



MINISTRY OF EDUCATION

BIOLOGY

For Senior High Schools

TEACHER MANUAL



YEAR THREE



**NATIONAL COUNCIL FOR
CURRICULUM & ASSESSMENT
OF MINISTRY OF EDUCATION**

MINISTRY OF EDUCATION



REPUBLIC OF GHANA

BIOLOGY

For Senior High Schools

Teacher Manual

Year Three



NATIONAL COUNCIL FOR
CURRICULUM & ASSESSMENT
OF MINISTRY OF EDUCATION

BIOLOGY TEACHER MANUAL

Enquiries and comments on this manual should be addressed to:

The Director-General

National Council for Curriculum and Assessment (NaCCA)

Ministry of Education

P.O. Box CT PMB 77

Cantonments Accra

Telephone: 0302909071, 0302909862

Email: info@nacca.gov.gh

website: www.nacca.gov.gh



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Introduction for the Year Three Teacher Manual

The National Council for Curriculum and Assessment (NaCCA) has developed the third and final set of curriculum materials to support the implementation of the new Senior High School curriculum.

This Year Three Teacher Manual covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively support learners in their final year of Senior High School. All the necessary information for the Student Assessment Portal has been included in the Year Three Teacher Manual to simplify the development of weekly learning plans, meaning that teachers have a single reference document.

The Year Three Teacher Manual has two main objectives:

- To support learners to consolidate and deepen their understanding of the content, pedagogy, and assessment across all three years of the new Senior High School curriculum in preparation for the West Africa Senior Secondary Certificate Examination (WASSCE).
- To equip teachers with the tools and resources needed to deliver revision-focused, assessment-led lessons that build on the knowledge learners have acquired from Year One to Year Three.

In this third year, teachers will be supporting learners to prepare for the WASSCE. Each section of the Teacher Manual is therefore structured around the highest Depth of Knowledge (DoK) levels, allowing learners to build progressively on knowledge acquired from Year One to Year Three. For each week, learning tasks and pedagogy are built around the assessment, ensuring that classroom activities directly prepare learners for the demands of the examination. Two sets of sample examination papers are also provided; one administered by Week 12 as a first semester practice examination, and one by Week 20 as a mock examination, to gauge learners' competencies and identify areas requiring remediation.

To further support teachers in delivering Year Three, NaCCA, working with the Ghana Education Service, has developed a subject specific App for each subject.

The Year Three PLC sessions have been revised in response to findings from the 2025 annual evaluation survey. The survey confirmed that teachers have made strong progress in lesson planning, use of varied instructional methods, ICT integration and modes of assessment. To address the identified gap in explaining concepts clearly using examples familiar to learners, each PLC session now includes a dedicated Content Exploration segment. This ten-minute segment brings the subject group together to work through one challenging problem or concept from the week's Teacher Manual content, not to plan how to teach it, but to ensure that every teacher in the group fully understands it.

The PLC sessions in Year Three also place particular emphasis on connecting the week's content to equivalent topics taught in Years One and Two. Teachers are encouraged to note the recap weeks signposted throughout the Teacher Manual and to use the App to explore how content across all three years links together.

As in previous years, teachers are expected to integrate National Values, Gender Equality and Social Inclusion (GESI), Social and Emotional Learning (SEL), and 21st-century skills into their learning activities, assessment tasks, and rubrics and mark schemes. The subject-specific App will support teachers in doing this throughout the year.

Ghana Education Service acknowledges the dedication of the teachers who have implemented the new curriculum across Years One and Two and recognises that Year Three represents both the culmination of that effort and a critical moment for learners. The Year Three Teacher Manual and its accompanying resources have been developed to ensure that every learner, regardless of background, ability, or school context, is fully prepared to demonstrate what they know and can do in the WASSCE and to progress confidently to further studies, the world of work, and adult life.

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The writing team was made up of the following members:

National Council for Curriculum and Assessment (NaCCA)	
Name of Staff	Designation
Reginald Quartey	Ag. Director, Curriculum Development Directorate
Anita Cordei Collison	Ag. Director, Standards, Assessment and Quality Assurance Directorate
Dr. Mercy Nyamekye	Ag. Director, Research, Planning, Monitoring, and Evaluation
Joana Adua Vanderpuije	Ag. Director, Instructional Resources Directorate
Rebecca Abu Gariba	Ag. Director, Corporate Affairs
Nii Boye Tagoe	Senior Curriculum Development Officer
Juliet Owusu-Ansah	Principal Curriculum Development Officer
Samuel Owusu Ansah	Principal Curriculum Development Officer
Godwin Mawunyo Kofi Senanu	Assistant Curriculum Development Officer
Stephen Acquah	Principal Curriculum Development Officer
Thomas Kumah Osei	Principal Curriculum Development Officer
Ayuuba Sullivan	Principal Curriculum Development Officer
Dr.Jephtar Adu-Mensah	Principal Standards, Assessment and Quality Assurance Officer (SAQA)
Richard Teye	Principal Standards, Assessment and Quality Assurance Officer (SAQA)
Nancy Asieduwaa Gyapong	Assistant Standards, Assessment and Quality Assurance Officer (SAQA)
Bridget Aku Anku	Principal, Standards, Assessment and Quality Assurance Officer (SAQA)
Francis Agbalenyo	Principal Research, Planning, Monitoring and Evaluation Officer
Joseph Barwuah	Senior Instructional Resource Officer
Samuel Amankwa Ogyampo	Senior Corporate Affairs Officer
Seth Nii Nartey	Corporate Affairs Officer

S/N	Name	Name of Institution	Subject
1	Bernard Adobaw	West African Examinations Council	Accounting
2	Emmanuel Kodwo Arthur	Instittue of Chartered Accountants, Ghana	
3	Benedicta Ama Yekua Etuaful	Ogyeedom SHTS	Additional Mathematics
4	Innocent Nunana Duncan	KNUST SHS	
5	Benedicta Carbilba Foli	Pope Johns SHS & Minor Seminary, Koforidua	Agricultural Science
6	David Esela Zigah	Achimota School	
7	Prof. Jakpasu Victor Kofi Afun	Kwame Nkrumah University of Science and Technology	
8	Eric Morgan Asante	St. Peter's Boys SHS	Agriculture
9	Prof. Frederick Adzitey	University for Development Studies, Tamale	
10	Akuffo Twumhene Frederick	Koforidua SHTS	Applied Technology
11	Emmanuel Korletey	Benso SHTS	
12	Firmin Anewuoh	Presbyterian College of Education, Akropong	
13	Isaac Buckman	Armed Forces SHTS	
14	Kunkyuuri Philip	Kumasi Senior High Technical School	
15	Lavoe Daniel Kwaku	Sokode SHTS	
16	Philip Turkson	St Joseph's SHTS, Bekwai	
17	Dr. Sherry Kwabla Amedorme	Univ. of Skills Training and Entrepreneurial Development	
18	Walter Banuenumah	Univ. of Skills Training and Entrepreneurial Development	
19	Wisdom Dzidzienyo Adzraku	Univ. of Skills Training and Entrepreneurial Development	
20	Abass Umar Mohammed	University of Ghana, Legon	Arabic
21	Mohammed Mahey Ibrahim	Tijjaniya Senior High School, Kumasi	
22	Dr. Ebenezer Acquah	University of Education, Winneba	Art and Design Studio and Foundation
23	Dr. Mantey Jectey-Nyarko	Kwame Nkrumah University of Science and Technology	
24	Kwame Opoku-Bonsu	Kwame Nkrumah University of Science and Technology	
25	Seyram kojo Adipah	GES- Ga East	

26	David Kofi Oppong	Kwame Nkrumah University of Science and Technology	Aviation and Aerospace
27	Obed Frimpong	Zipline International	
28	Jo Ann Naa Dei Neequaye	Nyakrom SHTS	Biology
29	Paul Beeton Damoah	Prempeh College, Kumasi	
30	Dr. Daniel Akwei Addo	Kwame Nkrumah University of Science and Technology	Biomedical Science
31	Dr. Mrs. Dorothy Araba Yakoba Agyapong	Kwame Nkrumah University of Science and Technology	
32	Avole Baba Ansbert	Bolga SHS	Business Management
33	Emmanuel Caesar Ayamba	Bolgatanga Technical University	
34	Faustina Graham	GES HQ	
35	Bismark Kwame Tunu	Opoku Ware School, Kumasi	Chemistry
36	Patrick Nsobila Awumbire	Bolgatanga S.H.S.	
37	Francis Normanyo	Mt Mary College of Education	Christian Religious Studies & Islamic Religious Studies
38	Francis Opoku	Valley View University	
39	Haruna Zagoon-Sayeed	University of Ghana	
40	Kabiru Soumana	GES HQ	
41	Richardson Addai-Mununkum	University of Education, Winneba	
42	Seth Tweneboah	University of Education, Winneba	Clothing and Textiles
43	Jusinta Kwakyewaa (Rev.Sr.)	St Francis SHTS, Akim Oda	
44	Rahimatu Yakubu	Potsin T.I Ahmadiyya SHS	Computing and ICT
45	Dordoe Raphael Senyo	Ziavi SHTS	
46	Gaddafi Abdul-salaam	Kwame Nkrumah University of Science and Technology	
47	Kwasi Abankwa Anokye	Ghana Education Service	Design and Communication Technology
48	Gabriel Boafo	Kwabeng Anglican Senior High Technical School	
49	Mensah Henry Angmor	Anglican Senior High School, Kumasi	
50	Phyllis Mensah	University of Skills Training and Entrepreneurial Development (	Economics
51	Charlotte Kpogli	Ho Technical University	
52	Salitsi Freeman Etoram	Anlo SHS, Anloga	Engineering
53	Daniel Kwesi Agbogbo	Kwabeng Anglican Senior High Tech School	
54	Dr Valentina Osei-Himah	Atebubu College of Education	

55	Benjamin Orrison Akrono	Islamic Girls' SHS	English Language
56	Esther Okaitsoe Armah	Mangoase SHS	
57	Kukua Andoh Robertson	Breman Asikuma SHS	
58	Perfect Quarshie	Mawuko Girls SHS, Ho	
59	Ama Achiaa - Afriyie	St. Louis SHS, Kumasi	Food and Nutrition
60	Lily-Versta Nyarko	Mancell Girls SHTS, Kumasi	
61	Osmanu Ibrahim	Mount Mary College of Education, Somanya	French
62	Mawufemor Kwame Agorgli	Akim Asafo SHS	
63	Comfort Korkor Sam	University for Development Studies, Tamale	General Science
64	Robert Arhin	S.D.A SHS, Akim Sekyere	
65	Ishmael Yaw Dadson	University of Education, Winneba	Geography
66	Prof Ebenezer Owusu - Sekyere	University for Development Studies, Tamale	
67	Raymond Nsiah-Asare	Methodist Girls' SHS, Mamfe	
68	Catherine Ekua Mensah	University of Cape Cape	Ghanaian Language
69	David Sarpei Nunoo	University of Education, Winneba	
70	Prof Kwasi Adomako	University of Education, Winneba	
71	Arko Blay Augustine	University of Education, Winneba	Government
72	Josephine Akosua Gbagbo	Ngleshie Amanfro SHS	
73	Anitha Oforiwah Adu-Boahen	University of Education, Winneba	History
74	Prince Essiaw	Enchi College of Education	
75	Blessington Dzah	Ziavi SHTS	Literature-in-English
76	Juliana Akomea	Mangoase SHS	
77	Dorcas Akosua Opoku	Winneba SHS	Management in Living
78	Grace Annagmeng Mwini	Tumu College of Education	
79	Eric Abban	Mt. Marys College of Education, Somanya	Mathematics
80	Isaac Buabeng	Mamprobi Sempe 2 JHS	
81	Benjamin Ofori	Cocoa Research Institute of Ghana Primary School	Music
82	Cosmas W. K. Mereku	University of Education, Winneba	
83	Davies Obiri Danso	New Juaben SHS	
84	Prof. Joshua Alfred Amuah	University of Ghana, Legon	

85	Evans Kofi Mati	GES HQ	
86	Wilson Klebi	GES HQ	
87	Professor Emmanuel Obed Acquah	University of Education, Winneba	
88	Chris Ampomah Mensah	Bolgatanga S.H.S	Performing Arts
89	Doreen Deedee Quarcoo	University of Education, Winneba	
90	Dr. Latipher Osei Appiah-Agyei	University of Education, Winneba	
91	Albert Sackey	KNUST SHS	Physical Education and Health (Core and Elective)
92	Ebenezer Ewiah-Quarm	Nkroful Agric SHS	
93	Evans Asare Yeboah	Adisadel College	
94	John Benedict Nyarko	Adisadel College	
95	Dr. Mary Aku Ogum	University of Cape Coast	
96	Dr. Linus Kweku Labik	KNUST	Physics
97	Sylvester Affram	Kwabeng Anglican SHTS	
98	Anthony Mensah	Abetifi Presbyterian College of Education	RME
99	Clement Nsorwineh Atigah	Tamale SHS	
100	Eliel Keelson	Kwame Nkrumah University of Science and Technology	Robotics
101	Isaac Nzoley	Wesley Girls High School	
102	Jemima Ayensu	Holy Child Girls SHS, Cape Coast	Social Studies
103	Mohammed Adam, Ph.D.	University of Education, Winneba	
104	Simon Tengan	Wa Senior High Technical School	
105	Franklina Kabio-Danlebo	University of Ghana	Spanish
106	Mishael Annoh-Achampong	University of Media, Art and Communication	
107	Augustina Gloria Henyo	West African Examinations Council	Inclusive Education
108	Dr. Gideon Kwesi Obosu	University of Cape Coast	
109	Dr. Daniel Fobi	University of Education, Winneba	
110	Dr. Martha-Pearl Okai	University of Cape Coast	
111	Francis Kweku Essel	Ashesi University	
112	Richard Doku	Mampong/Akw SHTS For The Deaf	
113	Yao Mati Abotsi	Ghana Blind Union	
114	Seth Kwame Ativor	Okuapemman SHS, Akropong	

115	Bernard Duorinaah	Presbyterian College of Education	
116	Evans Odei	Achimota Senior High School	

S/N	Subject	Name of Reviewer	Institution
1	Accounting	Ms. Ivy Eklemet	Univ. of Professional Studies, Accra
2	Additional Mathematics	Francis Tornyenor	Pope John SHS & Minor Seminary, Koforidua
3	Agricultural Science	Selina Acheampong	Univ. College of Agriculture and Environmental
4	Agriculture	Mr. Godwin B. K. Doli	Municipal Educ. Office, Amasaman
5	Arabic	Abdullah Musah Abdullah	Univ. of Media Arts & Communication, UniMAC
6	Art and Design Studio	Ernest Kwasi Elelakpodia	Hope College, Gomoa Fetteh
7	Art and Design Foundation	Ernest Kwasi Elelakpodia	Hope College, Gomoa Fetteh
8	Automotive & Metal Technology	Okyere Kojo Alex	Ada College of Education
9	Aviation & Aerospace Engineering	Dr. Augustine Akuoko Kwarteng	Univ. of Mines and Technology
10	Biology	Rev. Joseph Kweku Delanyo	formerly of Hope College, Gomoa Fetteh
11	Biomedical Science	Dr. Irene Adzo Agbo	Univ. of Professional Studies, Accra
12	Building Construction & Woodwork Technology	Mr. Alex A. Appah	Christ Calvary Prep. Sch.
13	Business Management	Mr. Emmanuel Boakye	Ghana Employers Association
14	Chemistry	Joyce Okreyewa Odei	Hope College, Gomoa Fetteh
15	Clothing and Textiles	Rosemary Quarcoo	Department of Clothing and Textiles, UEW
16	Design & Communication Technology	Esme Serwaa Boateng	Ghana National College, Cape Coast
17	Economics	Dr. Kofi Kamasa	Department of Management Studies, UMaT
18	Electrical & Electronics Technology	Dr. Emmanuel Ampoma Affum	Telecom Engineering Department, KNUST
19	Engineering	Dr. Albert Kotawoke Awopone	Univ. of Skills Training & Entrepreneurial Development

20	English Language	Prof. Philip Gborsong	University of Cape Coast
21	Food and Nutrition	Sylvia Baaba Yankey	
22	French	Gregory Nana Kobina Nketsia Mensah	Mfantsipim School, Cape Coast
23	General Science	Joyce Okreyewa Odei	Hope College, Gomoa Fetteh
24	Geography	Prof Kofi Adu Boahen	University of Education, Winneba
25	Ghanaian Languages	Prof. Regina Caesar	University of Education, Winneba
26	Government	Clement Adu Acheampong	Prempeh College SHS, Kumasi
27	History	Prof Wilson Yayoh	University of Cape Coast
28	Information Communication Technology	Felicia Archeresuah	Nkoronza Technical Institute
29	Manufacturing Engineering	Dr. Frank Kwabena Nyarko	Kwame Nkrumah Univ. of Science and Technology
30	Mathematics	Ezekiel Osei Bonsu	Bono East Regional Education Office, Nkoranza
31	Management in Living	Ms. Anna Holdbrooke	Swedru Senior High School
32	Music	Prof Mark-Millas Fish	University of Education, Winneba
33	Physical Education and Health Core	Francis Maxwell Ayamba	Atebubu College of Education
34	Physical Education and Health Elective	Sulemana Ahmed Tijani	Atebubu College of Education
35	Performing Arts	Dr. Godfred Asare Yeboah	University of Education, Winneba
36	Physics	Peter Bekoe	Our Lady of Mount Carmel Girls SHS, Techiman
37	Religious and Moral Education	Christian Kwarteng Mensah Oppong	Prempeh College, Kumasi
38	Robotics	Dr. Yaw Okraku-Yirenki	Kofi-Annan Centre of Excellence in ICT
39	Social Studies	Samuel Larbi	St Louis Girls SHS, Kumasi
40	Spanish	Prof. Jonson Asunka	University of Ghana Legon

SECTION 1: BIOLOGY AS A SCIENCE OF LIFE

STRAND: EXPLORING BIOLOGY IN SOCIETY

Sub-Strand: Biology and Entrepreneurship

Learning Outcome: *Apply the knowledge and skill in biotechnology to enhance the value of products that help improve human lives and the environment.*

Content Standard: *Demonstrate knowledge and skills of some basic concepts in biotechnology and their application to enhance the value of products that help improve human lives and the environment.*

INTRODUCTION AND SECTION SUMMARY

In Week 4 of Section 1, Sub-strand 2 (Biology and Entrepreneurship) of Strand 1 of the Teacher Manual Year 2, we discussed crop production. This was a continuation of our discussions on Sub-strand 2 of Strand 1, Teacher Manual Year 1, where in Week 4, we discussed fish farming, processing and conservation. In Year 3, we complete Sub-strand 2 of Strand 1 with lessons on biotechnology and its principles in biology and entrepreneurship within the Ghanaian context.

The intersection of Biology and entrepreneurship offers vast opportunities for innovation and development. This lesson equips students with knowledge and skills in biotechnology, enabling them to create local products and services that improve human lives and the environment. Ghana's rich agricultural sector provides a fertile ground for biotech applications, considering that agriculture is the bedrock of the nation's economy. This is particularly so as raw materials such as maize and cassava for local food preparation are in abundance. Biological principles in biotechnology are applied in other areas in local communities apart from food production. Examples include biofuel production, which creates sustainable energy sources. These local activities create jobs for the youth and elderly alike, while they open opportunities for research in academia and make way for larger or commercial scale productions at the industrial level. This then boosts market and sales and improves on the economic standards of the Ghanaian populace. The weeks and the indicators covered by the section are:

- **Week 1:** Describe the biological principles behind the preparation of some local foods and beverages
- **Week 2:** Describe the process of tissue culture and its application in food production.
- **Week 3:** Describe how genetic recombinant technology is applied in biotechnology for the production of GMOs
- **Week 4:** Describe the application of biological concepts in the treatment of water, extraction of minerals (e.g., gold) and production of bio-oils

Recap weeks

Year 1	Week 4: 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.
Year 2	Week 4: 1. Identify some basic concepts in Biology and how these can be used to improve crop production. 2. Explain some basic concepts in Biology and how these can be used to improve animal production. Week 5: Apply knowledge of the cell theory and structure to classify and describe the types of cells and relate their structures to their functions. Week 7: Describe the Watson–Crick Model of the DNA and state the significance of the model in a eukaryotic cell. Week 8: Examine the processes of DNA replication Week 10: Describe how proteins are formed in the cell and explain the importance of protein synthesis in living things.

SUMMARY OF PEDAGOGICAL EXEMPLARS

To effectively deliver the lessons on the sub-strand, Biology and Entrepreneurship, a blend of teaching pedagogies will be used. For example, group projects will encourage collaborative biotech-based product development, fostering teamwork and innovation. This approach allows students to share ideas, divide tasks, and work towards a common goal, mirroring real-world entrepreneurial environments. Individual learning will also be emphasized, with learners conducting research on biotech applications to develop critical thinking and problem-solving skills. Task-based learning will ensure learners designing and implementing sustainable business models, applying biotech concepts to real-world scenarios and developing practical solutions. Talk-for-learning will be used to enhance communication and pitching skills, essential for entrepreneurship, as learners present their projects.

The blend of pedagogies will ensure that each learner engages actively in every aspect of lessons taught. This will ensure the development of essential skills, and foster creativity, innovation, and problem-solving, and assist learners to gain hands-on experience in applying biotech concepts to enhance product value and improve human lives and the environment.

ASSESSMENT SUMMARY

Indicators	DOK Level	Assessment Strategy and/or Mode
Describe the biological principles behind the preparation of some local foods and beverages.	Level 2	Class exercise
Describe the process of tissue culture and its application in food production.	Level 4	Group presentation
Describe how genetic recombinant technology is applied in biotechnology for the production of GMOs	Level 4	Group presentation
Describe the application of biological concepts in the treatment of water, extraction of minerals (e.g., gold) and production of bio-oils	Level 3	Case study

WEEK 1

Learning Indicator: Describe the biological principles behind the preparation of some local foods and beverages

FOCAL AREA: BIOLOGICAL PRINCIPLES APPLIED IN THE PREPARATION OF SOME LOCAL FOODS AND BEVERAGES

Introduction to Food Biotechnology

Food biotechnology involves using biological processes, organisms, or systems to develop or make products for human consumption. Many traditional Ghanaian **foods and beverages** rely on biotechnological processes that have been refined over generations, long before the science was understood. Organisms such as microbes play essential roles in food processing. These roles include fermentation of carbohydrates, production of flavour, preservation through acid or alcohol production, modifying product textures and enhancing nutritional value.

Indigenous or traditional food preparation methods contain indigenous knowledge systems that were developed through observation and experimentation. These methods were passed down through generations to modern Ghanaian communities and are often aligned with modern scientific principles. These principles represent biotechnological innovations that are unique to specific cultures.

Principles and Applications of fermentation

Fermentation is a metabolic process that converts carbohydrates to acids, gases, or alcohol using microorganisms under anaerobic conditions. There are various forms of the process employed in food processing. These include **lactic acid fermentation**, which converts sugars to lactic acid (e.g., kenkey, banku), **alcoholic fermentation** for the conversion of sugars to ethanol and CO₂ (e.g., pito, palm wine), **acetic acid fermentation**, which converts alcohol to acetic acid (e.g., vinegar production), and **alkaline fermentation**, which produces alkaline conditions during food production (e.g., dawadawa).

The general pathways in the various fermentation processes are given below:

Lactic Acid Fermentation: $\text{Glucose} \rightarrow 2 \text{ Pyruvate} \rightarrow 2 \text{ Lactic Acid} + \text{Energy (2 ATP)}$

Alcoholic Fermentation: $\text{Glucose} \rightarrow 2 \text{ Pyruvate} \rightarrow 2 \text{ Ethanol} + 2 \text{ CO}_2 + \text{Energy (2 ATP)}$

Acetic Acid Fermentation: $\text{Ethanol} + \text{O}_2 \rightarrow \text{Acetic Acid} + \text{H}_2\text{O}$

Microorganisms in Fermentation

Common microorganisms in Ghanaian fermented foods include:

Bacteria: Examples are lactic acid bacteria (LAB) such as *Lactobacillus plantarum*, *Lactobacillus fermentum*, *Pediococcus*, acetic acid bacteria which include *Acetobacter*, *Gluconobacter*, *Bacillus* forms include *Bacillus subtilis* (in dawadawa)

Fungi: Yeasts species include *Saccharomyces cerevisiae* (in pito, palm wine), *Candida* species *Pichia* species. Moulds used include *Aspergillus* species and *Penicillium* species.

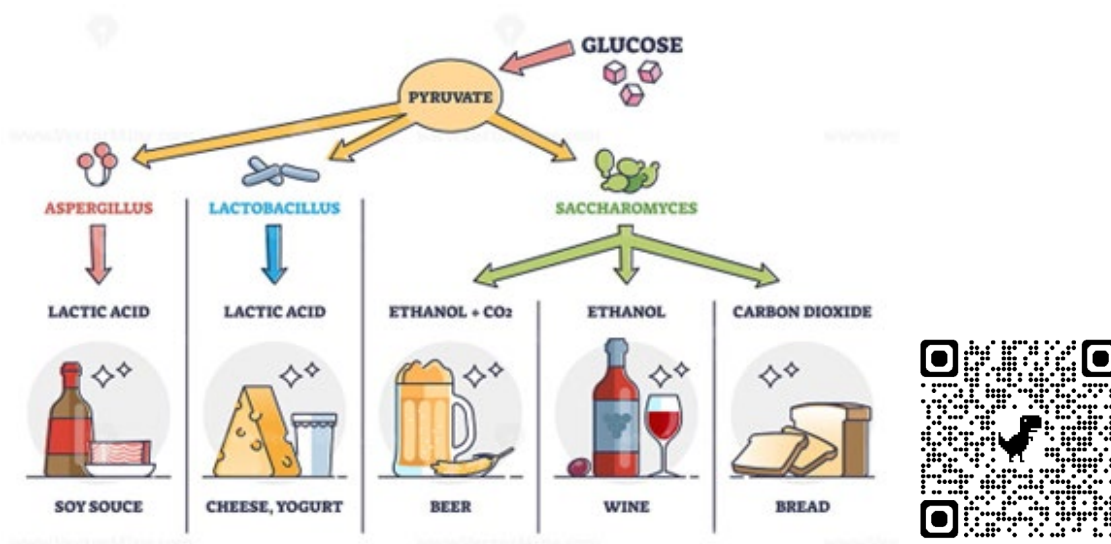


Figure 1.1: *Fermentation processes*

Factors Affecting Fermentation

1. Temperature
 - a. Affects microbial growth rates and enzyme activities.
 - b. Each microorganism has an optimal temperature range generally between 25-40°C for most fermentations.
 - c. Traditional processes rely mostly on normal environmental temperatures.
2. pH (Acidity or Alkalinity)
 - a. Influences which microorganisms are more involved in the process.
 - b. Most fermentations start near neutral pH (pH of 7.0)
 - c. Lactic acid fermentations become acidic (pH 3.5-4.5)
 - d. Alcoholic fermentations typically reach pH 4.0-5.0
3. Oxygen Availability
 - a. Aerobic vs. anaerobic conditions determine fermentation type
 - b. Lactic acid and alcoholic fermentations are anaerobic (does not require oxygen).
 - c. Acetic acid fermentation is aerobic (requires oxygen)
4. Substrate Composition
 - a. Nutrient availability affects microbial growth
 - b. Carbohydrate type influences fermentation products
 - c. Protein and mineral content affect flavour development
5. Nutrient Availability
 - a. Controls microbial growth
 - b. Used in many fermentations as a control measure

Microbial Succession in Fermentation

Most natural fermentations involve a sequence of different microorganisms:

1. **Initial Phase:** Fast-growing organisms that can tolerate the initial conditions (e.g. *Enterobacter* spp).
2. **Middle Phase:** Organisms that tolerate the changing conditions (e.g. *Lactobacillus* spp).
3. **Final Phase:** Organisms that contribute to final flavour and texture development (e.g. *S. cerevisiae*).

Common Examples of Fermented Indigenous/Local Foods

1. Production of Kenkey

This is a Ghanaian traditional staple meal made from fermented corn dough wrapped in plantain leaves or maize cob sheaths, and has a sour taste with a firm, doughy texture. It originated from the Fante and the Ga people of Ghana.

Raw Materials: Maize (corn) and water, with salt as optional ingredients.

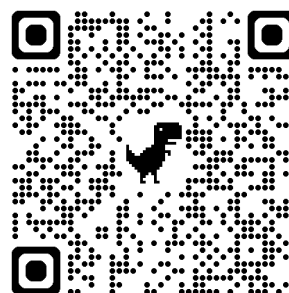


Figure 1.2: Moulding of Ga kenkey

Steps for preparation

- a. The maize is steeped/soaked in water for about two to three days.
- b. It is milled into a dough
- c. It is spontaneously allowed to ferment between 1-3 days
- d. A portion of the fermented dough is cooked and mixed with uncooked fermented portion.
- e. The mixture is then rolled into balls, wrapped in corn husk and boiled. It is often eaten with hot pepper and fish.

Biological principles involved include fermentation by lactic acid bacteria to produce lactic acid, thereby lowering pH. The main microbes involved in the flavour and texture are bacteria such as *Enterobacteriaceae*, *Lactobacillus* species, and yeast like *Saccharomyces* and *Candida*. Biochemical changes that occur during the preparation include starch hydrolysing by amylase, protein degradation by proteases, production of organic acids (mainly lactic acid), pH reduction from 6.5 to 3.8, development of characteristic sour flavour.

Nutritional Values

Kenkey is rich in carbohydrates, fibres, vitamins (especially vitamin B) and minerals such as magnesium, iron and potassium required for growth and metabolic processes in the body.

2. Production of yoghurt

This is a dairy product is made by adding bacterial cultures to milk, thereby fermenting lactose to produce lactic acid, and forming a thick, creamy texture with a tangy flavour.

Raw Materials: Milk (whole, low-fat, or non-fat), starter culture (mixture of microbes) and incubation tools. Optional ingredients may include sugars or sweeteners, flavours (e.g., fruit flavours, vanillas, etc.) and probiotic cultures (beneficial bacteria).

Steps Involved in the Preparation of Yoghurt

- Milk is first standardised by adjusting fat content to a desired level
- The milk is heated to kill any bacteria and enzymes that may interfere with culturing.
- The milk is inoculated by adding starter culture (mainly *Lactobacillus bulgaricus* and *Lactobacillus thermophiles*) which ferments the milk and produces yoghurt.

Biological principles involved microbial activities such as the fermentation of lactose by starter culture bacteria to produce lactic acid that gives the distinctive flavour and taste of yoghurts. There is also a symbiotic association between the two species of bacteria in the starter culture, as the compounds produced by one bacteria group stimulate growth in the other.

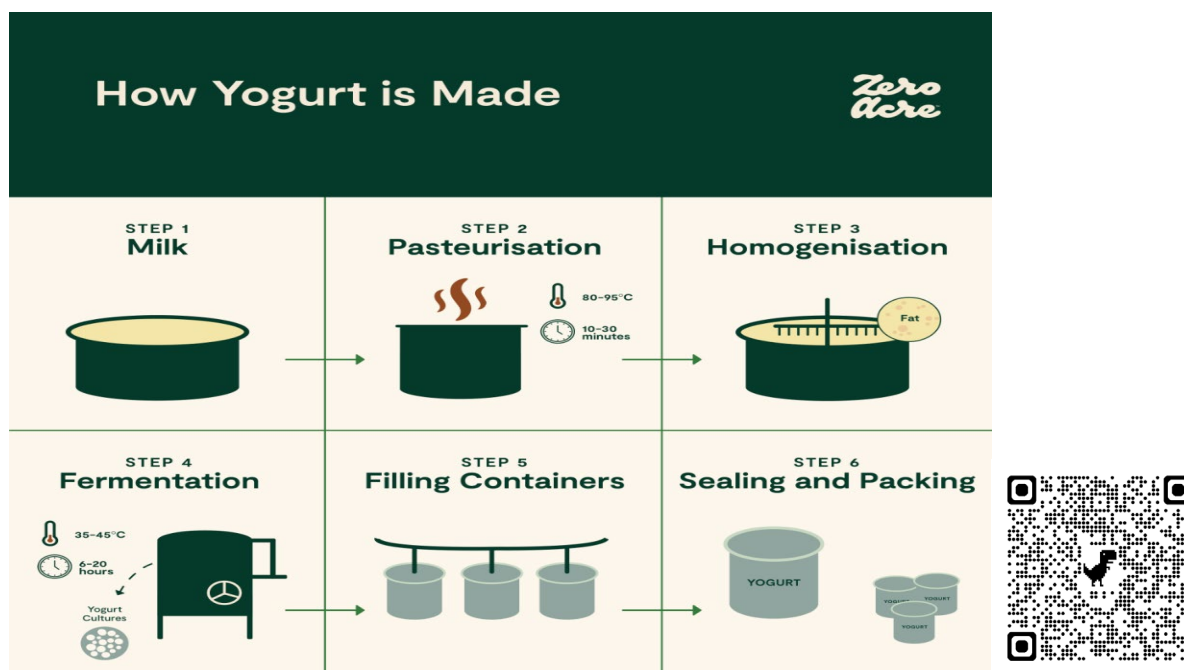


Figure 1.3: Processes of yoghurt production

Nutritional Values

Yoghurt is rich in nutrients such as protein, calcium vitamins B12 and D, and probiotics. It allows for easy digestion.

3. Pito Production

This refers to a Ghanaian traditional alcoholic beverage brewed from fermented corn or millet, which produces slightly bitter and sweet taste, depending on the length of fermentation and optional ingredients added. It originated from the northern part of Ghana and is popular among the Dagombas and northern tribes of the country.



Figure 1.4: *Pito*

Raw Materials: Sorghum or millet, water, with local herbs and spices as optional ingredients.

Steps Involved in the Production of *Pito*

- a. Malting sorghum/millet (germination for 3-5 days)
- b. The malted grain is dried and pounded into flour.
- c. The flour is mashed with water and boiled.
- d. The mixture is cooled and inoculated with previous brew sediments (to provide a starter for the microbes).
- e. It is allowed to ferment by allowing it to settle for about 12 to 23 hours.
- f. The final mixture is filtered and consumed.

Biological Principles

Malting: This involves controlled germination to activate endogenous enzymes such as amylases which convert starch to fermentable sugars, and proteases that break down proteins to amino acids.

Mashing/ Pounding: This is the enzymatic hydrolysis of complex carbohydrates.

Boiling: This is done to stop enzyme activity and concentrates sugars.

Fermentation: There is a two-stage fermentation process: First is when lactic acid bacteria act to produce lactic acid. Second is when yeasts (*Saccharomyces cerevisiae*) cause the production of alcohol.

Biochemical changes that occur include the conversion of starches to maltose by amylase. Second, there is the conversion of maltose to glucose. The process also involves alcoholic fermentation by converting glucose to form ethanol (alcohol) and CO₂.

Nutritional Value: *Pito* contains B vitamins, probiotic bacteria and Low alcohol content (2-3%)

4. ***Asana (Asaana) production***

Asana a non-alcoholic, Ghanaian traditional drink made from fermented maize (corn) and

caramelised sugar that produce a sweet taste. It is a popular drink in public places around the country, especially in the Volta Region where it is believed to have originated.

Raw Materials: Crushed corn, sugars, water. Milk may be added after refrigeration/freezing.

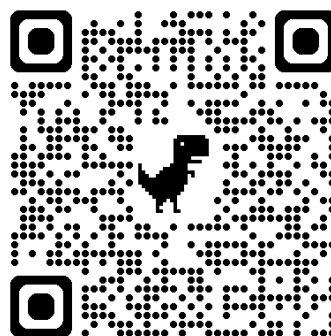


Figure 1.5: *Asana drink*

Steps Involved in the Production of *Asana*

- Milled or crushed corn is fermented in water for about two to three days.
- The fermented corn mixture is boiled, and the liquid is extracted.
- Caramelised sugar is added to the liquid to produce a rich, brown syrup.
- It is chilled and served with or without milk.

Biological principles and biochemical processes involved include crushing of maize or corn and mixing with water for easy and quick fermenting, lactic acid bacteria such as *Lactobacillus* producing lactic acid, and yeast (*Saccharomyces cerevisiae*, a fungus), which ferment sugars and produce compounds that give a distinctive flavour and aroma.

Nutritional Values

Like other fermented maize or corn products, it contains carbohydrates and minerals such as potassium, magnesium and iron which gives energy and protection to the body. It may also contain antioxidants due to the fermentation process.

Principles of Pasteurisation and its Applications

Pasteurisation is the heating of liquids (e.g., milk or juice) to a specific temperature for a short period, followed by rapid cooling, in order to destroy harmful microorganisms and reduce spoilage microorganisms to safe levels, thereby ensuring the safety and quality of products. Apart from food, it is also used in treating pharmaceutical products and biological materials. The process also helps preserve nutrient quality and extends shelf life.

Biological Principles of Pasteurisation

The main biological principles by which pasteurisation is done is heating liquid substances to required temperatures which denatures proteins, from which microbes are formed, and making them non-functional. It also disrupts the cell membranes of microbes, thereby inactivating and destroying them.

Target microorganisms that are generally targeted in the process include pathogenic bacteria (e.g., *Salmonella*, *E. coli*, *Listeria*), spoilage organisms (e.g., psychrotrophs, many yeasts and moulds). It also ensures enzyme inactivation to prevent quality deterioration.

Factors affecting Pasteurisation

- Temperature:** High temperatures are more effective but may also affect product quality.
- Time:** Longer exposure of liquid to heat can increase the death of microbes.
- Microbial Density/Load:** the greater the number of microbes, the more intense the process of pasteurisation.
- Types of microbes:** Some microbes have higher heat resistance capacities, and can withstand high temperatures
- Composition of product:** factors such as fat contents and pH affect the effectiveness and product quality of pasteurised substances. Presence of fat protects microbes and so requires higher temperatures for the process to be effective. pH also influences microbial heat resistance and protein stability.

Pasteurisation Methods

Low-Temperature Long-Time (LTLT): This heats to around 63-65°C for 30 minutes. It may also involve traditional batch method.

High-Temperature Short-Time (HTST): This heats to 72-75°C for 15-20 seconds.

Steps Involved in Pasteurisation

The process involves several steps. These have been simplified below:

- The substance to be pasteurised is first heated to a temperature close to the pasteurisation temperature (preheating).
- The product is heated to the desired temperature and held for a specified time (pasteurisation)
- The product is maintained at the pasteurisation temperature for a period of time (holding).
- The product is rapidly cooled to a temperature that inhibits microbial growth.

