Response to Stimuli**: *Amoeba* can respond to changes in the environment, such as moving towards a food source or away from harmful substances.

The Economic Importance of *A. Proteus* Are*:*

1. They assist in nutrient recycling by consuming microorganisms such as bacteria and algae to maintain ecological balance.
2. They serve as model organisms in scientific research in areas such as cytology, genetics and microbiology in scientific.
3. They form an important component of the food chain of an ecosystem.
4. They serve as indicator species in a habitat, as the changes in amoebae populations are an indication of interference in water quality levels.
5. Some species of Amoeba are parasitic and pathogenic and cause diseases to humans and damage to crops.

Learning Task

1. Name at least three life processes of *Amoeba* and the special adaptations for these processes. Limit content expectation to the identification at least three life processes in Amoeba, and the adaptive features to perform these life processes.
2. Describe how *Amoeba* undergoes movement and nutrition. Limit content to describing how *Amoeba* moves around in its habitat, and how it obtains it food in the water. Provide extra support for struggling learners.
3. Discuss the economic importance of *Amoeba* in its habitat. Limit content to the beneficial and harmful sides of the presence of Amoeba in a habitat.

Pedagogical Exemplars

Teacher should consider the following activities;

Use task-based Learning for learners to observe the *Amoeba* under the light microscope from temporary slides prepared from freshly fetched water from a ditch or pond; make diagrams of these in sketch books. Learners acquire critical observation skills; learners develop their technological skills through the use of the microscope.

Use talk for learning approach for learners in mixed-ability groups to *Amoeba* describe their observations findings and record them. The more confident and outspoken learners should describe their observation to reinforce understanding learners that learn slowly.

Use collaborative learning among learners to analyse microscope and video tape observations of *Amoeba* and discuss results in their various groups. Open discussion learning allows all levels of learners to share what they observe with others in the group, thereby building good communication and confidence.

Key Assessment- DoK

Level 1: List at least three life processes of *Amoeba*, briefly describing each.

Level 2: Describe any two of the following processes in *Amoeba*: nutrition, movement, excretion, reproduction

Level 3: Outline the economic importance of *Amoeba* in a named ecosystem.

Accept discussion on the beneficial and harmful aspects of *Amoeba* in any named ecosystem.

Theme or Focal Area 2: Discuss the Life Processes and Economic Importance of *Euglena Viridis*

Life Processes:

1. **Nutrition**: *Euglena viridis* is a unique organism as it can be both autotrophic (capable of photosynthesis) and heterotrophic (eats other plants or animals).
2. **Photosynthesis**: *Euglena* contains chloroplasts which allow it to perform photosynthesis and produce its food in the presence of sunlight.
3. **Respiration**: *Euglena* undergoes cellular respiration to derive energy from the breakdown of food molecules in the presence of oxygen.
4. **Reproduction**: *Euglena*. reproduces asexually through binary fission, like *Amoeba*. It can also undergo a form of sexual reproduction called conjugation, where genetic material is exchanged between two individuals.
5. **Excretion**: Waste products are eliminated through the pellicle, a semi-rigid outer covering.
6. **Response to Stimuli**: *Euglena*. has a light-detecting eyespot that allows it to sense and move towards light, enabling it to perform photosynthesis efficiently.

Economic Importance of *E. viridis*

Euglena sp. have potential economic significance due to their ability to perform photosynthesis and produce a carbohydrate compound called paramylon. Paramylon has some health benefits, including lowering blood cholesterol levels.

Learning Task

1. Describe the life processes of *Euglena* and the special adaptations for these processes. Limit content expectation to the identification of three life processes in *Euglena*, and the adaptive features to perform these life processes.
2. Describe the unusual nutrition of *Euglena* and how *Euglena* finds light for photosynthesis. Limit content to describing how *Euglena* moves around in its habitat, and how it obtains its food in the water. Provide extra support for struggling learners.
3. Discuss the economic importance of *Euglena* in its habitat. Limit content to the beneficial and harmful sides of the presence of *Euglena* in its habitat.

Pedagogical Exemplars

The teacher should consider the following activities:

Use task-based 'learning for learners' to observe *Euglena* under the light microscope from temporary slides prepared from freshly fetched water from a ditch or pond; make diagrams of these in sketch books. Learners acquire critical observation and technical skills using the microscope.

Use 'talk for learning' approach for learners in mixed-ability groups to *Euglena* describe their observations and findings and record them. The more confident and outspoken learners should describe their observations to reinforce the understanding of learners who learn slowly.

Use collaborative learning among learners to analyse microscope and video tape observations of *Euglena* and discuss results in their various groups.

Open discussion learning allows all levels of learners to share what they observe with others in the group, thereby building good communication and confidence.

Key Assessment-DoK

Level 1: List three life processes of *Euglena*, and briefly explain each.

Accept three life processes with brief explanations of each.

Level 2: Describe at least one of the following processes in *Euglena*: nutrition, movement, excretion, reproduction

Level 3: Describe the economic importance of *Euglena* in a named natural habitat

Accept description of the economic importance of *Euglena* in a named natural habitat

Level 4: Discuss whether *Euglena* or *Amoeba* is the more advanced protoctist, indicating the parameters used for the comparison.

Accept a list of at least three life processes in these two organisms, with a comparison of each

Theme or Focal Area 3: Discuss the life processes and Economic Importance of *Spirogyra porticalis.*

Life Processes:

1. **Nutrition**: *Spirogyra porticalis* is a photosynthetic organism. It contains chloroplasts that enable it to synthesize its food using sunlight, carbon dioxide and water.
2. **Respiration**: *Spirogyra porticalis* undergoes respiration to obtain energy from the breakdown of stored sugars.

3. **Reproduction**: *Spirogyra porticalis* reproduces both asexually through fragmentation (breaking into pieces that grow into new individuals) and sexually through the conjugation process.
4. **Excretion**: Waste products are eliminated through the cell membrane.
5. **Response to Stimuli**: *Spirogyra porticalis* exhibits a slow, passive movement in response to environmental changes.

Economic Importance: *Spirogyra porticalis* plays a vital role in aquatic ecosystems as it contributes to oxygen production through photosynthesis. Additionally, *Spirogyra* serve as a food source for certain aquatic organisms, supporting the aquatic food chain. In research and education, *Spirogyra porticalis* is a commonly studied organism for understanding plant cell structure.

Learning Task

1. Give the life processes of *Spirogyra* and the special adaptations for these processes. Limit content expectation to the identification of at least three life processes in *Spirogyra*, and the adaptive features to perform these life processes.
2. Describe how *Spirogyra* undergoes movement and nutrition. Limit content to describing how *Spirogyra* how it manufactures food. Provide extra support for struggling learners.
3. Discuss the economic importance of *Spirogyra* in its habitat. Limit content to the benefits of the presence of *Spirogyra* in its natural environment.