Additional steps may include pre-treatment (such as filtration and standardisation) and packaging (filling the product into sterile containers or packaging materials).

Learning Tasks

- Identify biological principles/processes behind the preparation of local foods e.g., kenkey and *Pito* or *Asana*
- Design and conduct a small-scale investigation to monitor the fermentation process in kenkey preparation.
- Compare and contrast the biological processes in two different fermented foods (e.g., kenkey and *pito* or *asana*)
- Design a modified production method for a traditional Ghanaian food or beverage that improves a specific biological process.

Pedagogical Exemplars

1. Differential Project-Based Learning

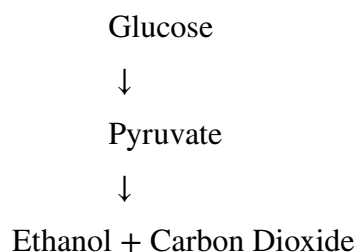
- a. In mixed-ability, gender-responsive and all-inclusive differential tasked-based groups, identify some common local foods and beverages in the community E.g., local yoghurt, kenkey, pito or asana, bread, akpeteshie. Visit the production sites in the community to gain first-hand information on the production processes. Learners inculcate new cultures and shed off harmful and socially sensitive beliefs about some cultures and their eating habits. Learners learn to respect the positive beliefs of some cultures and develop the spirit of team working.
- b. Identify some common biological principles employed in the preparation of these local foods (e.g., fermentation in the preparation of yoghurt, kenkey, pito or asana and bread), and describe in a written report how these biological processes are applied in preparing each food item. Learners develop self-confidence both in teamwork and in individual assigned roles during independent and group research.

2. Experiential/Project Based Learning

- a. Collect different resources and raw materials and work in groups at the laboratory to produce some local foods and beverages such as kenkey, yogurt, pito or asana: by this, learners connect to real-life scenarios and disconnect from harmful beliefs and taboos they ignorantly attach to. Learners learn to work to achieve results and offer emotional support and respect to peers they work with

Key Assessment: Level 2 – Individual Class Exercise

1. a. Compare and contrast the biological processes involved in the fermentation of kenkey and pito or asana.
b. Explain how microorganisms contribute differently to the final products formed.
(20 marks)
2. Using specific examples of local beverages, explain how the process of pasteurisation enhances food safety while preserving nutritional quality. (10 marks)
3. A yoghurt producer noticed inconsistent results in product quality. Design an investigation to determine which factors might be affecting the fermentation process. Include three variables you would test and explain why each is important. (10 marks)
4. The chart below shows the fermentation pathway in the production of a local alcoholic beverage:



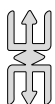
Explain

- a. why anaerobic conditions are necessary for this process
 - b. how temperature affects the rate of this process
 - c. how this process differs from lactic acid fermentation seen in yogurt production
- (10 marks)

PLC Session 1

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

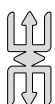

Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **individual class exercise**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes
Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).


Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 2

Learning Indicator: Describe the process of tissue culture and its application in food production

FOCAL AREA: TISSUE CULTURE AND ITS APPLICATION

Tissue Culture

Tissue culture is a laboratory technique used to cultivate and propagate cells, tissues, or organs from plants or animals in a controlled environment, typically outside their natural habitat. This method allows for the growth and multiplication of cells under sterile conditions, enabling researchers and cultivators to study cellular processes, develop new varieties, and produce organisms efficiently.

In this technique fragments (cells, tissues or organs) of plants called **explants** are cultured and grown in a laboratory. The medium in which the explants are grown is called **broth** and **agar**. This technique is also known as micropropagation. It has proved beneficial to produce disease-free plants and increase plant yield in developing countries. It requires a sterile workplace (laboratory), greenhouse, trained manpower, and a nursery. Plants produced through tissue culture in developing countries include oil palm, banana, eggplant, pineapple, rubber tree, tomato, sweet potato.



Figure 1.6: Plantlets

Key Principles of Tissue Culture

1. Aseptic Conditions

The success of tissue culture relies on maintaining sterile environments to prevent contamination from bacteria, fungi, and viruses. This is typically achieved using laminar flow hoods, autoclaved tools, and disinfected growth media.

2. Nutrient Medium

Cells require specific nutrients to grow, which are supplied through a growth medium. This medium typically contains:

- a. macronutrients: Carbohydrates, proteins, and lipids.
- b. micronutrients: Vitamins and minerals essential for cellular functions.
- c. hormones: Plant growth regulators like auxins and cytokinins that control cell division and differentiation.

3. Environmental Control

Optimal conditions such as temperature, light, and humidity are maintained to ensure proper growth. For plant cells, light is crucial for photosynthesis and development.

Types of Cultures

Primary Culture: it is the initial culture obtained directly from the tissue/explant. When the explant used is a cell cultured in a proper medium, a mass of unorganised, dividing cells called a callus develops. The growth of callus is followed by organ differentiation. The culture is grown on a gel-like medium composed of agar and specific nutrients required for the growth of the cells.

Secondary Culture: are cultures derived from primary cultures, often used to expand or manipulate specific cell lines.

Embryo Culture: This involves the in-vitro development of an embryo. A mature or an immature embryo is isolated from a living organism can be used in the process. Mature embryos can be obtained from ripe seeds. The immature embryos are obtained from the seeds that failed to germinate. The ovule, seed or fruit is already sterilised; therefore, it does not need to be sterilized again.

Cell Suspension Culture: Involves the cultivation of individual cells or small groups of cells in a liquid medium, allowing for the study of cellular processes and product formation.

Organ Culture: Whole organs or tissues (such as roots, shoots, or leaves) are cultured in vitro, enabling the examination of organ-specific functions, development, physiology and interactions.

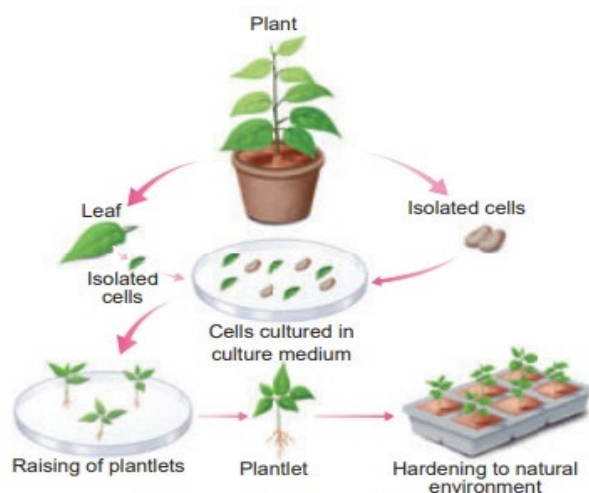


Figure 5.6: Organ Culture

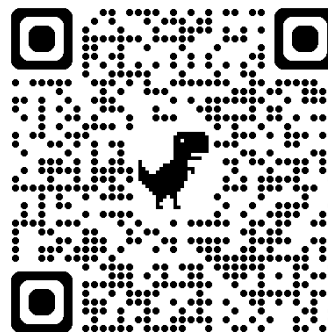


Figure 1.7: Organ culture

Somatic Cell Culture: Culture of somatic (non-reproductive) cells can be used for genetic studies or pharmaceutical production.

Specific Techniques/steps in Tissue Culture

Explant Preparation

- Selection:** Choosing the right plant part (leaf, stem, root, or flower) for culture.
- Sterilization:** Explants are typically surface sterilized using chemical agents (e.g., bleach or alcohol) to eliminate contaminants. After the explant is sterilised, it is initiated into a medium/ culture for growth.

Media Composition: In the medium the cells multiply. This is the multiplication phase. Basic components in a medium are nutrient agar, sugars (usually sucrose), and plant growth regulators.

Growth regulators called auxins (plant hormones that promote root formation) and cytokinins (plant hormones that promote shoot formation) are critical for tissue differentiation and organ formation.

Cultivation Conditions

- a. **Light:** period of light exposure (Photoperiod) is controlled to optimize growth; some cultures may require specific light wavelengths and intensities.
- b. **Temperature and Humidity:** Maintaining optimal conditions for specific plants is crucial for successful growth.

Subculturing: this technique involves the transfer of cultured tissue to fresh media at regular intervals to provide nutrients and encourage further growth of the roots and shoots.

Acclimatisation: When the plant starts developing (called plantlets), it is transferred to the greenhouse to develop under controlled environmental conditions. It is then finally transferred to the nurseries to grow under natural environmental conditions.

Applications of Tissue Culture

Plant Propagation: Tissue culture is widely used in horticulture and agriculture to produce disease-free plants, conserve rare species, and develop new varieties with desirable traits (e.g., improved yield, disease resistance).

Genetic Engineering: Tissue culture facilitates the introduction of new genetic material into plants, allowing for the creation of genetically modified organisms (GMOs) with enhanced characteristics.

Medical Research: In animal tissue culture, researchers can study cell behaviour, test drugs, and develop vaccines. It is essential in cancer research, regenerative medicine, and understanding disease mechanisms.

Pharmaceutical Production: Plant cell cultures can be used to produce valuable secondary metabolites, such as alkaloids and flavonoids, which have medicinal properties.

Advantages of Tissue Culture

Rapid Production: the plantlets are obtained in a very short time with a small amount of plant tissue producing large quantities of plants in a shorter time irrespective of the season in the year as compared to traditional methods.

Disease-Free Plants: the tissue culture method allows for the cultivation of plants free from pathogens, which is crucial for agricultural productivity.

Genetic Uniformity: the process ensures that all offspring are genetically identical, which is beneficial for maintaining specific traits in the production of new varieties to meet the marketplace demands.

Conservation of Rare Species: the process enables the preservation of endangered plant species by creating viable populations from small tissue samples. This technique is also being used to produce ornamental plants such as dahlia, chrysanthemum, orchids, etc.

Research Flexibility: it provides a controlled environment for studying cellular processes, genetics, and responses to environmental changes. A large space is not required to grow plants by tissue culture technique.

Limitations of Tissue Culture

Cost: the setup and maintenance of tissue culture facilities can be expensive, requiring specialized equipment and trained personnel.

Technical Expertise: successful tissue culture requires significant skill and experience, which may not be readily available in all regions.

Contamination Risks: despite aseptic techniques, contamination can still occur, leading to failed cultures and loss of material.

Genetic Variation: while tissue culture produces clones, there may be variations, which can lead to unexpected traits in regenerated plants.

Regulatory Challenges: the use of genetically modified organisms is subject to strict regulations, which can complicate the commercialization of products developed through tissue culture.

Learning tasks

1. Create a detailed visual flowchart of the tissue culture process for a food crop.
2. Simulate or perform (if facilities allow) key steps in the tissue culture process.
3. Design and conduct comparative analysis of traditional and tissue culture propagation methods.
4. Analyse a case study of successful tissue culture application in Ghanaian agriculture and its entrepreneurial prospects.

Pedagogical Exemplars

1. Individual/Independent Learning Approach

Research from textbooks, the internet, documentaries and other relevant sources, and make summary notes on tissue culture and the major processes involved in it: learners research on their own to develop the skill of independence and build confidence and strength. Learners also learn from their peers and seek personal collaboration with them, thereby developing respect for one another.

2. Diamond Nine Learning Approach

In mixed-ability, all-inclusive groups, create flow charts on the processes involved in making tissue culture, and critique each group's work in class discussions; learners learn the act of fair grading/judgment and to accept constructive criticisms. Learners also learn public speaking and learn from one another through critiquing.

3. Experiential/Group Project Learning Approach

Learners work in large groups to make sample plant tissue cultures with support and resources from the teacher and lab/resource personnel (e.g., from scientific resource centres in institutions and universities), with each group presenting a report on the project: Learners obtain real-world experience on study. Learners learn to help one another socially and emotionally in teamwork.

Key Assessment Level 4: Group Project

1. Create a detailed flowchart of the tissue culture process for a named food crop. Include a decision point where the type of explant chosen, affects the process and summarize the benefits of tissue culture in improving crop yields and disease resistance. For each step provide a brief description (one to two sentences) explaining what happens and why it is important.

2. In Ghana, cassava is a crucial staple crop, providing food security and income for many farmers. However, it has been severely affected by diseases such as cassava mosaic disease. The Ghana Agricultural Research Institute (GARI) launched a project in collaboration with local entrepreneurs to apply tissue culture techniques aimed at producing disease-resistant cassava varieties. This initiative was designed to enhance food security and boost the livelihoods of farmers.

Using the scenario above, analyse the application of tissue culture in cassava production, focusing on its implementation, outcomes, and the entrepreneurial prospects it presents for Ghanaian agriculture.

3. Conduct a comparative analysis of the advantages and disadvantages of seed propagation versus tissue culture propagation methods and evaluate how these factors influence the choice of propagation technique in maize cultivation in different regions of Ghana.

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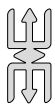
Assign Group Project to learners and give them reasonable time to complete it. Use the SS App to generate the project as well as the rubric. Learners' projects should be marked immediately and scores entered into the SAP.

PLC Session 2

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

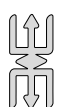
- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).

- a. The key assessment for the week is **group project**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the project (NTS 3k-3q).

10 minutes**Content Exploration**

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through the problem individually for 3–4 minutes
 - c. the group then works through it together the problem, step by step
 - d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).

**Note**

- *This part is not 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
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30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
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 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 3

Learning Indicator: Describe how genetic recombinant technology is applied in biotechnology for the production of GMOs

FOCAL AREA: GENETIC RECOMBINANT TECHNOLOGY AND ITS APPLICATION

Genetic Recombinant Technology

Genetic recombinant technology, also known as recombinant DNA technology (rDNA), refers to a set of molecular techniques that involve combining DNA molecules from different sources to create a new set of genes. This technology allows scientists to cut and join DNA molecules from different organisms and insert them into host organisms to produce new genetic combinations in organisms.

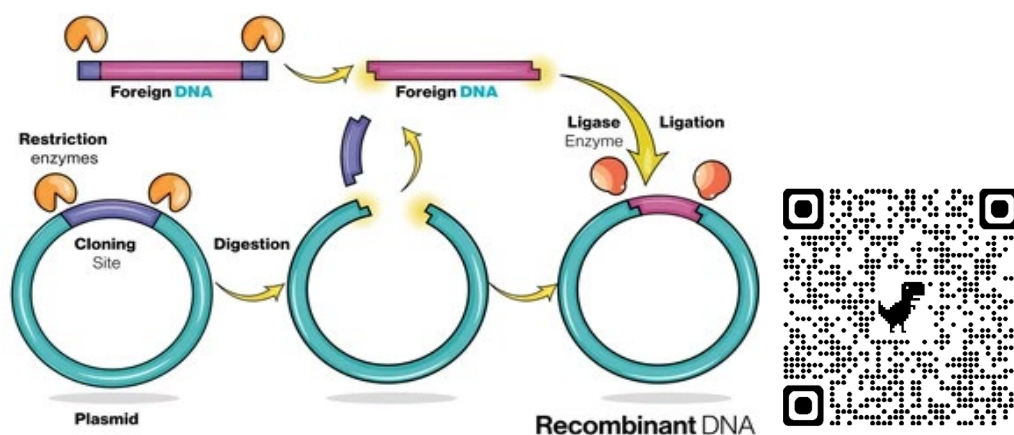


Figure 1.8: *Genetic recombinant DNA*

The technique has important applications in science, medicine, agriculture, and industry.

Key Processes in Genetic Recombinant Technology

DNA technology involves a series of steps which lead to the formation of several copies of the recombinant DNA in which the gene of interest is found for the production of the required product. These steps are complex, but have been simplified in the outline below:

Steps

1. **Isolation of DNA:** Extraction of DNA from the donor organism containing the gene of interest.
2. **Restriction Enzyme Digestion:** Special enzymes called **restriction endonucleases** cut the DNA at specific recognition sites, creating fragments with sticky ends.
3. **Vector Preparation:** A vector (such as a plasmid or bacteriophage) is cut with the same restriction enzyme to create compatible sticky ends.
4. **DNA Ligation:** The DNA fragment of interest is joined with the vector using **DNA ligase** enzyme, creating a recombinant DNA molecule.
5. **Transformation/Transfection:** The recombinant DNA is introduced into a host cell through processes such as transformation or transfection.
6. **Selection and Screening:** Host cells that have successfully taken up the recombinant DNA are identified through selection markers (e.g., antibiotic resistance genes).

7. **Amplification and Expression:** The host cells replicate, producing many copies of the recombinant DNA. The gene of interest is expressed, producing the desired protein or trait.

The donor DNA is carried through a special laboratory technique to amplify specific DNA sequences to produce more copies of the gene or DNA fragment of interest. This technique is called **polymerase chain reaction (PCR)**. The main processes involved are heating (denaturation) cooling (annealing) and synthesis (extension) of DNA strands to produce new ones. The process by which DNA fragments are separated and analysed by their sizes is known as **gel electrophoresis**.

Some common examples of Genetically Modified Organisms

Genetically Modified Organisms (GMOs) are living organisms whose genetic material has been artificially manipulated through genetic engineering techniques to introduce novel traits.

Some common examples are

1. **Genetically Modified Crops (GMCs):** **Bt crops** are crops modified to express the *Bacillus thuringiensis* (Bt) toxin gene, making them resistant to certain insects. Examples: Bt cotton, Bt maize. **Herbicide-resistant** crops such as soybeans, cotton, maize. **Nutritionally enhanced** crops (e.g., the golden rice which is enriched with beta-carotene. **Drought and salinity tolerant crops** (e.g., drought-resistant maize, salt-tolerant rice)
2. **Genetically Modified Animals: Faster-Growing Fish** (e.g., aqu-salmon with growth hormone gene from chinook salmon, **Disease-resistant animals** (e.g. pigs modified to resist diseases like PRRS)

Other examples include **genetically modified microorganisms: bacteria-producing insulin** such as *E. coli* modified to produce human insulin and microorganisms used for breaking down pollutants in bioremediation.

Socio-cultural and Emotional Concerns about GMOs in Africa

1. **Cultural Concerns**
 - a. Impact on traditional farming practices and seed-saving traditions
 - b. Cultural significance of certain crops and farming methods
2. **Economic Concerns**
 - a. Dependence on multinational seed companies
 - b. Cost of GM seeds and export market acceptance
3. **Health and Safety Concerns**
 - a. Perceptions about safety of GM foods for consumption
 - b. Concerns about potential allergenicity or toxicity
4. **Environmental Concerns**
 - a. Potential for cross-pollination with wild relatives
 - b. Impact on non-target organisms and biodiversity

Learning Tasks

1. Explain the basic concept involved in recombinant DNA technology and the production of genetically modified organisms.
2. Create a comprehensive flowchart illustrating the key processes involved in genetic recombinant technology.

3. Produce a list of forms of genetically modified organisms and the role they serve.
4. Evaluate the potential ecological and socioeconomic impacts of introducing drought-resistant maize in Ghana.

Pedagogical Exemplars

1. Group-Based Learning

In mixed ability, all-inclusive groups, listen to a presentation by a resource person (or the teacher offers introductory lessons) on genetic recombinant technology (also known as recombinant DNA technology, or rDNA) and note down observations and discuss these observations: Learners develop teamwork and involvement attitude.

2. Individual Project Learning

Each learner designs a flow chart on the key processes involved in recombinant DNA technology. Learners contribute to assigned tasks, thereby building self-confidence and respect.

3. Group Project-Based Learning

In mixed-ability, all-inclusive groups, learners read/research from textbooks, libraries, journals and newspapers to acquire further information on genetically modified crops and animals in Africa produced using recombinant DNA technology. Learners gain broader understanding on the socio-cultural and emotional concerns on genetically modified organisms and crops (GMOs and GMCs) and educate families and the general population on these beliefs. Learners share information and acknowledge the efforts of peers.

Key Assessment Level 4 - Group Discussion and Presentation

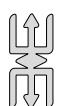
1. A student research team in Ghana is developing a drought-resistant maize variety using genetic recombinant technology to address food security challenges in northern regions affected by climate change. Evaluate the potential ecological and socioeconomic impacts of introducing this drought-resistant maize in Ghana. Your analysis should consider multiple perspectives and be supported by scientific evidence.
2. Ghana faces challenges with vitamin A deficiency among children in rural communities. You are part of a team of biologists tasked with developing a solution using genetic recombinant technology. Design a comprehensive plan to develop a vitamin A-enhanced crop variety suitable for Ghanaian conditions using the following parameters: a. Selection of an appropriate local crop and justification b. Detailed methodology for genetic modification
3. Select two indigenous plants and animals each that can undergo genetic modification, and use the criteria below to assess their potential implementation in an attempt to improve on food security in Ghana:
 - a. The scientific rationale for genetic modification.
 - b. The potential ecological consequences of introducing these modified organisms into Ghana's ecosystems.

PLC Session 3

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to

- a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
- a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

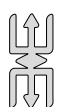
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
- a. The key assessment for the week is **group discussion and presentation**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the presentation (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
- a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

- b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

- 7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
- 8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
- 9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 4

Learning indicator: Describe the application of biological concepts in the treatment of water, extraction of minerals (e.g., gold) and production of bio-oils

FOCAL AREA: APPLICATION OF BIOLOGICAL CONCEPTS IN OTHER AREAS

Biological Water Treatment

Water treatment refers to the use of natural systems such as microorganisms (e.g., bacteria, protozoa, algae) to remove contaminants and pollutants from water. It involves biological methods such as bioremediation, activated sludge process and biofiltration in order to break down organic matter, nutrients and other substances to improve on water quality. Biological water treatment methods are considered less harmful, cost-effective and relatively less harmful than chemical treatments.

Bioremediation

This is the use of living organisms such as microbes, plants or enzymes to detoxify or degrade pollutants and remove them from the environment. The contaminated medium can be soil, water or air. The method improves on the quality of the environment.

Steps in Bioremediation

1. The pollutants and the site of contamination are identified.
2. A suitable microorganism or a biodegrading agent is chosen for degradation.
3. A bioremediation system such as bioreactors or landfarming is acquired.
4. The microorganism or biodegrading agent is applied to the site of contamination.
5. Contaminant levels and microbial activities are monitored until conditions are normalised.

Biological concepts/principles involved in bioremediation are

1. **Biodegradation:** This is where microorganisms break down pollutants into simpler, degradable compounds.
2. **Enzymatic reactions:** This is where microbial enzymes catalyse and initiate degradation reactions.
3. **Microbial metabolism:** This refers to the conversion of pollutants into energy sources.
4. **Bioaugmentation:** It is the addition of microorganisms to a pollutant to enhance degradation or digestion.
5. **Bio stimulation:** This is the provision of nutrients and suitable conditions to facilitate the growth of microbes, used in bioremediation processes.

An example of bioremediation is the use of *Pseudomonas* to break down petroleum hydrocarbons in contaminated water.

Advantages of Bioremediation

1. It poses less harm to the environment.
2. It is cost effective

3. It can destroy pollutants rather than transferring, thus, offering a permanent answer to remediation processes.

Disadvantages

1. It is a slow process
2. Its effectiveness depends on the conditions of the site such as temperature and moisture.
3. It may not be suitable for some pollutants.

Activated Sludge Process

This is a biological treatment method that uses aerobic microbes to break down organic matter in wastewater. The microbes form a sludge which is subsequently separated from the treated water. The microorganisms involved include various species of bacteria, protozoa, rotifers, and fungi that form a complex ecosystem.

The reaction can be represented as $\text{organic matter} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{new bacterial cells}$

Steps Involved in the Treatment Process

1. Wastewater is mixed with air to provide oxygen for the microbes.
2. The microbes break down organic matter in the waste treatment.
3. The treated water is separated from the sludge (or collection of microbes).
4. Some sludge is recycled back into the aeration tank to maintain microbial population.

The biological concepts/principles involved in this treatment method are

1. **Aerobic degradation:** This is where oxygen is supplied to the microbes to break down organic matter.
2. **Microbial metabolism:** This refers to the process of treating wastewater by breaking down organic matter, removing harmful substances, and recycling nutrients. This process is primarily facilitated by various types of microorganisms, including bacteria, fungi, and protozoa.
3. **Bio flocculation:** This refers to the formation of flocs by microorganisms to speed up sludge separation.

Advantages

1. It is very effective
2. It is a flexible, hence can be designed to suit removal of waste in different types of wastewaters.
3. It can achieve high levels of pollutant removal.

Disadvantages

1. It requires high amount of energy for aeration and mixing.
2. The process generates sludge that always requires further treatment and disposal.
3. The method can be affected by changes in wastewater composition or flow.

Biomining and Bioleaching for Mineral Extraction

Biomining uses microorganisms to extract valuable metals from low-grade ores that would otherwise be uneconomical to extract using conventional methods.

Bioleaching Process

Microbial Action in Gold Extraction

Microorganisms involved include *Acidithiobacillus ferrooxidans*, *Acidithiobacillus thiooxidans*, *Leptospirillum ferrooxidans*.

The steps involved are:

- Microbes oxidize sulphide minerals containing gold
- Gold becomes exposed and accessible
- Cyanide solution then dissolves the gold
- Gold is recovered from solution through precipitation

The biological concepts/principles involved in this method are:

Biochemical Mechanisms

- Direct leaching:** Microbes attach directly to mineral surfaces and extract metals through enzymatic reactions
- Indirect leaching:** Microbes produce chemical oxidants (Fe^{3+}) that dissolve the minerals
- Key reaction:** $\text{Fe}^{2+} + \frac{1}{4}\text{O}_2 + \text{H}^+ \rightarrow \text{Fe}^{3+} + \frac{1}{2}\text{H}_2\text{O}$ (catalysed by bacteria)

Advantages

Environmental and Economic Benefits

- Requires less energy than conventional mining
- Reduces greenhouse gas emissions
- Can extract metals from low-grade ores (increasing resource availability)
- Produces less toxic waste
- Can be used to remediate mine sites

Current Applications

- Commercial bioleaching operations for gold in South Africa, Brazil, Australia
- Copper extraction in Chile and the United States
- Uranium extraction in Canada

Production of Bio-oils

Bio-oils are liquid fuels derived from biological materials through various conversion processes that apply biological principles.

Sources and Production Methods

1. Microalgae-Based Bio-oil Production

Process

- Cultivation of oil-rich microalgae species (e.g., *Chlorella*, *Botryococcus*)
- Harvesting of algal biomass

- c. Extraction of lipids
- d. Conversion to biofuels through transesterification

Biological advantages: High photosynthetic efficiency, rapid growth, high oil content (up to 60% of dry weight)

Environmental benefits: Carbon-neutral process that can utilize wastewater and CO₂ from industrial emissions

2. Enzymatic Conversion of Biomass

Process: Uses enzymes (biological catalysts) to break down complex plant materials into simpler compounds.

Key enzymes

- a. Cellulases: break down cellulose into glucose
- b. Lipases: catalyze transesterification reactions
- c. Amylases: convert starch to fermentable sugars

Advantage: Works at lower temperatures than chemical processes, reducing energy requirements

Fermentation for Bio-oil Production

Process: Microorganisms convert sugars to alcohols that can be used as fuel

Example: Yeast fermentation of sugars to produce bioethanol

Advanced applications: Engineered bacteria that can produce hydrocarbon molecules directly

Pyrolysis with Biological Pre-treatments

Process: Thermal decomposition of organic material in the absence of oxygen

Biological pre-treatment: Enzymes or microorganisms partially break down biomass before pyrolysis

Advantage: Improves yield and quality of bio-oil

Applications of Bio-oils

- a. Transportation fuels (biodiesel, bioethanol)
- b. Heating and electricity generation
- c. Production of biochemicals and bioplastics
- d. Carbon sequestration when combined with carbon capture

Learning Tasks

1. Investigate and analyse the effectiveness of different biological principles/methods and microbes in water treatment processes.
2. Analyse and evaluate the biological processes involved in mineral extraction, with focus on gold bioleaching.
3. Design and evaluate a system for converting local agricultural waste into bio-oil using biological processes.
4. Develop an integrated solution that applies biological concepts from all three areas (water treatment, mineral extraction, bio-oil production) to solve a complex environmental challenge.

Pedagogical exemplars

1. Collaborative/Project Based Learning

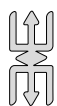
In mixed-ability, gender-responsive and all-inclusive groups, read and share knowledge on the use of biological principles in treating polluted water, extracting minerals, and the production of biofuels: Learners share tasks and encourage one another socially and emotionally to complete tasks within a set time.

2. Observational Learning Approach

Listen to a presentation or watch a video on the types of microbes (bacteria) that are employed in the treatment of polluted water, extraction of minerals, and production of biofuels and make personal notes to be used in group work. Learners learn independent inquiry and learn to reach out to others for support when necessary.

3. Experiential/Observational Learning Approach

In mixed-ability, all-inclusive groups, research on the biological activities involved in large-scale treatment of water and in the extraction of minerals and production of bio-oils. Design a laboratory method of biological treatment of water for group class presentations. Learners develop confidence in their abilities and learn from one another.



Teacher Notes

Make sure each group includes learners with different abilities. Help learners who need extra support. Connect lessons to local environmental issues that learners can see in their communities.

Key Assessments Level 3: Case Study

1. A community is experiencing contamination of its local water supply due to industrial runoff. The runoff contains organic pollutants (e.g., pesticides and oil residues) and heavy metals (e.g., lead and mercury). Design a biological water treatment system that addresses both types of contaminants, explaining the biological principles involved and evaluating potential limitations of your approach.
2. Compare and evaluate conventional mining methods with biomining for gold extraction. In your answer, analyse the environmental impacts, economic viability, and biological mechanisms involved. Propose how biomining techniques could be optimized for a specific mining site with low-grade ore in a water-sensitive region.
3. A coastal region has problems with excessive growth of algae (algal blooms) caused by nutrient-rich agricultural runoff (eutrophication) and wants to develop a sustainable energy source. Investigate how these issues could be addressed simultaneously through a bio-oil production system. Your answer should include an analysis of the biological processes involved, a strategy for implementation, and an evaluation of potential challenges and benefits.

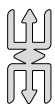
PLC Session 4

45 minutes

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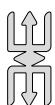
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **case study**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the case study (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
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9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

Section 1 Review

In the past four weeks, we discussed lessons on Biology and entrepreneurship, focusing on practical examples and application of biological concepts in biotechnology. In Week 1, we discussed the biological principles behind the preparation of some local foods and beverages, where learners were expected to understand the role of microorganisms in local food preparation, in processes such as fermentation. Learners were expected to be able to describe the biological principles in the preparation of indigenous Ghanaian local foods and beverages such as kenkey, local yogurts, pito and asana. In Week 2 we discussed tissue culture, where the learner was expected to understand the application of this concept in the mass-production of healthier and more robust, disease-resistant crops to improve on crop production. We focused on genetic recombinant technology and genetically modified organisms in Week 3, where learners were expected to comprehend the principles by which crops and other organisms are genetically engineered to increase food production. In the final Week, we focused on the biological concepts in certain treatment processes such as water, minerals and biofuels.

The sub-strand with its related learning guides such as the content standards and learning indicators has equipped the learner with practical knowledge of biological principles and their application in various industries, from food production, treatment and extraction of substances to the sustainable use of resources within the environment. Lessons in this section have equipped the Ghanaian learner with the requisite knowledge, tools and skills to develop into successful entrepreneurs and innovators to drive the nation's economy.



MARKING SCHEMES FOR THE KEY ASSESSMENTS

WEEK 1

Question 1 (20 Marks)

- Compare and contrast the biological processes involved in the fermentation of kenkey and pito or asana.
- Explain how microorganisms contribute differently to the final products formed.

Criterion 1: Description of the fermentation process in kenkey (4 marks)

- Clearly describes the fermentation process, including the role of microorganisms and the production of lactic acid. **(4 marks)**
- Gives a generally correct description with minor omissions. **(3 marks)**
- Gives a basic description showing partial understanding. **(2 marks)**
- Gives a limited or inaccurate description. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 2: Description of the fermentation process in pito or asana (4 marks)

- Clearly describes the fermentation process, including the role of microorganisms and the production of alcohol and carbon dioxide where appropriate. **(4 marks)**
- Gives a generally correct description with minor omissions. **(3 marks)**
- Gives a basic description showing partial understanding. **(2 marks)**
- Gives a limited or inaccurate description. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 3: Comparison of the two fermentation processes (4 marks)

- Clearly compares both processes, identifying appropriate similarities and differences. **(4 marks)**
- Gives a good comparison but omits some important points. **(3 marks)**
- Gives a basic comparison with limited detail. **(2 marks)**
- Gives minimal comparison. **(1 mark)**
- No comparison made. **(0 marks)**

Criterion 4: Role of microorganisms in the final products (4 marks)

- Clearly explains how different microorganisms produce different end products and influence the characteristics of each food or beverage. **(4 marks)**
- Gives a generally correct explanation with minor omissions. **(3 marks)**
- Gives a basic explanation showing partial understanding. **(2 marks)**
- Gives a limited explanation. **(1 mark)**
- No relevant explanation. **(0 marks)**

Criterion 5: Scientific accuracy and organisation (4 marks)

- Response is scientifically accurate, logically organised and uses appropriate biological terminology throughout. **(4 marks)**

- Mostly accurate and well organised with minor errors. **(3 marks)**
- Generally organised but contains several inaccuracies. **(2 marks)**
- Poorly organised with many inaccuracies. **(1 mark)**
- No meaningful response. **(0 marks)**

Total: 20 Marks

Grading Scale

- **16–20:** Highly Proficient
- **11–15:** Proficient
- **6–10:** Developing
- **0–5:** Emerging

Question 2 (10 Marks)

Using specific examples of local beverages, explain how the process of pasteurisation enhances food safety while preserving nutritional quality.

Criterion 1: Understanding of pasteurisation (2 marks)

- Correctly explains pasteurisation as heating a product to a suitable temperature for a specified time followed by rapid cooling to destroy harmful microorganisms while maintaining quality. **(2 marks)**
- Gives a generally correct explanation but omits one important aspect. **(1 mark)**
- Incorrect or no explanation. **(0 marks)**

Criterion 2: Enhancement of food safety (3 marks)

- Clearly explains how pasteurisation destroys harmful microorganisms, reduces spoilage microorganisms and improves food safety. **(3 marks)**
- Explains two of these functions correctly. **(2 marks)**
- Gives only a simple explanation (e.g. “kills germs”). **(1 mark)**
- Incorrect or no explanation. **(0 marks)**

Criterion 3: Preservation of nutritional quality (3 marks)

- Clearly explains how pasteurisation preserves most nutrients and desirable product qualities while causing minimal nutrient loss. **(3 marks)**
- Gives a generally correct explanation with minor omissions. **(2 marks)**
- Gives a basic explanation showing limited understanding. **(1 mark)**
- Incorrect or no explanation. **(0 marks)**

Criterion 4: Application using local beverage examples (2 marks)

- Uses appropriate local beverage example(s) effectively to support the explanation. **(2 marks)**
- Uses one appropriate example with limited explanation. **(1 mark)**
- No suitable example provided. **(0 marks)**

Total: 10 Marks

Grading Scale

- **8–10:** Highly Proficient

- **6–7: Proficient**
- **4–5: Developing**
- **0–3: Emerging**

Question 3 (10 Marks)

A yoghurt producer noticed inconsistent results in product quality. Design an investigation to determine which factors might be affecting the fermentation process. Include three variables you would test and explain why each is important.

Criterion 1: Aim or research question (2 marks)

- States a clear and relevant investigation aim or research question. **(2 marks)**
- States a partially relevant aim. **(1 mark)**
- No appropriate aim stated. **(0 marks)**

Criterion 2: Identification of variables (3 marks)

- Identifies three relevant variables that could influence fermentation. **(3 marks)**
- Identifies two relevant variables. **(2 marks)**
- Identifies one relevant variable. **(1 mark)**
- No appropriate variables identified. **(0 marks)**

Criterion 3: Explanation of the importance of the variables (3 marks)

- Clearly explains how each selected variable could affect fermentation and product quality. **(3 marks)**
- Explains most variables correctly but with minor omissions. **(2 marks)**
- Gives a limited explanation. **(1 mark)**
- No relevant explanation. **(0 marks)**

Criterion 4: Investigation design (2 marks)

- Presents a logical investigation, including how observations or measurements would be made and how a fair test would be ensured. **(2 marks)**
- Gives a basic investigation with limited detail. **(1 mark)**
- No appropriate investigation design. **(0 marks)**

Total: 10 Marks

Grading Scale

- **8–10: Highly Proficient**
- **6–7: Proficient**
- **4–5: Developing**
- **0–3: Emerging**

Question 4 (10 Marks)

The chart below shows the fermentation pathway in the production of a local alcoholic beverage.

- Explain why anaerobic conditions are necessary for this process.
- Explain how temperature affects the rate of this process.
- Explain how this process differs from lactic acid fermentation seen in yoghurt production.

a. Anaerobic conditions (3 marks)

- Clearly explains that oxygen-free conditions are required for alcoholic fermentation and relates this to ethanol production by yeast. **(3 marks)**
- Gives a generally correct explanation with minor omissions. **(2 marks)**
- Gives a basic explanation showing limited understanding. **(1 mark)**
- Incorrect or no explanation. **(0 marks)**

b. Effect of temperature (3 marks)

- Clearly explains that temperature affects enzyme activity and microbial growth, increasing the rate up to an optimum before excessive heat reduces or stops fermentation. **(3 marks)**
- Gives a generally correct explanation with minor omissions. **(2 marks)**
- Gives a basic explanation showing limited understanding. **(1 mark)**
- Incorrect or no explanation. **(0 marks)**

c. Comparison with lactic acid fermentation (4 marks)

- Clearly compares alcoholic fermentation with lactic acid fermentation, including the microorganisms involved, end products formed and their biological significance. **(4 marks)**
- Gives a good comparison but omits one important point. **(3 marks)**
- Gives a basic comparison showing partial understanding. **(2 marks)**
- Gives a limited comparison. **(1 mark)**
- No relevant comparison. **(0 marks)**

Total: 10 Marks

Grading Scale

- **8–10:** Highly Proficient
- **6–7:** Proficient
- **4–5:** Developing
- **0–3:** Emerging

WEEK 2**Question 1 (20 Marks)**

Create a detailed flowchart of the tissue culture process for a named food crop. Include a decision point where the type of explant chosen affects the process and summarise the benefits of tissue culture in improving crop yields and disease resistance. For each step provide a brief description (one to two sentences) explaining what happens and why it is important.

Criterion 1: Sequence of the tissue culture process (6 marks)

- Presents a complete and logically ordered flowchart showing all major stages of tissue culture. **(6 marks)**
- Presents most of the major stages in the correct order with minor omissions. **(4–5 marks)**
- Presents some stages but the sequence is incomplete or contains errors. **(2–3 marks)**
- Presents very few stages or the sequence is largely incorrect. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 2: Decision point involving explant selection (4 marks)

- Clearly identifies an appropriate decision point involving explant selection and explains how the choice influences subsequent stages of the process. **(4 marks)**
- Identifies a decision point and provides a partial explanation of its importance. **(3 marks)**
- Mentions explant selection but gives little explanation of its effect on the process. **(2 marks)**
- Makes only a vague reference to explants. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 3: Explanation of each stage (4 marks)

- Provides clear and accurate explanations of each stage, explaining both what happens and why it is important. **(4 marks)**
- Explains most stages accurately with minor omissions. **(3 marks)**
- Gives basic explanations showing partial understanding. **(2 marks)**
- Gives limited explanations. **(1 mark)**
- No relevant explanation. **(0 marks)**

Criterion 4: Benefits of tissue culture (4 marks)

- Clearly explains how tissue culture improves crop yield, disease resistance and propagation efficiency. **(4 marks)**
- Explains most benefits correctly with minor omissions. **(3 marks)**
- Gives a basic explanation of some benefits. **(2 marks)**
- Gives limited or inaccurate benefits. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 5: Organisation and scientific accuracy (2 marks)

- Flowchart is well organised, scientifically accurate and uses appropriate biological terminology. **(2 marks)**
- Generally organised with minor scientific or presentation errors. **(1 mark)**
- Poor organisation or significant scientific inaccuracies. **(0 marks)**

Total: 20 Marks**Grading Scale**

- **16–20:** Highly Proficient
- **11–15:** Proficient
- **6–10:** Developing
- **0–5:** Emerging

Question 2 (20 Marks)

Using the scenario above, analyse the application of tissue culture in cassava production, focusing on its implementation, outcomes and the entrepreneurial prospects it presents for Ghanaian agriculture.

Criterion 1: Understanding of tissue culture application (5 marks)

- Clearly explains how tissue culture is applied in cassava production and relates it to the scenario. **(5 marks)**

- Gives a generally correct explanation with minor omissions. **(4 marks)**
- Demonstrates partial understanding of tissue culture application. **(2–3 marks)**
- Gives a limited explanation. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 2: Analysis of implementation (5 marks)

- Thoroughly analyses how tissue culture can be implemented, including production, multiplication and distribution of disease-free planting materials. **(5 marks)**
- Gives a good analysis with some omissions. **(4 marks)**
- Gives a basic analysis showing partial understanding. **(2–3 marks)**
- Gives a limited analysis. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 3: Analysis of outcomes (5 marks)

- Clearly evaluates expected outcomes such as increased productivity, improved disease resistance, food security and farmer livelihoods. **(5 marks)**
- Explains most outcomes correctly with minor omissions. **(4 marks)**
- Gives a basic discussion of outcomes. **(2–3 marks)**
- Gives limited discussion. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 4: Entrepreneurial prospects (5 marks)

- Thoroughly evaluates entrepreneurial opportunities such as commercial production of planting materials, agribusiness development, employment creation and income generation. **(5 marks)**
- Gives a good evaluation with minor omissions. **(4 marks)**
- Gives a basic evaluation showing partial understanding. **(2–3 marks)**
- Gives limited discussion. **(1 mark)**
- No relevant response. **(0 marks)**

Total: 20 Marks

Grading Scale

- **16–20:** Highly Proficient
- **11–15:** Proficient
- **6–10:** Developing
- **0–5:** Emerging

Question 3 (20 Marks)

Conduct a comparative analysis of the advantages and disadvantages of seed propagation versus tissue culture propagation methods and evaluate how these factors influence the choice of propagation technique in maize cultivation in different regions of Ghana.

Criterion 1: Comparison of propagation methods (6 marks)

- Presents a comprehensive comparison of seed propagation and tissue culture, identifying appropriate similarities and differences. **(6 marks)**

- Gives a good comparison with minor omissions. **(4–5 marks)**
- Gives a basic comparison showing partial understanding. **(2–3 marks)**
- Gives a limited comparison. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 2: Advantages and disadvantages (6 marks)

- Clearly explains the advantages and disadvantages of both propagation methods using relevant biological principles. **(6 marks)**
- Explains most advantages and disadvantages with minor omissions. **(4–5 marks)**
- Gives a basic explanation showing partial understanding. **(2–3 marks)**
- Gives a limited explanation. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 3: Evaluation of factors influencing method choice (6 marks)

- Critically evaluates factors such as cost, disease prevalence, availability of facilities, scale of production and environmental conditions in different regions of Ghana. **(6 marks)**
- Gives a good evaluation with minor omissions. **(4–5 marks)**
- Gives a basic evaluation showing partial understanding. **(2–3 marks)**
- Gives a limited evaluation. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 4: Scientific accuracy and organisation (2 marks)

- Response is scientifically accurate, logically organised and uses appropriate biological terminology. **(2 marks)**
- Generally accurate with minor errors or weaknesses in organisation. **(1 mark)**
- Poor organisation or significant scientific inaccuracies. **(0 marks)**

Total: 20 Marks

Grading Scale

- **16–20:** Highly Proficient
- **11–15:** Proficient
- **6–10:** Developing
- **0–5:** Emerging

WEEK 3

Question 1: Drought-resistant maize in Ghana

Total: 20 marks

Criterion 1: Understanding of recombinant technology and the scenario (4 marks)

- Clearly explains how recombinant technology may be used to develop drought-resistant maize and links it to food security in northern Ghana. **(4 marks)**
- Gives a generally correct explanation with minor omissions. **(3 marks)**
- Shows partial understanding of the technology or scenario. **(2 marks)**
- Gives a limited or unclear explanation. **(1 mark)**

- No relevant response. **(0 marks)**

Criterion 2: Ecological impact analysis (5 marks)

- Thoroughly evaluates possible ecological impacts, such as gene flow, effects on biodiversity, pest resistance, soil health and ecosystem balance. **(5 marks)**
- Gives a good analysis with minor omissions. **(4 marks)**
- Gives a basic analysis of some ecological impacts. **(2–3 marks)**
- Gives limited or mostly descriptive points. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 3: Socioeconomic impact analysis (5 marks)

- Clearly evaluates impacts on farmers, food security, income, seed access, cost, dependency on seed companies and rural livelihoods. **(5 marks)**
- Gives a good evaluation with minor omissions. **(4 marks)**
- Gives a basic discussion of some socioeconomic impacts. **(2–3 marks)**
- Gives limited points. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 4: Multiple perspectives and scientific evidence (4 marks)

- Considers different perspectives, including farmers, consumers, scientists, environmentalists and policymakers, and supports arguments with sound scientific reasoning. **(4 marks)**
- Considers some perspectives with generally sound reasoning. **(3 marks)**
- Mentions limited perspectives with little scientific support. **(2 marks)**
- Gives one-sided views with weak support. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 5: Presentation and group collaboration (2 marks)

- Presentation is clear, organised, balanced and shows good group participation. **(2 marks)**
- Presentation is fairly clear but has some weaknesses in organisation or participation. **(1 mark)**
- Poor presentation or weak group participation. **(0 marks)**

Question 2: Vitamin A-enhanced crop variety

Total: 20 marks

Criterion 1: Selection and justification of crop (4 marks)

- Selects an appropriate local crop and clearly justifies it based on consumption, adaptability, nutritional need and relevance to Ghanaian communities. **(4 marks)**
- Gives a suitable crop with good but incomplete justification. **(3 marks)**
- Gives a crop with limited justification. **(2 marks)**
- Crop selected is weakly linked to the problem. **(1 mark)**
- No suitable crop selected. **(0 marks)**

Criterion 2: Scientific rationale for vitamin A enhancement (4 marks)

- Clearly explains the link between vitamin A deficiency, beta-carotene/provitamin A and child health. **(4 marks)**

- Gives a generally correct explanation with minor omissions. **(3 marks)**
- Shows partial understanding. **(2 marks)**
- Gives limited or unclear explanation. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 3: Methodology for genetic modification (6 marks)

- Presents a clear and logical methodology, including gene identification, insertion, transformation, selection, testing and multiplication. **(6 marks)**
- Gives a good methodology with minor omissions. **(4–5 marks)**
- Gives a basic methodology showing partial understanding. **(2–3 marks)**
- Gives a limited or inaccurate procedure. **(1 mark)**
- No relevant methodology. **(0 marks)**

Criterion 4: Suitability for Ghanaian conditions (3 marks)

- Clearly considers climate, soil, local farming systems, consumer acceptance and nutritional needs. **(3 marks)**
- Considers some relevant Ghanaian conditions. **(2 marks)**
- Makes limited reference to Ghanaian conditions. **(1 mark)**
- No Ghanaian context. **(0 marks)**

Criterion 5: Presentation and teamwork (3 marks)

- Presentation is clear, well organised, scientifically accurate and shows balanced group participation. **(3 marks)**
- Presentation is generally clear with minor weaknesses. **(2 marks)**
- Presentation is weak or unevenly delivered. **(1 mark)**
- Poor or no presentation. **(0 marks)**

Question 3: Indigenous plants and animals for genetic modification

Total: 20 marks

Criterion 1: Selection of organisms (4 marks)

- Selects two appropriate indigenous plants and two appropriate indigenous animals relevant to food security in Ghana. **(4 marks)**
- Selects three appropriate organisms. **(3 marks)**
- Selects two appropriate organisms. **(2 marks)**
- Selects one appropriate organism. **(1 mark)**
- No appropriate organism selected. **(0 marks)**

Criterion 2: Scientific rationale for modification (6 marks)

- Clearly explains valid reasons for genetic modification, such as improved yield, disease resistance, drought tolerance, nutritional value or growth rate. **(6 marks)**
- Gives good explanations with minor omissions. **(4–5 marks)**
- Gives basic explanations showing partial understanding. **(2–3 marks)**
- Gives limited or weak reasons. **(1 mark)**

- No relevant explanation. **(0 marks)**

Criterion 3: Ecological consequences (5 marks)

- Thoroughly evaluates possible ecological consequences, such as gene flow, loss of biodiversity, effects on wild relatives, food chains and ecosystem balance. **(5 marks)**
- Gives a good evaluation with minor omissions. **(4 marks)**
- Gives a basic discussion of some ecological consequences. **(2–3 marks)**
- Gives limited points. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 4: Link to food security in Ghana (3 marks)

- Clearly explains how the modified organisms could contribute to food availability, nutrition, income and resilience in Ghana. **(3 marks)**
- Gives a reasonable link to food security. **(2 marks)**
- Gives a weak or limited link. **(1 mark)**
- No clear link to food security. **(0 marks)**

Criterion 5: Presentation and group discussion (2 marks)

- Group presents clearly, responds to questions well and shows balanced participation. **(2 marks)**
- Presentation is fairly clear but participation or responses are limited. **(1 mark)**
- Poor presentation or weak collaboration. **(0 marks)**

Grading Scale for Each Question

- **16–20 marks:** Highly Proficient
- **11–15 marks:** Proficient
- **6–10 marks:** Developing
- **0–5 marks:** Emerging

WEEK 4

Case Study Marking Scheme

Question 1: Biological water treatment system

Total: 20 marks

Criterion 1: Understanding of the contamination problem (4 marks)

- Clearly identifies both organic pollutants and heavy metals and explains why they require different biological treatment approaches. **(4 marks)**
- Identifies both pollutant types with a generally correct explanation. **(3 marks)**
- Identifies one pollutant type clearly or shows partial understanding. **(2 marks)**
- Gives a limited or unclear explanation. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 2: Design of biological treatment system (6 marks)

- Designs a logical system that addresses both organic pollutants and heavy metals using appropriate biological methods. **(6 marks)**
- Gives a good design with minor omissions. **(4–5 marks)**

- Gives a basic design that addresses one or both pollutants partially. **(2–3 marks)**
- Gives a limited or impractical design. **(1 mark)**
- No relevant design. **(0 marks)**

Criterion 3: Explanation of biological principles (5 marks)

- Clearly explains relevant biological principles such as biodegradation, bioaccumulation, biosorption, phytoremediation or microbial metabolism. **(5 marks)**
- Gives a good explanation with minor omissions. **(4 marks)**
- Gives a basic explanation of some biological principles. **(2–3 marks)**
- Gives limited or weak explanation. **(1 mark)**
- No relevant explanation. **(0 marks)**

Criterion 4: Evaluation of limitations (3 marks)

- Evaluates realistic limitations such as cost, time, maintenance, toxicity to organisms, incomplete removal and safe disposal of contaminated biomass. **(3 marks)**
- Gives some relevant limitations. **(2 marks)**
- Gives one limited point. **(1 mark)**
- No limitations discussed. **(0 marks)**

Criterion 5: Scientific accuracy and organisation (2 marks)

- Response is scientifically accurate, logical and well organised. **(2 marks)**
- Response is generally accurate but has minor weaknesses. **(1 mark)**
- Response is poorly organised or contains major inaccuracies. **(0 marks)**

Question 2: Conventional mining and biomining

Total: 20 marks

Criterion 1: Comparison of conventional mining and biomining (4 marks)

- Clearly compares both methods in terms of process, scale, resources required and suitability for different ore grades. **(4 marks)**
- Gives a good comparison with minor omissions. **(3 marks)**
- Gives a basic comparison showing partial understanding. **(2 marks)**
- Gives a limited comparison. **(1 mark)**
- No relevant comparison. **(0 marks)**

Criterion 2: Biological mechanisms of biomining (5 marks)

- Clearly explains how microorganisms assist metal extraction through processes such as bioleaching, oxidation of minerals or production of acidic conditions. **(5 marks)**
- Gives a good explanation with minor omissions. **(4 marks)**
- Gives a basic explanation of biomining mechanisms. **(2–3 marks)**
- Gives limited explanation. **(1 mark)**
- No relevant explanation. **(0 marks)**

Criterion 3: Environmental impact analysis (4 marks)

- Thoroughly analyses environmental impacts of both methods, including land disturbance, water pollution, chemical use, waste generation and possible reduction of impact through biomining. **(4 marks)**
- Gives a good analysis with minor omissions. **(3 marks)**
- Gives a basic analysis of some environmental impacts. **(2 marks)**
- Gives limited points. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 4: Economic viability (3 marks)

- Evaluates cost, technology needs, time, ore grade, labour, infrastructure and commercial feasibility. **(3 marks)**
- Gives a reasonable discussion of economic viability. **(2 marks)**
- Gives a limited economic point. **(1 mark)**
- No economic discussion. **(0 marks)**

Criterion 5: Optimisation for low-grade ore in a water-sensitive region (4 marks)

- Proposes a practical optimisation strategy considering water conservation, containment, microbial selection, monitoring, site conditions and environmental safeguards. **(4 marks)**
- Gives a good strategy with minor omissions. **(3 marks)**
- Gives a basic strategy with limited detail. **(2 marks)**
- Gives a weak or impractical strategy. **(1 mark)**
- No relevant strategy. **(0 marks)**

Question 3: Algal blooms and bio-oil production**Total: 20 marks****Criterion 1: Understanding of eutrophication and algal blooms (4 marks)**

- Clearly explains how nutrient-rich runoff causes excessive algal growth and why this creates environmental problems. **(4 marks)**
- Gives a generally correct explanation with minor omissions. **(3 marks)**
- Gives a basic explanation showing partial understanding. **(2 marks)**
- Gives a limited or unclear explanation. **(1 mark)**
- No relevant response. **(0 marks)**

Criterion 2: Biological processes in bio-oil production (5 marks)

- Clearly explains relevant biological processes such as algal growth, photosynthesis, biomass accumulation, lipid production and conversion to bio-oil. **(5 marks)**
- Gives a good explanation with minor omissions. **(4 marks)**
- Gives a basic explanation of some biological processes. **(2–3 marks)**
- Gives limited explanation. **(1 mark)**
- No relevant explanation. **(0 marks)**

Criterion 3: Strategy for implementation (5 marks)

- Presents a logical strategy for collecting or cultivating algae, managing nutrient inputs, processing biomass and producing bio-oil. **(5 marks)**
- Gives a good strategy with minor omissions. **(4 marks)**
- Gives a basic strategy with partial detail. **(2–3 marks)**
- Gives a limited or impractical strategy. **(1 mark)**
- No relevant strategy. **(0 marks)**

Criterion 4: Evaluation of benefits and challenges (4 marks)

- Thoroughly evaluates benefits and challenges, including pollution reduction, renewable energy, cost, technology needs, ecological risks and sustainability. **(4 marks)**
- Gives a good evaluation with minor omissions. **(3 marks)**
- Gives a basic evaluation of some benefits or challenges. **(2 marks)**
- Gives limited points. **(1 mark)**
- No relevant evaluation. **(0 marks)**

Criterion 5: Scientific accuracy and organisation (2 marks)

- Response is scientifically accurate, well organised and clearly linked to the case study. **(2 marks)**
- Generally accurate with minor weaknesses. **(1 mark)**
- Poorly organised or scientifically inaccurate. **(0 marks)**

Grading Scale for Each Question

- **16–20 marks:** Highly Proficient
- **11–15 marks:** Proficient
- **6–10 marks:** Developing
- **0–5 marks:** Emerging

SECTION 2: CYTOLOGY

STRAND: LIFE IN THE FUNDAMENTAL UNIT

Sub-strand: Cell Structure and Functions

Learning Outcomes

1. Explain key terms and their applications in Genetics.
2. Relate Mendel's laws and concepts of inheritance to human blood groups and their importance.

Content Standards

1. Demonstrate understanding of the concept of Genetics.
2. Demonstrate knowledge and understanding of Mendel's laws and concepts of inheritance, blood groups and their applications in life.

INTRODUCTION AND SECTION SUMMARY

In the second year, the DNA synthesis leading to protein synthesis and its relevance in living things were discussed. The DNA being the genetic material that governs inheritance and variation within eukaryotic cells. The nucleus contains chromosomes composed of DNA, which carry genes determining traits passed from parents to offspring. During the cell cycle, genetic material is duplicated and distributed through mitosis for growth and repair, or through meiosis for sexual reproduction, creating genetic variation. This genetic foundation underlies Mendelian inheritance patterns observable in traits like blood groups, which follow principles of dominance, segregation, and independent assortment. Our understanding in cell structure and functions, throws more light on how genetic information is organized, expressed, and transmitted, connecting microscopic cellular processes to macroscopic traits and evolutionary mechanisms. This knowledge has profound applications in medicine, agriculture, and biotechnology, making genetics central to modern biological sciences. The weeks with their indicators covered in this section are

Week 5: Explain the application of the key terminologies in the study of Genetics

Week 6: Explain Mendel's laws of inheritance.

Week 7: Explain Mendel's laws of inheritance.

Week 8: Discuss why it is necessary to know one's blood group and Rhesus factor in classification.

Week 9: Discuss variation and its causes, stating the processes and factors affecting each. Describe the application of principles of variation among humans to improve life.

Week 10: Describe various evidence of the processes (theories) of evolution and the factors affecting them.

Week 11: Describe the cell cycle and relate it to how mitosis and meiosis occur in a living cell.

Recap weeks

Year 1	week
Year 2	Week 10: Describe how proteins are formed in the cell and explain the importance of protein synthesis in living things

SUMMARY OF PEDAGOGICAL EXEMPLARS

The teaching of genetics, inheritance patterns, and cell division will be effectively facilitated through diverse pedagogical approaches to enhance better understanding. These varying pedagogies ensure that every learner appreciates the lessons discussed regardless of their learning background. For instance, individual learning supports differentiated instruction by providing personal research opportunities on key genetic terminology, allowing students to create personalized glossaries and genetic concept maps at their own pace. Talk for learning cultivates scientific discourse through structured debates on blood group compatibility or guided discussions about Mendelian inheritance patterns observed in family traits. Experiential learning transforms abstract concepts into tangible realities through blood typing simulations, microscope observations of cell division stages, or interactive chromosome modelling activities. Project-based learning deepens understanding through multi-week investigations where learners create family pedigrees tracking inheritance patterns, design digital animations of meiosis and mitosis, or develop educational materials explaining blood type compatibility for a community health campaign. These complementary approaches accommodate diverse learning styles while building critical thinking skills essential for understanding complex genetic principles.

ASSESSMENT SUMMARY

Indicators	DOK Level	Assessment Strategy and/or Mode
Explain the application of the key terminologies in the study of Genetics	Level 3	Class exercise
Explain Mendel's laws of inheritance	Level 4	Group assignment
Explain Mendel's laws of inheritance	Level 4	Case study presentation
Discuss why it is necessary to know one's blood group and Rhesus factor classification.	Level 4	demonstration
Discuss variation and its causes, stating the processes and factors affecting each.	Level 4	Group research
Describe the application of principles of variation among humans to improve life.	Level 4	homework
Describe the various evidence of the processes (theories) of evolution and the factors affecting them.	Level 4	Class exercise
Describe the cell cycle and relate it to how mitosis and meiosis occur in a living cell.	Level 4	Group discussion

WEEK 5

Learning Indicator: Explain the application of the key terminologies in the study of Genetics

FOCAL AREA 1: GENETIC TERMS AND THEIR MEANINGS

Genetics

Genetics is the branch of biology that studies **heredity** and **variation** in organisms. It involves understanding how traits and characteristics are passed down from one generation to another through **genes**.

Heredity is the process by which genetic traits and characteristics are passed from parents to their offspring. This fundamental principle of biology that explains how traits are inherited through generations.

Genes are segments of DNA that carry the information for specific traits necessary for the development and functioning of living beings. How these traits/genes are inherited determines similarities between individuals and their parents.

Variation refers to the differences in inherited traits and characteristics among individuals within a population. It underlies the mechanisms of natural selection and adaptation.



Figure 2.1: *Variety of dog species*

Key concepts/terms used in this section are outlined below:

Alleles: Different forms of a gene that can exist at a specific locus (location on a chromosome) and can lead to variations in traits.

Genotype: The genetic makeup of an organism. This is represented by the alleles it carries. e.g., AA, Aa, or aa.

Phenotype: The observable characteristics or traits of an organism determined by its genotype and environmental influences. e.g., purple or white flowers.

Purebred: A purebred organism is one that comes from a lineage of ancestors that are genetically uniform for a specific trait or traits. This means that the organism has consistently inherited the same alleles from its parents.

P Generation (Parental Generation): The original parents used in a genetic cross. Their genotypes determine the characteristics of the offspring produced.

First Filial (F₁) Generation: The first generation of offspring produced from the cross between the parental (P) generation. The characteristics of the F₁ generation depend on the genotypes of the parental organisms.

Second Filial (F₂) Generation: The second generation of offspring produced by crossing or self-fertilising individuals from the F₁ generation. The characteristics of the F₂ generation depend on the genotypes of the F₁ individuals and may show different combinations of inherited traits.

Dominant allele: An allele that is expressed in the phenotype when at least one copy is present in the genotype. It masks the expression of a recessive allele in a heterozygous individual.

Recessive allele: it is the allele that only expresses its trait in the phenotype when two copies are present in the genotype. This means that an individual must have two recessive alleles for a specific trait to display that trait.

Homozygous: An organism with two identical alleles for a particular gene.

Heterozygous: An organism with two different alleles for a particular gene.

Monohybrid Cross: A genetic cross that examines the inheritance of a single trait. For example, crossing two heterozygous pea plants (Aa x Aa) to study flower colour.

Dihybrid Cross: A genetic cross that examines the inheritance of two traits simultaneously (e.g., seed shape and colour).

Test cross: it is a genetic cross performed to determine the genotype of an individual expressing a dominant phenotype. It involves crossing the individual in question with a homozygous recessive individual for the trait being examined.

Punnett Square: A grid used to predict the genotypes and phenotypes of offspring from a cross between two parents.

Mendelian Inheritance

Gregor Mendel (1822- 1884) was a monk born in Austria. He was a botanist, teacher, who performed breeding experiments with pea plants (*Pisum sativum*) in the monastery garden to examine patterns of inheritance.



Figure 2.2: Gregor Mendel

When two true bred plants (P generation) that differed in a single trait (round peas vs. wrinkled seeds, short stems vs. tall stems, white flowers vs. purple flowers, etc) were crossed, Mendel found that

the next generation/ first offspring, (F₁) comprised whole individuals that exhibited only one trait. However, after the first generation was interbred, its offspring which is the second generation(F₂) showed a 3:1 ratio wherein three individuals had similar traits like a parent. Through meticulous breeding experiments, he formulated the foundational principles of inheritance, now known as Mendel's Laws of Segregation and Independent Assortment. In the early 20th century, scientists rediscovered Mendel's work, leading to the establishment of genetics as a distinct field. Mendel is often referred to as the "father of modern genetics" due to his pioneering work in understanding inheritance patterns, which laid the groundwork for the field of genetics. His principles are still fundamental to biological sciences today.

Learning Tasks

1. Create a glossary of terms, from history and key concepts of genetics.
2. Design a concept map of the relationship between the terms identified.
3. Discuss the meaning of four selected terms.

Pedagogy Exemplars

Individual/Independent Learning Approach: Learner researches from textbooks, the Internet, libraries and other relevant sources, the background to the study of genetics, and terms used in describing genetic processes and activities; the learner believes in the capacity to work independently when required and learns diverse learning experiences from other peers in similar research assignments. Learner develops the necessary emotional and psychological strength to work that accompanies independent working.

Talk for Learning: In mixed ability, all-inclusive groups, brainstorm and discuss the key terminologies used in genetics (e.g., heredity, traits, chromosomes, genotypes, etc): Each member of a group is assigned at least a term to discuss before the class: Learner develops self-confidence by learning to speak before peers. Peers of the same group learn to offer the required social and emotional support to their members during the class discussion.

Key Assessment Level 3: Class Exercise

1. **Differentiate between** dominant and recessive alleles.
2. **Explain** the concepts of homozygous and heterozygous genotypes.
3. **Outline** the historical context of Mendel's work and its rediscovery in the early twentieth century.
4. **Describe** the P (parental), F₁ (first filial) and F₂ (second filial) generations in genetic crosses.

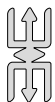
PLC Session 5

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to

- a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
- b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
- c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

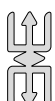
4. Plan the week's key assessment with your app

- a. The key assessment for the week is **class exercise**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?

iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 6

Learning Indicator 1: Explain Mendel's laws of inheritance

FOCAL AREA: MENDEL'S FIRST LAW OF INHERITANCE (LAW OF SEGREGATION)

Mendelian Inheritance

In Mendel's classic monohybrid cross, the parental (P) plants were homozygous, with one parent having the dominant genotype (AA) and the other having the recessive genotype (aa). Their offspring (F₁ generation) were all heterozygous (Aa). When the F₁ individuals were crossed, the F₂ generation consisted of the genotypes AA, Aa and aa. The combination of alleles inherited from the parents determines the organism's genotype, while the interaction between the alleles influences the phenotype (the observable or measurable characteristic).

Gregor Mendel's experiments with pea plants established foundational principles of heredity. Mendel's conclusions could be described in the following principles/laws:

Mendel's first law of inheritance (Law of Segregation)

This first law states that, *During the formation of gametes, the two alleles for a trait separate from each other so that each gamete carries only one allele.*

When fertilisation occurs, the offspring receives one allele from each parent. Which allele is inherited from a parent is determined by chance during fertilisation?

When Mendel crossed contrasting, true-breeding white- and purple-flowered pea plants, all the F₁ hybrids were purple. When Mendel crossed the F₁ hybrids, many of the F₂ plants had purple flowers, but some had white. Mendel discovered a ratio of about three purple flowers to one white flower in the F₂ generation. Mendel reasoned that only the purple flower factor was affecting flower colour in the F₁ hybrids. Mendel called the purple flower colour a dominant trait and the white flower colour a recessive trait. The factor for white flowers was not diluted or destroyed because it reappeared in the F₂ generation

Mendel observed the same pattern of inheritance in six other pea plant characters, each represented by two traits. What Mendel called a "heritable factor" is what is now call a gene.

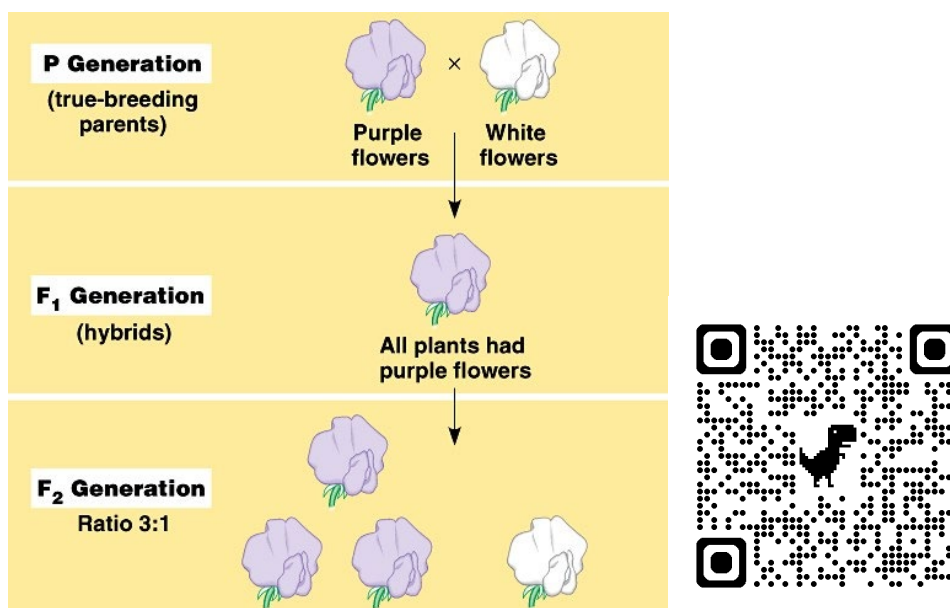


Figure 2.3: Illustration of the law of segregation

- A gene may exist in two or more alternative forms called alleles.
- During meiosis, the two alleles of a gene separate so that each gamete receives only one allele.
- Every organism inherits one allele for a gene from each parent.
- The two alleles of a gene may be the same (homozygous) or different (heterozygous).

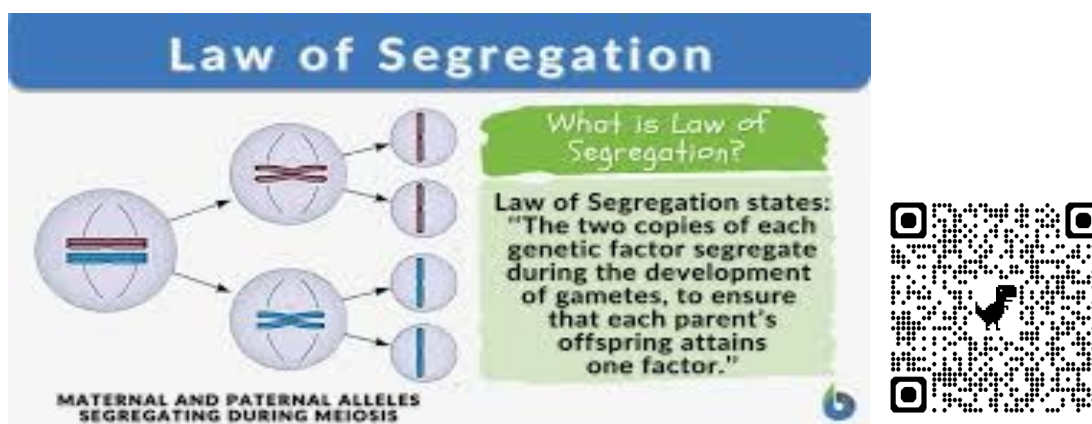


Figure 4: Segregation during cell division

Learning Tasks

1. Investigate **Mendel's experiments on genetic inheritance** and identify the characteristics he studied using pea plants.
2. Identify variations in inherited characteristics among organisms in the environment and relate **them** to the concepts of dominant and recessive traits.
3. Use simple models or genetic crosses to demonstrate **Mendel's Law of Segregation**.
4. Identify and distinguish between dominant and recessive traits using appropriate examples.

Pedagogical Exemplars

1. Experiential, Project-Based Learning

In mixed-ability, all-inclusive groups, learners research Mendel's experiments using pea plants from textbooks, libraries and other learning resources. Where possible, the class visits a nearby farm or school garden to observe variations in the characteristics of plants and other organisms. Learners also examine charts, photographs and simple genetic diagrams illustrating **monohybrid inheritance and Mendel's Law of Segregation**. They record their observations, discuss their findings in groups and present their conclusions to the class. This activity promotes collaboration, observation, communication and critical thinking.

2. Task-Based Learning Approach

Using coloured marbles, beads or counters to represent alleles, learners model the separation of alleles during gamete formation and demonstrate **Mendel's Law of Segregation**. Learners work in groups to predict possible offspring genotypes from simple genetic crosses and compare their predictions with those of other groups. The activity strengthens learners' understanding of allele segregation through practical experience.

3. Talk-for-Learning Approach

Using practical examples, learners discuss how **Mendel's Law of Segregation** explains the inheritance of characteristics from parents to offspring. In groups, learners explain why offspring may inherit different combinations of alleles and present their ideas to the class. The teacher guides the discussion by asking probing questions that encourage learners to justify their responses using appropriate biological concepts.

Key Assessment Level 4: Mid-Semester Examination

1. Relate a specific example of genetic variation in a population to Mendel's principles of inheritance. How does this variation support or challenge Mendelian concepts?
2. Research on how environmental factors can influence phenotypic expression of traits in organisms. Provide examples that illustrate the interaction between genetics and the environment.

HINT



Conduct *Mid-semester Examination*. It should cover the contents taught from Week 1 to 5. Refer to the *Table of Specification and Structure of the Paper*. Learners' papers should be marked immediately and scores entered into the SAP.

Structure of Mid-Semester Examination

Section A: 25 Multiple-choice questions

Section B: 2 Essay Questions

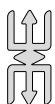
Table of specification for item construction for section A and B

Week	Learning Indicator	Types of questions	DoK Levels				Total
			1	2	3	4	
1	Describe the biological principles behind the preparation of some local foods and be beverages	MCQs	2	2	-		4
		ESSAY	-	-	-		-
2	Describe the process of tissue culture and its application in food production	MCQs	2	2	2		6
		ESSAY	-	-	1		1
3	Describe how genetic recombinant technology is applied in biotechnology for the production of GMOs	MCQs	-	2	1		3
		ESSAY	-	-	-		
4	Describe the application of biological concepts in the treatment of water, extraction of minerals (e.g., gold) and production of bio-oils	MCQs	3	2	1		6
		ESSAY					
5	Explain the application of the key terminologies in the study of Genetics	MCQs	1	3	2		6
		ESSAY			1		1
		Total	8	11	8		27

PLC Session 6

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

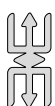

Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).
 - a. The key assessment for the week is **mid-semester examination**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the mid-semester examination (NTS 3k-3q).

10 minutes
Content Exploration

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through the problem individually for 3–4 minutes
 - c. the group then works through it together the problem, step by step
 - d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).


Note

- This part is not 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 7

Learning Indicator 1: Explain Mendel's laws of inheritance

FOCAL AREA: MENDEL'S LAW OF DOMINANCE AND MENDEL'S SECOND LAW OF INHERITANCE (LAW OF INDEPENDENT ASSORTMENT)

Law of Dominance

Mendel's law of dominance states "When parents with pure, contrasting traits are crossed together, only one form of trait appears in the next generation. The hybrid offsprings will exhibit only the dominant trait in the phenotype."

In a heterozygous organism (having two different alleles for a trait), the dominant allele will mask the expression of the recessive allele, resulting in the dominant phenotype being displayed while recessive alleles are always masked by dominant alleles. Hence, a cross between a homozygous recessive and a homozygous dominant shows the dominant phenotype by still having a heterozygous genotype.

This law could be further explained by the monohybrid cross experiment. In the case of a cross among the two organisms with contrasting traits, the character that is visible in the F₁ generation is known as dominant and the one that is suppressed is known as recessive. Every character is handled by a pair of dissimilar factors and only one among the characters shows the results.

Monohybrid cross

A **monohybrid cross** is a genetic cross that involves **one gene or one pair of contrasting traits**. It is used to study how a single characteristic is inherited from one generation to the next.

In his experiments, Mendel studied traits such as **tall versus dwarf plants** by crossing pea plants with different genotypes. Depending on the genotypes of the parents, different offspring genotypes and phenotypes may be produced.

Parent Generation (P Generation)

The **parental (P) generation** consists of the original parents used in a genetic cross. Their genotypes determine the genotypes and phenotypes of the offspring. The parents may be **homozygous or heterozygous**, depending on the purpose of the cross.

Example: In Mendel's classic monohybrid experiment, the parental plants were **TT (homozygous tall)** and **tt (homozygous dwarf)**.

First Filial (F₁) Generation

The **F₁ generation** is the first generation of offspring produced from the parental (P) generation. The genotypes and phenotypes of the F₁ offspring **depend on the genotypes of the parental plants**.

Example: In Mendel's classic cross (TT × tt), all F₁ offspring had the genotype **Tt** and expressed the dominant trait (tall).

Second Filial (F₂) Generation

The **F₂ generation** is produced by crossing or self-fertilising individuals from the F₁ generation. The genotypes and phenotypes of the F₂ offspring **depend on the genotypes of the F₁ parents**.

Example: In Mendel's classic experiment, crossing $Tt \times Tt$ produced offspring with a **genotypic ratio of 1 TT : 2 Tt : 1 tt** and a **phenotypic ratio of 3 tall : 1 dwarf**.