Pedagogical Exemplars

Use task-based 'learning for learners' to observe the *Spirogyra* under the light microscope from temporary slides prepared from freshly fetched water from a ditch or pond; make diagrams of these in their sketchbooks. Learners acquire critical observation skills; learners develop their technological skills through the use of the microscope.

Use 'talk for learning' approach for learners in mixed-ability groups to describe their observations and findings and record them. The more confident and outspoken learners should describe their observations to reinforce the understanding of learners who learn slowly.

Use collaborative learning among learners to analyse microscope and video tape observations of *Spirogyra* and discuss results in their various groups. Open discussion allows all levels of learners to share what they observe with others in the group, thereby building confidence.

Key Assessment-DoK

Level 1: List at least three life processes of *Spirogyra*, and briefly explain each.

Accept at least three life processes with brief explanations of each.

Level 2: Describe at least one of the following processes in *Spirogyra*: nutrition, movement, excretion, or reproduction

Level 3: Examine the economic importance of *Spirogyra* in a named natural habitat

Accept description of the economic importance of *Spirogyra* in any named natural habitat.

Level 4: Discuss whether *Spirogyra* or *Euglena* is the more advanced protoctist.

Indicate the parameters used in your analysis.

Accept a list of at least three life processes in these organisms as the indicators.

Section 4: Review

In this Section, we have discussed the construction and use of biological keys and the classification of organisms. We narrowed this down to hierarchical classification to describe the eight taxa in modern classification to ensure that the learner acquires the relevant basic skills and competencies in the learning attitude. We looked into binomial nomenclature, tracing its brief history and dwelling more on some common examples important to the growth of Ghana's economy. We discussed how binomial names are assigned to living things considering factors such as DNA, morphology and behaviour.

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SECTION 5: ECOLOGY

Strand: **Diversity of Living Things and Their Environment**

Sub-strand: Ecology

Content Standards:

1. Demonstrate knowledge and understanding of ecological terms and the significance of ecological concepts.
2. Demonstrate knowledge and understanding of how the living and non-living components of the environment interact to ensure the sustenance of life.
3. Demonstrate knowledge and understanding of the use of ecological devices and methods such as the quadrat, pitfall trap, pooter, and Lincoln's index to study populations of organisms.
4. Demonstrate knowledge and understanding of methods of determining energy flow in an ecosystem.
5. Demonstrate knowledge and understanding of energy flow and efficiency in an ecosystem with emphasis on ecological pyramids.

Learning Outcomes:

1. *Apply the knowledge of ecological terms to describe the concept of ecology.*
2. *Explain how the living and non-living components of the environment interact to ensure the sustenance of life.*
3. *Show how various simple ecological tools can be used to estimate the populations of species in each habitat.*
4. *Explain the relevance of direct counting, gut examination and radioactive/tracer methods of determining the flow of energy in an ecosystem.*
5. *Explain the methods of determining and comparing the efficiency of energy flow in pyramids of numbers, biomass and energy.*

INTRODUCTION AND SECTION SUMMARY

Ecology, a vital branch of Biology, is the study of the intricate relationships between living organisms and their environment. It explores interactions among plants, animals, microorganisms and abiotic factors like air, water and soil. Learners grasp ecological terms significance and understand how living and non-living elements sustain life and employ tools like quadrats and methods such as Lincoln's index to estimate species populations. They learn to utilize ecological devices and methods to study populations and explain energy flow in ecosystems through direct counting, gut examination and radioactive techniques. Learners compare energy flow efficiency in pyramids of numbers, biomass, energy and study ecosystem dynamics. This knowledge aids in developing sustainable agriculture systems, resource management, biodiversity conservation, and addressing climate change, to ensure the health and stability of ecosystems for future generations.

The Section covers the following weeks:

Week 9:

a. The study of ecology, along with the various ecological terms.
b. Examples of different habitats

Week 10:

a. Interdependence of organisms in various habitats.
b. The outcome of the interdependence of living organisms in their environment.

Week 11:

a. Ecological tools and sampling techniques for estimating population size and density.
b. Direct counting, gut examination and radioactive/tracer methods of determining the flow of energy in an ecosystem.

Week 12: The relevance of each of the methods used in determining energy flow in an Ecosystem**.**

SUMMARY OF PEDAGOGICAL EXEMPLARS

This section advocates for practical learning experiences such as nature walks and field trips, along with field and laboratory activities. It emphasizes pedagogical methods including individual-based and experiential learning, inquiry-based learning, critical thinking and problem-solving. Communication, collaboration, group-based learning, leadership and personal development are encouraged through diverse roles within groups. Cultural identity and global citizenship are promoted by relating learned concepts to various ecosystems worldwide. Digital literacy is fostered through the use of technology to explore ecosystems. Safety precautions are stressed for both field and laboratory activities, with support provided for learners with special educational needs. Overall, the approach aims to provide learners with hands-on experiences, critical thinking skills, cultural awareness and technological proficiency in ecology.

ASSESSMENT SUMMARY

Assessments in this section are mainly formative oral questions and responses, quizzes and observation checklists to guide learner understanding and progress. The assessments have been prepared to accommodate all levels of the depth of knowledge (DoK) of learners. Complex assessments such as projects, scientific writings and presentations and experiential design tasks have been given as mixed-ability group work to deepen the understanding, critical and analytical thinking skills of all learners where the highly proficient ones serve as support for the others. Additional support must be given to learners with special education needs (SEN), through extended time, simplified instructions and less complex alternative formats of assessments to support the SEN learner to also demonstrate his or her knowledge and skills in ecology effectively. The assessments in this section suit the learning needs of all learners, so each can fully appreciate ecology. With these diverse assessment modes, all learners are assured of showcasing their understanding of ecology and its application in everyday life.

Week 9

Learning Indicators:

1. *Demonstrate knowledge of various ecological terms*
2. *Describe the importance of ecological concepts in named habitats.*

Theme or Focal Area 1: Explain the Term Ecology and the Various Ecological Terms

Ecology: This is the branch of biology that deals with the scientific study of interactions between organisms and their environment. It encompasses a wide range of terms and concepts that help us understand the relationships and processes that occur within ecosystems. Here are some important ecological terms explained.

Biosphere: This refers to the global sum of all ecosystems, encompassing all living organisms (biota) and their interactions with each other and with the abiotic (non-living) components of Earth's surface, such as the atmosphere, hydrosphere, and lithosphere. Simply put it is the Earth and all its parts where life exists.

Biomes: Biomes are large ecological areas characterized by distinctive climates, vegetation, and animal life. Examples include tropical rainforests, deserts, grasslands, and tundra.