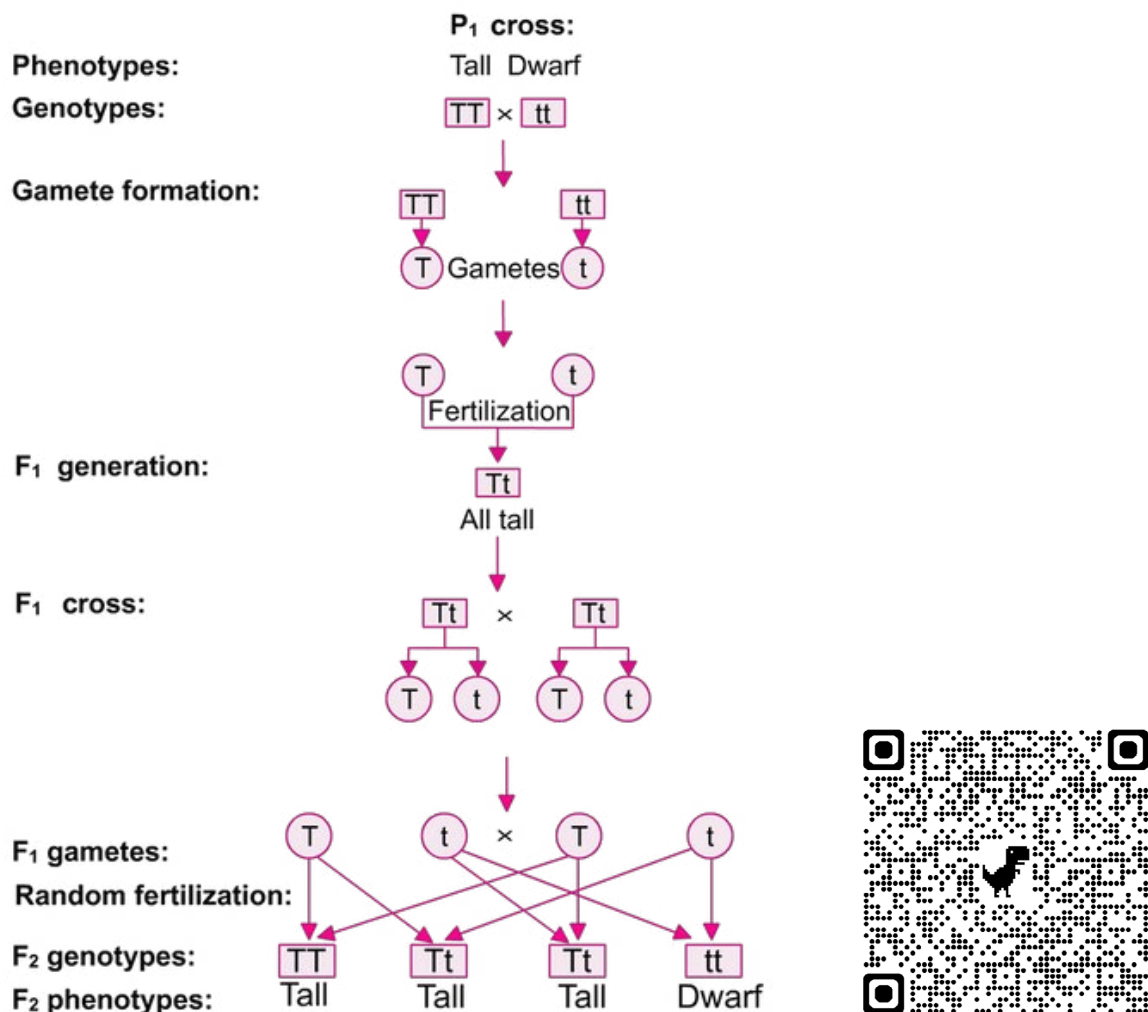


Figure 2.5: Monohybrid genetic mapping

Table 1: Punnett square showing the cross of the P generation resulting in the F₁ generation

♀ \ ♂	t	t
T	Tt	Tt
T	Tt	Tt

Table 2: Punnett square showing the cross of the F₁ generation, resulting in the F₂ generation.

♀ \ ♂	T	t
T	TT	Tt
t	Tt	tt

Genotypic ratio----- 1TT:2Tt:1tt

Phenotypic ratio----3 tall plants: 1 short plant

Typical examples of **monohybrid inheritance** in humans include **tongue rolling** (R) versus inability to roll the tongue (r), **cleft chin** (C) versus smooth chin (c), **free earlobes** (E) versus attached earlobes (e), **widow's peak** (W) versus a straight hairline (w), and **normal pigmentation** (A) versus **albinism** (a), where normal pigmentation is dominant over albinism.

Law of Independent Assortment

Mendel's **Law of Independent Assortment** states that **alleles of different genes assort independently into gametes during meiosis**. Consequently, the inheritance of one trait generally does not influence the inheritance of another trait **when the genes controlling the traits are located on different chromosomes or are sufficiently far apart on the same chromosome**. This independent assortment produces different combinations of alleles in the offspring.

The Law of Independent Assortment can be illustrated using a **dihybrid cross**, which follows the inheritance of two different genes simultaneously. In Mendel's classic experiments, the two genes studied assorted independently because they were located on different chromosomes. Consequently, the offspring exhibited various combinations of the two traits according to the principles of independent assortment.

Dihybrid cross

Consider the characteristics of seed colour and seed texture for two pea plants, one that has green, wrinkled seeds (*yyrr*) and another that has yellow, round seeds (*YYRR*). Because each parent is homozygous, the law of segregation indicates that the gametes for the green/wrinkled plant all are *yr*, and the gametes for the yellow/round plant are all *YR*. Therefore, the F_1 generation of offspring are all *YyRr*.

For the F_2 generation, each gamete receives either an *R* allele or an *r* allele and either a *Y* allele or a *y* allele. The law of independent assortment states that a gamete into which an *r* allele sorted would be equally likely to contain either a *Y* allele or a *y* allele. Thus, there are four equally likely gametes that can be formed when the *YyRr* heterozygote is self-crossed, as follows: *YR*, *Yr*, *yR*, and *yr*.

Arranging these gametes along the top and left of a 4×4 Punnett square gives us 16 equally likely genotypic combinations. From these genotypes, we see a phenotypic ratio of 9 round/yellow:3 round/green:3 wrinkled/yellow:1 wrinkled/green as shown in Figure 2. 6. These are the offspring ratios we would expect, assuming we performed the crosses with a large enough sample size.

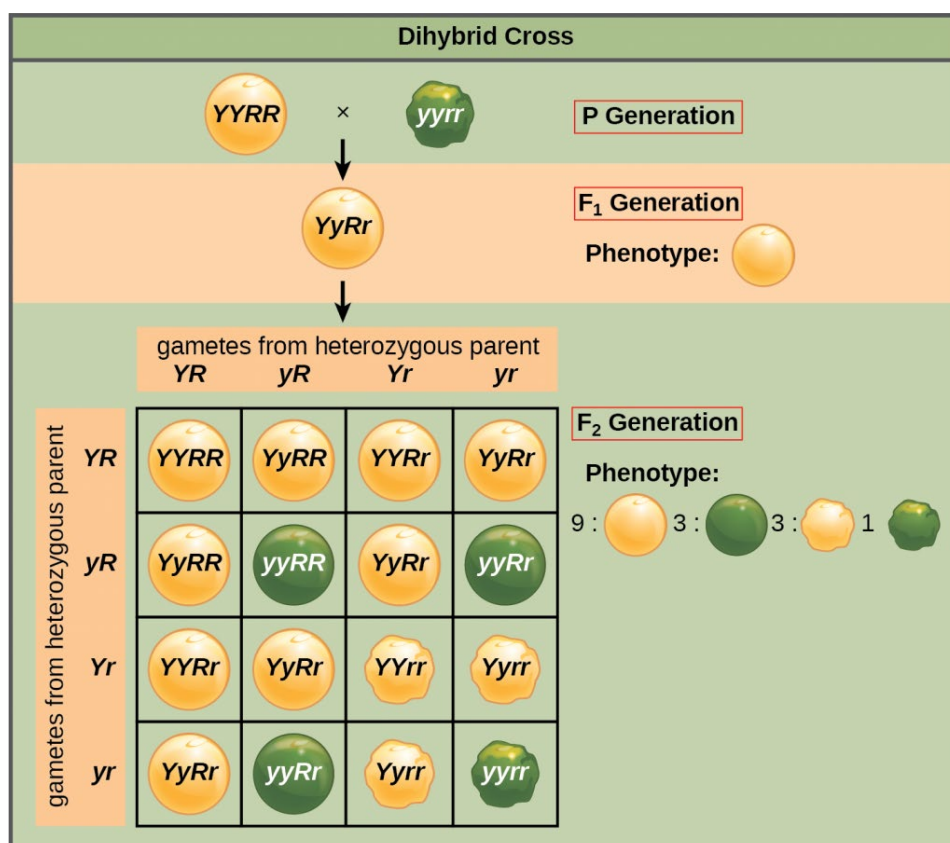


Figure 2.6: Dihybrid cross of pea plants involving the genes for seed colour and texture

Because of independent assortment and dominance, the 9:3:3:1 dihybrid phenotypic ratio can be collapsed into two 3:1 ratio, characteristic of any monohybrid cross that follows a dominant and recessive pattern. Ignoring seed colour and considering only seed texture in the above dihybrid cross, we would expect that three quarters of the F₂ generation offspring would be round, and one quarter would be wrinkled. Similarly, isolating only seed colour, we would assume that three quarters of the F₂ offspring would be yellow, and one quarter would be green. The sorting of alleles for texture and colour are independent events.

The proportion of round and yellow F₂ offspring is expected to be 9/16, and the proportion of wrinkled and green offspring is expected to be 1/16. Round, green and wrinkled, yellow offspring can be found in proportions of 3/16, as each of these genotypes includes one dominant and one recessive phenotype.

The law of independent assortment also indicates that a cross between yellow, wrinkled (YYrr) and green, round (yyRR) parents would yield the same F₁ and F₂ offspring as in the YYRR × yyrr cross.

Learning Tasks

1. Construct Punnett squares for given monohybrid and dihybrid crosses to predict the possible genotypes and phenotypes of the offspring.
2. Use Punnett squares to determine the expected genotypic and phenotypic ratios resulting from different genetic crosses.
3. Analyse simple inheritance scenarios to explain how Mendel's Law of Dominance, Law of Segregation and Law of Independent Assortment account for the observed patterns of inheritance.
4. Construct a simple family pedigree using given inherited characteristics and identify the possible pattern of inheritance.

Pedagogical Exemplars

1. **Experiential, Project-Based Learning:** In mixed ability, all-inclusive groups, learners research from textbooks and libraries on Mendel's experiments with the pea plant, and the class embarks on a visit to a nearby farm (e.g., the school farm) where learners may observe common organisms used as models for genetic experiments. Equally, learners may observe charts and pictures showing the results of Mendel's experiments on monohybrid and dihybrid inheritance. Learners note their observations for presentation. Learners develop self and group emotional support and social support in these activities.
2. **Task-Based Learning Approach:** Using marbles of different colours demonstrate the application of Mendel's first law (law of segregation), second law (law of independent assortment, and third law (the law of Dominance) of inheritance in mixed ability, all-inclusive groups. Learners acquire self-confidence and emotional satisfaction by experiencing genetic principles and how they work through such simple exercises.
3. **Talk-for-Learning Approach:** Using practical examples, discuss, based on the groups, how Mendel's laws can be applied to ensure the breeding of off-springs with desired characteristics: Learners learn from one another in group presentations and boost their confidence in contributing to group work.

Key Assessment Level 4: Case Study

1. A monohybrid cross is carried out between two heterozygous pea plants ($Rr \times Rr$). Construct a Punnett square to determine the expected genotypic and phenotypic ratios of the offspring. Explain how the results demonstrate Mendel's Law of Segregation.
2. In a genetic cross, a homozygous purple-flowered pea plant (PP) is crossed with a heterozygous purple-flowered pea plant (Pp). Construct a Punnett square and determine the expected genotypic and phenotypic ratios of the offspring. Explain how the inheritance pattern illustrates Mendel's Law of Segregation.
3. A plant breeder crosses two pea plants that differ in seed colour and seed texture. Using a Punnett square, predict the possible genotypes and phenotypes of the offspring and explain how the results illustrate Mendel's Law of Independent Assortment.
4. Explain how Mendel's experiments with pea plants contributed to the development of modern genetics. In your answer, describe the key principles established through his experiments and explain their importance in understanding inheritance.
5. Compare Mendel's Law of Segregation with Mendel's Law of Independent Assortment. Use appropriate genetic crosses to illustrate the difference between the two laws.

Multiple Choice Questions

1. In cocoa plants, resistance to black pod disease is determined by a dominant allele **R**, while susceptibility is determined by the recessive allele **r**. Pod colour is controlled by another gene, with brown (**B**) dominant over green (**b**). A farmer crosses two heterozygous plants (**RrBb** $\times$ **RrBb**). What proportion of the offspring is expected to be **resistant with green pods**?
2. Which phenotypic ratio is expected from a **dihybrid cross** between two heterozygous parents (**YyRr** $\times$ **YyRr**) when the genes assort independently?
 - A. 3 : 1
 - B. 1 : 2 : 1
 - C. 9 : 3 : 3 : 1
 - D. 1 : 1

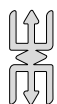
3. Which of the following best illustrates **Mendel's Law of Segregation**?
 - A. Different genes assort independently during gamete formation.
 - B. Each gamete receives only one allele for each gene during meiosis.
 - C. Dominant alleles always occur more frequently than recessive alleles.
 - D. All offspring are genetically identical to their parents.
4. A homozygous tall pea plant (**TT**) is crossed with a homozygous dwarf pea plant (**tt**). What is the genotype of all the **F₁** offspring?
 - A. TT
 - B. tt
 - C. Tt
 - D. TT and tt
5. Which statement correctly describes **Mendel's Law of Independent Assortment**?
 - A. Every offspring receives identical alleles from both parents.
 - B. Alleles of different genes assort independently into gametes when the genes are located on different chromosomes or are far apart on the same chromosome.
 - C. Dominant alleles always mask recessive alleles.
 - D. Each gamete receives two alleles for every gene.
6. A cross between two **heterozygous black guinea pigs (Bb × Bb)** produces black and white offspring. What are the most likely genotypes of the **parental (P) generation**?
 - A. BB × BB
 - B. BB × Bb
 - C. Bb × Bb
 - D. BB × bb

PLC Session 7

45 minutes

Planning & Reviewing the Learning Plan

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2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
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Note

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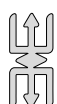
4. Plan the week's key assessment with your app

- The key assessment for the week is **case study**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the case study (NTS 3k-3q).

10 minutes

Content Exploration

- As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - all teachers in the group work through a similar problem individually for 3–4 minutes
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30 minutes

Enactment

- Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
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5 minutes

Reflection

- Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
- Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).

9. Remember to

- a. transfer your chats into your learning planner template.
- b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
- c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 8

Learning Indicator 2: Discuss why it is necessary to know one's blood group and Rhesus factor classification

FOCAL AREA: BLOOD GROUPING

Human blood is classified into two major blood group systems: the **ABO blood group system**, first described by Karl Landsteiner in 1901, and the **Rhesus (Rh) blood group system**, which was discovered by Karl Landsteiner and Alexander S. Wiener in 1940. These blood group systems are widely used in blood transfusion and medical practice.

The ABO Blood Group System

The ABO blood group system classifies human blood according to the presence or absence of **antigens** A and B on the surface of red blood cells (erythrocytes).

Antigen: A substance, usually a protein or glycoprotein, that is recognised by the immune system and can stimulate the production of antibodies.

Antibody: A protein produced by the immune system in response to a specific antigen. Antibodies help protect the body by recognising and neutralising foreign substances.

There are four main blood groups in the ABO blood group system:

- Blood Group A:** Has antigen A on the red blood cells and antibody anti-B in the plasma.
- Blood Group B:** Has antigen B on the red blood cells and antibody anti-A in the plasma.
- Blood Group AB:** Has both antigens A and B on the red blood cells but neither anti-A nor anti-B antibodies in the plasma.
- Blood Group O:** Has neither antigen A nor antigen B on the red blood cells but has both anti-A and anti-B antibodies in the plasma.

The ABO blood group is controlled by a single gene (**ABO**) that has **multiple alleles**.

Multiple alleles: A condition in which a gene exists in more than two alternative forms (alleles) within a population, although each individual inherits only two alleles, one from each parent.

The three alleles controlling the ABO blood group are I^A , I^B , and i .

The I^A and I^B alleles are **codominant**, meaning that when both are present, they are expressed equally, producing blood group **AB**. Both I^A and I^B are dominant over the i allele, which is recessive. Consequently:

- $I^A I^A$ or $I^A i$ produces blood group **A**.
- $I^B I^B$ or $I^B i$ produces blood group **B**.
- $I^A I^B$ produces blood group **AB**.
- ii produces blood group **O**.

Table 3

Blood group	Antigen	Antibody	Phenotype	Possible Genotypes
A	A	B	A	$I^A I^A$ or $I^A i^O$ (AA or AO)
B	B	A	B	$I^B I^B$ or $I^B i^O$ (BB or BO)
AB	A and B	None	AB	$I^A I^B$ (AB)
O	None	A and B	O	$i^O i^O$ (OO)

The inheritance of ABO blood groups follows Mendelian principles involving **multiple alleles** and **codominance**. For example, when two parents with blood group **O** (genotype **ii**) have children, all their offspring will have blood group **O**.

If a heterozygous blood group **A** parent ($I^A i$) is crossed with a blood group **O** parent (**ii**), each child has a **50% chance** of having blood group **A** and a **50% chance** of having blood group **O**.

Similarly, if a heterozygous blood group **A** parent ($I^A i$) is crossed with a heterozygous blood group **B** parent ($I^B i$), the offspring may have any of the four blood groups (**A**, **B**, **AB**, or **O**), depending on the combination of alleles inherited.

Blood group distribution varies among different populations. Globally, blood group **O** is the most common. In Ghana, the approximate distribution is:

- Blood Group O:** 50–55%
- Blood Group A:** 20–25%
- Blood Group B:** 20–22%
- Blood Group AB:** 3–5%

Blood Transfusion

Blood transfusion is the process of transferring blood or blood components from one person (the **donor**) to another person (the **recipient**). Successful blood transfusion requires compatibility between the donor's and recipient's blood groups.

Compatibility is the ability of donated blood to be safely transfused into a recipient without causing harmful immune reactions.

Agglutination is the clumping together of red blood cells that occurs when antibodies in the recipient's plasma react with incompatible antigens on the donor's red blood cells. Agglutination can block blood vessels and may lead to serious or life-threatening complications.

Individuals with blood group **O** can donate red blood cells to all ABO blood groups and are therefore referred to as **universal donors**. Individuals with blood group **AB** can receive red blood cells from all ABO blood groups and are referred to as **universal recipients**.

Signs of a transfusion reaction include fever, chills, lower back pain, difficulty in breathing, kidney failure, shock and, in severe cases, death.

Table 4: shows the compatibility of donor and recipient blood groups for blood transfusion.

Recipient	Donor							
	O-	O+	A-	A+	B-	B+	AB-	AB+
O-	✓	×	×	×	×	×	×	×
O+	✓	✓	×	×	×	×	×	×
A-	✓	×	✓	×	×	×	×	×
A+	✓	✓	✓	✓	×	×	×	×
B-	✓	×	×	×	✓	×	×	×
B+	✓	✓	×	×	✓	✓	×	×
AB-	✓	×	✓	×	✓	×	✓	×
AB+	✓	✓	✓	✓	✓	✓	✓	✓

Keys: ✓ = *Compatible*, × = *Incompatible*

Importance of Knowing One's Blood Group

It is important to know one's blood group because it:

1. Helps ensure safe blood transfusions during medical emergencies.
2. Assists in determining compatibility for organ transplantation.
3. Supports the management of pregnancy where blood group incompatibility may occur.
4. Enables individuals to donate blood to help save the lives of others.

Rhesus Factor

Rhesus (Rh) factor is an antigen found on the surface of red blood cells. It was named after the Rhesus monkey in which it was first discovered. The most important Rhesus antigen is the D antigen. People who have the D antigen (the Rhesus antigen) on their red blood cells are described as **Rh-positive (Rh+)**. **Rh-negative (Rh-)** individuals are people who do not possess antigen D in their blood. Rhesus factor status of a person is determined by a gene with two alleles, a dominant allele R, which codes for antigen D, and a recessive allele r, coding for the absence of antigen D. Thus, the possible genotypes for an individual who is a Rhesus positive (Rh+) is RR or Rr. For an individual lacking the Rhesus antigen, (Rhesus negative, or Rh-), the genotype is rr. During blood transfusion, both the ABO and Rhesus factor classification are required to be compatible for a successful process. People with negative signs attached to their blood groups (e.g., O-) are Rhesus negative individuals. Those with positive signs attached to their blood groups (e.g., B+) are those that are Rhesus positive individuals.

Rhesus Incompatibility in Pregnancy

Rhesus incompatibility occurs when an **Rh-negative mother** carries an **Rh-positive fetus**. This usually happens when the fetus inherits the Rh-positive allele from an Rh-positive father. The condition develops as follows:

1. An Rh-negative woman conceives an Rh-positive baby. During the first pregnancy, the baby's red blood cells are normally separated from the mother's circulation by the placenta, so the fetus is usually not affected.
2. During childbirth, miscarriage, abortion, trauma, or certain medical procedures, a small amount of the baby's Rh-positive blood may enter the mother's bloodstream. The mother's immune system recognises the Rh antigen as foreign and becomes **sensitised**, producing anti-D antibodies against Rh-positive red blood cells.
3. In a subsequent pregnancy with another Rh-positive fetus, the mother's **anti-D (IgG) antibodies** can cross the placenta and destroy the fetus's Rh-positive red blood cells. This may result in **haemolytic disease of the newborn (HDN)**, also known as **haemolytic disease of the fetus and newborn (HDFN)**.

Haemolytic disease of the newborn may cause **anaemia in the fetus, jaundice in the newborn, brain damage (kernicterus), heart failure, hydrops fetalis, or even stillbirth in severe cases.**

Rh incompatibility can usually be prevented by giving an **anti-D immunoglobulin (Rho(D) immune globulin or RhoGAM)** injection to an Rh-negative mother during pregnancy and after the birth of an Rh-positive baby, or after any event that may expose her to Rh-positive fetal blood. The anti-D immunoglobulin destroys any Rh-positive fetal red blood cells that enter the mother's circulation before her immune system becomes sensitised, thereby preventing the production of anti-D antibodies.

Genetic Counselling

Genetic counselling is the process through which trained healthcare professionals help individuals and families understand the genetic basis of inherited conditions, assess the risk of passing these conditions to their children, and make informed medical and reproductive decisions. It also provides psychological and emotional support to affected individuals and families.

Genetic counselling is important for the following reasons:

1. Rhesus-negative women planning pregnancies.
2. For families with histories of blood disorders to understand their family background.
3. For people to with unusual blood group inheritance patterns.
4. It may be required for planning potential medical interventions.

Some important ethical principles are: (1) providing information without seeking to influence decisions (non-directiveness), (2) confidentiality (being confidential), (3) informed consent (seeking permission before taking information), (4) respecting people's independent decisions (respect for autonomy).

Learning Tasks

1. Investigate and discuss all possible blood group inheritance patterns among students in the class.
2. Conduct a simulation using coloured water to represent different blood types:
3. Research the Rhesus factor and its implications for pregnancy and create an informative poster addressing what?
4. Create and perform a role play depicting a genetic counselling session.

Pedagogical Exemplars

1. **Enquiry-Based Learning:** Research from textbooks, the Internet, the library and other relevant sources, the background and importance of blood groups, blood transfusion and Rhesus factor in humans, and discuss your findings in class discussions; Learners develop emotional and psychological satisfaction through their ability to find answers to questions through research.
2. **Task-Based Learning:** Learners work in mixed-ability groups to create charts on the various blood groups and the associated blood donors and recipients, presenting their lessons in discussions; learners learn from one another during discussions, and express opinions in modest constructive and presentable tones.

Key Assessment Level 3: Demonstration

1. A couple who both have **blood group A** have a child with **blood group O**.
 - a. Using a Punnett square, explain how this inheritance pattern is possible.
 - b. State the most likely genotypes of the parents and the child.
 - c. Determine the probability that another child born to the same parents will have blood group O.
2. A medical centre in a major urban area in the middle belt of Ghana has experienced an emergency situation following a major road traffic accident involving multiple casualties, resulting in severe blood loss.
 - a. Develop an emergency blood transfusion contingency that addresses the critical shortage of specific blood types.
 - b. Design and justify an evidence-based emergency blood transfusion system for mass casualty incidents that addresses ethical considerations when prioritising limited blood supplies.
3. The Akuapem North District Hospital in Ghana has reported an increasing number of cases of haemolytic disease of the newborn (HDN) related to Rhesus incompatibility.
Create a community health programme to address this issue and evaluate potential barriers to implementing this (20 marks).

Suggested text for Rh blood group

If a Rh- woman has a child with a man who is Rh+, there is a chance the child will be Rh+.

If so, there is a risk that she will produce antibodies against the Rh antigens on the red blood cells of her baby, which can sometimes cross the placenta and stimulate an antibody response. This is not a problem with the first child, because the response is too slow and at a low level. But if she has a second Rh+ child some years later, her body's response is much quicker and stronger. The antibodies she produces can then cross the placenta and destroy her baby's red blood cells, with very serious consequences.

A treatment is to inject the mother with anti-D factor which neutralises any Rh+ blood cells which cross the placenta into the mother's blood, before they can stimulate a response.

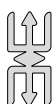
PLC Session 8

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to

- a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
- a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

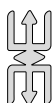
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
- a. The key assessment for the week is **demonstration**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the demonstration (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
- a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.

- b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 9

Learning Indicators

1. Discuss variation and its causes, stating the processes and factors affecting each
2. Describe the application of principles of variation among humans to improve life

FOCAL AREA 1: VARIATION AND ITS CAUSES

Variation

Variation refers to the differences that exist among individuals of the same species. These differences may occur in physical characteristics, physiological functions or genetic makeup. Variation arises from **genetic factors**, **environmental factors**, or the interaction between the two.

Variation can be classified into two main types:

a. Continuous Variation

Continuous variation shows a continuous range of phenotypes with many intermediate forms between two extremes. It is usually influenced by **many genes** and **environmental factors**.

Examples: Height in humans, body mass, skin colour and intelligence.

b. Discontinuous Variation

Discontinuous variation produces distinct categories with no intermediate forms. It is usually controlled by one or a few genes and is less affected by the environment.

Examples: ABO blood groups, tongue rolling, attached or free earlobes, and the ability to taste PTC (phenylthiocarbamide).

Causes of Variation

Variation in populations arises from both **genetic** and **environmental** factors.

a. Genetic Causes of Variation

Genetic variation is inherited and can be passed from parents to offspring. The main sources include:

- i. **Genetic recombination** – Crossing over and independent assortment during meiosis produce new combinations of alleles.
- ii. **Random fertilisation** – The random fusion of gametes creates unique combinations of genes in offspring.
- iii. **Mutation** – Changes in DNA create new alleles that may introduce new characteristics.
- iv. **Gene flow** – The movement of alleles between populations through migration increases genetic diversity.
- v. **Genetic drift** – Random changes in allele frequencies, particularly in small populations, may alter genetic variation over time.

b. Environmental Causes of Variation

Environmental variation results from differences in the conditions in which organisms live and is **not inherited**.

Examples of environmental factors include:

- i. Nutrition
- ii. Climate
- iii. Disease
- iv. Physical activity
- v. Exposure to sunlight
- vi. Education and lifestyle

For example, identical twins may have different body masses because of differences in diet and exercise, even though they have the same genetic makeup.

Natural Selection

Natural selection is the process through which individuals with favourable **genetic** variations are more likely to survive and reproduce than individuals with less favourable variations.

The process of natural selection involves the following steps:

- a. **Genetic variation** exists among individuals in a population.
- b. Environmental conditions create selection pressures that favour some individuals over others.
- c. Individuals possessing favourable inherited traits are more likely to survive and reproduce.
- d. These favourable alleles are passed on to the next generation.
- e. Over many generations, the frequency of favourable alleles increases, causing the population to become better adapted to its environment.

Importance of Variation

- a. Variation enables adaptation to changing environments.
- b. It provides resistance against diseases.
- c. It forms the basis for evolution.
- d. Variation increases chances of species survival.

Factors Affecting Variation

Variation among organisms is influenced by two broad categories of factors:

1. **Genetic Factors**
2. **Environmental Factors**

Genetic Factors

Genetic factors produce **heritable variation**, meaning the differences can be passed from parents to offspring.

1. Mutation

Mutations are permanent changes in the DNA sequence that create new alleles. Mutations may occur naturally or be caused by mutagens such as radiation or certain chemicals. They provide new genetic variation on which natural selection can act.

2. Genetic Recombination

Genetic recombination occurs during meiosis through:

- a. **Crossing over**, where segments of homologous chromosomes are exchanged.
- b. **Independent assortment**, where homologous chromosomes are distributed randomly into gametes.

These processes create new combinations of alleles in offspring.

3. Random Fertilisation

Random fusion of male and female gametes produces unique combinations of alleles, increasing genetic variation within a population.

4. Gene Flow

Gene flow is the movement of alleles between populations through migration and interbreeding. It introduces new alleles into populations and increases genetic diversity.

5. Genetic Drift

Genetic drift is the random change in allele frequencies, especially in small populations. It may increase or decrease the frequency of particular alleles by chance.

Environmental Factors

Environmental factors influence the expression of characteristics but **are not inherited**.

Examples include:

1. Nutrition

Adequate nutrition promotes healthy growth and development, while poor nutrition may limit growth.

Examples

- a. Plants supplied with sufficient nutrients grow taller than nutrient-deficient plants.
- b. Animals receiving balanced diets generally grow larger than poorly nourished animals.
- c. Identical twins raised on different diets may differ in body mass or height.

2. Light

Light affects growth, development and pigmentation.

Examples

- a. Plants grown in adequate light produce more chlorophyll than plants grown in darkness.
- b. Human skin may become darker after prolonged exposure to sunlight.

3. Temperature

Temperature affects metabolic activities and growth.

Examples

- a. Cold temperatures reduce the growth rate of many plants.
- b. Reptiles are generally more active in warm conditions than in cold conditions.

4. Physical Activity

Exercise influences muscle development and physical fitness.

Examples

- a. Regular exercise increases muscle strength in humans.
- b. Animals that are highly active often develop stronger muscles than less active individuals.

5. Diseases and Parasites

Diseases and parasites may affect normal growth and development.

Examples

- a. Viral diseases may reduce crop yields.
- b. Parasitic infections may reduce growth in livestock.
- c. Chronic illnesses can influence human growth and development.

Learning Tasks

1. Distinguish between **genetic** and **environmental** causes of variation.
2. Explain how mutation, genetic recombination, random fertilisation, gene flow and genetic drift contribute to genetic variation.
3. Describe how environmental factors influence the characteristics of organisms using appropriate examples.
4. Compare genetic variation with environmental variation and explain why only genetic variation can be inherited.

Pedagogical Exemplars

1. **Collaborative Learning:** In mixed-ability, all-inclusive groups, study pictures/videos or charts and documentaries on variation and discuss its causes and consequences in class group presentations: Learners learn from one another during discussions and develop tolerance in dealing with their emotions.
2. **Differential, Group-based:** In mixed-ability, all-inclusive, socially minded groups, develop various charts and maps on the concept of variation, its causes, processes and factors: Group based work ensure emotional and psychological support from the group to each member. Each individual takes part in the lesson when task is differentiated within the group. Contribution by members in group gives inner strength, satisfaction and confidence when each learner feels involved in the work.

Key Assessment Level 4: Case Study

1. A farming community has observed that maize plants grown in two different locations differ in height, leaf colour and yield.
 - a. Distinguish between **genetic** and **environmental** causes of variation in the maize plants.
 - b. Explain how each factor could contribute to the observed differences.
 - c. Suggest **two** ways farmers could reduce environmentally caused variation in crop production.
2. A pair of identical twins have different body masses and physical fitness levels.
 - a. Explain why identical twins can show differences even though they have the same genetic makeup.
 - b. Identify environmental factors that may have contributed to these differences.

- c. State whether these differences can be inherited by their children. Give a reason for your answer.
3. A population of insects contains individuals with different body colours. Birds feed more easily on the lighter-coloured insects, while the darker insects survive and reproduce more successfully.
- a. Explain how genetic variation contributes to this situation.
 - b. Describe how natural selection changes the characteristics of the population over time.
 - c. Predict what may happen to the population after many generations.

FOCAL AREA 2: GENETIC DISORDERS AND GENETIC COUNSELLING

Genetic disorders are diseases or abnormalities caused by changes in an individual's **genetic makeup**. They may be inherited from one or both parents or may result from new mutations. Examples include **Down syndrome, sickle cell disease, cystic fibrosis** and **Huntington's disease**.

Personalised Medicine and Genetic Variation

Advances in genetics allow healthcare professionals to use information about an individual's **genetic makeup** to predict the risk of certain inherited diseases and to help select the most appropriate treatment. This approach supports disease prevention, early diagnosis and improved patient care.

Applications of DNA Technology in Forensic Science

DNA technology has many applications in forensic investigations, including:

1. DNA profiling for identifying individuals.
2. Paternity and relationship testing.
3. Identification of victims in mass disasters.
4. Determining biological relationships using genetic markers.

DNA Techniques Used in Forensic Investigations

Common DNA techniques used in forensic science include:

1. DNA profiling based on differences in DNA sequences among individuals.
2. Short Tandem Repeat (STR) analysis for individual identification.
3. Mitochondrial DNA analysis for tracing maternal lineage.
4. Y-chromosome analysis for tracing paternal lineage.

Genetic Factors in Disease Susceptibility

Some diseases are caused by changes in a single gene, whereas others result from the combined effects of many genes together with environmental influences.

Examples include:

- a. **Single-gene disorders:** Sickle cell disease, cystic fibrosis and Huntington's disease.
- b. **Polygenic disorders:** Diabetes, hypertension and some forms of heart disease.
- c. **Gene–environment interactions:** Conditions whose development is influenced by both inherited genes and environmental factors such as diet, lifestyle and exposure to pollutants.

Understanding these genetic factors helps in disease prevention, diagnosis and treatment.

Importance of Understanding Genetics

Understanding genetics enables individuals to:

1. Make informed decisions about personal health and disease prevention.
2. Understand how inherited disorders are passed from one generation to another.
3. Appreciate the importance of genetic counselling and genetic screening.
4. Make informed reproductive decisions where inherited disorders may occur.
5. Understand the applications of genetics in medicine, agriculture and biotechnology.
6. Develop a better understanding of biological concepts such as inheritance, evolution and biodiversity.

Learning Tasks

1. Research a case study on a genetic disorder and explore how genetic counselling can support an individual or a family.
2. Examine the benefits and challenges of personalised medicine, considering genetic variation and its effect on treatment
3. Discuss the role of variation in forensic science and crime activities.
4. Analyse how variation affects an individual's susceptibility to a specific disease, and the implication on the person.

Pedagogical Exemplars

1. **Think Pair Share:** through think pair sharing, the learner research and share with another learner the advantages and disadvantages associated with genetic variation among humans. A general class discussion follows, think pair share allows many learners to share their thoughts, as it also fosters social and emotional well-being as thoughts are shared with the other learner. The strategy, together with class discussions, improves learner oratory.
2. **Task-Based/Talk for Learning Approaches:** In a mixed-ability, all-inclusive groups, share with the rest present learners present discussions on the application of variation to improve the well-being and health of humans: learners in group share common emotional and psychological thoughts, and support one another for a healthy academic exercise. Learners socially connect through mixed-ability class groupings.

Key Assessment Level 4: Group Research

1. A couple has a family history of sickle cell anaemia. The man is a carrier (AS), while the woman's status is unknown. They are planning to have children and are concerned about the risk of having a child with sickle cell disease.
 - a. Draw a Punnett square to show the possible genotypes of their children if the woman is also a carrier (AS). (5 marks)
 - b. Explain three ways genetic counselling would help this couple make informed decisions about their reproductive options. (9 marks)

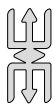
- c. Discuss one ethical challenge that might arise during the genetic counselling process for this couple. (6 marks).
2. You are a healthcare administrator tasked with implementing a personalized medicine program in your hospital.
 - a. Explain how genetic variation influences the effectiveness of cancer treatments and provide a specific example. (6 marks)
 - b. Identify and analyse two significant challenges your hospital might face when implementing this personalized medicine program. (6 marks)
 - c. Propose one solution to address one of the challenges you identified. (3 marks)
3. Recent research has identified several genetic variants associated with increased risk of Type 2 diabetes. A community has a high prevalence of this disease.
 - a. Explain how genetic variation and environmental factors might interact to influence Type 2 diabetes risk in this community. (6 marks)
 - b. Design a public health intervention that addresses both genetic and environmental risk factors for this community. (6 marks)
 - c. Describe one way this intervention respects human variation while improving public health. (3 marks)

PLC Session 9

45 minutes

Planning & Reviewing the Learning Plan

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2. Use your subject specific app to explore the content before planning. Ask the app to
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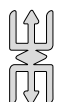
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- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **group research**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the research (NTS 3k-3q).

10 minutes**Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
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**Note**

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30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
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5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
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WEEK 10

Learning Indicator: Describe the various evidence of the processes (theories) of evolution and the factors affecting them

FOCAL AREA: EVOLUTION AND THE EVIDENCE OF EVOLUTION

Evolution

Evolution is the gradual change in the heritable characteristics of biological populations over successive generations. These changes are influenced by the environment and passed from one generation to another. The changes allow organisms to adapt to their environment for better survival and reproduction. Evolution offers clearer understanding into diversity of life and how different species are related within a habitat.

Types of Evolution

There are two main types of evolution. These are microevolution and macroevolution.

1. **Microevolution** refers to small-scale changes in allele frequencies in a population over a few generations. Examples of micro evolution are
 - a. the development of antibiotic resistance in bacteria.
 - b. pesticide resistance in insects.
 - c. changes in beak shape among Galapagos finches during drought periods.
 - d. sickle cell trait prevalence in malaria-endemic regions of Ghana and West Africa.
 - e. Industrial melanism in peppered moths in response to pollution in industrial areas.
2. **Macroevolution** is the large-scale evolutionary changes that occur over huge geological time periods, often leading to speciation (formation of new species) Examples include the evolution of whales from land-dwelling mammals, development of birds from dinosaur ancestors, evolution of humans from ape-like ancestors, transition of fish to amphibian and the evolution of flowering plants.

Evidence of Evolution

a. Fossil Records

Fossils are preserved remains or traces of ancient organisms. Fossil record shows a progression from simple to complex organisms over geological frame of time. Fossils found in Ghana, particularly marine fossils in sedimentary rocks, provide local evidence of evolutionary changes.

b. Comparative Anatomy

This is the study of similarities and differences in anatomical structures across species. Structures studied include

- i. **Homologous structures:** These are structures with similar anatomy but different functions (e.g., human arm, whale flipper, bat wing)
- ii. **Analogous structures:** They are structures with similar functions but different anatomy. Examples are insect wings and bird wings)

- iii. **Vestigial structures:** These refer to the reduced or functionless remains of structures that were functional in the ancestors of an organism. Examples are the appendix in humans and the pelvic bones in whales)

c. **Embryological Evidence**

Embryos of different vertebrates look similar in early stages of development. Human embryos temporarily develop gill pouches, tail, and other features similar to other vertebrates. These similarities suggest common ancestry

d. **Molecular and Biochemical Evidence**

Molecular and biochemical evidence for evolution comes from comparing the DNA and protein sequences of different organisms. The greater the similarity in DNA or protein sequences, the more closely related the organisms are likely to be. This evidence supports the idea that all living organisms share a common ancestor through the universal genetic code.

For example, the protein **cytochrome c** has very similar amino acid sequences in humans and chimpanzees (about 99% similarity), indicating a close evolutionary relationship.

Mitochondrial DNA (mtDNA) provides valuable evidence for evolution because it is inherited almost exclusively from the mother and undergoes relatively few changes over time. As a result, it is useful for tracing evolutionary relationships, studying patterns of human migration, and investigating the ancestry of populations. Studies of mitochondrial DNA suggest that the earliest modern human populations originated in Africa before spreading to other parts of the world.

e. **Biogeographical Evidence**

Biogeographical evidence is based on the geographical distribution of organisms across the Earth. Different regions contain distinct groups of plants and animals that have evolved in response to their environments and geographical isolation. Endemic species are those found naturally in only one particular geographical region.

For example, Australia's long geographical isolation has resulted in the evolution of a unique group of mammals known as marsupials. Although marsupials occupy ecological roles similar to those of placental mammals found elsewhere in the world, they evolved independently after Australia became isolated.

Similarly, unrelated organisms living in similar environments may independently evolve similar adaptations to perform similar ecological roles. This process is known as convergent evolution. For example, sharks (fish), dolphins (mammals) and ichthyosaurs (extinct reptiles) evolved similar streamlined body shapes, fins and tails as adaptations for efficient swimming in aquatic environments, despite belonging to different evolutionary lineages. These similarities evolved independently in response to similar environmental pressures rather than because of a recent common ancestor.

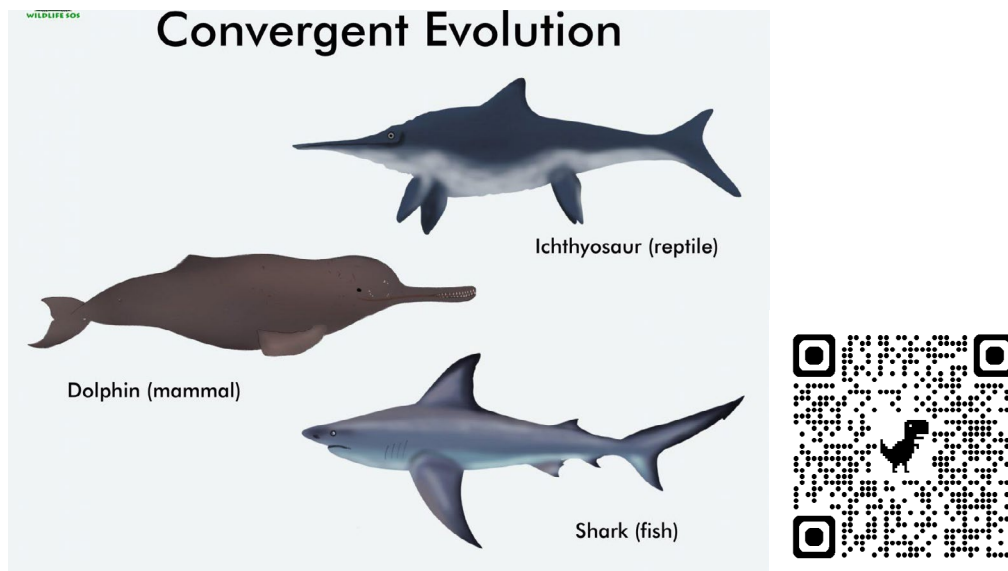


Figure 2. 7: *Convergent evolution*

Sharks, dolphins and ichthyosaurs independently evolved similar streamlined bodies and fins as adaptations for swimming in aquatic environments, even though they belong to different groups of vertebrates.

On the other hand, divergent evolution occurs when two or more related species become increasingly different over time as they adapt to different environments or ecological niches. This process results in the evolution of distinct characteristics and adaptations from a common ancestor.

A classic example of divergent evolution is Darwin's finches on the Galápagos Islands. These finches evolved from a common ancestral species, but over many generations they developed different beak shapes and sizes as adaptations to different food sources and feeding habits. The variation in beak structure enabled the different species to exploit different ecological niches, reducing competition and increasing their chances of survival.

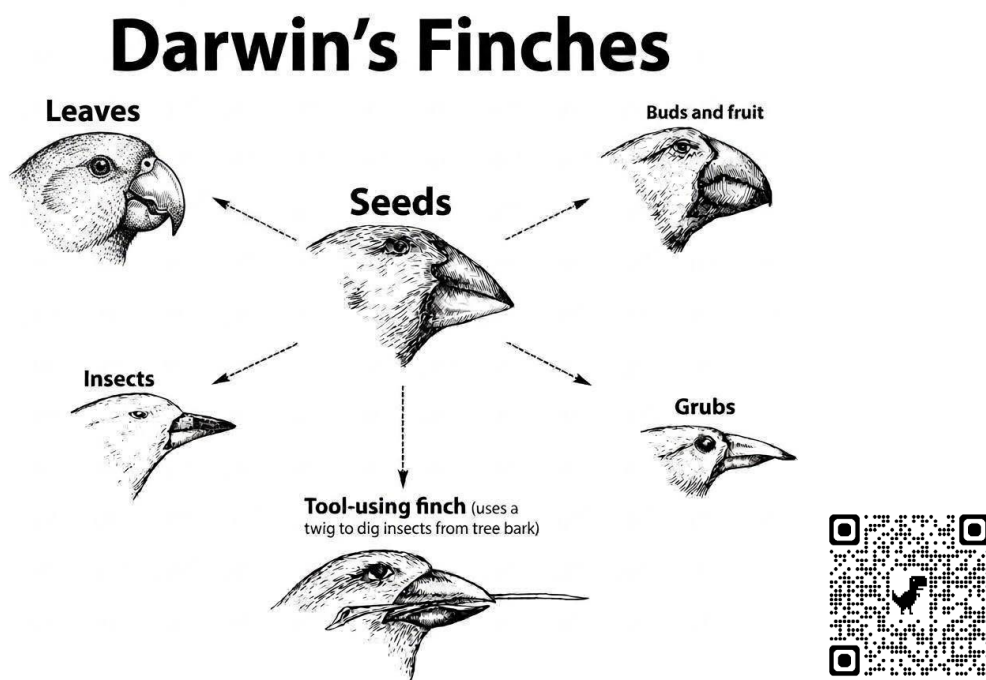


Figure 2.8: *Divergent evolution illustrated by Darwin's finches, showing the evolution of different beak shapes from a common ancestor*

Theories of Evolution

Lamarck's Theory of Evolution

This theory was proposed by the French naturalist, Jean-Baptiste Lamarck (1744-1829). The essential components of his theory are

1. Organisms can change their physical features during their lifetime in response to environmental challenges.
2. These acquired characteristics are passed on to their offspring.
3. Evolution occurs through the inheritance of acquired characteristics.

A typical illustration of this theory is observed in giraffes stretching their necks to reach high leaves. Eventually, they would develop longer necks, and this trait would be passed to offspring. Another illustration is the blacksmith's muscles, where the theory taught that the descendants of a blacksmith acquired muscles due to the blacksmith's arm muscles developing as a result of constant use.

This theory is also known as the theory of **Inheritance of Acquired Characteristics**.

Criticisms of Lamarck's Theory

1. Acquired characteristics (like muscle development through exercise) are not inherited
2. No mechanism was proposed for how acquired traits could affect reproductive cells
3. Modern genetics has disproven the inheritance of acquired characteristics

Darwin's Theory of Evolution

The British naturalist **Charles Darwin (1809–1882)** proposed the **Theory of Evolution by Natural Selection** to explain how species change over time. Darwin suggested that populations contain inherited variations, and individuals with favourable characteristics are more likely to survive and reproduce. Over many generations, these favourable characteristics become more common in the population, leading to evolutionary change.

Darwin's theory is based on the following key principles:

1. Organisms produce more offspring than the environment can support.
2. Individuals within a population show variation in their characteristics.
3. Some of these variations are inherited from parents.
4. Individuals with favourable inherited characteristics are more likely to survive and reproduce (survival of the fittest).
5. Over many generations, favourable inherited characteristics become increasingly common within the population.

Modern Evolutionary Synthesis

The **Modern Evolutionary Synthesis** combines Darwin's Theory of Evolution by Natural Selection with modern knowledge of genetics. It explains that evolution occurs through changes in allele frequencies within populations over time.

The modern evolutionary synthesis recognises that:

- a. **Genes and DNA** are the units through which inherited characteristics are passed from parents to offspring.

- b. **Mutations** create new alleles that provide the genetic variation required for evolution.
- c. **Genetic drift** causes random changes in allele frequencies, especially in small populations.
- d. **Gene flow** introduces new alleles into populations through migration and interbreeding.
- e. **Natural selection** acts on genetic variation, increasing the frequency of favourable alleles in a population.

Factors That Influence Evolution

Several biological processes contribute to evolutionary change.

1. Natural Selection

Natural selection is the process by which individuals with favourable inherited characteristics are more likely to survive and reproduce than those with less favourable characteristics. As these individuals leave more offspring, favourable alleles become more common in the population over successive generations.

2. Mutation

A **mutation** is a permanent change in the DNA sequence of an organism. Mutations create new alleles and are the ultimate source of new genetic variation within populations. Mutations may occur naturally or be caused by environmental factors such as radiation or certain chemicals.

Mutations may be:

- a. **Beneficial**, improving an organism's chances of survival.
- b. **Harmful**, reducing survival or causing genetic disorders.
- c. **Neutral**, having little or no effect on the organism.

Example: A mutation in the **HBB** gene gives rise to the sickle cell allele. Individuals who inherit one copy of the sickle cell allele (heterozygotes) have increased resistance to malaria, whereas individuals who inherit two copies develop sickle cell disease. This example illustrates how a mutation can have both beneficial and harmful effects depending on the genetic context.

3. Genetic Drift

Genetic drift refers to random changes in allele frequencies within a population due to chance events rather than natural selection. It has the greatest effect in small populations, where random events can cause certain alleles to become more common or disappear entirely.

For example, if a natural disaster randomly eliminates many individuals in a small population, the surviving individuals may not represent the original genetic diversity of the population. As a result, allele frequencies may change simply by chance.

4. Gene Flow

Gene flow is the movement of alleles between populations through migration and interbreeding. When individuals move from one population to another and reproduce, they introduce new alleles into the receiving population. Gene flow increases genetic variation within populations while reducing genetic differences between populations.

Example: Human migration between different regions of Africa has resulted in the exchange of genetic material among populations. Similarly, the movement of pollen between plant populations by wind or insects introduces new alleles into different populations, increasing genetic diversity.

5. Non-random Mating

Non-random mating occurs when individuals choose mates based on particular characteristics rather than by chance. This influences the distribution of alleles and genotypes within a population.

Common forms of non-random mating include:

- Positive assortative mating**, where individuals with similar characteristics are more likely to mate.
- Negative assortative mating**, where individuals with different characteristics are more likely to mate.
- Sexual selection**, where individuals possessing traits that improve mating success are more likely to reproduce.

Example: Male peacocks with large, brightly coloured tail feathers are more likely to attract females and reproduce than males with less conspicuous tails. As a result, genes associated with these attractive traits become more common in the population over time.

6. Geographic Isolation

Geographic isolation occurs when populations of the same species become separated by physical barriers such as mountains, rivers, lakes or oceans. Because the isolated populations can no longer interbreed freely, they experience different environmental conditions and evolutionary pressures. Over many generations, genetic differences accumulate, which may eventually lead to the formation of new species.

Example: Different species of cichlid fish found in isolated crater lakes in Ghana have evolved independently after becoming geographically separated. Similar examples are found in the African Great Lakes, where geographical isolation has contributed to the evolution of numerous cichlid species with diverse feeding habits, body forms and behaviours.

Learning Tasks

- Discuss evolution and the major evidence of evolution.
- Discuss the two main types of evolution with examples.
- Examine Lamarck's and Darwin's theories of evolution in the light of modern evolutionary trends
- Briefly discuss the factors that affect evolution.

Pedagogical Exemplars

- Individual-Based Project Learn:** individually, learners collect pictures/videos/documentaries on different sources of evidence of evolution (such as fossil records, comparative anatomy, comparative embryology, geographical distribution, etc.) and study them.
- Group-based Learning:** In mixed-ability, all-inclusive groups, learners brainstorm their findings, write and present group reports. These ensure that learners learn from one another and appreciate the efforts of each member in group discussions.
- Talk for Learning Approach:** learners in mixed-ability groups discuss the unique features of the forms of evidence of evolution and create group posters for class discussions: learners become inquisitive in explaining charts and posters. Learners acknowledge the strength of each member and offer required psychological and emotional support to achieve group goals.

Key Assessment Level 4: Homework

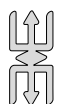
1. The peppered moth (*Biston betularia*) population in industrial England changed from predominantly light-coloured to predominantly dark coloured during the Industrial Revolution, then shifted back toward light-coloured as air pollution decreased. Meanwhile, over millions of years, mammals evolved from small rodent-like creatures to diverse forms including whales that returned to aquatic environments.
 - a. Classify which type of evolution the peppered moth example represents and explain your reasoning. (6 marks)
 - b. Compare and contrast this moth example with the evolution of whales, explaining the key differences in the evolutionary processes involved. (8 marks)
 - c. Analyse how these two examples provide evidence supporting the theory of evolution. (6 marks).
2. A giraffe population in the Savanna has necks that average 2 metres long. After a severe drought that kills many shorter-necked individuals, the next generation has a higher proportion of longer-necked giraffes.
 - a. Explain how Lamarck would interpret this change in the giraffe population. (6 marks)
 - b. Explain how Darwin would interpret the same change. (6 marks)
 - c. Evaluate which theory better explains this observation in light of modern genetic understanding, providing specific evidence to support your conclusion. (8 marks)
3. A small group of 50 elephants is moved from a wildlife reserve in Kenya to a previously uninhabited island off Ghana's coast for conservation purposes. The island has different vegetation and no large predators.
 - a. Analyse how natural selection might influence this elephant population over several generations. (6 marks)
 - b. Explain how genetic drift might affect this population differently than it would the original larger population. (6 marks)
 - c. Evaluate how the combined effects of multiple evolutionary factors (including those not mentioned above) might shape this population's evolution over 300 years. (8 marks)

PLC Session 10

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)

- c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

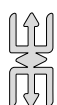
4. Plan the week's key assessment with your app

- a. The key assessment for the week is **homework**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the homework (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - all teachers in the group work through a similar problem individually for 3–4 minutes
 - the group then works through the problem together step by step
 - highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
- Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - After the enactment, ask for structured feedback from the group
 - was the concept explained in a way that a learner with no prior knowledge could follow?
 - were the examples grounded in contexts familiar to Ghanaian learners?
 - did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 11

Learning indicator: Describe the cell cycle and relate it to how mitosis and meiosis occur in a living cell

FOCAL AREA: CELL CYCLE, MITOSIS AND MEIOSIS

Cell Cycle

As a cell grows it goes through stages to divide into two daughter cells. Prokaryotes and Eukaryotes have comparable cell cycles, but the eukaryotic cycle is more clearly marked. It consists of a resting stage (Gap 0), an interphase (which includes the Gap1, Synthesis, and Gap 2 phases) and the cell division stage (Mitosis phase). These stages are in a sequential series of events (phases) that include the growth of the cell, duplication of its DNA (DNA replication) and some of its organelles. It is then followed by the partitioning of the cell's chromosomes, cytoplasm and other components into two daughter cells in a process called cell division. The cell cycle is an essential process for growth, development, and tissue repair in living organisms.

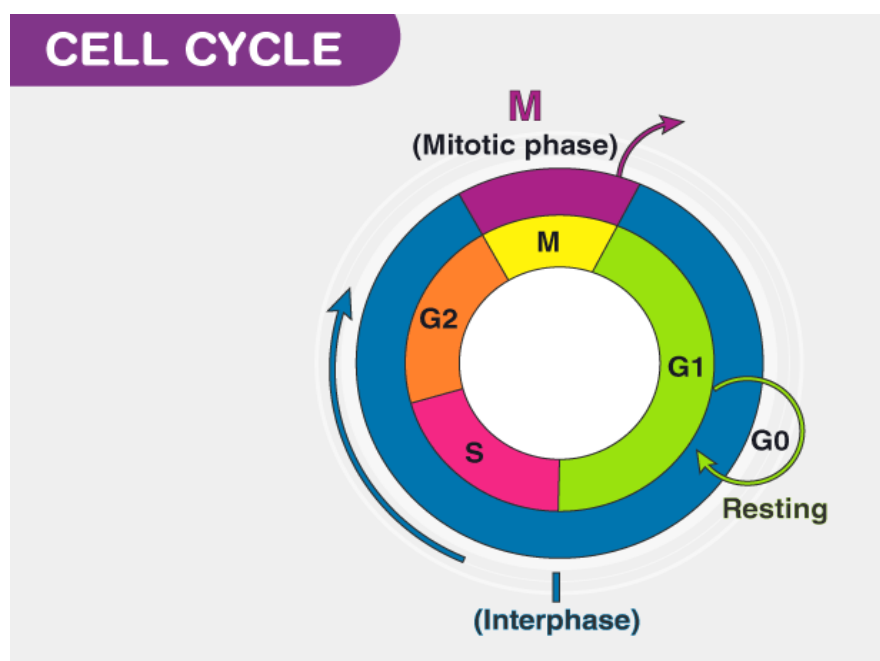


Figure 2.9: The cell cycle

Stages and Phases of the Cell Cycle

The resting stage is characterised by the Gap 0/G0 phase. This is a resting or inert stage in the cell cycle where cells exit the active cycle and enter a state of dormancy. Cells in this phase are not actively preparing to divide but may still carry out normal functions specific to their cell type. Cells in this phase can re-enter the cell cycle if conditions are favourable for growth and division for instance in response to growth factors or tissue repair needs. The G0 phase is important for maintaining cellular function and regulating the overall cell population in tissues.

The Interphase stage is the longest stage of the cell cycle, during which the cell prepares for division. It consists of three phases: Gap1, Synthesis, and Gap 2.

Phases of Interphase

G1 Phase (Gap 1)

In this phase the cell grows and increases in size and synthesizes proteins and organelles. The cell assesses its environment and resources to ensure conditions are suitable for DNA replication.

S Phase (Synthesis)

When all conditions are suitable the cell duplicates its entire DNA content, resulting in two identical sets of chromosomes. The centrosomes also duplicate to prepare for mitosis.

G2 Phase (Gap 2)

After the DNA duplication, the cell continues to grow and produce more proteins and organelles and checks for any DNA damage and ensures all DNA is properly replicated in preparation for mitosis. This ensures that errors are prevented during cell division, maintaining genetic stability.

Cell division stage in the cell cycle is where the cell divides into two daughter cells. It consists of two main phases: mitosis and cytokinesis.

Mitotic Cell Division

Mitosis is the process where nuclear division occurs, resulting in two daughter nuclei (karyokinesis). Mitosis is further divided into:

1. Prophase

Chromosomes condense and become visible, and the nuclear envelope begins to break down. The mitotic spindle forms from centrioles.

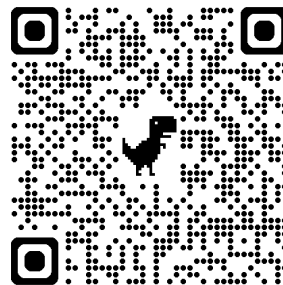
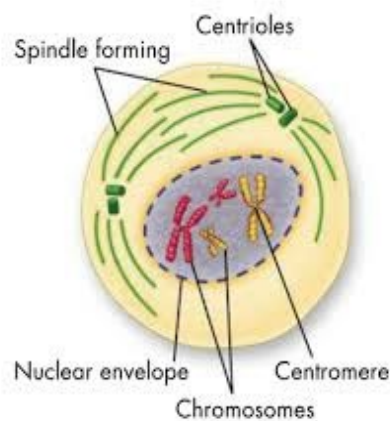


Figure 2.10: *Prophase*

2. Metaphase

Chromosomes align at the cell's equatorial plate (metaphase plate) and spindle fibres attach to the centromeres of the chromosomes.

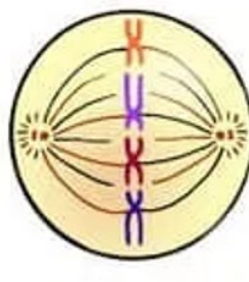


Figure 2.11: *Metaphase*

3. Anaphase

Sister chromatids are pulled apart and move toward opposite poles of the cell. The cell elongates as the chromatids migrate to opposite poles.

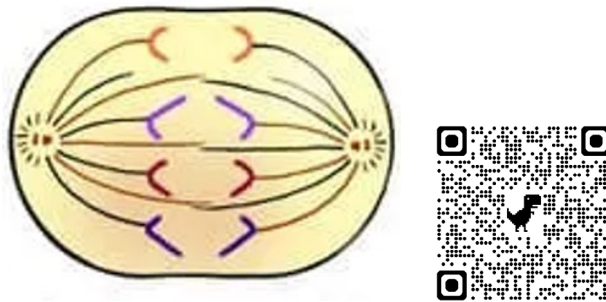


Figure 2.12: *Anaphase*

4. Telophase

Chromatids reach the poles and de-condense back into chromatin. The nuclear envelope reforms around each set of chromosomes. The chromosomes uncoil and assume their threadlike forms.

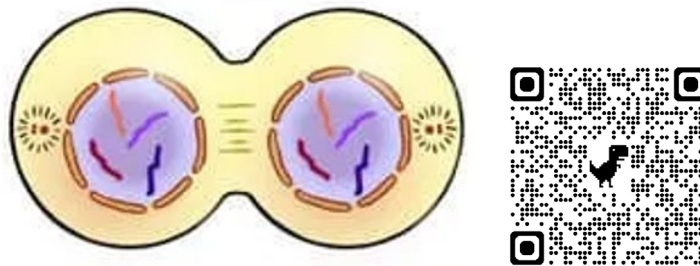


Figure 2.13: *Telophase*

5. Cytokinesis

This is the process that divides the cytoplasm and organelles into two daughter cells. In animal cells, a cleavage furrow forms, pinching the cell into two while in plant cells, a cell plate forms, eventually developing into a new cell wall.

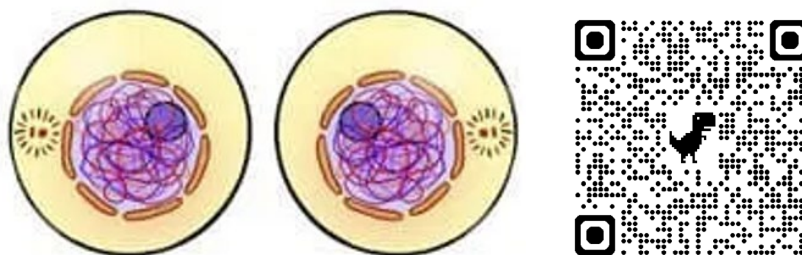


Figure 2.14: *Two daughter cells*

Importance of Mitosis

1. In multicellular organisms, mitosis is essential for growth, repair and development, allowing them to increase in size by producing new cells.
2. Mitosis ensures that each daughter cell receives an identical set of chromosomes, maintaining genetic stability and continuity.

3. Mitosis ensures that worn-out or damaged cells are replaced with new healthy ones, thereby maintaining the integrity of tissues and organs.
4. In single-celled organisms and some multicellular organisms, mitosis is the primary means of producing new individuals.

Mitosis occurs in somatic (body) cells, which are all the cells of an organism except the reproductive cells (gametes). It is responsible for growth, development, tissue repair and replacement of worn-out or damaged cells.

Meiosis is the specialised type of cell division that occurs in reproductive cells to produce haploid reproductive cells or spores. In animals, meiosis takes place in the testes to produce sperm cells and in the ovaries to produce egg cells (ova). In flowering plants, meiosis occurs in the anthers to produce pollen grains and in the ovules to produce megaspores, which develop into the female gametophyte. The cells produced by meiosis contain half the chromosome number (haploid) of the parent cell (diploid), allowing the diploid chromosome number to be restored during fertilisation.

Meiotic Cell Division

Meiosis is a specialised type of cell division that reduces the chromosome number by half, producing four genetically distinct haploid cells. In animals, these cells develop directly into gametes (sperm or egg cells). In plants, meiosis produces spores, which later develop into the male and female gametophytes that produce gametes. Meiosis is essential for sexual reproduction because it maintains a constant chromosome number from one generation to the next. Before meiosis begins, DNA replication occurs during the S phase of interphase, so that each chromosome consists of two identical sister chromatids joined together at the centromere.

Phases of Meiosis

Meiosis consists of two main stages: Meiosis I and Meiosis II, each with several sub-phases.

1. Meiosis I

a. Prophase I

Chromosomes condense and become visible and similar (homologous) chromosomes pair up. In humans there are 23 pairs of homologous chromosomes accounting for the 46 chromosomes. Homologous chromosomes pair with each other and undergo genetic recombination, a programmed process in which DNA may be cut and then repaired, which allows them to exchange some of their genetic information with its pair. The recombination events result in crossing over. Crossing over is the process where genetic material is exchanged between non-sister chromatids (the halves of each homologous chromosome) at chiasmata (points of contact). This process creates new combinations of genes on each chromosome, contributing to genetic variation. The nuclear envelope breaks down after the crossing over process.

b. Metaphase I

Homologous chromosome pairs align at the equatorial plate. Spindle fibres attach to the centromeres of each pair.

c. Anaphase I

Homologous chromosomes are pulled apart to opposite poles of the cell. Sister chromatids remain attached at this stage.

d. Telophase I

Chromosomes reach the poles and de-condense. The nuclear envelope may reform, resulting in two haploid cells.

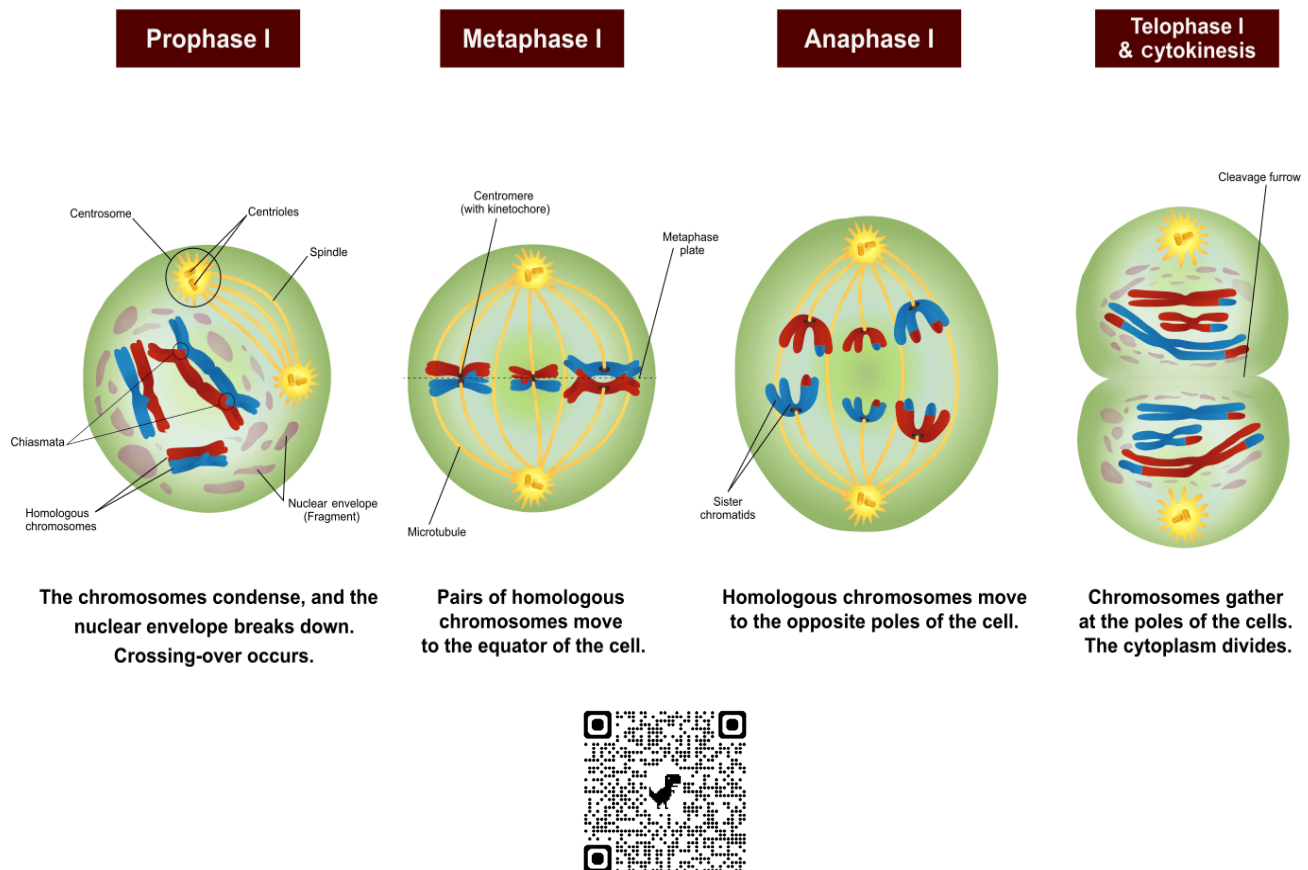


Figure 2.15: *The sub phases of meiosis I*

2. Meiosis II

a. Prophase II

Chromosomes condense again, and the nuclear envelope breaks down if it reformed and spindle fibres form.

b. Metaphase II

Chromosomes align at the equatorial plate. Spindle fibres attach to the centromeres of sister chromatids.

c. Anaphase II

Sister chromatids are pulled apart to opposite poles.

d. Telophase II

Chromatids reach opposite poles of each cell and de-condense into chromatin. Nuclear envelopes reform around each set of chromosomes. Cytokinesis then occurs in both cells, producing a total of four genetically distinct haploid daughter cells.

Meiosis II occurs simultaneously in each of the two haploid cells produced during Meiosis I. The stages of Prophase II, Metaphase II, Anaphase II and Telophase II therefore take place in both cells at the same time. In the illustration below, the two rows represent these two cells progressing through Meiosis II simultaneously. At the end of Telophase II and cytokinesis, each cell divides, producing a total of four genetically distinct haploid daughter cells.

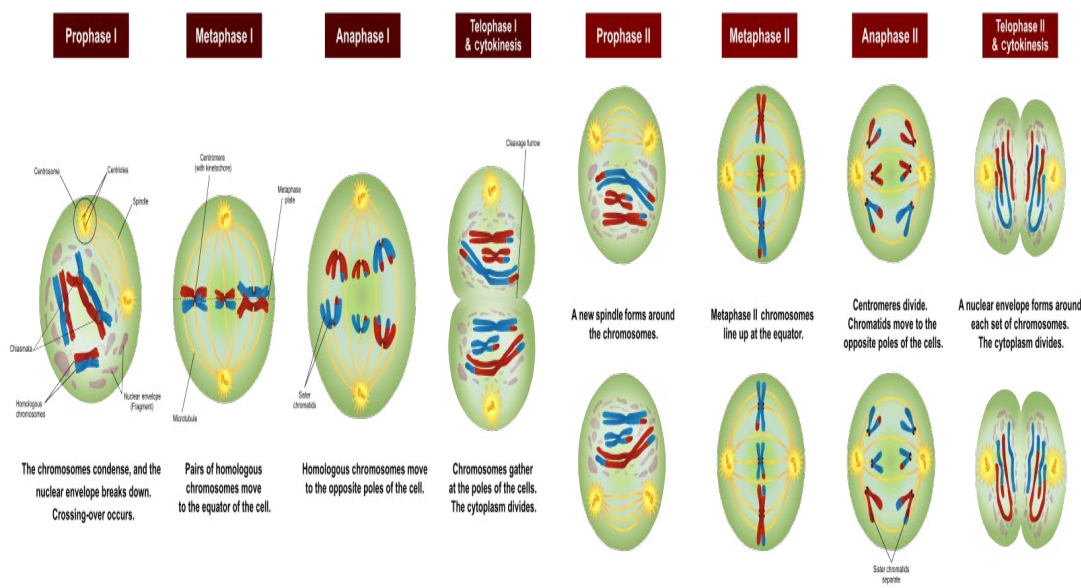


Figure 2.16: Stages of Meiosis II occurring simultaneously in the two haploid cells produced during Meiosis I, resulting in four genetically distinct haploid daughter cells.

Genetic Variation During Meiosis

Meiosis generates genetic variation through two important processes:

Crossing Over

Crossing over occurs during **Prophase I**, when homologous chromosomes pair up and exchange corresponding segments of DNA. This exchange creates new combinations of alleles on each chromosome, making the resulting gametes genetically different from one another.

Independent Assortment

Independent assortment occurs during **Metaphase I**, when homologous chromosome pairs align randomly along the equator of the cell. Each pair separates independently during **Anaphase I**, producing different combinations of maternal and paternal chromosomes in the gametes.

In humans, there are **23 pairs of chromosomes**. Because each pair can align in **two different ways** during Metaphase I, independent assortment alone can produce **2^{23} (8,388,608)** different combinations of chromosomes in gametes. Crossing over further increases this genetic variation.

Importance of Meiosis

- Meiosis is crucial for sexual reproduction, as it produces gametes with half the number of chromosomes.
- It introduces genetic diversity through crossing over and independent assortment, which are essential for evolution and adaptation in populations.

Pedagogical Exemplars

- Individual/Independent-Based Learning:** Each learner collects and study charts, maps and diagrams on mitosis and meiosis, and analyses them to understand the basic concepts of cell division; learner builds self-confidence in the ability to perform tasks independently. Learner becomes inquisitive and learns from others.

2. **Group Based-Talk for Learning:** In mixed ability, all-inclusive groups, discuss the events that occur in the cell during division (i.e., the interphase and the five stages of the cell cycle (gap 1/G1 stage, synthesis/S stage, gap 2/G2 stage and mitosis/M stage)). Groups compare and contrast mitosis and meiosis in living things. Learners become inquiry-based and learn from one another. Learners improve on their speaking skills. Learners are emotionally and psychologically connected during group work.
3. **Project-Based Learning:** Design charts on the stages of meiosis and mitosis.

Key Assessment Level 4: Class Exercise

1. Describe the main phases of the cell cycle and explain where mitosis fits into this cycle.
2. Explain how meiosis differs from mitosis in its relationship to the cell cycle.
3. Describe the cell cycle and relate it to how mitosis and meiosis occur in a living cell. In your answer, include:
 - a. The main phases of the cell cycle and their functions
 - b. How mitosis is integrated into this cycle
 - c. How meiosis relates to the cell cycle
 - d. Example of cells in a multicellular organism that undergo each type of division

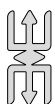
Multiple Choice Questions (1 mark each)

1. Which of the following events occurs during S phase of the cell cycle?
 - A. Cell growth and protein synthesis
 - B. DNA replication
 - C. Chromosome alignment at the equator
 - D. Cytokinesis
2. Meiosis differs from mitosis in that meiosis...
 - A. does not require DNA replication
 - B. involves two cell divisions without intervening DNA replication
 - C. only occurs in plants
 - D. always produces four diploid daughter cells
3. In which phase of mitosis do sister chromatids separate and move to opposite poles?
 - A. Prophase
 - B. Metaphase
 - C. Anaphase
 - D. Telophase
4. Which of the following plant cell types typically undergo meiosis?
 - A. Leaf cells
 - B. Root hair cells
 - C. Pollen mother cells in the anther
 - D. Guard cells

PLC Session 11

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

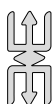

Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **class exercise**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the exercise (NTS 3k-3q).

10 minutes
Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).


Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

Section Review

In this section, learners discussed the fundamental concepts of genetics and cellular inheritance. Learners mastered key genetic terminologies such as alleles, chromosomes, genotypes, and mutations, demonstrating their understanding through practical applications. Learners analysed Mendel's laws of inheritance and related these principles to human blood group inheritance, comprehending their medical significance in transfusions and pregnancy. They articulated the importance of knowing one's blood group and Rhesus factor for healthcare purposes. Learners examined genetic variation and its causes, exploring how these principles apply to human diversity and advancement. The evolutionary processes and supporting evidence were also investigated, enhancing learners' understanding of biological development over time. The lesson concluded with learners demonstrating knowledge of the cell cycle by comparing mitosis and meiosis in eukaryotic cells, effectively connecting these processes to inheritance patterns. Learners are expected to show proficiency in both conceptual understanding and practical application of genetic principles after the successful completion of lessons.



MARKING SCHEMES FOR THE KEY ASSESSMENTS

WEEK 5

Question 1 (Total: 10 Marks)

- o Clear and accurate definitions of dominant and recessive alleles. (2 marks)
- o Expression in Phenotype: Explanation of how dominant alleles express traits regardless of the number of copies. Explanation of how recessive alleles require two copies for expression. (2 marks)
- o Genotypic Representation: Correct representation of dominant and recessive alleles using uppercase and lowercase letters. (1 mark)
- o Inheritance Patterns: Discussion on how dominant alleles mask recessive alleles. (1 mark)
- o Mention how recessive traits can appear to skip generations. (2 marks)
- o Examples: Relevant examples demonstrating dominant and recessive alleles (e.g., pea plants, human traits). (2 marks)

Question 2 (Total: 10 Marks)

- o Clear and accurate definitions of homozygous and heterozygous genotypes. (2 marks)
- o Allele Composition: Explanation of the allele composition for both homozygous (identical alleles) and heterozygous (different alleles) genotypes. (2 marks)
- o Phenotypic Expression: Description of how homozygous dominant and recessive individuals express their traits. Explanation of how heterozygous individuals express the dominant phenotype. (2 marks)
- o Genetic Variation: Discussion on the implications of being homozygous versus heterozygous in terms of genetic variation and diversity. (2 marks)
- o Examples: Relevant examples illustrating homozygous (e.g., PP, pp) and heterozygous (e.g., Pp) genotypes. (2 marks)

Question 3 (Total: 6 Marks)

- o Mendel's Background and Experiments: Brief description of Mendel's identity and his experiments with pea plants. (2 marks)
- o Rediscovery in the Early 20th Century and its significance. (2 marks)
- o Impact on Genetics: Explanation of how the rediscovery contributed to the establishment of genetics and Mendel's legacy. (2 marks)

Question 4 (Total: 8 Marks)

- **Definition of P Generation:** Correctly defines the P generation as the original parental cross used in an investigation. The genotypes may vary depending on the cross. (2 marks)
- **Definition of F₁ Generation:** Correctly defines the F₁ generation as the first generation of offspring produced from the P generation. (2 marks)
- **Definition of F₂ Generation:** Correctly defines the F₂ generation as the offspring produced when individuals from the F₁ generation are crossed or self-fertilised. (2 marks)

- **Relationship among the generations:** Clearly explains that the genotypes and phenotypes of the F_1 and F_2 generations depend on the genotypes of the parents used in the preceding cross. (2 marks)

WEEK 6

Question 1 (Total Marks: 10)

- Identification of Genetic Variation (3 marks)
 - o Clearly identifies a specific example of genetic variation in a population (1 mark).
 - o Describes the traits involved. (2 marks).
- Connection to Mendel's Principles (4 marks)
 - o Relates the example to Mendel's principles of inheritance (e.g., Law of Segregation) (2 marks).
 - o Explains how the observed variation supports or challenges these principles (2 marks).
- Clarity and Depth of Explanation (2 marks)
 - o Presents a well-organized and coherent explanation (1 mark).
 - o Uses appropriate genetic terminology and concepts (1 mark).
- Conclusion (1 mark)

Summarizes the significance of the example in the context of genetic variation and Mendelian principles.