Ecosystem: An ecosystem is a community of living organisms (plants, animals, and microorganisms) interacting with each other and their physical environment (abiotic factors) within a defined area. Examples include forests, grasslands, coral reefs and ponds.

Biotic Factors: Biotic factors are all the living components of an ecosystem, including plants, animals, fungi and micro-organisms. They interact with each other and the abiotic factors in the environment.

Abiotic Factors: Abiotic factors refer to all the non-living physical and chemical components of an ecosystem, such as sunlight, temperature, water, soil, air, and nutrients. These factors influence the distribution and abundance of living organisms.

Population: A population is a group of individuals of the same species living in a specific area and time, capable of interbreeding and producing fertile offspring.

Community: A community is a group of different populations of organisms living and interacting in the same ecosystem. It includes all the living organisms present in the area.

Habitat: A habitat is a specific place within an ecosystem where an organism or a population naturally lives and thrives. It provides the necessary resources for their survival.

Niche: A niche refers to the role and position of an organism or population within its habitat. It includes how the organism uses resources, interacts with other species, and responds to environmental conditions.

Food Chain: A food chain is a linear sequence of organisms through which energy and nutrients are transferred in an ecosystem. It shows the flow of energy from one organism to another based on their feeding relationships.

Food Web: A food web is a more complex representation of feeding relationships within an ecosystem. It consists of multiple interconnected food chains, showing the various pathways through which energy and nutrients flow.

Producer/Autotroph: Producers are organisms, mostly plants and some bacteria, capable of producing their food through photosynthesis or chemosynthesis. They form the basis of the food chain/web.

Consumer/Heterotroph: Consumers are organisms that obtain their energy and nutrients by consuming other living organisms. They can be herbivores, carnivores, omnivores, or decomposers.

Herbivores: Herbivores are primary consumers that feed on plants and other producers.

Carnivores: Carnivores are secondary or tertiary consumers that primarily consume other animals.

Omnivores: Omnivores are consumers that eat both plants and animals.

Decomposers: Decomposers are organisms, such as bacteria and fungi, that break down dead organic matter, recycling nutrients back into the ecosystem.

Predators: Predators are organisms that hunt, kill, and consume other organisms (prey) for food. They play a crucial role in regulating population sizes and maintaining ecosystem balance.

Prey: Prey refers to organisms that are hunted and consumed by predators. They are an essential part of the food chain, serving as a source of energy for the predators.

Competition: Competition is the struggle between individuals or species for limited resources, such as food, water, and shelter. It can be intraspecific (within the same species) or interspecific (between different species).

Symbiosis: Symbiosis is a close and long-term interaction between two different species living together. There are three main types of symbiosis: mutualism (both species benefit), commensalism (one species benefits and the other is unaffected), and parasitism (one species benefits at the expense of the other).

Biodiversity: Biodiversity refers to the variety of life forms and species within a particular area or on Earth as a whole. High biodiversity is crucial for ecosystem resilience and stability.

Ecological Succession: Ecological succession is the process of change in the species composition and community structure of an ecosystem over time. It occurs after disturbances like wildfires or in abandoned fields.

Primary Succession: Primary succession occurs in a newly formed or bare area, such as a volcanic island or glacial retreat, where no soil exists. Pioneer species (like lichens and mosses) colonize the area, paving the way for other plant and animal communities.

Secondary Succession: Secondary succession happens in an area that has been disturbed but still retains some soil, such as abandoned farmland or a cleared forest. It starts with colonizing species, including grasses and shrubs, and progresses toward a mature ecosystem.

Ecological Footprint: The ecological footprint measures the human impact on the environment by calculating the number of natural resources and land required to support an individual, community, or country's lifestyle and consumption patterns.

Carbon Footprint: The carbon footprint is a specific type of ecological footprint that measures the amount of carbon dioxide and other greenhouse gases emitted because of human activities, such as burning fossil fuels for energy.

Conservation: Conservation refers to the protection and sustainable use of natural resources, biodiversity, and ecosystems to maintain their health and function for present and future generations.

Learning Task

1. Explain the term ecology Limit content expectation to the definition or brief explanation of ecology.
2. Explain at least four ecological terms Extend content expectation to correct explanation of at least four ecological terms
3. Distinguish between any two closely related ecological terms. Encourage learners to distinguish between closely related ecological terms.

Pedagogical Exemplars

The teacher should consider the activities below;

Individual-based learning: Learners individually research textbooks, the internet and other relevant sources to understand the meaning of various ecological terms (e.g., ecology, biosphere, environment, ecosystems, community, population, habitat, biome, biotic and abiotic factors).

Using group-based learning: learners in mixed-ability groups discuss the various ecological terms and note down the correct explanation for each. Learners become analytical and critical thinkers through systematic examination and differentiation of closely related ecological terms. Learners learn to accept peers from different social, emotional, psychological and economic backgrounds. They also learn from one another and accept the contributions of others during group work.

Critical thinking and problem-solving: Learners engage in thorough thinking as they examine the importance of ecological concepts.

Communication and Collaboration: Learners express themselves and learn to tolerate others' views and collaborate during ecological tours and class discussions. Learners broaden their scope of understanding of ecology and real-life situations. Learners become technologically inclined as they acquire knowledge in the operation of laptops and projectors.

Key Assessment- DoK Levels

Level 1: Describe briefly the term ecology

Accept an explanation with any three keywords:

a. branch of biology
b. study
c. interaction between
d. living organisms
e. environment.

Level 1: List ecological terms you are familiar with and describe any two.

Accept at least any four terms listed and any two correctly described

Level 3: Distinguish between the following:

a. Environment and ecosystems
b. Niche and habitat
c. Biosphere and biome
d. Food chain and food web
e. Primary succession and secondary succession.

Accept any three correctly differentiated terminologies

Theme or Focal Area 2: Identify Ecological Concepts in Some Major Habitats

1. **Grasslands**: Grasslands, whether they are prairies, steppes, or savannas, are important ecosystems where grasses are the dominant vegetation. They support a variety of life, from grass-eating herbivores to predators.

   The concept of herbivory, where animals (like bison or gazelles) feed on plants (grasses), is key to these ecosystems. These animals help control the grass population and provide a food source for predators.

   Fires, both natural and human-induced, are part of the disturbance regime in many grasslands. They help maintain the ecosystem by preventing the invasion of tree species and triggering the growth of fire-adapted grasses.

2. **Deserts**: Deserts are harsh and arid environments, and the concept of adaptations is prominent here. Organisms in deserts have evolved specific adaptations to cope with extreme conditions of temperature (heat and cold), scarcity of water, and other challenging conditions. There are two types of deserts. These are hot and dry deserts and cold and dry deserts.