Question 2 (Total Marks: 10)

- Explanation of Environmental Influence (3 marks)
 - o Clearly explains how environmental factors can influence phenotypic expression (1 mark).
 - o Discusses specific mechanisms (e.g., temperature, nutrition, light) that affect traits (2 marks).
- Examples of Gene-Environment Interaction (4 marks)
 - o Provides at least two relevant examples illustrating the interaction between genetics and the environment (2 marks).
 - o Examples should clearly show how environmental conditions affect phenotypic outcomes (2 marks)
- Clarity and Organization (2 marks)
 - o Presents a well-structured and coherent response (1 mark).
 - o Uses appropriate terminology and maintains clarity throughout the explanation (1 mark).
- Conclusion (1 mark)

Summarizes the importance of understanding the interaction between genetics and environmental factors in phenotypic expression.

WEEK 7**Question 1 Total Marks: 10**

- Introduction to the Genetic Cross (1 mark)
Clearly state the cross between two heterozygous pea plants (Rr).
- Punnett Square Creation (3 marks)
 - o Accurately draw and label a Punnett square for the cross. 1 mark
 - o Show all possible allele combinations. 2 marks
- Genotypic Ratio Calculation (2 marks)
Correctly identify and calculate the genotypic ratio: RR : Rr : rr (e.g., 1:2:1).
- Phenotypic Ratio Calculation (2 marks)
Correctly identify and calculate the phenotypic ratio: Dominant: Recessive (e.g., 3:1).
- Explanation of Ratios and Law of Segregation (2 marks)
 - o Explain how the observed ratios illustrate Mendel's Law of Segregation.
 - o Discuss the separation of alleles during gamete formation.

Question 2 Total 20marks

Criteria	Excellent (4 marks)	Good (3 marks)	Satisfactory (2 marks)	Needs Improvement (1 mark)	Unsatisfactory (0 marks)	Score
Introduction to the Scenario	Clearly states the cross between PP and Pp.	States the cross but lacks some clarity.	Mentions the plants but omits key details.	Vague description of the plants or cross.	No mention of the scenario.	/4
Genotypic Ratio Calculation	Correctly creates a Punnett square and calculates 1 PP:1 Pp.	Correctly identify genotypes but minor errors in ratios.	Lists genotypes but calculations are incomplete or incorrect.	Fails to correctly identify genotypes.	No genotypic ratio provided.	/4
Phenotypic Ratio Calculation	Accurately determines 2 purples:0 white and explains.	Correctly identify phenotypes but lack full explanation.	Lists phenotypes but do not calculate ratios accurately.	Fails to identify phenotypes.	No phenotypic ratio provided.	/4
Analysis of Law of Segregation	Thorough explanation of how ratios illustrate the law.	Good explanation but lacks some detail or clarity.	Basic explanation with limited connection to the law.	Minimal understanding of the law displayed.	No analysis provided.	/4
Conclusion	Clearly summarizes findings and reinforces Mendel's principles.	Summarizes but lacks some clarity or completeness.	Basic conclusion but does not effectively summarize.	Weak conclusion with little relevance to findings.	No conclusion provided.	/4

Scoring Guidelines

- **16-20:** Excellent understanding and analysis of genetic principles.
- **11-15:** Good understanding with minor errors or omissions.
- **6-10:** Satisfactory but lacks depth in analysis and explanation.
- **1-5:** Needs significant improvement in understanding and presentation.
- **0:** Unsatisfactory; no evidence of understanding provided.

Question 3: Total Marks: 10

- Introduction to Mendel's Law of Segregation (2 marks)
- Clearly define Mendel's Law of Segregation and its relevance to genetics.
- Application in Agriculture (3 marks)
- Explain how the law can be applied in agriculture for developing new crop varieties.
- Discuss the process of selective breeding based on genetic principles.
- Examples of Specific Traits (3 marks)
- Provide specific examples of traits that can be enhanced through selective breeding (e.g., disease resistance, drought tolerance, yield).
- Explain how these traits are linked to Mendelian genetics.
- Conclusion (2 marks)
- Summarize the importance of applying Mendel's principles in agriculture, highlighting the potential benefits for crop improvement and food security.

Question 4: Total Marks: 10

- Introduction to Mendel's Experiments (2 marks)
- Briefly describe Mendel's experiments with pea plants.
- Key Principles Established (4 marks)
- Clearly identify and explain the key principles Mendel established:
- Law of Segregation
- Law of Independent Assortment
- Provide examples from his experiments that illustrate these principles.
- Relevance to Modern Genetics (3 marks)
- Discuss how Mendel's principles are foundational to modern genetics.
- Provide examples of how these principles apply to current genetic research and breeding practices.
- Conclusion (1 mark)
- Summarize the impact of Mendel's work on our understanding of genetic inheritance.

Question 5: Total 10 marks

- Clear explanation of the Law of Independent Assortment (2 marks)
- Accurate differentiation from the Law of Segregation (2 marks)

- Description of a relevant dihybrid cross (2 marks)
- Correct explanation of the 9:3:3:1 ratio (2 marks)
- Explanation of how this demonstrates independent assortment (2 marks)

Multiple Choice Questions

Answer

1. A
2. C
3. B
4. C
5. B
6. C

WEEK 8

Sample Answers to Question 1

Part A: Investigation Model Design Explanation of blood type O child from type A parents	Presents a comprehensive model showing heterozygous parents ($I^A i \times I^A i$) with clear inheritance pattern explanation. Includes accurate Punnett square with correct probability calculations (25% chance of type O). Explains genotype- phenotype relationships thoroughly with precise genetic terminology.	Presents a generally correct model showing heterozygous parents. Includes a Punnett square with minor errors. Explains the inheritance pattern adequately but may lack some precision in genetic terminology or probability explanation.	Presents a basic model with significant conceptual errors. Punnett square may be incomplete or incorrect. Limited explanation of inheritance patterns or confused understanding of genotype-phenotype relationships.	10
Part B: Evaluation of Investigative Approaches Analysis of different methods for studying blood group inheritance	Thoroughly evaluates at least three different approaches (e.g., family pedigrees, blood typing tests, molecular genetic analysis). Provides specific, detailed strengths and limitations for each approach. Includes thoughtful comparison between methods and explains contextual factors affecting their application in Ghana.	Evaluates at least two different approaches with adequate detail. Identifies several strengths and limitations but may lack depth in some areas. Some comparison between methods but limited consideration of contextual factors.	Describes rather than evaluates approaches with minimal detail. Few relevant strengths and limitations identified. Little or no comparison between different methods. Limited scientific understanding of investigative techniques.	10

Question 2

Criteria	Excellent (8-10)	Good (5-7)	Needs improvement (1-4)	Marks
<i>Part A: Emergency Blood Transfusion Contingency Plan for addressing critical blood shortages</i>	<i>Develops a comprehensive, practical contingency with clear steps addressing all blood types. Includes strategic use of universal donors, type-specific matching protocols, emergency donor recruitment, and inter-hospital coordination. Demonstrates thorough understanding of blood compatibility and transfusion principles. Plan is realistic and specifically tailored to Ghanaian urban healthcare context.</i>	<i>Develops a reasonable contingency with steps addressing most blood types. Includes some consideration of universal donors and type-specific matching. Demonstrates adequate understanding of blood compatibility. Plan is generally realistic but may lack some specific details relevant to the Ghanaian context.</i>	<i>Presents a basic contingency that addresses few blood types or lacks critical steps. Limited understanding of blood compatibility principles. Plan may be impractical or too vague to implement in an emergency situation. Minimal consideration of local healthcare resources.</i>	10
<i>Part B: Mass Casualty Transfusion System Evidence-based system with ethical considerations</i>	<i>Designs a comprehensive, systematic approach with clear triage protocols based on medical evidence. Thoroughly addresses multiple ethical considerations (fairness, need, benefit, etc.) with balanced rationales. Provides specific evidence from research or guidelines to support system design. Includes detailed practical implementation steps and addresses potential challenges. Thoughtfully balances individual patient needs with population-level outcomes.</i>	<i>Designs a reasonable system with adequate triage protocols. Addresses several ethical considerations with some supporting evidence. System is generally sound but may lack detail in some areas. Some consideration of practical implementation but limited discussion of potential challenges. Basic consideration of individual versus population needs.</i>	<i>Presents a basic system lacking important details or clear protocols. Minimal ethical considerations with little supporting evidence. System may be impractical or difficult to implement. Limited understanding of the complexities of mass casualty management or blood resource allocation.</i>	

Question 3

Criteria	Excellent (8-10)	Good (5-7)	Needs improvement (1-4)	Marks
<i>Community Health Programme Design Comprehensive plan to address Rhesus incompatibility and HDN</i>	<i>Creates a comprehensive, well-structured programme with multiple evidence-based interventions including education campaigns, prenatal screening protocols, Anti-D immunoglobulin administration guidelines, and follow-up care systems. Programme components are clearly explained and specifically tailored to Akuapem North District context. Shows thorough understanding of Rhesus incompatibility and HDN prevention.</i>	<i>Creates a generally sound programme with several relevant interventions covering education, screening, and treatment aspects. Most programme components are adequately explained with some consideration of local context. Shows good understanding of Rhesus incompatibility and HDN prevention with minor conceptual gaps.</i>	<i>Presents a basic programme with limited interventions or significant omissions in critical areas. Programme lacks detail or coherence. Limited consideration of local context. Shows partial understanding of Rhesus incompatibility and HDN with notable misconceptions.</i>	10
<i>Barrier Evaluation Analysis of implementation challenges</i>	<i>Thoroughly evaluates a wide range of relevant barriers (educational, cultural, economic, geographical, healthcare system) with specific examples from Akuapem North context. Analysis demonstrates deep insight into local healthcare challenges. Evaluates how barriers interact with each other and affect different programme components. Considers both obvious and subtle obstacles to implementation.</i>	<i>Evaluates several relevant barriers with adequate depth. Some specific examples relevant to the local context but may lack detail in certain areas. Analysis shows reasonable understanding of healthcare challenges. Some consideration of how barriers relate to different programme components.</i>	<i>Identifies few barriers with superficial analysis. Examples may be generic rather than context specific. Limited understanding of healthcare implementation challenges. Analysis lacks depth or critical thinking about the complexities of programme implementation.</i>	10

Rubrics

Question 1

Component	Criteria	Marks
Research Design	• Comprehensive methodology including sampling techniques• Appropriate identification of variables to measure• Ethical considerations• Statistical analysis methods	5
Analysis of Genetic Factors	• Identification of specific genetic mechanisms (mutation, recombination). • Discussion of how genetic factors contribute to adaptation• Evidence-based reasoning connecting genetic variation to survival	5
Analysis of Environmental Factors	• Identification of relevant environmental pressures• Discussion of phenotypic plasticity vs. genetic adaptation• Analysis of how environmental factors interact with genetic factors	5
Prediction & Evaluation	• Well-reasoned predictions based on principles of evolution• Critical evaluation of which factors are most influential• Consideration of multiple possible future scenarios• Limitations of predictions acknowledged	5
Total		20

Question 2

Component	Criteria	Marks
Species Selection & Background	• Appropriate selection of two contrasting species• Clear description of natural variation patterns in these species• Relevant background on normal evolutionary processes	4
Analysis of Human Impact	• Specific human activities identified with their mechanisms of impact• Evidence showing altered variation patterns• Comparative analysis before/after human influence	5
Evolutionary Assessment	• Clear criteria for evaluating “progress” vs “regression”• Application of evolutionary principles• Balanced consideration of multiple perspectives• Evidence-based conclusions	6
Ethical Analysis	• Identification of key ethical considerations• Balanced discussion of competing ethical viewpoints• Connections between scientific facts and ethical implications• Consideration of long-term consequences	5
Total		20

Question 3

Component	Criteria	Marks
Climate Change Analysis	• Identification of specific climate-related selection pressures• Discussion of timeframe and intensity of changes• Regional differences in climate impacts	4

Evaluation of Variation Sources	• Comprehensive analysis of each variation mechanism• Comparative assessment of their adaptive potential• Evidence-based reasoning for conclusions• Consideration of limitations	6
Model Creation	• Clear, logical structure showing factor interactions• Inclusion of feedback mechanisms• Visual representation of relationships• Appropriate incorporation of time dimension	5
Regional Predictions	• Distinct predictions for at least three geographical regions• Integration of cultural and technological factors• Consideration of population genetics principles• Recognition of uncertainty and multiple possible outcomes	5
TOTAL		20

WEEK 9

Question 1

Component	Criteria	Marks
a) Punnett square	• Correct parental genotypes (AS × AS) (1 mark) • Correct gametes shown (1 mark) • Complete and accurate Punnett square (1 mark) • Correct identification of all possible genotypes: AA, AS, AS, SS (1 mark) • Correct probability ratios: 25% AA, 50% AS, 25% SS (1 mark)	5
b) Genetic counselling benefits	• Three clearly explained ways genetic counselling would help (3 marks per point) • Points may include: risk assessment, education about sickle cell disease, explanation of inheritance patterns, discussion of reproductive options (e.g., IVF with PGD), psychological support, etc. • Award full marks for comprehensive explanations that show understanding of both genetic principles and counselling aspects	9
c) Ethical challenge	• Identification of a relevant ethical challenge (2 marks) • Thoughtful discussion of the challenge (4 marks) • May include: dilemmas around termination of pregnancy, balancing directive vs. non-directive counselling, psychological impacts of testing, confidentiality issues, etc.	6
TOTAL		20

Question 2

Component	Criteria	Marks
a) Genetic variation and cancer treatment	• Clear explanation of how genetic variation affects cancer treatment (3 marks) • Specific, relevant example with accurate scientific details (3 marks) • Example might include: HER2 testing for breast cancer treatment, EGFR mutations in lung cancer, BRAF mutations in melanoma, etc.	6

b) Challenges analysis	• Identification of two relevant challenges (1 mark each) • Thorough analysis of each challenge (2 marks each) • Challenges might include cost of genetic testing, staff training needs, ethical issues, infrastructure requirements, insurance coverage issues, etc.	6
c) Proposed solution	• Practical solution that directly addresses one of the identified challenges (1 mark) • Explanation of implementation approach (1 mark) • Discussion of potential effectiveness (1 mark)	3
TOTAL		15

Question 3

Component	Criteria	Marks
a) Gene–environment interaction	• Accurate explanation of specific genetic variants linked to Type 2 diabetes (2 marks) • Clear description of relevant environmental factors (2 marks) • Thoughtful explanation of how these factors interact (2 marks)	6
b) Public health intervention	• Intervention clearly addresses genetic aspects (2 marks) • Intervention clearly addresses environmental aspects (2 marks) • Intervention is practical, ethical, and appropriate for the community context (2 marks)	6
c) Respecting variation	• Clear description of how the intervention respects individual or population variation (1 mark) • Explanation of how this approach improves effectiveness (1 mark) • Demonstration of strategic reasoning in balancing individual differences with population health goals (1 mark)	3
TOTAL		15

WEEK 10

Question 1

Criteria	Level 3 (5–8 marks)	Level 2 (3–4 marks)	Level 1 (1–2 marks)
Classification and reasoning	Correctly identifies the type of evolution with a comprehensive explanation, including the time scale, genetic mechanisms and effects on populations.	Correctly identifies the type of evolution and provides an adequate explanation of its main characteristics.	Correctly identifies the type of evolution but provides only a minimal explanation.

<i>Comparison</i>	<i>Thoroughly analyses the similarities and differences between the examples, including time scales, selection pressures and genetic changes.</i>	<i>Compares the examples and provides some analysis of the evolutionary processes involved.</i>	<i>Lists basic differences between the examples with limited analysis.</i>
<i>Evidence analysis</i>	<i>Provides a comprehensive analysis showing how the examples support evolution and links them to multiple lines of evolutionary evidence.</i>	<i>Analyses how the examples provide evidence for evolution with some connection to evolutionary theory.</i>	<i>Describes how the examples support evolution with minimal analysis.</i>

Question 2

Criteria	Level 3 (5–8 marks)	Level 2 (3–4 marks)	Level 1 (1–2 marks)
<i>Lamarck's Interpretation</i>	<i>Comprehensively explains Lamarck's theory and accurately applies it to the giraffe scenario, including the inheritance of acquired characteristics and how neck length was thought to increase over generations.</i>	<i>Explains Lamarck's theory correctly and applies it to the giraffe scenario with some supporting detail.</i>	<i>Identifies the basic concept of acquired characteristics with little or no application to the giraffe scenario.</i>
<i>Darwin's Interpretation</i>	<i>Thoroughly explains Darwin's theory of natural selection and applies it to the giraffe scenario, including variation, selection pressures, survival advantage and reproductive success.</i>	<i>Explains Darwin's theory and applies it to the giraffe scenario with some supporting detail.</i>	<i>Identifies the basic concept of natural selection with little or no application to the giraffe scenario.</i>
<i>Evaluation</i>	<i>Provides a well-reasoned evaluation supported by appropriate scientific evidence, explains why Darwin's theory is accepted today, identifies limitations of Lamarck's theory, and relates the explanation to modern genetics.</i>	<i>Evaluates both theories with adequate reasoning and some supporting scientific evidence.</i>	

Question 3

Criteria	Level 3 (5–8 marks)	Level 2 (3–4 marks)	Level 1 (1–2 marks)
<i>Natural Selection Analysis</i>	<i>Provides a comprehensive analysis of multiple selection pressures and clearly explains how they influence survival, reproduction and the development of advantageous adaptations in the population.</i>	<i>Analyses several selection pressures and explains their effects on the population with reasonable accuracy.</i>	<i>Identifies basic selection pressures with minimal analysis or explanation.</i>
<i>Genetic Drift Explanation</i>	<i>Thoroughly explains genetic drift and applies it accurately to the scenario, including the effects of small population size, chance events, founder effects or population bottlenecks, and their consequences for genetic diversity.</i>	<i>Explains genetic drift and adequately applies it to the effects of population size and chance on genetic variation.</i>	<i>Describes genetic drift with limited explanation and minimal application to the scenario.</i>
<i>Evaluation of Combined Evolutionary Factors</i>	<i>Provides a comprehensive evaluation of how natural selection, genetic drift, mutation and isolation interact to influence evolution, including possible interactions, long-term consequences and evolutionary outcomes.</i>	<i>Evaluates several evolutionary factors and provides some analysis of how they interact to influence the population.</i>	<i>Lists evolutionary factors with minimal explanation and little or no integration of their effects.</i>

WEEK 11

Question 1

The cell cycle consists of interphase and the M phase. Interphase includes G₁ (cell growth and normal metabolic activities), S phase (DNA replication), and G₂ (preparation for division). The M phase consists of mitosis and cytokinesis.

Mitosis is the division of the nucleus, producing two genetically identical daughter nuclei. It occurs in four main stages: prophase, metaphase, anaphase and telophase. Cytokinesis follows mitosis and divides the cytoplasm, producing two daughter cells.

After cytokinesis, the daughter cells may enter G₁ of a new cell cycle or exit the active cycle into the G₀ phase.

Marking Scheme

- Accurate description of interphase components (G₁, S, G₂) (2 marks)
- Clear explanation of M phase components (mitosis, cytokinesis) (1 mark)
- Correct positioning of mitosis within the cell cycle (1 mark)
- Explanation of what happens after mitosis completion (1 mark)

Question 2

Model Answer: While mitosis is a regular part of the cell cycle in somatic cells, meiosis is a specialized form of cell division that occurs only in cells destined to form gametes. Both processes follow DNA replication during S phase of interphase. However, meiosis involves two consecutive nuclear divisions (meiosis I and meiosis II) without an intervening S phase. After completing interphase, cells entering meiosis undergo unique events in prophase I (including synapsis and crossing over between homologous chromosomes) before proceeding through the first division, which separates homologous chromosomes. After a brief interkinesis (without DNA replication), meiosis II separates sister chromatids. Unlike mitosis, which produces diploid cells that typically re-enter the cell cycle, meiosis produces haploid cells that differentiate into gametes rather than continuing in the cell cycle.

Marking Scheme

Clear distinction between mitosis as regular cycle vs. meiosis as specialized (1 mark)

Explanation of two consecutive divisions without intervening S phase (1 mark)

Reference to unique events in meiosis (crossing over, homologous separation) (1 mark)

Explanation of the different outcomes (diploid vs. haploid) (1 mark)

Explanation of cell fate after division (re-entry vs. differentiation) (1 mark)

Extended Response Question (15 marks)

Question 3

Model Answer

The cell cycle is the sequence of events that a cell undergoes from its formation until it divides. It consists of interphase and M phase (mitotic phase).

Interphase is divided into three sub-phases:

G₁ (Gap 1): The cell increases in size, synthesizes proteins and organelles, and carries out normal cellular functions. The G₁ checkpoint ensures conditions are favourable for division.

S (Synthesis): DNA replication occurs, resulting in chromosomes consisting of two sister chromatids joined at the centromere. Centrosomes also duplicate during this phase.

G₂ (Gap 2): Further growth and protein synthesis occur, and the G₂ checkpoint ensures DNA is correctly replicated before division.

M phase consists of mitosis (nuclear division) and cytokinesis (cytoplasmic division).

Mitosis is integrated into the cell cycle as the mechanism for nuclear division in somatic cells. It follows the completion of interphase and proceeds through:

Prophase: Chromosomes condense, the nuclear envelope breaks down, and spindle fibres form.

Metaphase: Chromosomes align at the metaphase plate with spindle fibres attached to centromeres.

Anaphase: Sister chromatids separate and move toward opposite poles.

Telophase: Nuclear envelopes reform around separated chromosomes, and chromosomes begin to decondense.

Cytokinesis typically begins during late anaphase/telophase, dividing the cytoplasm to form two daughter cells. After completing mitosis and cytokinesis, cells enter G₁ of a new cycle or enter a non-dividing state called G₀.

Meiosis has a different relationship to the cell cycle. While it also follows interphase (including DNA replication in S phase), meiosis consists of two consecutive divisions without an intervening S phase:

Meiosis I

Prophase I: Homologous chromosomes pair up (synapsis) and exchange genetic material (crossing over).

Metaphase I: Homologous pairs align at the equator.

Anaphase I: Homologous chromosomes separate and move to opposite poles.

Telophase I: Nuclear envelopes may reform briefly.

A brief interkinesis follows without DNA replication.

Meiosis II

Similar to mitosis but occurs in cells that are already haploid.

Sister chromatids separate during anaphase II.

The outcome of meiosis is four haploid cells, each with half the chromosome number of the parent cell and genetically different due to crossing over and independent assortment.

Examples in multicellular organisms

Mitosis: Skin epithelial cells divide continuously to replace cells lost through wear; intestinal epithelium renews every 3-5 days; bone marrow stem cells produce blood cells.

Meiosis: In humans, meiosis occurs in the testes to produce sperm and in the ovaries to produce eggs. In flowering plants, meiosis occurs in the anthers to produce pollen and in the ovules to produce egg cells.

Marking Scheme

- Interphase description (3 marks)
- Accurate description of G₁, S, and G₂ phases (1 mark each)
- Mitosis in the cell cycle (4 marks)
- Clear explanation of mitosis phases (2 marks)
- Explanation of how mitosis follows interphase (1 mark)
- Description of what happens after mitosis (1 mark)
- Meiosis relation to cell cycle (5 marks)
- Explanation of meiosis following interphase (1 mark)
- Description of meiosis I key events (1 mark)
- Explanation of no DNA replication between divisions (1 mark)
- Description of meiosis II events (1 mark)
- Explanation of outcomes and how they differ from mitosis (1 mark)
- Examples of cells (2 marks)
- Relevant examples of mitotic division (1 mark)
- Relevant examples of meiotic division (1 mark)
- Organization and scientific accuracy (1 mark)
- Well-structured answer with correct use of biological terminology

Multiple Choice Questions (1 mark each)

1. B
2. B
3. C
4. C
5. B

SECTION 3: DIVERSITY OF LIVING THINGS

STAND: DIVERSITY OF LIVING THINGS AND THEIR ENVIRONMENT

Sub-strand 1: Living Organisms

Learning Outcome: *Relate the knowledge of the characteristic features and life processes of tilapia, toad, wall gecko and domestic fowl to their economic importance.*

Content Standard: *Demonstrate knowledge and understanding of the characteristic features and life processes of tilapia, frog/toad, wall gecko and Domestic fowl and their economic importance.*

Sub-strand 2: Ecology

Learning Outcomes

1. Explain the interdependencies of living things and their environment and indicate the ecological importance of each.
2. Accurately collect and analyse data, draw valid conclusions and inferences to address problems in the environment.

Content standards

1. *Demonstrate knowledge and understanding of the interaction between the living and non-living components of the environment to ensure the sustenance of life.*
2. *Demonstrate knowledge and understanding of data collection, analysis, interpretation and making valid conclusions and inferences to address problems in the environment.*

Sub-strand 3: Diseases and Infections

Content Standard: *Explore some emerging diseases and infections and show their prevention methods.*

Learning Outcome: *Examine and explain emerging diseases and infections and suggest how they can be prevented.*

INTRODUCTION AND SECTION SUMMARY

In year two, we discussed selected insects' (grain weevil, butterfly, housefly and honeybee) characteristic features, life cycles, economic importance and how to control their populations. This was to gain understanding of their impact on plants and animal life in the ecosystem. The tropical habitats of these organisms were studied in the sub-strand, Ecology. Learners acquired basic knowledge on tropical habitats and how living things are adapted to survive in these habitats. In this section learners will continue discussions on one organism each from an osteichthytes, amphibia, reptilia and aves taxa. Interdependencies existing within ecosystems will also be discussed. Learners will be introduced to the collection and analysis of data from an ecological point of view. Still on ecology, some diseases with an impact on human, plant and animal life will be studied as well.

The weeks covered by the section are:

Week 12 & 13

1. Describe the characteristic features and life processes of the tilapia, frog/toad, wall gecko, and domestic fowl.
2. Discuss the economic importance of tilapia, frog/toad, wall gecko and domestic fowl.

Week 14

1. Describe the interdependency of living and non-living components of the environment.
2. Explain the interdependency of living things and its importance to life.

Week 15

1. Accurately collect and analyse data on BMI from learners in the class who are willing to and plant density on the school compound.
2. Draw valid conclusions and inferences on the analysed data.

Week 16: Discuss how emerging human diseases (SARS-COVID-19, Ebola, Buruli ulcer, Swine flu/H1N1 flu and Monkeypox) are transmitted and suggest steps to prevent their spread.

Week 17: Research on other diseases of plants and animals and suggest steps to prevent their spread.

SUMMARY OF PEDAGOGICAL EXEMPLARS

Pedagogies to be used in the lessons have been carefully chosen to arouse learner interest in the lessons. They are intended to create a biology classroom buzzing with excitement—learners eagerly examining specimens, passionately debating conservation strategies, and collaboratively collecting data that matters to their lives! This dynamic learning environment can only be attained through thoughtfully selected pedagogical approaches to spark curiosity and accommodate different learning styles of all learners.

For vertebrate characteristics, experiential learning through specimen handling and discussions transforms abstract concepts into tangible discoveries. When exploring economic importance, talk-for-learning activities like structured discussions cultivate critical thinking whilst honouring indigenous knowledge. Project-based learning naturally suits environmental interdependency topics, empowering learners to investigate diseases and infections while pursuing personal interests. For data collection, collaborative learning with assigned group roles celebrates diverse strengths and nurtures peer teaching. Disease transmission concepts come alive through a blended approach using simulations and campaign design that resonates with different learning preferences. For data collection, collaborative learning with assigned group roles celebrates diverse strengths and nurtures peer teaching. Disease transmission concepts come alive through a blended approach using simulations and campaign design that resonates with different learning preferences. Thus, the pedagogies to be used in discussing the lessons effectively cater for the learning needs of all individuals, thereby promoting inclusivity.

ASSESSMENT SUMMARY

Several modes of assessment are employed in learning in this section. The tests provide a broad-based, comprehensive assessment of the learners' knowledge as advised in the Curriculum and the Teacher Assessment Manual and Toolkits. This allows consistency in evaluating learners' academic progress.

Indicators	DOK Level	Assessment Strategy and/or Mode
Describe the characteristic features and life processes of tilapia, frog/toad, wall gecko, and domestic fowl.	Level 4	comparative essay writing
Discuss the economic importance of tilapia, frog/toad, wall gecko and domestic fowl.	Level 4	Individual observation
Describe the interdependency of living and non-living components of the environment.	Level 4	Case Study
Describe the interdependency of Living things and explain its importance to life.	Level 3	Case Study
Accurately collect and analyse data on BMI of the class and plant density on the school compound.	Level 4	Practical
Draw valid conclusions and inferences on the analysed data.	Level 3	Practical
Discuss how emerging human diseases (SARS-COVID-19, Ebola, Buruli ulcer, Swine flu/H1N1 flu and Monkeypox) are transmitted and suggest steps to prevent their spread.	Level 4	Discussion and presentation
Research on other diseases of plants and animals and suggest steps to prevent their spread.	Level 4	Case study

WEEK 12

Learning Indicators

1. Describe the characteristic features and life processes of the tilapia, frog/toad, wall gecko, and domestic fowl
2. Discuss the economic importance of Tilapia, frog/toad, wall gecko and domestic fowl

FOCAL AREA: CHARACTERISTIC FEATURES, LIFE PROCESSES AND ECONOMIC IMPORTANCE OF TILAPIA AND FROG/TOAD

Characteristic Features of Tilapia

Tilapia is a highly adaptable aquatic organism and can tolerate a range of environmental conditions, including varying salinity and temperature making it a popular choice for aquaculture and an important species in many freshwater ecosystems. They thrive in freshwater environments, particularly in warm, shallow waters like lakes, rivers, and ponds.

Tilapia has a streamlined, laterally flattened, oval body shape, which aids in movement in water. Tilapia species typically exhibit a range of colours, including shades of grey, brown, or olive green, with some species displaying bright colours, especially during the breeding season.

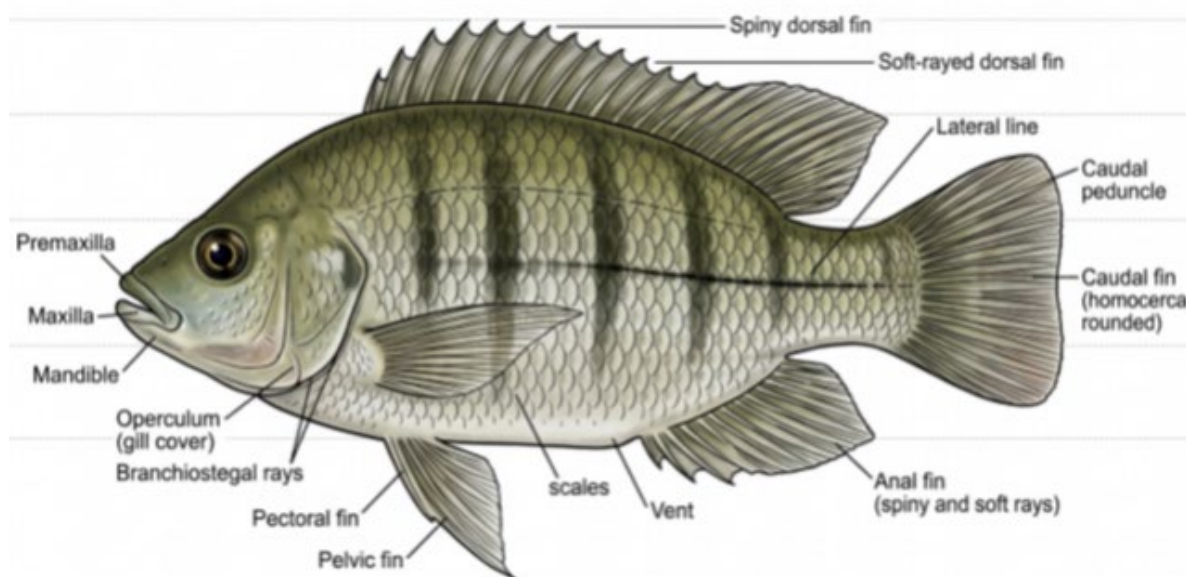


Figure 3.1: A labelled diagram of the lateral view of Tilapia

The dorsal fin is long and continuous, often with a pronounced spiny section. Ventral/Anal fins, pelvic fins and pectoral fins are also elongated, supporting stability in the water. They possess large, smooth scales that provide protection and help reduce drag in the water. The operculum covers and protects the gills. The lateral line has pits for detecting changes in pressure.

Depending on the species, tilapia size can range from 0.45kg to 4.50kg or more.



Figure 3.2: *Size of a young tilapia*

Selected Life Processes

Nutrition

Tilapia is omnivorous and has a noticeable mouth, allowing them to feed effectively on algae, small invertebrates e.g., mosquito larvae and minute aquatic plants e.g., plankton and aquatic protoctists. Water containing food is taken into the mouth. As it flows through the slender projections called the **gill rakers**, at the sides of the head, it prevents the food particle from escaping. The food then moves into the pharynx behind the buccal cavity (the mouth) and is swallowed. This process is called **filter feeding**. When farming tilapia (aquaculture), it is important to supplement the feed of the fish with specially formulated feed to improve production.

Excretion

Ammonia is the nitrogenous waste substance excreted. Other excretory substances are excess salts and water. These are excreted by the kidney in urine. Carbon dioxide is excreted by diffusion out of the body through the gills.

Reproduction

The sexually matured male and female dig a shallow pit in the bed of the pond or lake. The female lays eggs and the male sheds sperms over them. The sperm swim to the eggs and fertilize them (external fertilization). The fertilized eggs are abandoned by the parents, and most are eaten by predators.

Certain species of Tilapia exhibit, a degree of parental care called **mouth brooding**. In this mouth-brooding behaviour, the male carries the fertilized eggs in his mouth for about two weeks until they hatch into tiny fish called fry. The fry retreat into the parent's mouth when there is danger.

Movement

Tilapia moves in water by swimming. Rapid forward movement is brought about by the side-to-side lashing of the tail. This is controlled by the contraction of the muscle blocks on both sides of the body of the fish which are well developed especially in the tail region. The caudal fin also works with the paired fins in steering the fish through the water. During rapid movement, the paired fins are held close to the body and when extended, they slow down **to or** stop the fish. The unpaired fins control yawing (the tendency of the body to zigzag from side-to-side) and rolling (rotation of the body around its longitudinal axis). The paired fins control pitching (tendency of the head to rise and fall).

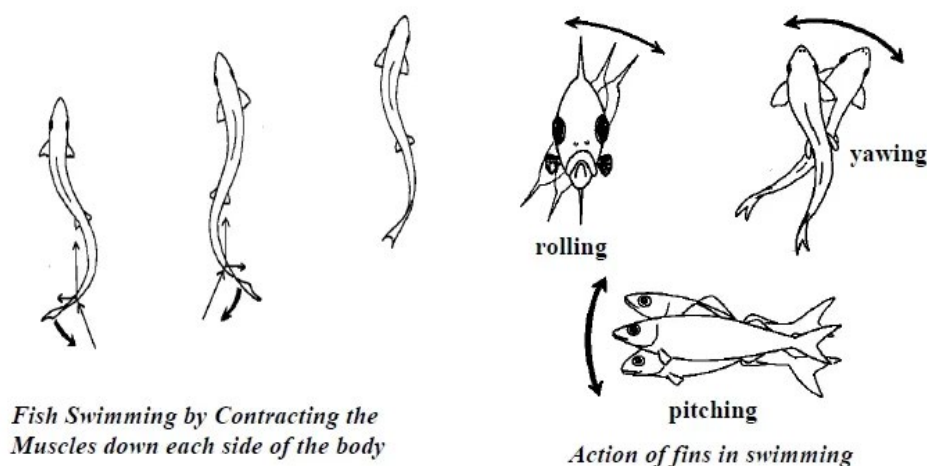


Figure 3.3: Movement actions in the Tilapia

The air or swim bladder enables up and down movement in the water without swimming. Gases diffuse from the blood into the bladder to inflate it, rendering the fish less dense and rising easily. When the bladder is deflated the fish becomes denser and sinks.

Economic Importance of Tilapia

1. **Health Benefits:** As a low-fat source of protein rich in essential nutrients, tilapia contributes to public health by providing affordable, nutritious food options.
2. **Aquaculture:** Tilapia is one of the most widely farmed fish globally, making significant contributions to the aquaculture industry. It is mostly used due to its rapid growth, hardiness, and ability to thrive in diverse conditions. Tilapia can be raised in environmentally sustainable ways, such as integrated farming systems that utilise waste products for crop production and therefore enhancing overall farm productivity. For example, in Ghana the farming of Tilapia has created livelihood opportunities for many people, especially in rural areas.
3. **Food Source:** Tilapia provides a rich source of protein and is a staple in many diets around the world. Its mild flavour makes it a great choice in various cuisines.
4. **Employment Opportunities:** The tilapia farming industry creates numerous jobs in aquaculture, processing, distribution, and retail, contributing to local economies and livelihoods. For example, the people of Weija, Akosombo and Ada trade in the fresh or dried Tilapia
5. **Export Revenue:** Countries that produce tilapia often export it to international markets, generating significant income. This supports national economies, particularly in developing regions.
6. **Cultural Significance:** In many cultures, tilapia is associated with traditional fishing practices and culinary heritage, supporting local customs and tourism for example in Ghana Tilapia is a popular dish often served in hotels, restaurants, and other eating places and has become an important part of Ghanaian hospitality, reflecting the country's wealth of local cuisine.
7. **Research and Development:** The tilapia industry drives research in aquaculture practices, genetics, and nutrition, leading to innovations that improve fish farming efficiency and sustainability.

Characteristic Features of Toads

Toads have **short, stout bodies** with dry, bumpy (warty) skin that helps to reduce water loss. They have strong hind limbs adapted for hopping and short jumps. Their large, bulging eyes are positioned on the top of the head, providing a wide field of vision for detecting predators and prey. The nostrils are located on the upper part of the snout, allowing toads to breathe while partially submerged in water.

The external **tympanic membranes** (eardrums), located behind the eyes, are visible and function in hearing.

Toads are generally earth-toned in colour, which helps them blend into their surroundings (camouflage). They possess **parotoid glands** behind the eyes that secrete toxic substances as a defence mechanism against predators. Compared with frogs, toads are more terrestrial and are better adapted to drier environments.

During the breeding season, **male toads** produce distinctive croaking calls to attract females. **Female toads** lay their eggs in long gelatinous chains, usually in freshwater habitats.

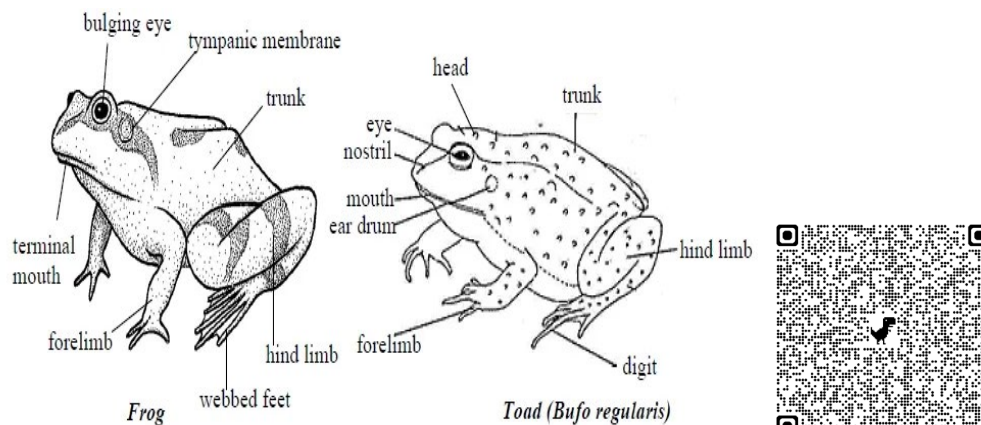


Figure 3.4: Toad

Selected Life Processes

Nutrition

Toads are carnivorous mainly feeding on worms, slugs, spider, beetles and other insects. They have an elongated, sticky tongue which is flicked out to catch insects even in flight and redraw it back into the mouth. They swallow the prey whole without much chewing.

Excretion

Ammonia, excess salts and water are excreted by the kidney in urine through the cloaca. Carbon dioxide is excreted from the body through the lungs, buccal cavity or skin by diffusion.

Movement

The feet have adaptations for movement both on land and in water.

On land, toads move by hopping or leaping and crawling. The long, muscular folded hind limbs are straightened to push and lift the toad off the ground when hopping. The forelimbs absorb the shocks of landing after hopping. The toads usually move by crawling with the limbs moving diagonally.

In water, toads swim by using the powerful hind limbs. The webbed feet increase the surface area that pushes against the water. The forelimbs are used in steering.

Reproduction

The breeding season typically occurs in the rainy season when males begin to call (croaking) to attract females. When a female is attracted the male climbs onto the female's back and grasps her with his forelimbs. This position helps ensure that the male fertilizes the eggs as the female lays them. This mating behaviour is known as amplexus.

The female releases eggs into water, usually in shallow ponds or temporary water bodies. The eggs are laid in long chains, depending on environmental conditions. The male releases sperm over the eggs as the female lays them, allowing for fertilization to occur in the water.

The fertilized eggs develop into embryos, typically hatching within 3 to 14 days, depending on temperature and water conditions. After hatching, the larvae (tadpoles) are aquatic and undergo metamorphosis. They initially have gills and a tail for swimming.

Over several weeks to months, tadpoles undergo transformation (metamorphosis), developing lungs, legs, and losing their tails. This transformation prepares them for a terrestrial lifestyle. Once metamorphosis is complete, juvenile toads leave the water and begin their life on land, where they continue to grow and mature. *Bufo regularis* typically reaches sexual maturity within 2 to 3 years, at which point they can participate in the breeding cycle.

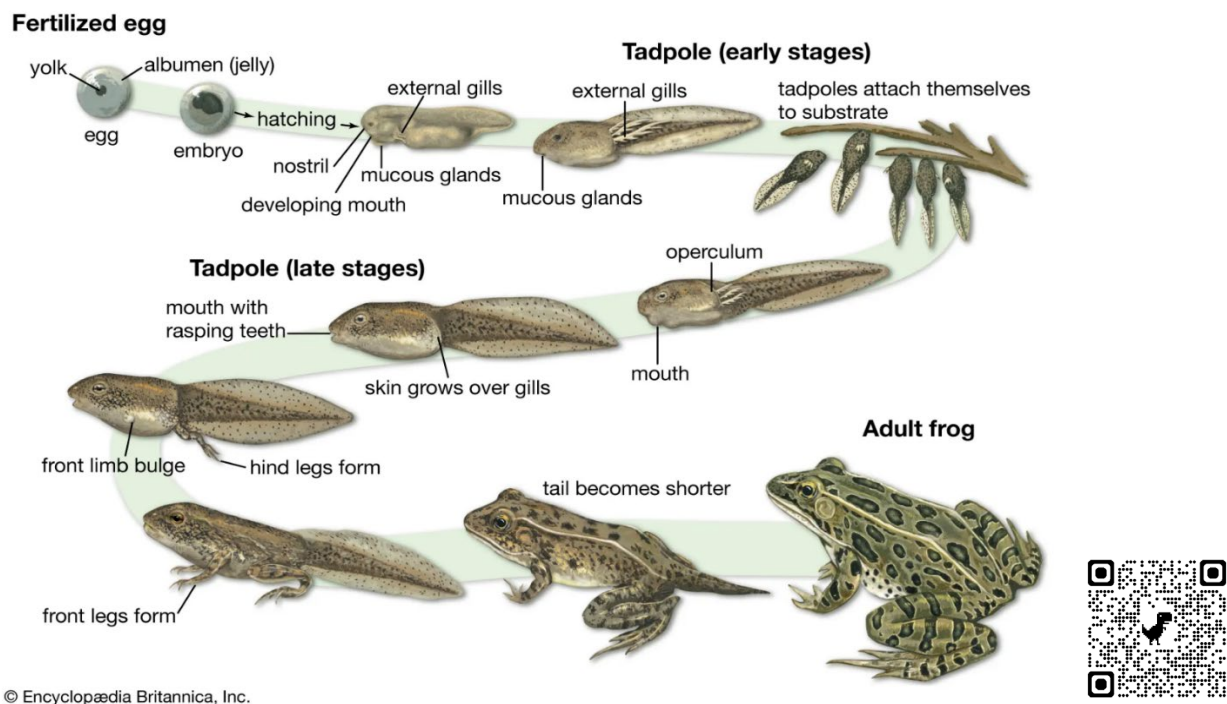


Figure 3.5: Metamorphosis in the frog

Economic Importance of Frogs/Toads

1. **Biodiversity Indicators:** Frogs/toads and toads serve as bioindicators of ecosystem health. Their presence or absence can indicate environmental changes, helping in conservation efforts and land management.
2. **Agricultural Benefits:** They play a crucial role in controlling insect populations, including agricultural pests, thereby benefiting farmers by reducing the need for chemical pesticides.
3. **Medicinal Research:** Compounds derived from the skin secretions of some frog/toad species have been studied for potential medicinal properties, including antimicrobial and pain-relieving effects.
4. **Pet Trade:** Certain species of frogs/toads and toads are popular in the exotic pet trade, contributing to local economies through breeding and sales.
5. **Cultural Significance:** Frogs/toads and toads feature prominently in various cultures, folklore, and traditional practices, often symbolizing fertility and transformation.
6. **Ecotourism:** Frogs/toads and toads attract nature enthusiasts and researchers, supporting ecotourism initiatives that generate revenue for local communities.

7. **Education and Research:** Their unique biological and ecological characteristics make them valuable subjects for scientific research, contributing to educational programs and studies in biology and environmental science.
8. **Food Source:** In some cultures, frog/toad legs are considered a delicacy, providing a source of protein and income for local populations.

Learning Tasks

1. Identify the adaptative characteristics for survival of tilapia and toad in its habitat.
2. Examine the life processes of Tilapia and frogs/toads.
3. Explore the economic importance of Tilapia and toad.
4. Analyse the interactions of humans with the tilapia and toad.

Pedagogy Exemplars

1. **Project-Based Learning:** Work in large groups to conduct research on the life cycle of the Tilapia and frog/toad with particular emphasis on their general characteristics.
2. **Collaborative Learning:** Examine the life processes of the Tilapia and frog/toad by discussing in groups and making observations and notes on these.
3. **Talk-for-Learning Approach:** Do group presentations with the aid of charts, pictures or PowerPoint slides on the tilapia and frog/toad.
4. **Talk-for-Learning Approach:** engage in a whole class discussion on the economic importance of tilapia and frog/toad.
5. **Task-based Learning:** observe the tilapia and frog/toad within your locality; make notes and discuss some of the unique attributes and perceptions the locals have on these organisms, and how this informs their approach and interactions with the organisms.

Key Assessment: Practice Paper 1

1. Compare the adaptive characteristics of Tilapia and toads, discussing how these adaptations influence their respective roles in the ecosystem and their interactions with other species. (10 marks)

2. Scenario

Pioneer Ventures is an emerging player in the tilapia aquaculture sector in Ghana, focusing on sustainable practices while aiming to enhance local livelihoods through farming. The company uses methods that minimise environmental impact. The responsible water management practice through efficient use and recycling of water resources contributes to the conservation of local water bodies and promotes practices that protect local biodiversity. The use of organic feed promotes fish health and the surrounding ecosystem. Pioneer Ventures offers training for local farmers on sustainable tilapia farming practices empowering the communities to adopt eco-friendly methods to enhancing their productivity and income. By sourcing tilapia from local farmers, the company strengthens community ties and increases local economies

- a. How can balancing ecological concerns with economic objectives influence the company's growth? (10 marks)

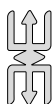
- b. Discuss potential ecological challenges the company might face in regarding perceptions of the local society. (10 marks)
3. Evaluate the role of metamorphosis in frogs/toads compared to the growth and development processes in tilapia. (10marks)

HINT

Conduct **Practice Paper 1**. It should cover the contents taught from Year 1 to 3. Refer to the **Table of Specification and Structure of the Paper** at the end of this section. Learners' papers should be marked immediately and scores entered into the SAP.

PLC Session 12**45 minutes****Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

**Note**

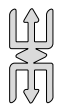
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the *Values Learning Community Handbook* and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).
 - a. The key assessment for the week is **Practice Paper 1**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the practice paper (NTS 3k-3q).

10 minutes**Content Exploration**

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

- b. all teachers in the group work through the problem individually for 3–4 minutes
- c. the group then works through it together the problem, step by step
- d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not ‘How do I teach this?’ but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 13

Learning Indicators

1. Describe the characteristic features and life processes of the tilapia, frog/toad, wall gecko, and domestic fowl
2. Discuss the economic importance of Tilapia, frog/toad, wall gecko and domestic fowl

FOCAL AREA: CHARACTERISTIC FEATURES, LIFE PROCESSES AND ECONOMIC IMPORTANCE OF WALL GECKO AND DOMESTIC FOWL

Characteristic Features of Wall Gecko

The common wall gecko is a small lizard commonly observed on walls in urban environments, mainly in warm areas cohabitating with humans as insect, spider and other small invertebrate hunters. It is a reptile of the *Hemidactylus sp.* growing up to 15cm in length and commonly found in rocky areas, cliffs, rock fields, and on many construction sites, ruins, building walls, and inside houses and it is not poisonous and harmless to humans. It is mostly nocturnal with the ability to climb walls and ceilings.

They have a robust body, a flat head, and large, bulging eyes with no eyelids. The skin is scaly and rugged, brownish-grey or brown in colour with darker or lighter spots. Its colours change in intensity according to the light allowing them to blend into their environment. Its toes equipped with special adhesive pads enable them to climb walls and ceilings. The tail is detachable as a defence mechanism if threatened.



Figure 3.6: Wall gecko

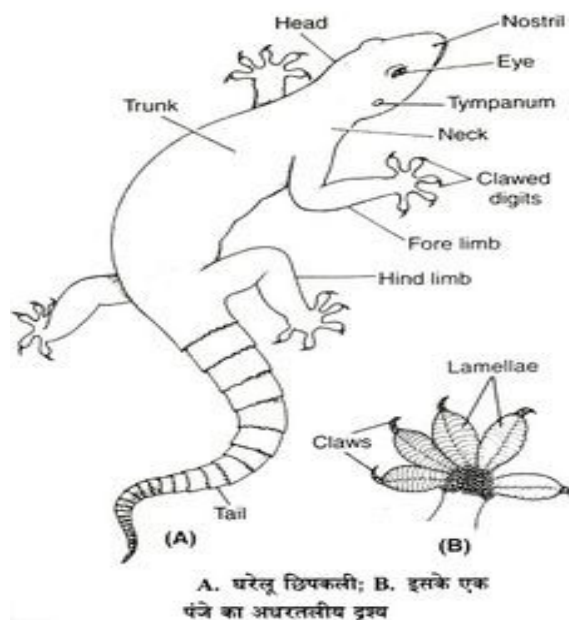


Figure 3.7: Drawing of the Wall gecko

Selected Life Processes of Wall Gecko

Nutrition

The wall gecko forages singly in the warmer months of the year. Wall geckos are carnivores (insectivores) and feed mainly on various types of insects and small invertebrates. They are seen hunting nocturnal insects near light sources and streetlamps at night.

Excretion

Wall geckos, like most reptiles, excrete nitrogenous waste mainly as **uric acid**, which requires very little water for excretion compared with ammonia or urea. This adaptation helps them conserve water, making them well suited to life in relatively dry environments. The waste is eliminated through the **cloaca**, a common opening into which the digestive, urinary and reproductive systems empty. As a result, faeces, uric acid and reproductive products all leave the body through this single opening.

Movement

Wall geckos have strong muscles in their limbs and trunk that enable them to move efficiently on walls, rocks and trees. Their flexible bodies allow precise limb movements during climbing.

A distinctive feature of wall geckos is their specialised toe pads, which contain millions of microscopic hair-like structures called **setae**. These setae generate strong adhesive forces through molecular interactions known as **van der Waals forces**, allowing the gecko to cling to smooth vertical surfaces and even move across ceilings without using liquid adhesives.

Wall geckos also use their tails to maintain balance and stability while climbing and to control their movement when landing after a fall.

Reproduction

Wall geckos reproduce throughout the year in warm climates. During mating, the male grasps the female with its jaws and brings the cloacae of both animals together to transfer sperm.

After mating, the female lays one or two eggs in sheltered places such as cracks, crevices or beneath rocks. The incubation period ranges from about **30 to 50 days**, depending on environmental conditions.

The newly hatched young are less than **5 cm** long and are independent from the moment they hatch. They grow rapidly and usually reach sexual maturity within **6 to 12 months**.

Economic Importance of Wall Geckos

1. Wall geckos are beneficial to humans because they feed on insects such as mosquitoes, flies and agricultural pests. By naturally controlling insect populations, they help reduce crop damage and may reduce the need for chemical pesticides.
2. Wall geckos also play an important role in food chains, serving as prey for birds, snakes and other animals. Their presence therefore contributes to maintaining ecological balance within ecosystems.
3. In addition, the remarkable adhesive properties of gecko toe pads have inspired the development of **biomimetic technologies**. Scientists have used these natural adaptations to design reusable adhesives, climbing devices and specialised medical tapes, demonstrating the importance of wall geckos in biotechnology and engineering.
4. Although wall geckos sometimes enter houses and may be regarded as a nuisance by some people, they are generally harmless to humans. Their ecological and scientific benefits greatly outweigh any minor inconveniences they may cause.
5. **Biological Pest Control:** a single wall gecko can consume approximately 50-100 insects per night, including mosquitoes, flies, cockroaches, and termites. This reduces the need for chemical pesticides, saving households on pest control measures. By consuming mosquitoes that transmit malaria, dengue fever, and other diseases, wall geckos indirectly reduce healthcare costs and productivity losses. In Ghana and other tropical countries, this ecosystem service has significant economic value, potentially saving in healthcare costs. In rural farm buildings and structures, wall

geckos help control insects that damage stored grains and produce. Natural predators like wall geckos can reduce post-harvest losses in traditional storage systems.

6. **Research and Biotechnology:** the wall gecko's remarkable ability to adhere to and climb smooth vertical surfaces has inspired biomimetic technologies worth millions in research and development. Gecko-inspired adhesives have applications in medical devices and bandages, robotics and climbing technologies, industrial materials handling and space technology applications.
7. **Cultural Value:** In many cultures, including some communities in Ghana, wall geckos are regarded as harmless and beneficial animals because they feed on insects found in and around homes. In some traditions, their presence is considered a sign of a healthy environment and they form part of local ecological knowledge and cultural heritage.
8. **Food Contamination and Household Hygiene:** Wall gecko droppings may contaminate uncovered food, utensils and water if proper hygiene is not maintained. For this reason, food should be stored in covered containers and kitchens should be kept clean. Although gecko droppings may require occasional cleaning of walls and ceilings, the inconvenience is generally minor compared with the ecological benefit of natural insect control provided by wall geckos.
9. **Invasive Species Impacts:** When introduced to new environments, some wall gecko species become invasive, potentially displacing native species and disrupting local ecosystems, which can have indirect economic consequences. In areas where they have become problematic invasive species, control programs require financial investment.

Characteristic Features of Domestic Fowl

The domestic fowl, *Gallus domesticus*, is a **warm-blooded (homeothermic)** organism, meaning that it maintains a relatively constant body temperature regardless of changes in the surrounding environment.

The body consists of the **head, trunk and tail**. The head is relatively small and rounded. It bears a strong, pointed, horny **beak**, on which is a pair of slit-like nostrils. The head also has a pair of eyes with upper and lower eyelids and a **nictitating membrane** (third eyelid). Behind each eye is an ear opening concealed by feathers.

On the top of the head is a red, fleshy structure called the **comb**, while beneath the beak is a **pair of hanging fleshy lobes called wattles**. The comb and wattles are generally larger and more prominent in the male than in the female. The head is covered with feathers except for the beak, comb and wattles.

The head is connected to the trunk by a long neck. The trunk bears fore-limbs and hind-limbs with the pair of forelimbs modified into wings. The legs and toes are covered with overlapping scales with each leg having four digits ending in sharp, curved claws (three are directed forward and one back). The tail is short and covered with long strong feathers (quill/flight feathers) with an oil gland (preen gland) on it. The preen glands produces oil which is used to preen or groom feathers to keep them glossy and waterproof.

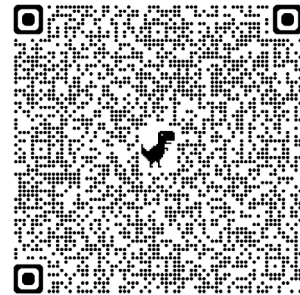
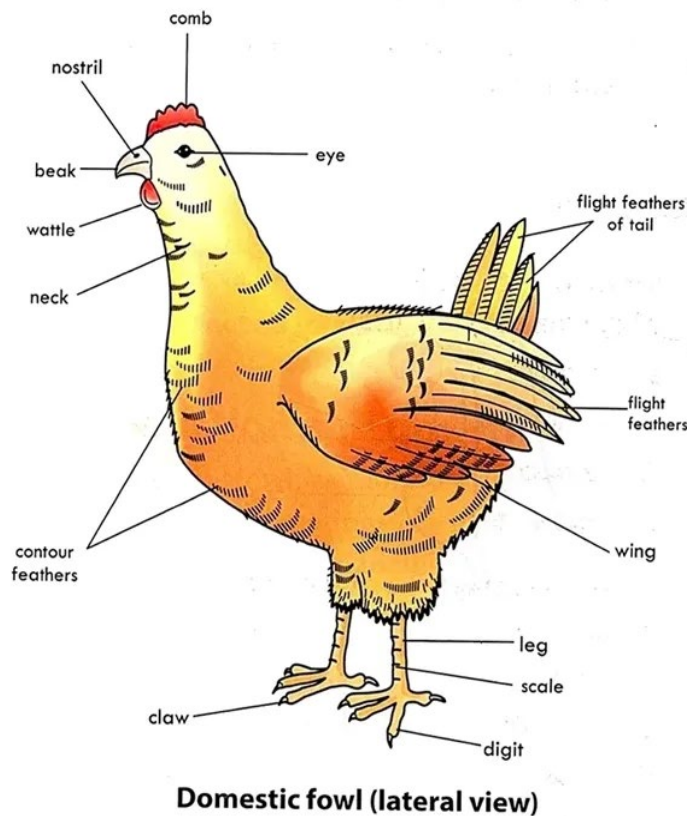


Figure 3.8: *The domestic fowl*

Selected Life Processes of Domestic Fowl

Nutrition

The domestic fowl is omnivorous, feeding on insects, worms and plant materials such as seeds and leaves. The sharp, strong claws are used to scratch the soil in search of food, which is picked with the sharp pointed beak. The food is swallowed through the oesophagus into the crop, where it is temporary stored. The food enters the proventriculus (first part of the stomach) and digestive juices are secreted to digest the food. The partially digested food then enters the gizzard (the second stomach). Churning and mechanical breakdown of the food takes place in the gizzard. The presence of small fine stones in the gizzard aids in mechanical grinding of the food. The digesting food enters the intestine for further breakdown and absorption of nutrients. The caeca absorb water from the food and the rectum empties the undigested food into the caeca to be eliminated as faeces through the cloaca.

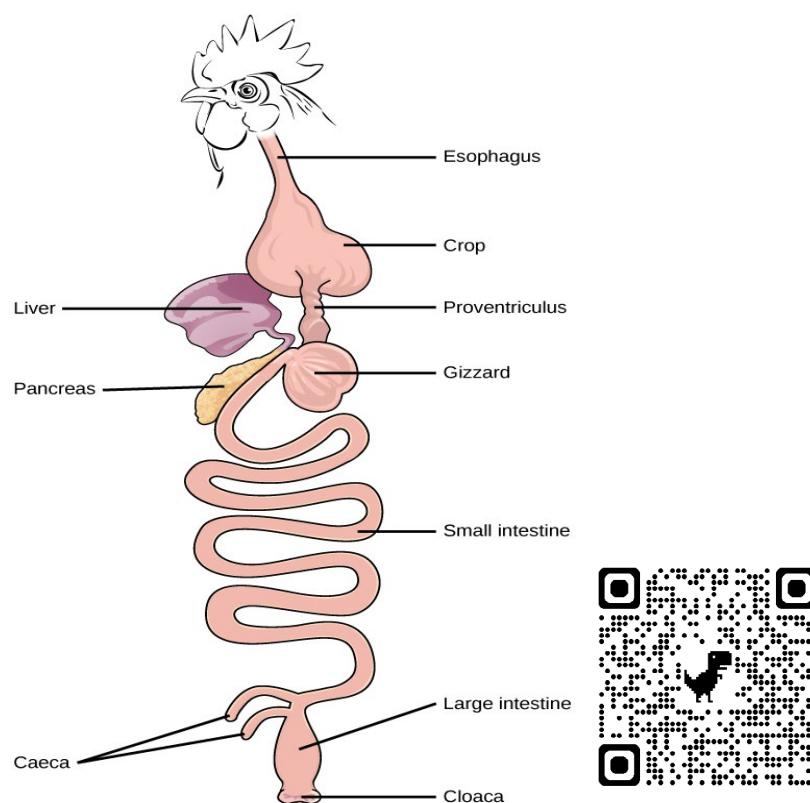


Figure 3.9: Digestive system of a Domestic fowl

Excretion

Excretion in domestic fowl involves the removal of waste products from their body, primarily through droppings. The domestic fowl does not have a bladder, and the urine produced enters the cloaca which permits excess water to be re-absorbed before elimination. This re-absorbed water is available for use by the fowl and, to some extent, offsets the limited ability of fowl to concentrate their urine as efficiently as mammals. The urine, in a thick pasty form with a very low water content but high in uric acid is deposited as a whitish or cream cap on some faeces.

Movement

Domestic fowl are primarily **terrestrial birds**, spending most of their time walking, running and scratching the ground in search of food. Although they are capable of flight, their flights are usually short and involve rapid wing flapping rather than prolonged gliding or soaring.

Several adaptations enable domestic fowl to move efficiently on land and to make short flights:

- a. A streamlined body helps reduce air resistance during flight.
- b. Well-developed **pectoral muscles** provide the force needed for wing flapping.
- c. A large **keel** on the sternum provides a broad surface for the attachment of the flight muscles.
- d. Hollow bones reduce body weight while maintaining strength.
- e. Strong hind limbs with clawed toes enable walking, running, scratching the ground and perching.
- f. The tail feathers help maintain balance during movement and assist with steering and braking during short flights.
- g. The eyes are positioned on the sides of the head, giving the domestic fowl a wide field of view that helps it detect predators while feeding.

Reproduction

Hens (female domestic fowls) start laying eggs at around six months of age. A rooster/cockerel (male domestic fowl) dances around or near a hen called “a circle dance” during courtship. It lowers the wing and displays its colourful feathers. The male mounts the female, applies his reproductive openings to hers and passes sperm into her oviduct where eggs are fertilised (Internal Fertilization)

The fertilized egg is bounded by a layer of albumen and a shell during its passage down the oviduct and is finally laid in the nest. Usually, one egg is laid each day and incubation does not begin until the full clutch or group has been laid. The female is responsible for incubating the eggs by keeping them at a temperature approximately to her body temperature. It covers them with her body and press them against her body to keep the eggs warm and prevent water loss. At this temperature, the eggs develop and hatch after about three weeks. The living cells in the egg's embryo divide to make the tissues and organs of the young birds. The yolk provides food, and the albumen, both food and water for the developing embryo. The eggshell and shell membranes are permeable to air. Oxygen diffuses into the air space and is absorbed by the network of capillaries which spread out over the yolk and over a special sac called the allantois. The blood carries the oxygen to the embryo. Carbon dioxide diffuses out of the air space through the eggshell. When the chicks are fully developed, they break out of the shell by using their beaks. The chicks are covered with down feathers and can run about soon after hatching but stay close to the hen. The hen covers them with the body and wings and protect them against predators such as cats and hawks.

The reproductive process in chickens is well-known for egg production.

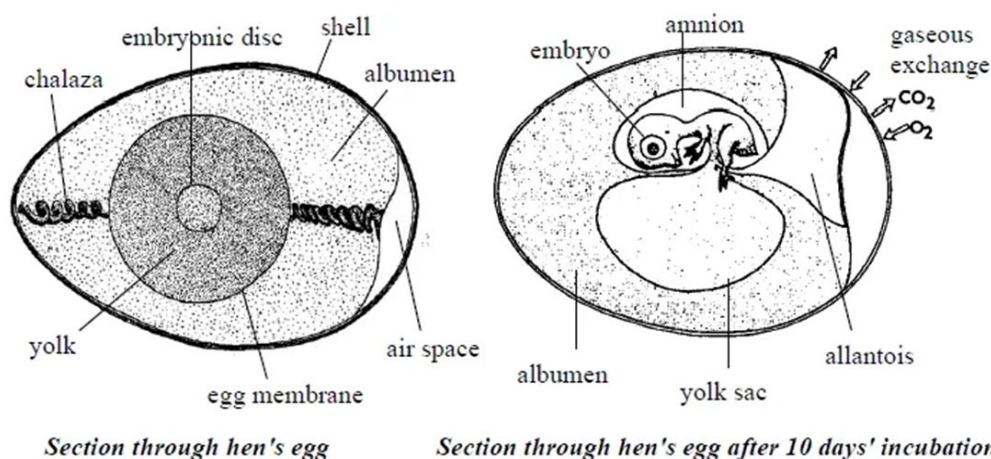


Figure 3.10: Longitudinal section through the hen's egg before and during incubation

Function of the Parts of Egg

- The amnion is a fluid-filled sac which suspends and protects the embryo.
- The allantois stores excretory products and carries oxygen to the embryo in its numerous blood vessels.
- The yolk sac shrinks as the embryo uses up its food store and is absorbed into the body at hatching.
- The yolk provides proteins and lipids (fats) for developing embryo.
- The albumen provides proteins and water for the developing embryo.
- The chalaza is a twisted strand of dense albumen, holds the yolk in place.
- The shell and egg membrane are permeable to air and protect the embryo.

Economic importance of domestic fowl

The domestic fowl is one of the most economically significant domesticated species worldwide. Its importance covers direct food production, employment generation, agricultural integration, cultural significance, and emerging opportunities in value addition and environmental services. Poultry keeping serves as both a pathway out of poverty for smallholders and an opportunity for commercial agricultural development.

Food Production: meat from the domestic fowl (chicken) is the second most consumed meat worldwide which contains high-quality protein and essential micronutrients, like B vitamins, iron, and zinc. Eggs provide complete protein, essential fatty acids, vitamins A, D, E, and B-complex, and minerals including iron and phosphorus. Local poultry production contributes to the domestic chicken demand, with traditional free-range systems supporting rural food security for low-income households compared to other animal proteins.

Employment and Income Generation: Large-scale poultry operations create employment throughout the value chain, from farm workers to processing plant employees. Small-scale poultry keeping requires minimal initial investment and provides supplementary income for rural households. The rearing of fowls creates jobs in feed production, veterinary services, equipment manufacturing, transportation, slaughterhouses, egg processing facilities, cold storage, transportation, and retail.

Integrated Agricultural Systems: chicken manure serves as valuable fertilizer, containing approximately 4% nitrogen, 2% phosphorus, and 2% potassium. Free-range chickens consume insects and weed seeds, reducing pest pressure in crop production. Crop residues feed chickens, while poultry manure fertilizes crops, creating circular farming systems and reducing the need for synthetic fertilizers and pesticides.

By-Products

- a. Feathers are used in bedding, clothing to provide insulation.
- b. Droppings are used for producing manure.
- c. Eggshells are used in calcium supplements, crafts, and soil amendments.

Cultural and Social Importance

- a. Domestic fowl are used in various traditional rituals and religious ceremonies across Ghanaian cultures.
- b. Live fowls are often given as gifts during significant life events (weddings, funerals, childbirth).
- c. Chicken dishes are prepared for honoured guests signifying respect and goodwill.

Learning Tasks

1. Identify the adaptative characteristics for survival of tilapia and toad in its habitat.
2. Create a mind map summarising the life cycle of wall gecko and domestic fowl.
3. Examine the life processes of wall gecko and domestic fowl.
4. Analyse the interactions of humans with the Wall gecko and domestic fowl.

Pedagogy Exemplars

1. **Project-Based Learning:** Work in large groups to conduct research on the life cycle of the wall gecko and domestic fowl with particular emphasis on their general characteristics.
2. **Collaborative Learning:** Examine the life processes of the wall gecko and domestic fowl by discussing in groups and making observations and notes on these.
3. **Talk-for-Learning Approach:** Do group presentations with the aid of charts, pictures or PowerPoint slides on the wall gecko and domestic fowl.
4. **Talk-for-Learning Approach:** engage in a whole class discussion on the economic importance wall gecko and domestic fowl.
5. **Task-based Learning:** observe the wall gecko, and domestic fowl within your locality; make notes and discuss some of the unique attributes and perceptions the locals have on these organisms, and how this informs their approach and interactions with the organisms.

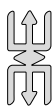
Key Assessment Level 4: Individual Observation

1. Carefully observe a wall gecko and Domestic fowl (or video footage) in its natural habitat. Compare the adaptive characteristics of Wall gecko and Domestic fowl, discussing how these adaptations influence their respective roles in the ecosystem and their interactions with other species. (20 marks)
2. Examine a preserved/model/diagram of the digestive system of a domestic fowl and explain why this system is adapted for the bird's diet and lifestyle. (20 marks)

PLC Session 13

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



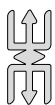
Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **individual observation**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the observation (NTS 3k-3q).

10 minutes**Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).

**Note**

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 14

Learning Indicators

1. Describe the interdependency of living and non-living components of the environment
2. Explain the interdependency of Living things and its importance to life

FOCAL AREA: INTERDEPENDENCY OF LIVING AND NON-LIVING THINGS AND THEIR IMPORTANCE

- a. Food Chain, Food Web and Decomposition
- b. Biological/Symbiotic Associations (Mutualism, Commensalism and Parasitism)

Ecological Interdependency in Ghanaian Ecosystems

Interdependency in Ecosystems

In Ghana's diverse ecosystems, from coastal mangroves to northern savannas, the interactions between biotic and abiotic components determine biodiversity patterns and ecosystem functioning.

Energy Flow and Nutrient Cycling

Energy flow refers to the one-way transfer of energy through an ecosystem, beginning with the capture of energy by producers, and moving through various consumers. **Nutrient cycling** on the other hand, refers to the movement and exchange of organic and inorganic matter back into the production of matter.

Energy flows through ecosystems in one direction, from sunlight captured by producers to various consumers, unlike energy, nutrients cycle within ecosystems through biogeochemical cycles. Among the biogeochemical cycles are

Carbon cycle: The carbon cycle is the continuous movement of carbon among living organisms, the atmosphere, water, soil and rocks. Carbon is exchanged between these components through processes such as photosynthesis, respiration, decomposition, combustion and sedimentation.

Green plants and other photosynthetic organisms absorb carbon dioxide from the atmosphere during photosynthesis and convert it into organic compounds. Carbon is then transferred through food chains as animals feed on plants and other organisms.

Both plants and animals release carbon dioxide back into the atmosphere through respiration. When plants and animals die, decomposers break down their organic matter, releasing carbon dioxide into the atmosphere and returning carbon compounds to the soil. The combustion of wood and fossil fuels also releases carbon dioxide into the atmosphere.

Some carbon is stored for long periods in oceans, soils, rocks and fossil fuels. Human activities such as deforestation and the burning of fossil fuels increase the amount of carbon dioxide in the atmosphere, contributing to climate change.

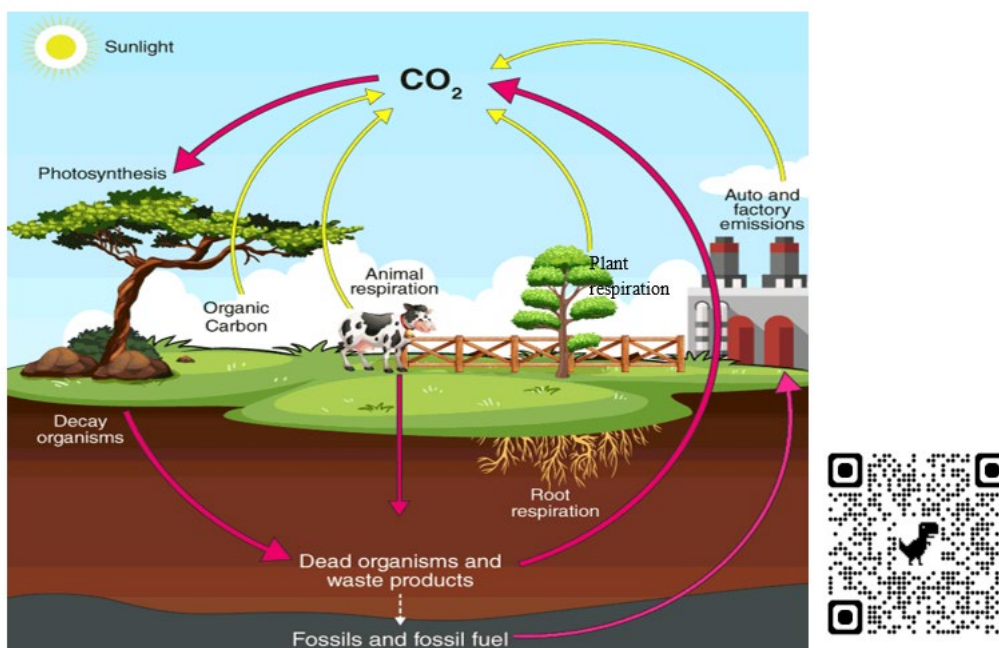


Figure 3.11: Carbon cycle

Nitrogen cycle: It is the biogeochemical cycle by which nitrogen is converted into various chemical forms as it circulates among the atmosphere, terrestrial, and marine ecosystems.

Leguminous plants common in Ghanaian agriculture (like groundnuts and cowpeas) host nitrogen-fixing bacteria in root nodules, enriching soil fertility.

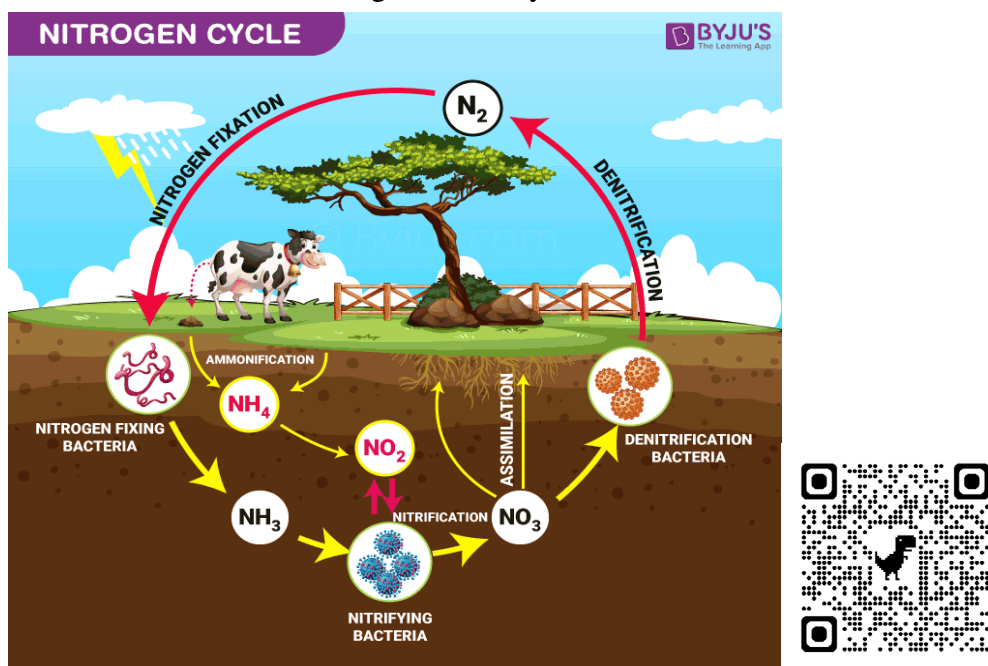


Figure 3.12: Nitrogen cycle

Water cycle: It is the continuous movement of water within the Earth and atmosphere through evaporation, condensation, precipitation, and runoff.