   The water cycle is a critical concept in deserts, as water is scarce and the availability of this precious resource dictates the distribution of life. Plants and animals have adapted to conserve and utilize water efficiently. For example, cacti have thick, waxy skins and spines to reduce water loss. Interactions between predators and prey are significant in desert ecosystems, as resources are limited. Animals like snakes, scorpions and birds of prey have adapted specialized hunting techniques to find and catch their prey.

3. **Forests**: Forests are rich in biodiversity. This habitat serves as a haven for many species of plants and animals. The concept of a food web is crucial here, as forests host a complex network of organisms that rely on each other for food. Decomposition is another vital ecological process in forests. Dead plant and animal materials are broken down by decomposers like fungi and bacteria. This process recycles nutrients back into the soil, promoting healthy plant growth. Forests also exemplify the concept of ecological succession, as disturbances like wildfires can lead to a gradual change in the types of species present in the forest over time.

   Forest habitats are the epitome of biodiversity. The concept of species richness is evident here, as these habitats host an incredible variety of plants, animals, and micro-organisms.

   The intricate mutualistic relationships between various species are vital in tropical rainforests. For instance, many plants depend on specific animals for pollination and seed dispersal, while those animals rely on plants for food and shelter.

   The rainforest canopy and forest floor exemplify vertical zonation, where different layers of vegetation support various organisms, each adapted to its unique niche.

4. **Freshwater bodies**: Freshwater bodies such as lakes, rivers and ponds are characterized by their low salt concentration.

   The flow of water in these ecosystems influences the distribution of organisms and the movement of nutrients and organic matter. Riparian zones, the transitional areas between land and water, are vital components of freshwater ecosystems.

   a. *Food and shelter***:** These zones provide habitat, food and shelter for various species and their vegetation plays a crucial role in stabilizing stream banks and preventing erosion. Aquatic organisms rely on one another for various resources and services shaping complex webs of interactions. These interactions include the following:
   b. *Provision of oxygen and food:* For instance, algae and aquatic plants remove dissolved carbon dioxide and provide oxygen and food for other organisms through photosynthesis.

In turn, herbivorous species like certain fish and invertebrates graze on these primary producers.

c. *Predation and Decomposition:* Predators such as larger fish and birds feed on herbivores, regulating their populations. Decomposers like bacteria and fungi break down organic matter, recycling nutrients essential for plant growth.

d. *Symbiosis*: Additionally, symbiotic relationships occur such as between certain fish species and cleaning organisms that remove parasites. This interdependency ensures the flow of energy and nutrients, maintains biodiversity and supports the overall health of river ecosystems.

e. *Anthropogenic activities*: Eutrophication as a result of human activities can lead to harmful algal blooms and disrupt the balance of the aquatic community. Other human activities like pollution, habitat destruction and overfishing can disrupt these delicate balances, threatening the stability of river ecosystems and the services they provide.

5. **Arctic Tundra**: The Arctic tundra is a cold and treeless biome found in the high-latitude regions. The concept of permafrost is critical here, referring to permanently frozen ground. Permafrost influences the availability of water and the types of plants that can grow in this extreme environment. Climate change is a significant ecological concept impacting Arctic tundra habitats. Warming temperatures can lead to the melting of permafrost, affecting plant and animal communities and releasing stored carbon, potentially exacerbating global warming.

   The concept of seasonal migration is prevalent in the Arctic tundra, where many animals, like caribou and birds, undertake long-distance migrations to find food and suitable breeding grounds.

6. **Mangroves**: Mangroves are unique coastal ecosystems found in tropical and subtropical regions. The concept of adaptations to saline environments is crucial here, as mangroves have specialized root systems and mechanisms to cope with saltwater conditions. Mangroves provide important nursery habitats for numerous fish species and other marine organisms. The complex root systems offer protection and shelter, helping support diverse marine life. These ecosystems act as buffer zones against storms and tidal surges, reducing the impact of coastal erosion and protecting nearby communities and infrastructure.

7. **Coral Reefs**: Coral reefs are some of the most biodiverse ecosystems on Earth. The symbiotic relationship between corals and algae (zooxanthellae) is central to the survival of these habitats. The coral provides a safe home for the algae, and in return, the algae supply nutrients to the coral through photosynthesis. Competition also plays a significant role in coral reef ecosystems. Various species of fish, corals, and other organisms compete for limited resources, including food, space and light.

   Predator-prey dynamics are critical in coral reefs as well, keeping populations balanced and preventing any one species from becoming too dominant.

8. **Mountains**: Mountain ecosystems encompass a wide range of habitats and altitudinal zones. The concept of altitudinal zonation is prominent, as different elevations support distinct vegetation and wildlife, with adaptations to varying temperatures and oxygen levels. Mountains play a crucial role in maintaining water supply as they capture and store water, which gradually releases downstream, contributing to river flow and supporting downstream ecosystems and human communities.

9. **Glacial habitats**: Glacial environments are characterized by vast expanses of ice and snow, with extreme cold temperatures and minimal vegetation cover. Glacial retreat is an important ecological concept in mountainous regions affected by climate change. As glaciers melt and recede, they impact water availability, ecosystems, and human activities downstream. Despite the harsh conditions of extremely cold temperatures, glaciers support a variety of life forms, including microorganisms, algae, invertebrates, and occasionally larger animals like birds and

mammals. Glacial habitats also include features such as glacial lakes, ice caves, and icefalls, which contribute to the overall biodiversity of these ecosystems.

10. **Wetlands**: Wetlands are valuable ecosystems that bridge the gap between terrestrial and aquatic habitats. The concept of hydrology is essential here, as wetlands are characterized by their unique water flow and hydrological patterns, which influence the types of plants and animals that can thrive in these areas. Wetlands also demonstrate the concept of biogeochemical cycling, where various elements, such as carbon, nitrogen, and phosphorus, are cycled through the ecosystem. Wetlands act as natural filters, purifying water and removing excess nutrients, helping to maintain water quality. The migration of various bird species is a notable ecological concept within wetlands. Many wetlands serve as crucial stopover sites for migratory birds during their long-distance journeys, providing essential rest and feeding areas.

Learning Task

1. Identify some ecological concepts in the following habitats:
   - **a)** Grasslands
   - **b)** Forests
   - **c)** Freshwater bodies
   - **d)** Mangroves
   - **e)** Coral Reefs
   - **f)** Mountains
   - **g)** Wetlands
   - **h)** Arctic Tundra
   - **i)** Glacial habitats
   - **j)** Deserts

Pedagogical Exemplars

The teacher should consider the activities below;

Observational and experiential-based learning: In mixed ability, gender-responsive groups and learners under the guide of the teacher, undertake a nature walk on the school compound to observe the activities of living things within the community (insects serving as agents of pollination, fungi and bacteria causing decomposition, and trees providing shade for animals). Learners develop critical competencies such as teamwork, being very observant and improving their communication skills by working in groups and sharing ideas. Teacher should give support to learners with special learning needs and a fear of wildlife.

Communication and collaboration: Learners discuss in their groups how living things are supported by the non-living components of an ecosystem and depend on one another for their survival. Learners also develop global citizenship by comparing the interaction of biotic and abiotic components learned in their ecosystems and other ecosystems in other parts of the world.

Key Assessment- DoK Levels

Level 1: List some ecological interactions found in a named habitat.

Accept at least four ecological interactions

Level 3: Discuss the interactions of biotic and abiotic factors within an ecosystem.

Accept at least four named interactions of biotic and abiotic factors in a named habitat.

Level 4: Study the vegetative map of Ghana and discuss the ecological factors that account for the observed distribution.

Accept reasons for three observed vegetative distributions.

Week 10

Learning Indicators:

1. *Analyse the interdependency of living organisms in their named habitats.*
2. *Explain the outcome of the interdependency of living organisms in their environment.*

Theme or Focal Area 1: Interdependency of Living Organisms in Various Ecological Habitats

The interdependency of living organisms refers to the reliance of different species on each other for survival and well-being within an ecosystem. This interdependence is a fundamental aspect of ecological relationships and plays a crucial role in shaping the structure and functioning of ecosystems. It is a central feature of ecosystems and shapes the life patterns and population dynamics within them.

Below are some examples observed in different habitats.

1. **Forests:** The forests exhibit a high degree of interdependency due to their extraordinary biodiversity. Plants, animals and decomposers in these ecosystems are intricately linked through various ecological relationships such as:
   a. **Primary productivity and shelter**: In forest ecosystems, trees play a foundational role. They provide habitats, oxygen and food for a wide variety of organisms. Many bird and insect species rely on specific tree species for nesting sites or food sources.
   b. **Provision of carbon dioxide and pollination**: The animals, in turn, provide the trees with the carbon dioxide necessary for photosynthesis. Many flowering plant species in forests rely on specific pollinators for successful reproduction. For example, certain orchid species depend on specific insect species for pollination.
   c. **Dispersal:** Some animals, like frugivorous (fruit-eating) birds and mammals, are important seed dispersers for many plant species. They eat fruits and then disperse the seeds through their droppings, aiding in the dispersal and regeneration of plants across the rainforest.
   d. **Competition for light:** Forest trees and climbers engage in fierce competition for light. Trees dominate the upper canopy, shading out competitors below. Climbers, equipped with strategies like rapid growth and flexible stems, exploit gaps to reach sunlight in the crowded forest's middle store. Undergrowth species, adapted to low light conditions, thrive beneath the canopy. This competition drives vertical stratification, shaping the forest's diverse structure and species composition.
   e. **Decomposition:** Decomposers, such as fungi and bacteria, play a vital role in breaking down dead organic material, converting it back into nutrients that plants can use, which shows the dependency of plants on these organisms. The cycle of life and death in rainforests is highly dependent on these decomposers.
   f. **Predation:** Predators and their prey are interdependent, as predators control the population of prey species, preventing overgrazing or overpopulation, which could negatively impact the ecosystem.
   g. **Symbiosis:** The forest harbours diverse symbiotic relationships crucial for ecosystem balance. Mycorrhizal fungi form mutualistic associations with tree roots, aiding in nutrient uptake and water absorption. Nitrogen-fixing bacteria in the root nodules of certain plants provide essential nutrients, benefiting both parties. Additionally, epiphytes, such as mosses, ferns, and orchids, establish symbiotic relationships with trees, using them as support structures while obtaining moisture and nutrients from the air and debris. Parasitic interactions also occur; for instance, mistletoe extracts nutrients from host trees.

2. **Wetlands:** Wetlands are home to specialized plant species like cattails and reeds, which can tolerate water-saturated soils.
    a. **Nutrition and shelter:** These plants provide food and habitat for various animal species, such as insects, birds and mammals.

       Many bird species are dependent on wetlands for breeding and as stopover sites during migration. Some fish and amphibians also rely on the temporary pools created in wetlands for spawning.
    b. **Decomposition:** Wetlands also host numerous decomposer organisms, which breaks down dead plant material and recycle nutrients through the ecosystem. These nutrients support the growth of algae and other primary producers, which form the base of the food web in these systems.

    In each of these habitats, the various species depend on each other and the specific conditions of their environment. Changes or disruptions to any part of these ecosystems, whether due to human activity or natural events, can have significant impacts due to this interdependency.

3. **Grasslands**
    a. **Grazing:** In grassland ecosystems, the relationship between herbivores and grasses is a classic example of interdependency. Herbivores, such as zebras and bison, depend on grasses as their primary food source. The grazing activities of these herbivores help maintain the health and biodiversity of grassland habitats by preventing any single plant species from dominating the landscape.
    b. **Predation**: Grasslands are also home to many predators, such as lions and wolves, which are dependent on herbivores for their survival. The presence of predators helps regulate herbivore populations, ensuring that their grazing activities do not over-consume the vegetation.
    c. **Symbiosis:** Additionally, grassland ecosystems are also interconnected with the soil micro-organisms, such as mycorrhizal fungi, which form symbiotic relationships with plant roots. These fungi help plants absorb nutrients, particularly phosphorus, from the soil, making them crucial for the growth and health of grasses.

4. **Arctic Tundra:** In the harsh environment of the Arctic tundra, interdependency is evident in the relationships between species and their adaptation to extreme conditions.
    a. **Symbiosis:** Arctic plants, like Arctic willow and mosses, grow low to the ground, forming a dense carpet to protect against the cold temperatures and harsh winds. These plants provide food for herbivores like lemmings and caribou.
    b. **Predation:** The Arctic fox is a predator in this ecosystem, relying on small mammals like lemmings for sustenance.
    c. **Migration:** The tundra also hosts numerous migratory bird species that rely on the region's abundant insect population for food during their breeding seasons.
    5. **Coral Reefs:** Coral reefs are one of the most biodiverse habitats on the planet. Here, the interdependency of organisms is highly complex.

    a. Symbiosis: Corals and algae (zooxanthellae) have a symbiotic relationship. The corals provide the algae with a protected environment and the algae provide energy-rich foods in return.

6. **River:** Aquatic organisms rely on one another for various resources and services, shaping complex webs of interactions.
    a. **Provision of oxygen and food:** For instance, algae and aquatic plants provide oxygen and food for other organisms through photosynthesis. In turn, herbivorous species like certain fish and invertebrates graze on these primary producers.
    b. **Predation and decomposition:** Predators such as larger fish and birds feed on herbivores, regulating their populations. Decomposers like bacteria and fungi break down organic matter, recycling nutrients essential for plant growth.

c. **Symbiosis:** Additionally, symbiotic relationships occur such as between certain fish species and cleaning organisms that remove parasites. This interdependency ensures the flow of energy and nutrients, maintains biodiversity and supports the overall health of river ecosystems.

d. Anthropogenic activities: Human activities like pollution, habitat destruction and overfishing can disrupt these delicate balances, threatening the stability of river ecosystems and the services they provide.

Learning Task

1. Describe the interdependency of living things in a named habitat.
2. List the forms of the interdependency of living things in a named habitat.

Pedagogical Exemplars

The teacher should consider the activities below;

Observational and experiential-based learning: In mixed ability, gender-responsive groups, learners, under the guide of the teacher undertake a nature walk on the school compound to identify some of the interdependency of living things within the community such as pollination, predation, decomposition, provision of food and oxygen through photosynthesis, parasitism other symbiotic associations, recycling of nutrients by decomposers and several feeding relationships.

Learners develop critical competencies such as teamwork, being very observant and improving their communication skills by working in groups and sharing ideas. Teacher should give support to learners with special learning needs and a fear of wildlife.

Communication and collaboration: In mixed ability, gender-responsive groups, learners, identify and discuss some of the interdependency of living things in the school's ecosystem as they undertake the nature walk on the school compound.

Key Assessment- DoK Levels

Level 1: Name a given habitat and make a list of five living things and five non-living things that interact together and are interdependent on one another.

Accept the name of the habitat and at least give three living and three non-living things with their interactions.

Level 3: Predict at least three possible consequences of each of the following human activities on ecological systems.

a. Illegal mining

b. Bush fires

c. Disposal of sewage into water bodies.

Accept any two correctly predicted possible consequences in each case.

Level 3: Construct a food chain and a food web and use each to demonstrate how living things in an ecosystem depend on one another for their survival.

Accept any correctly constructed food chain and food web.

Level 4: Mr Manu observed that his maize yield decreased yearly over a four-year farming period. He was advised to apply organic manure and carry out irrigation, after which he had a good harvest.

Describe the kind of interactions that occurred between the living and non-living things that allowed a change in the soil components and made way for a good harvest.

Accept any three correctly described interactions in the soil that made way for the good harvest.

Theme or Focal Area 2: Discuss the Outcome of the Interdependency of Living Things in Their Environment

The outcome of the interdependency of living organisms in their environment is the complex web of life that sustains Earth's ecosystems, providing habitats for diverse species and essential services for both nature and humanity. It is a delicate balance that sustains the functioning of ecosystems and ultimately supports life on Earth. Recognizing and respecting these interdependencies is fundamental for the conservation and sustainable management of ecosystems.

Some key outcomes include the following:

1. **Ecological Balance:** Interdependency helps maintain ecological balance by regulating population sizes and preventing any one species from dominating an ecosystem. For example, predators keep prey populations in check, preventing them from overgrazing or over-reproducing, which could disrupt the balance of the ecosystem.
2. **Biodiversity:** Interdependency promotes biodiversity, as different species rely on each other for survival. This diversity enhances ecosystem resilience and stability, making it more adaptable to environmental changes.
3. **Nutrient Cycling:** Living organisms are interconnected through food webs and nutrient cycles. Decomposers break down dead organic matter, releasing nutrients back into the environment for other organisms to use. This cycling of nutrients is essential for the productivity of ecosystems.
4. **Ecosystem Services:** Interdependency supports the provision of ecosystem services essential for human well-being, such as pollination, water purification and soil formation. These services are often the result of complex interactions between multiple species within an ecosystem.
5. **Adaptation and Evolution:** The interdependency of organisms drives natural selection and adaptation over time. Species evolve traits and behaviours that allow them to better exploit resources or avoid predation, leading to a continuous coevolutionary process.
6. **Resilience:** Ecosystems with higher levels of interdependency tend to be more resilient to disturbances. When one species is affected by a disturbance, the effects can ripple through the ecosystem, but the interconnectedness often allows for recovery and stability over time.
7. **Human Impact:** Understanding the interdependency of living organisms is crucial for managing human impacts on ecosystems. Human activities such as habitat destruction, pollution, and climate change can disrupt these interdependencies, leading to ecosystem degradation and loss of biodiversity.

Learning Task

1. List the outcome of the interdependency of living things in an ecosystem.
2. Describe briefly the outcome of the interdependency of living things in an ecosystem.
3. Explain how negative human activities disrupt the stability of a named ecosystem.

Pedagogical Exemplars

The teacher should consider the activities below;

Observational and experiential-based learning: In mixed ability, gender-responsive groups, learners, under the guide of the teacher undertake a nature walk on the school compound to identify the results of the interdependency of living things within the community such as the formation of fruits, maintenance of ecological balance, recycling of nutrients by decomposers and biodiversity.

Learners develop critical competencies such as teamwork, being very observant and improving their communication skills by working in groups and sharing ideas. Teacher should give support to learners with special learning needs and a fear of wildlife.

Communication and collaboration: In mixed ability, gender-responsive groups and learners identify and discuss some of the outcomes of the interdependency of living things in the school's ecosystem as they undertake the nature walk on the school compound.

Key Assessment- DoK

Levels

Level 1: List five outcomes of the interdependency of living things in their environment.

Accept any three correctly listed outcomes of interdependency.

Level 2: Explain briefly the following:

a. Ecological balance
b. Nutrient cycling
c. Ecosystem service

Accept any two correctly explained outcomes of the interdependency of living things in their environment.

Assessment level 4: Discuss how three forms of human activities such as habitat destruction, pollution and overexploitation disrupt the delicate balance of ecosystems.

Accept any two forms of human activities that disrupt the balance of an ecosystem discussed correctly.

Week 11

Learning Indicator: *Ecological tools and sampling techniques for estimating population size and density.*

Theme or Focal Area 1: Identifying the Various Ecological Tools and How They are Used to Estimate Population Size and Density.

Ecological tools are instruments or methods used by ecologists and environmental scientists to study, monitor, manage, and conserve ecosystems and biodiversity. These tools help researchers gather data, analyse patterns, and make informed decisions regarding ecological management and conservation efforts. Some common ecological tools and their uses include the following:

1. **Quadrat:** A quadrat is a square or rectangular frame used to sample vegetation and study plant and animal populations. It helps to estimate abundance, density, and species composition in a specific area.
2. **Transect:** A transect is a straight line or path used to study changes in ecological parameters across a piece of land. Transects are used to gather data on vegetation, animal populations, or environmental factors like temperature and moisture.
3. **A pitfall trap:** It is a simple trap used to capture small ground-dwelling animals, such as insects, spiders, and other invertebrates. It consists of a container buried in the ground with its rim at ground level, and a cover is often placed over the top to prevent rainwater filling it up.
4. **Pooter:** A pooter, also known as a suction sampler, is a small device used to collect very small invertebrates without harming them. It consists of two tubes—one is used to gently suck air, and the other tube collects the insect into a container.
5. **Secchi disk:** This is a simple device used to measure water transparency or turbidity in bodies of water, particularly rivers, lakes or oceans. It consists of a circular disk, typically with four white and black alternating quadrants, attached to a rope or pole. The disk is lowered into the water until it disappears from view, and the depth at which it vanishes is recorded. This measurement indicates water clarity and can be used to monitor changes in water quality or assess the effects of pollution.
6. **Sweep net:** A sweep net is a tool used to collect small organisms from vegetation or water in ecological surveys. It consists of a mesh net attached to a handle, which is swept through vegetation or water to capture insects and other arthropods. Sweep nets are commonly used in studies of insect biodiversity, population dynamics, and pest management.
7. **Butterfly net:** A butterfly net, as the name suggests, is a specialized net used to catch butterflies and other flying insects. It typically consists of a long handle attached to a large, conical-shaped net with a fine mesh. Butterfly nets are used by researchers, collectors, and enthusiasts to capture butterflies for scientific study, identification, and conservation purposes. They are often used in field surveys to assess butterfly populations, monitor species diversity, and study butterfly behaviour and ecology.
8. **GPS (Global Positioning System):** GPS is used to precisely locate sampling sites, track animal movements, map habitat types and monitor changes in land cover and land use patterns.
9. **Water Quality Testing Kits:** Water quality testing kits are used to measure parameters such as pH, dissolved oxygen, turbidity, nutrient levels, and pollutants in aquatic ecosystems to assess water quality and identify sources of pollution.

10. **Camera Traps:** Camera traps are motion-activated cameras used to monitor wildlife populations, study animal behaviour, estimate population densities, and assess the effectiveness of conservation measures.

Lincoln Index: The Lincoln Index is a method used in ecology to estimate the population size of a species, particularly when individuals are difficult to observe directly. It's named after Frederick Charles Lincoln, an American biologist who developed the method in the early 1930s. It is based on the capture-mark-recapture technique. The process involves capturing and marking or tagging a sample of the population (e.g., with a unique identifier), releasing them back into the environment, and allowing enough time for complete mixing of individuals. After, the complete mixing of individuals in the population, another sample of individuals is captured from the same population. This second sample includes both marked (previously captured) and unmarked individuals.

Calculation: The Lincoln Index uses the proportion of marked individuals recaptured in the second sample to estimate the total population size.

The formula is given as: $N = (M \times C)/R$

N =the estimated population size.

M = the number of individuals initially marked and released.

C =the total number of individuals captured in the second sample.

R =the number of marked individuals recaptured in the second sample.

Assumptions: The Lincoln Index assumes that the marking does not significantly affect the behaviour or survival of the marked individuals, that the population is closed (no births, deaths, or migration during the study period), and that individuals have an equal probability of being captured on each occasion.

Learning Task

1. Identify and discuss the importance of at least five ecological tools used in the estimation of the population size of organisms in a habitat.
2. Describe how the named ecological tools can be used to estimate the population size of different plant and animal species.

Pedagogical Exemplars

Group learning: Watch a video or listen to a presentation on the estimation of population size and density of organisms in a habitat using the Lincoln Index and other tools. Submit a written report on the steps involved in the process.

Project-based learning: Select areas in the school compound or nearby community to estimate the population of various organisms using quadrats, pitfall traps, sweep nets and/or pooters.

The teacher should consider the following activities;

In a mixed ability, gender-sensitive and all-inclusive group employ talk for learning to help learners identify and discuss the importance of at least five ecological tools used in the estimation of population size in a named habitat.

Pair strategic partners (more confident learners) with less able learners to provide needed support with the task at hand. Give extra time for struggling students to finish the task and to enable advanced learners to think through the task at hand deeply.

Use a gamified program or an audiovisual aid (resource) and allow learners to watch /listen to a short video/audio on how to use a named ecological tool to estimate the population size of organisms in a named habitat using the Lincoln index.

Problem-based learning: Select areas in the school compound or nearby community to estimate the population of various organisms using a quadrant, pitfall trap, sweep net and pooter.

Allow learners to continue working in groups and present their findings through the following means;

a. Written piece
b. Drawing
c. Diagram
d. Presentation or
e. Multimedia.

NB: The teacher must ensure the selected area is safe for all students, and must be present throughout the fieldwork to supervise learners.

Provide special support for learners with special learning needs in terms of tools provided and advancements in learning space to accommodate physically challenged students.

Key Assessment-Dok

Level 1: What is the primary function of a quadrat in ecological studies?

Level 2: Describe a pitfall trap and what it is used for.

Level 2: Describe how the pooter is used in estimating the population of organisms.

Limit content expectation to the identification, description and estimation of population size by using a quadrat, pitfall trap and pooter respectively.

Assessment level 3: Describe how you will use a named ecological tool to estimate the population size and species diversity effectively.

Extend content expectation to the description of the sampling technique used in the estimation of population size.

Assessment level 3: After random sampling, 200 catfish are captured tagged and released. A week later,180 untagged and 20 tagged catfish were captured. Use the Lincoln index to estimate the total catfish population.

Accept oral/written responses for the procedure in using the Lincoln index to estimate the population size of catfish.

Week 12

Learning Indicator(s): *Distinguish between the direct counting, gut examination and radioactive/ tracer methods of determining the flow of energy in an ecosystem*

Theme or Focal Area 1: Explain Direct Counting, Gut Examination and Radioactive or Tracer Methods of Determining the Flow of Energy in an Ecosystem

Direct counting, gut examination, and radioactive/tracer methods are different techniques used to study and determine the flow of energy in an ecosystem. Each method has its relevance and provides valuable insights into the interactions between different organisms and the energy transfer within the ecosystem.

1. Direct coun**ting:** Direct counting involves the direct observation and counting of organisms within an ecosystem. This method is particularly useful for studying simple ecosystems or specific populations within a larger ecosystem. For example, researchers may count the number of individuals of different species in a specific area, such as counting the number of herbivores, carnivores, and producers in a grassland. By knowing the population sizes, scientists can estimate the flow of energy from one trophic level to another.

   Limitations: It's time-consuming, may not capture seasonal variations and might not be feasible for very small or elusive organisms.

2. **Gut examination:** Gut examination involves analysing the stomach contents of organisms to determine their diet and feeding habits. It is especially relevant for understanding the flow of energy in food chains and food webs. By examining the gut contents of predators or consumers, researchers can identify the prey or food items that contribute to their energy intake. This information helps in understanding the pathways of energy transfer between different trophic levels in the ecosystem.

   Limitations: It only reveals recent feeding activity and may not provide an accurate picture of the entire predator's diet. Additionally, some prey might be difficult to identify from partially digested remains.

3. **Radioactive/tracer methods:** Radioactive or tracer methods involve using isotopes or tagged substances to track the movement of energy through an ecosystem. In this technique, a specific isotope or tracer is introduced into the ecosystem, and its movement is monitored as it passes through different organisms or trophic levels. This method is highly precise and provides detailed information on energy transfer rates and pathways. It allows researchers to study complex interactions and the fate of energy within the ecosystem.

   Limitations: Requires specialised equipment and expertise to handle radioactive materials. Additionally, not all organisms readily take up the tracers.

   The best method depends on the specific ecosystem, research question, and resources available.
   a. Direct counting is often used for initial assessments or in simpler ecosystems.
   b. Gut examination works well for studying predator-prey interactions.
   c. Radioactive/tracer methods offer a more precise way to track energy flow through complex food webs.

   Ecologists often combine these methods for a more comprehensive understanding of energy flow in an ecosystem.

Learning Task

a) Identify at least two different techniques used to study and determine the flow of energy in an ecosystem. NB: Limit content expectation to identification of at least two techniques used to study and determine the flow of energy in an ecosystem. Guidance should be given to learners who may struggle with the identification of different techniques used to study and determine the flow of energy in an ecosystem.

b) Describe at least two different techniques used to study and determine the flow of energy in an ecosystem. Limit content expectation to description of two different techniques used to study and determine the flow of energy in an ecosystem.

c) Describe the three techniques used to the study and determine the flow of energy in an ecosystem and provide justification for your selection of one of the methods as the best technique. This task is an enrichment task for learners who show a high level of understanding of the concept. Extend content expectation to description of three techniques used to the study and determination of the flow of energy in an ecosystem and justification for selecting one of the methods as the best technique.

Pedagogical Exemplars

Teacher should consider the following activities;

Using shower thoughts: Learners identify at least two techniques used to study and determine the flow of energy in an ecosystem. Support should be given to learners who may struggle with the identification of different techniques used to study and determine the flow of energy in an ecosystem.

Orally, learners explain at least two different techniques used to study and determine the flow of energy in an ecosystem. Acknowledge learners' progress and provide support where applicable.

Using inquiry-based learning strategy: Ask learners in small mixed-ability groups to research or listen to presentations on the various methods of determining energy flow in an ecosystem.

Using radio reporter strategy: Ask learners to describe the three techniques used to the study and determine the flow of energy in an ecosystem and provide justification for selecting one of the methods as the best technique to be used.

Key Assessment- DoK Levels

Level 1: Identify three different techniques used to study and determine the flow of energy in an ecosystem.

Accept identification of at least two different techniques used to study and determine the flow of energy in an ecosystem

Level 3: Briefly describe each of the methods used in determining energy flow in a named ecological habitat. A response on at least two techniques used to study and determine the flow of energy should be accepted from learners.

Learning Indicator: *Explore the methods of determining pyramids of numbers, biomass and energy, and compare the efficiency of energy flow in them.*

Theme or Focal Area 1: Determination of Ecological Pyramids and Comparing the Efficiency of Energy Flow in Pyramids of Numbers, Biomass and Energy.

1. **Pyramid of Numbers:** This method represents the number of organisms at each trophic level in an ecosystem. It is the simplest method and involves counting the number of individuals at each trophic level and arranging them in a pyramid shape. In a typical pyramid of numbers, the number of individuals usually decreases with increasing trophic levels. This reflects the decreasing energy available as one moves up the food chain, due to energy losses through heat, waste materials and the fact that not all parts are consumed by organisms at higher trophic levels. Pyramids of numbers are not always true pyramids, because of the variation in size of the organisms involved. Compare an oak tree with aphids and the insects that eat aphids.
2. **Pyramid of Biomass:** The pyramid of biomass represents the total dry weight (usually) of the organisms at each trophic level. Biomass is a more accurate representation of energy available since it takes into account the actual total mass of living organisms, rather than the numbers of organisms. In a pyramid of biomass, the biomass always decreases at each trophic levels. This biomass pyramid provides a better indication of energy flow efficiency than the pyramid of numbers. Energy loss can be typically 90% or more from one level to the next.
3. **Pyramid of Energy:** The pyramid of energy represents the actual flow of energy through each trophic level in an ecosystem. It quantifies the amount of energy transferred from one trophic level to the next. The energy value is usually determined using the calorimetry method. This involves measuring the heat released or absorbed during chemical reactions, including the combustion of organic matter. By burning samples of biomass collected from different trophic levels and measuring the heat produced. By this, one can estimate the energy content of the biomass. This type of pyramid is always a proper upright pyramid. The pyramid of energy offers the most accurate representation of energy flow through an ecosystem, but is the most difficult to measure.

Learning Task

1. What does the pyramid of numbers represent in an ecosystem? Limit content expectation to the definition of the pyramid of numbers.
2. Define biomass and explain its significance in ecological studies. Extend content expectation to the definition of biomass and its importance in ecological studies.
3. Describe the direction of energy flow in a pyramid of energy. Extend content expectation to the discussion on the direction of energy flow in the pyramid of energy.

Pedagogical Exemplars

Group-based Learning: Watch a video or a presentation on the methods of determining the various ecological pyramids. Using field observations, allow students to observe and count different organisms at different locations of the school compound to construct their own pyramid of numbers, biomass, and energy.

Key Assessment-DoK

Level 1: What does the pyramid of numbers represent in an ecosystem? Accept the correct definition for the pyramid of numbers.

Level 1: Define biomass and explain its significance in ecological studies. Accept the definition of biomass and explanations of the importance of biomass.

Level 2: Discuss the potential reasons for an inverted pyramid of numbers in an aquatic ecosystem.

Level 2: Explain why the pyramid of energy is always upright and what factors contribute to the inefficiency of energy transfer between trophic levels.

Level 3: How will human activities, such as deforestation or overfishing, affect the shape and stability of a named ecological pyramid in an ecosystem?

Section 5: Review

In this section, learners have covered fundamental aspects of ecology, including defining key terms such as ecology, ecosystem, habitat and factors like biotic and abiotic elements. They also identified and studied a variety of ecological habitats. Weeks nine through to twelve saw a progression from understanding interdependency in habitats to studying ecological tools for population estimation and methods for determining energy flow within ecosystems. Discussions in week twelve focused on the relevance of different energy flow determination methods, and energy flow. These lessons equip learners to understand ecological concepts as they apply to different habitats. Such skills are vital for advising ecologists and contributing to environmental management, particularly in Ghana. Moreover, the acquired knowledge and skills prepare learners for further studies and eventual integration into the workforce, enhancing their capability to analyse and contribute to ecological research and environmental conservation efforts.

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