Ghana's seasonal rainfall patterns influence water availability in ecosystems, affecting both terrestrial and aquatic communities.

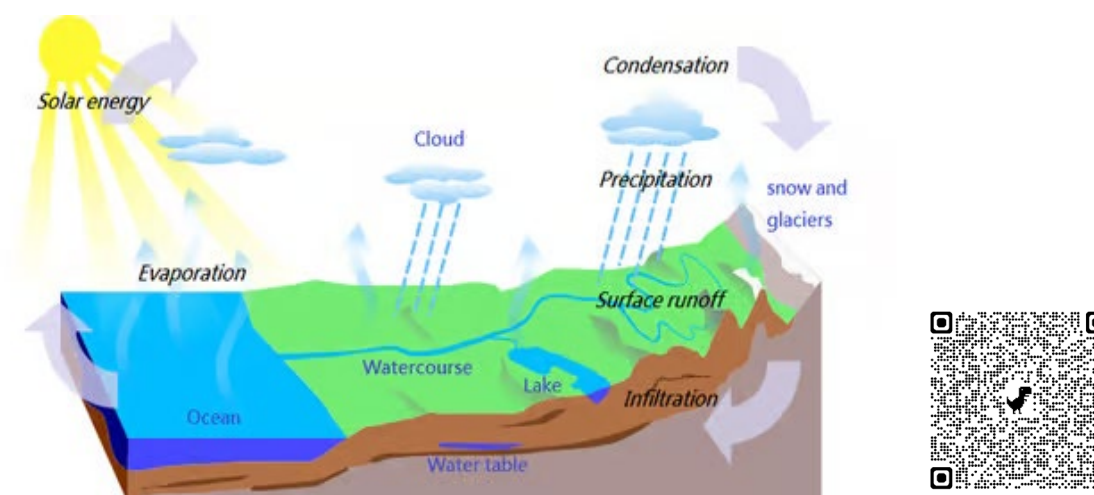


Figure 3.13: *Water cycle*

Food Chains, Food Webs and Decomposition

Food Chains

Food chain: This is a linear sequence of organisms through which energy and nutrients pass as one organism eats another. A food chain represents a single pathway of energy transfer through an ecosystem. Examples of food chains that may be constructed from various ecosystems in Ghana include:

- Forest Ecosystem (Kakum National Park):** Dead leaves → Termites → Agama lizard → African harrier hawk
- Savanna Ecosystem (Northern Ghana):** Grass → Grasshopper → Guinea fowl → Serval cat
- Coastal/Marine Ecosystem (Gulf of Guinea):** Phytoplankton → Anchovy → Sea bream → Fishing eagle
- Freshwater Ecosystem (Lake Volta):** Algae → Water insects → Tilapia → Nile perch → Kingfisher
- Wetland Ecosystem (Amanzuri Wetlands):** Water plants → Tadpoles → Mudfish → African fish eagle

Each step in a food chain represents a trophic level, which is the position in a food chain or ecological pyramid occupied by a group of organisms with similar feeding mode. The various forms or stages of trophic levels and the positions they occupy are

- Producers (first trophic level)
- Primary consumers (second trophic level)
- Secondary consumers (third trophic level)
- Tertiary consumers (fourth trophic level)

At each transfer, approximately 90% of energy is lost mainly as heat, and through wastes such as undigested food, uneaten parts, death and decomposition. This loss of energy contributes to the reason why the number of trophic levels is typically reduced to 4 or 5.

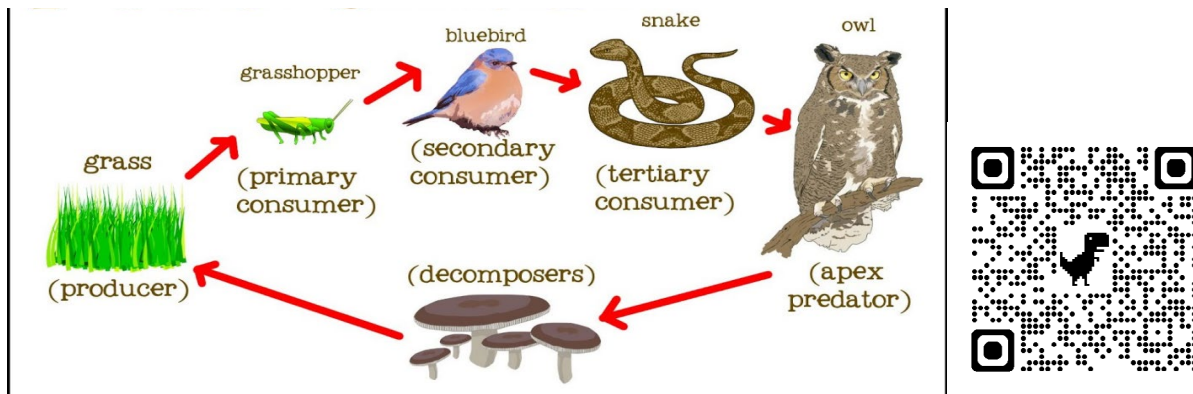


Figure 3.14: Food chain

Food Webs

Food web is a system of interlocking and interdependent food chains, showing the complex feeding relationships in an ecosystem.

Real ecosystems contain multiple interconnected food chains, forming complex food webs. In Ghana's forest ecosystems, a single tree species might support numerous herbivores, which are then consumed by various predators.

Food webs demonstrate:

- multiple feeding relationships
- alternative energy pathways
- ecosystem resilience through redundancy

The removal of **keystone species** (a species that has a disproportionately large effect on its environment relative to its abundance) can cause dramatic changes in ecosystem structure. For example, the decline of large predators in Mole National Park could lead to increased herbivore populations and subsequent vegetation changes.

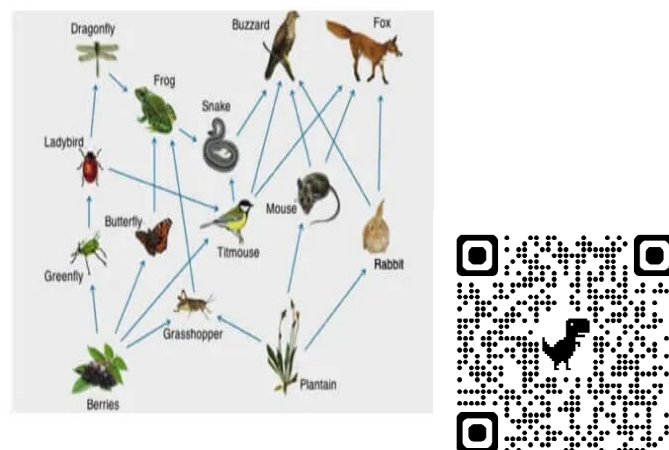


Figure 3.15: Food web

Decomposition

Decomposition: The process by which organic substances are broken down into simpler forms of matter, releasing nutrients back into the ecosystem.

Decomposition is essential for ecosystem functioning as it:

- recycles nutrients locked in dead organic matter back into forms usable by plants.
- prevents the accumulation of dead material in ecosystems.
- contributes to soil formation and fertility.
- completes biogeochemical cycles.

Decomposers in Ghanaian ecosystems include fungi (particularly abundant in humid forest areas, bacteria, and invertebrates like termites, earthworms and dung beetles.

Factors temperature (faster in warmer regions), moisture (seasonal variations affect activity of decomposers), oxygen and pH levels affect the rate of decomposition.

In Ghana's cocoa-growing regions, proper management of organic matter decomposition is essential for maintaining soil fertility and reducing dependency on chemical fertilisers.

Biological/Symbiotic Associations (Symbiosis)

Biological association refers to the relationship between different species living together in the same ecosystem, involving varying degrees of physical association and interdependence. These associations and interdependence may be beneficial, harmful, or neutral to the participating organisms.

Mutualism

This is a biological relationship between two species of organisms in which both benefit from the association. Common examples are

- Mycorrhizal symbiosis:** This is between fungi and forest trees (fungi provide minerals and increase water absorption in the tree, while the fungus receives food in the form of carbohydrates).
- In pollination, bees receive food in the form of nectar from plants, while they transfer pollen grains from plant to plant for fertilisation to occur.
- Nitrogen-fixing bacteria in root nodules of leguminous crops fix nitrogen for plant use while the root also provides nutrient and shelter to the bacteria.
- Gut microbiota in the digestive systems of ruminants like cattle and goats digest cellulose to make plant food materials available to animals while these bacteria also receive food and protection from the animal.



Figure 3.16: Honey bee on a coneflower

Mutualism is ecologically important because it:

- a. creates interdependencies that enhance ecosystem stability
- b. enables organisms to exploit resources or habitats otherwise unavailable to them
- c. drives co-evolutionary processes that increase biodiversity
- d. supports critical ecosystem functions like pollination and nutrient acquisition

Mutualistic relationships are often highly specific and have evolved over long periods. Their disruption can have significant ecological consequences, including reduced agricultural productivity and forest regeneration capacity in Ghana's diverse ecosystems.

Commensalism

This is a relationship between two different species where one benefits while the other neither gains nor is harmed. The organism that benefits is called the commensal, while the one that is neither benefits nor get harmed is called the host. Common examples of this association observed in Ghana include:

- a. cattle egrets feeding on insects disturbed by grazing livestock.
- b. epiphytic ferns growing on tree trunks in forests.
- c. small fish seeking protection among mangrove roots along Ghana's coast.
- d. birds nesting in tree cavities.
- e. the remora fish attaching to sharks for food scraps, transport and security.



Figure 3.17: *Cattle with an egret*

There are several ecological benefits to this association, among which are

- a. increasing habitat complexity and biodiversity
- b. providing alternative survival means for some organisms.
- c. facilitating new partnerships between species to develop over time
- d. making ecosystems stronger by having many different species working together.

In Ghana's agricultural landscapes, commensalism often supports beneficial organisms that provide pest control services. For example, spiders build webs near cocoa trees and catch pest insects without harming the trees. Farmers benefit from these relationships because they get natural pest control without needing to use as many chemical pesticides as possible. This saves money and is healthier for the environment.

Parasitism

This is the relationship between different species where one organism (the parasite) lives on or in another organism (the host), causing it harm while benefiting from the relationship. The harm caused by the parasite may eventually result in the death of the host organism. Common examples of host-parasite relationship are

- a. plasmodium (malaria parasite) transmitted by *Anopheles* mosquitoes
- b. mistletoe growing on shea and mango trees.
- c. intestinal worms affecting human health and livestock productivity.
- d. parasitic fungi on cocoa and other crops

Studying parasites within a habitat is ecologically necessary for the following reasons:

- a. Parasites control the numbers of host organisms in a habitat.
- b. They facilitate the development of host defences.
- c. They cause diseases and weaknesses among living organisms.
- d. Scientists can look at which parasites are present to understand if an ecosystem is healthy or in trouble.

On Ghanaian farms, farmers must control parasites like cocoa black pod disease or stomach worms in goats. If they don't, crops fail and animals get sick, causing farmers to lose money. However, in Ghana's forests and grasslands, these same parasites play important roles in controlling populations. They prevent any one plant or animal from taking over completely. This keeps many different species living together, which makes the ecosystem stronger and healthier.

Saprophytism

This is a symbiotic relationship in living things where an organism obtains nutrients from dead and decaying organic matter. Organisms that carry out the process are called saprophytes. Saprophytes include fungi such as moulds and mushrooms, bacteria including *Clostridium* and *Bacillus*, and some protozoa. Some common examples of saprophytic relationships are:

- a. fungi decomposing fallen logs in forest ecosystems
- b. bacteria breaking down leaf litter.
- c. termites consuming dead wood
- d. mushrooms appearing after the rainy season

The ecological importance of saprophytism includes:

- a. driving nutrient cycling essential for ecosystem productivity.
- b. contributing to soil formation and improvement.
- c. preventing accumulation of dead materials.
- d. supporting diverse food webs based on detrital energy pathways.

Saprophytes break down dead organisms. This is important because it returns nutrients to the soil and helps make new soil. In Ghana, traditional farming practices allow breaks or resting intervals (fallow periods) between farming seasons to allow the soil to replenish through decomposition of organic matter. Without saprophytes, nutrients would stay trapped in dead organic matter, making the land infertile and underproductive. This would ultimately affect food production in the country.

Epiphytism

This is the biological relationship in which one plant (the epiphyte) grows non-parasitically upon another plant (the host), using it for physical support but not for nutrients. Some common examples found in Ghana's environment are:

- orchids growing on trees in Ghana's tropical forests.
- mosses and lichens on tree trunks.
- ferns growing in tree crevices.
- algae growing on aquatic plants.



Figure 3.18: *Bromelad*(an epiphyte) on a tree trunk

The ecological importance of epiphytism includes:

- Increasing structural complexity in forest ecosystems
- Creating microhabitats for other organisms
- Contributing to canopy biodiversity
- Participating in nutrient cycling, particularly capturing nutrients from rainfall and air.

Epiphytes contribute to ecosystem complexity by creating microhabitats for other organisms like insects and amphibians. They are particularly diverse in Ghana's relic rainforests where they enhance biodiversity and participate in water and nutrient cycling, capturing resources that might otherwise be lost from the ecosystem.

Ecological Importance of Interdependency

- Living things depend on one another to ensure a stable ecosystem.
- Living things depend on each other to provide services like food, clean water, and fertile soil for their survival.
- The conservation of ecosystems depends on the interdependencies of all living things rather than a single species.

Learning Tasks

- Construct a food web showing energy flow in a local Ghanaian ecosystem.
- Conduct a decomposition experiment comparing breakdown rates of different plant materials.
- Create a field guide identifying local examples of mutualism, commensalism, parasitism, saprophytism and epiphytism.
- Develop a poster showing some nutrient cycling (e.g. the nitrogen cycle) in within a habitat.

Pedagogical Exemplars

Project-Based Learning: Embark on field trips to various habitats in and around your community to investigate the interdependencies and interactions among living things (e.g., how producers and consumers interact in nature, how decomposers bring about decomposition, and some biological associations found in the selected habitats.) Write down your observation and explain some common biological associations observed in the various habitats visited.

Talk-for-Learning: Discuss how the living and non-living components of the environment interact, and how living things and non-living things interact and interdepend on one another to ensure the survival of species.

Report Presentation: Learners in groups organise and present report on their findings.

Key Assessment Level 4: Case Study

1. Explain how water hyacinth affects food chains and living relationships in Lake Volta. Suggest a way to solve this problem that could also create jobs for people living near the lake. (20 marks)
2. How might changing rainfall patterns in northern Ghana affect the relationships between soil microbes, shea trees and local communities? Create a simple model showing these connections and how they might change in the future. (20 marks)
3. Design a new way of growing cocoa that uses helpful relationships between plants and other organisms to better survive climate change. Compare your method with normal cocoa farming in Ghana and explain why small-scale farmers should adopt it. (20 marks)
4. Examine the helpful relationship between certain fungi and trees in Mole National Park. Plan an experiment to test how this partnership helps tree seedlings survive during drought. Suggest ways to protect these underground networks. (20 marks)
5. Compare how mistletoe harms shea trees in northern Ghana with how it helps bird diversity. Suggest a management approach that balances these harmful and helpful effects. (20 marks)
6. Explain the relationship between cattle egrets (white birds) and livestock in the Volta Region. How might changing farming practices affect this relationship? Design a simple field study to test your ideas. (20 marks)
7. Design a waste management system for Ghanaian towns that uses local fungi to break down waste. Explain why this might be better than current waste treatment methods, considering both environmental and economic benefits. (20 marks)
8. Many orchids grow on trees in Ghana's forests without harming them. Design an investigation to determine whether these orchids might actually be helping the trees in some ways or slightly harming them under certain conditions. (20 marks)

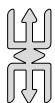
PLC Session 14

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.

- b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
- c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

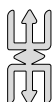
4. Plan the week's key assessment with your app

- a. The key assessment for the week is **case study**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the case study (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 15

Learning Indicators

1. Accurately collect and analyse data on body mass index (BMI) of a class and plant density on a school compound
2. Draw valid conclusions and inferences on analysed data

FOCAL AREA 1: ESTIMATING/ANALYSING THE BODY MASS INDEX (BMI) OF LEARNERS IN A CLASS AND ITS IMPLICATIONS AND THE PLANT DENSITY OF A SCHOOL FIELD

Estimating and Analysing body mass index (BMI) of a Person

Body mass index (BMI) is a value obtained by dividing the mass (in Kg) or weight of a person by the height (m^2). It is a common health indicator of weight-related health risks. It provides a simple measure to classify individuals as underweight, normal weight, overweight, or obese. BMI is calculated from the formula

$$\text{BMI} = \text{Weight (kg)} / [\text{Height (m)}]^2$$

The table below provides the classification for BMI.

BMI Range/Kg/m ²	Classification
Below 18.5	Underweight
18.5 - 24.9	Normal weight
25.0 - 29.9	Overweight
30.0 and above	Obese

Top of Form



Figure 3.19: BMI scale

Steps for Calculating BMI

1. Measure body mass (weight) in kilograms.
2. Measure height in metres.
3. Square the height measurement.
4. Divide weight by the squared height value.

Example: Calculating BMI from Sample Data

The following data was collected from some five individuals in a certain community.

Mass and Height of Five Learners in 2S

Learner	Mass/Kg	Height/m	Height/m ²
Kofi	65	1.70	2.89
Musa	55	1.65	2.56
Kwame	80	1.85	3.42
Akosua	50	1.65	2.72
Yaw	85	1.75	3.06

The BMI of each of the selected learners of the class is estimated from the formula:

$$\text{BMI} = \text{Mass (Kg)}/\text{Height (m}^2\text{)}$$

Inserting the specified values of each learner in the formula, the BMI values and their interpretation are given below:

Summary of Results of BMI of Five Members of 2S

Student	BMI	Classification
Kofi	22.5	Normal weight
Musa	21.5	Normal weight
Kwame	23.4	Normal weight
Akosua	18.4	Underweight
Yaw	27.8	Overweight

Common Precautions in Estimating BMI

1. Use calibrated scales and measure height with person standing straight against wall.
2. Take measurements without shoes and in light clothing only.
3. Do not calculate BMI for pregnant women or very muscular individuals.
4. Use age-specific BMI charts for children and adolescents.
5. Remember BMI doesn't distinguish between muscle and fat mass.

Limitations of BMI

1. The method does not distinguish between muscle and fat.
2. It may not be appropriate for athletes, pregnant women and the elderly.
3. Ethnic variations exist in body composition.
4. Children and adolescents require different interpretation using age-specific charts.

Plant Density Sampling Techniques

Density refers to the number of individuals of a species per unit area (or per unit volume in aquatic environments). Estimating population density helps ecologists understand population size, species distribution, biodiversity and ecosystem health.

Density sampling can be carried out for plants as well as sessile or slow-moving animals, such as barnacles, limpets, snails, earthworms and some insects. Common sampling methods include the use of quadrats and line transects, depending on the type of organism being studied and its distribution within the habitat.

Plant Density Sampling

Plant density refers to the number of individual plants per unit area within a habitat. Measuring plant density provides information about vegetation composition, species abundance, competition among plants and ecosystem stability. Quadrats and line transects are commonly used to estimate plant populations because plants are fixed in one location and can be counted accurately.

The plant density within a habitat is determined by the formula,

Plant Density = Total number of individuals of a plant species / Total area sampled

Or simply: Density = N/A ,

Where, N = number of individual species of plants counted, and A = total area sampled units: plants per square metre (plants/m²) or plants per hectare (plants/ha)



Figure 3.20: Plant population density using quadrat method

Steps for Calculating Plant Density

1. Define a clear study area and select an appropriate sampling method, such as a quadrat or a line transect, based on the habitat and the organisms being investigated.
2. Place sampling units randomly or systematically within the area.
3. Count all individuals of the target plant species in each sampling unit.
4. Calculate total number of plants and total area sampled.
5. Divide total number of plants by total area to determine density (plants/m²).

As an example, if five different 1m² quadrats are randomly placed in a school field to estimate the density of *Tridax procumbens*, and the number of *Tridax* in each quadrat are counted to be 12, 8, 15, 10, 5, then the density of *Tridax* in this habitat is determined as follows:

Total number of *Tridax* = 12 + 8 + 15 + 10 + 5 = 50 plants

Total area sampled = 5 quadrats × 1m² = 5m²

Plant density = 50 plants/5m² = 10 plants/m²

The density of *Tridax procumbens* is therefore 10 plants per square metre.

Precautions in Estimating Plant Density in a Habitat

1. Ensure truly random placement of sampling units to avoid bias.
2. Use appropriate quadrat size (smaller for dense vegetation, larger for sparse).
3. Maintain consistent identification criteria for the target species.
4. Collect sufficient samples to ensure reliability (minimum 5-10 quadrats).
5. Consider seasonal variations in plant growth and flowering.

Relationships between Plants in the Environment and Human Health

1. Green plants within the environment reduce stress and improve mental well-being.
2. Plants improve air quality by absorbing carbon dioxide during photosynthesis, releasing oxygen, and trapping dust and some air pollutants on their leaves, thereby helping to reduce respiratory health risks.
3. Green spaces encourage physical activity and help people maintain a healthy body weight.
4. Crops grown on farms and in gardens provide food and essential nutrients for growth and good health.
5. Parks and gardens enhance the beauty of the environment and contribute to human health and well-being.

Learning Tasks

1. Calculate the BMI for each person and prepare a frequency table showing the number of students in each BMI category.
2. Discuss possible sources of error in BMI measurements and suggest ways to minimise them.
3. Conduct plant sampling within a habitat and calculate the mean plant density.
4. Investigate how environmental factors such as light intensity, soil type, water availability and human activities affect plant distribution within a habitat.

Pedagogical Exemplar

Experiential Learning Approach: Learners use quadrats to estimate plant density in different locations within the school environment. They compare their findings, identify environmental factors influencing plant distribution, and discuss how these factors affect biodiversity.

Project-Based Learning Approach: Learners work in groups to investigate the distribution of plants in different parts of the school compound using quadrat sampling. They analyse the data collected and present recommendations for conserving plant diversity based on their findings.

Key Assessment Level 4: Practical

1. Using quadrat sampling, investigate the distribution and density of plants in three different areas of your school compound. Analyse how environmental factors such as light intensity, soil moisture and human activities influence plant distribution, and recommend practical measures to improve biodiversity. (20 marks)

2. Evaluate your school's BMI measurement technique. Design an improved protocol that addresses measurement errors and considers ethnic differences. Include procedures, equipment needed, and a data collection form. Explain how your method improves accuracy and interpretation for Ghanaian students. (20 marks).
3. Investigate relationships between school plant density and student health indicators (including BMI). Justify your methods, analyse your data, and propose evidence-based environmental changes to improve student wellbeing. (20 marks)

FOCAL AREA 2: IMPLICATIONS OF BMI VALUES

Implications of BMI on Individual Health

BMI values are health indicators. They provide useful information on the weight, hence health risks of a person. Based on the BMI range, every individual can be categorised as underweight, normal weight, overweight and obese.

Underweight (BMI < 18.5)

Factors that lead to underweight include medical conditions, poor nutrition, genetic factors, stress, lifestyle choices, medication. Signs of underweight include fatigue, hair loss, irregular menstruation in females, reduced immune function and hormonal imbalances. Long-term effects include *osteoporosis, anaemia, growth and developmental issues in adolescents*.

Normal Weight (BMI 18.5–24.9)

Individuals with normal BMI possess good physiological functioning of body organs and structures. They have appropriate energy levels and better recovery from illness. There is lower risk of weight-related diseases.

Overweight (BMI 25.0–29.9)

Individuals that are overweight show signs such as mild metabolic, stress potential insulin resistance, possible reduced stamina and joint stresses. Long-term effects include increased risk of type 2 diabetes, hypertension and cardiovascular and circulatory related disease.

Obese (BMI ≥ 30.0)

Individuals described as obese face significant metabolic dysfunction. This may result in several health signs and symptoms such as shortness of breath, joint pains, sleep apnea (pauses in breathing during sleep) and high blood pressure, leading to several cardiovascular and circulatory health challenges. Long-term effects of obesity include stroke, heart disease, certain cancers and diabetes.

Relationship between BMI and Physical Activity Effects of Physical Activity on BMI

- a. Regular activity increases muscle mass (may increase BMI slightly)
- b. Continuous physical activity keeps a healthy BMI over time.
- c. Moderate daily exercise (30–60 minutes) ensures normal BMI range
- d. Sedentary lifestyle results in higher BMI

Learning Tasks

1. Survey the physical activity habits of people and relate these to their BMI, looking for patterns between activity levels and environment use.
2. Draw evidence-based conclusions about the potential health implications of BMI on people.
3. Evaluate BMI's effectiveness as a health indicator and propose one improvement to the BMI measurement system.

Pedagogical Exemplars

1. **Task-based Learning:** organise the collected data for plotting of graphs, such as pie charts, histograms, bar charts, and frequency curves.
2. **Talk for Learning Approach:** analyse the results, discuss and interpret to make valid deductions/ conclusions and recommendations.

Key Assessment Level 4: Practical

1. The table below shows BMI data collected from a Form 2 class:

BMI Range	Number of Students	Percentage of Class
Below 18.5 (Underweight)	8	20%
18.5–24.9 (Normal weight)	20	50%
25.0–29.9 (Overweight)	10	25%
30.0 and above (Obese)	2	5%

Analyse this data to draw conclusions about the class's health status. Compare with national trends for Ghanaian adolescents. Explain how three factors might cause these results. Develop an action plan addressing both underweight and overweight concerns in your school. (20 marks).

2. The table below shows plant density data collected from a study area measuring one hectare (10,000 m²) located near a stream. For organisms that are few in number, such as shrubs and trees, a *complete count* (census) is used, where every individual within the study area is counted rather than estimated from samples.

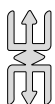
Plant Type	Sampling Method	Number Counted	Estimated Total Population	Density (plants/m ²)
Grass	10 randomly placed 1 m ² quadrats	450	45,000	4.5
Shrubs	Complete count (census)	25	25	0.0025
Trees	Complete count (census)	12	12	0.0012

Identify four methodological problems in this study. Explain how these affect the reliability of conclusions. Redesign the study to address these flaws. Explain how accurate plant density data could inform school environmental management. (20 marks)

PLC Session 15

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

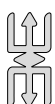

Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **practical**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the practical (NTS 3k-3q).

10 minutes
Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).


Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.

- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 16

Learning Indicator: Discuss how emerging human diseases (SARS-COVID-19, Ebola, Buruli ulcer, Swine flu/H1N1 flu and Monkeypox) are transmitted and suggest steps to prevent their spread

FOCAL AREA: EMERGING HUMAN DISEASES, TRANSMISSION AND CONTROL MECHANISMS: SARS-COV, COVID-19, EBOLA, BURULI ULCER, SWINE FLU/H1N1 FLU AND MONKEYPOX

Emerging Human Diseases: Transmission and Prevention

Emerging diseases are infections that have newly appeared in a population or have existed but are rapidly increasing in incidence or geographic range. Examples of these diseases are SARS-COVID-19, Ebola, Buruli ulcer, Swine flu/H1N1 flu and Monkeypox). Emerging diseases are identified by the following characteristics: They are either new or old but increasing in the number of new cases recorded in the population (incidence) and spread to new geographic locations and populations. They pose huge threat to the general public and can re-emerge after a period of decline.

Common Emerging Diseases

1. SARS-CoV (Severe Acute Respiratory Syndrome Coronavirus)

This is a serious respiratory illness that can lead to severe pneumonia and respiratory failures. It was first recorded in 2002 in Guangdong Province in China. It is believed to have originated from bats, which were suspected to be carrying the virus (bats are considered as the vectors).

Causative Organism: Coronavirus (SARS-CoV).

Transmission

- a. Respiratory droplets from coughs or sneezes.
- b. Close person-to-person contact.
- c. Contact with contaminated surfaces.

Signs and symptoms include high fever, headaches, body pains, dry cough and shortness of breath.

Control and Preventive Measures

- a. Wear nose mask and personal protective equipment (PPE).
- b. Practice good personal hygiene (such as handwashing).
- c. Isolate infected persons.
- d. Use vaccines.
- e. Implement strong travel restrictions and screening protocols.
- f. Quarantine suspected persons.
- g. Educate the public.



Figure 3.21: *Personal protective equipment (PPE)*

2. COVID-19 (Coronavirus Disease 2019)

This is a respiratory disease that can range from mild to severe forms. It was first identified in Wuhan, China, in December 2019. It is believed to have originated from bats, which are considered vectors for the disease.

Causative Organism: SARS-CoV-2.

Transmission

- Respiratory droplets and aerosols.
- Contact with contaminated surfaces (fomites).
- Possible airborne transmission in enclosed spaces.

Signs and Symptoms include fevers, coughs, shortness of breath (difficulty in breathing), fatigue, headaches, sore throats and runny or stuffy nose.

Control and Preventive Measures

- Vaccination.
- Wear mask in public places.
- Practice social distancing (at least six feet apart).
- Frequent handwashing.
- Avoid touching face.
- Isolate suspected persons.
- Avoid outing as much as possible, especially when sick.
- Quarantine suspected individuals.
- Educate the public about preventive measures.

3. Ebola Virus Disease

This is a severe and deadly viral disease which causes widespread bleeding and organ failure among infected individuals. It was first recorded in 1976, in the now Democratic Republic of Congo (DR Congo). The virus is believed to have originated from fruit bats.

Cause: Ebola virus (family *Filoviridae*).

Transmission

- Direct contact with blood, secretions, or other bodily fluids of infected persons
- Contact with contaminated objects (e.g., needles)

- c. Handling or consumption of infected wild animals (e.g., fruit bats, monkeys)

Signs and Symptoms include fever, vomiting, diarrhoea, abdominal pain, muscle and joint pain and bleeding.

Control and Preventive Measures

- a. Wear personal protective equipment (PPE) such as masks, gloves and gowns.
- b. Practice good personal hygiene such as handwashing.
- c. Isolate infected persons.
- d. Implement contact tracing protocols.
- e. Use vaccines
- f. Ensure safe burial of deceased or dead individuals by the disease.
- g. Educate the public.

4. Buruli Ulcer

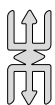
It is a bacterial infection which causes severe skin and tissue damage when left untreated.

It is found in tropical and sub-tropical regions of the world, especially in Africa, Australia and South-East of Asia. It is believed to be associated with stagnant waters.

Cause: *Mycobacterium ulcerans*

Transmission:

- a. Exact mode not fully understood
- b. Possibly through contaminated water, soil, or insect bites (aquatic environments)



Note

It is a slow-growing infection affecting the skin and sometimes bones.

Signs and symptoms include painless nodules or lumps under the skin, swelling of affected area, skin lesions or plaque and destruction of skin and underlying tissues.

Control and Preventive Measures

- a. Early detection and treatment with antibiotics.
- b. Wearing protective clothing (e.g., long sleeves, pants, etc.)
- c. Avoid contact with contaminated water.
- d. Ensure personal hygiene and improve wound care.
- e. Educate people.

5. Swine Flu (H1N1 Influenza)

Cause: H1N1 influenza virus (a subtype of Influenza A)

It is a type of respiratory illness that ranges that can range from mild illnesses to severe forms. It was first recorded in Mexico and the United States in 2009. The virus is believed to have been carried by pigs.

Transmission

- a. Respiratory droplets
- b. Contact with contaminated surfaces
- c. Human-to-human transmission is common

Signs and Symptoms include fever, cough, sore throat, runny or stuffy nose, headaches, fatigue, muscle or body aches and chills (feeling cold).

Control and Preventive Measures

- a. Get vaccinated.
- b. Practice good hygiene such as handwashing.
- c. Use mask in public places.
- d. Use prescribed antiviral medications.
- e. Stay home when sick.

6. Monkeypox

This is a viral disease that causes symptoms similar to smallpox. It was first identified in monkeys in 1958, primarily in Central Africa and West Africa. The virus is believed to be carried by rodents (which are vectors for this virus).

Cause: Monkeypox virus (a member of the *Orthopoxvirus* genus)

Transmission

- a. Close contact with infected individuals or animals.
- b. Contact with body fluids, lesions, or contaminated materials (e.g., bedding).
- c. Respiratory droplets during prolonged face-to-face contact.

Signs and Symptoms include fever, headache, muscle pains, back pain, swollen lymph nodes and rashes or skin lesions which progress from flat red spots to pus-filled blisters.

Control and Prevention Measures

- a. Vaccination.
- b. Avoid contact with infected animals (rodents and primates).
- c. Wear PPE when caring for infected persons.
- d. Practice good hygiene.
- e. Isolate infected persons.
- f. Educate the public about the disease and its consequences.

Learning Tasks

1. Explain why a disease is considered emerging and give one justified example.
2. Analyse how three emerging diseases spread and show the factors influencing their transmission.
3. Evaluate which preventive measures work best for different types of disease transmission.
4. Design a public health response plan for a new infectious disease outbreak.

Pedagogical Exemplars

1. **Project-Based Learning:** in mixed-ability, social and gender-responsive groups, research from textbooks, documentaries and other relevant sources, about emerging trends of diseases (e.g., SARS, Ebola, Covid-19, Swine flu/H1N1, etc.) and their threats to human life and present group

reports on these diseases. Learners connect socially to various beliefs associated with emerging diseases and vaccination projects and become better informed. Learners learn to be identified with local folks who are ignorant about the true nature of these diseases and support programmes to educate them.

2. **Group-Based/Collaborative Learning:** learners discuss in mixed-ability and all-inclusion groups, the modes of transmission of emerging human diseases (SARS-COVID-19, Ebola, Buruli ulcer, Swine flu/H1N1 flu and Monkey pox) and the preventive and curative methods available to control them: learners learn from one another and appreciate the efforts of peers.
3. **Initiating Talk for Learning:** learners prepare reports on emerging/contemporary diseases (e.g., SARS-COVID-19, Ebola, Buruli ulcer, Swine flu/H1N1 flu and Monkey pox) and present their findings and ways of combating and preventing them in class group presentations. Learners develop confidence for the knowledge obtained in emerging diseases: learners connect to victims both socially and emotionally and seek to support them through education and such other programmes.

Key Assessment Level 4: Research and Presentation

Level 4 extended critical thinking and reasoning

1. Imagine an outbreak of Monkeypox has been reported in a rural district in Ghana where people often live in close contact with livestock and wild animals. Design a community health education campaign that could help prevent the spread of the disease. Your campaign should include:
 - a. Key messages for different age groups
 - b. Methods of communication suitable for rural areas
 - c. Cultural practices that need to be addressed or modified
2. Evaluate the effectiveness of Ghana's public health response during the COVID-19 pandemic in terms of prevention, education, and vaccination. What lessons can be learned from this response to better handle future outbreaks such as Ebola or Swine flu?
3. As a science prefect in your senior high school, your teacher has asked you to lead a school-wide health and hygiene initiative. Propose a detailed plan to help your school prevent the spread of respiratory diseases like COVID-19 and Swine flu. Include strategies for:
 - a. Hygiene
 - b. Physical distancing
 - c. Health monitoring
 - d. Engaging parents and community leaders
4. Suppose a cluster of Buruli ulcer cases is discovered near a stagnant water body in a Ghanaian village. Analyse the possible causes of the outbreak and develop a multi-step public health action plan involving local leader, students, health workers, and environmental officers to stop its spread and prevent future cases.
5. Compare the transmission routes of Ebola and SARS-CoV-2 (COVID-19). Based on your comparison, recommend specific preventive measures that would be more effective in a Ghanaian urban market setting (e.g., Makola Market in Accra) versus a rural farming community (e.g., in the Northern Region).

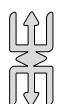
PLC Session 16

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to

- a. explain the week's concepts in a practical way that will make it easier for learners to understand
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Note

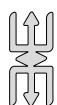
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
- a. The key assessment for the week is **research and presentation**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the presentation (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
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5 minutes**Reflection**

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9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 17

Learning Indicator: Research on other diseases of plants and animals and suggest steps to prevent their spread

FOCAL AREA: PLANT AND ANIMAL DISEASES: THEIR CONTROL AND PREVENTION

Plant Diseases, Control and Prevention

1. Blight disease

Blight refers to a type of plant disease caused by fungal or bacterial pathogens. These pathogens cause cell death (necrosis), of large areas on plants. Blight is characterised by a rapid and complete chlorosis, browning, and death of plant tissues like leaves, branches, twigs, or floral organs completely damaging the plant. Common plants affected are potatoes, tomatoes, capsicum/bell peppers and eggplants. There are different types of blight that can affect edible and ornamental plants.

A table of blight diseases, causative organism, plants and its parts affected, and symptoms is provided below.

Diseases	Causative organism	Plants and its parts affected	Symptoms
Early/target spot blight	Fungus: <i>Alternaria solani</i>	Tomatoes: leaves, stem, flowers potatoes: leaves,	distorted, dark brown to black spots on the leaves with distinct concentric ring pattern.
Halo blight	Bacteria: <i>Pseudomonas savastanoi</i> pv. <i>Phaseolicola</i>	Beans: leaves, pods,	brown spots with a light-green or yellow rings around spots
Late blight	Fungus: <i>Phytophthora infestans</i>	Potato: leaves Tomato: leaves	rapid leaf rot.
Fire blight	Bacteria: <i>Erwinia amylovora</i>	Pomes and pears: flowers, stem and leaves	dark orange-brown (apples) or black (pears) patches or whole areas.



Figure 3.22: *Blight disease on a tomato plant*

Control and Prevention

Pathogens can persist in infested soil, old plant materials or on other ‘host’ plants, like nearby weeds, for up to a year making it difficult to treat once established. It can spread through airborne spores and when conditions are moist and humid, the pathogen produces sporangia that can be dispersed by wind over long distances. The transmission of these spores can be facilitated by water splash, high humidity, conducive temperatures and human activities such as using contaminated tools or equipment and movement between fields without proper sanitation. Some measure can be taken to prevent and control the disease.

- Cultural Practices:** Maintaining optimal growing conditions, removing (burn) infected plant parts, and crop rotation can help manage blight. Plant disease-free seeds and only save seed from disease-free plants. Water the soil, avoid crown and root injuries, and feed plants regularly to keep them growing well – healthy plants can better resist pests and diseases.
- Chemical control:** Depending on the specific blight, fungicides can be used to protect healthy tissues from infection.
- Other measures:** Soil solarization involves tightly covering the area of soil with clear plastic and letting the sun heat up the soil for a couple of weeks to reduce the amount of fungus in the soil. After solarization, reintroduce beneficial fungi and bacteria into the soil before planting.

2. Wilt diseases

Wilt diseases are a group of plant diseases characterised by the wilting of leaves and stems, often leading to plant death. Wilt diseases are primarily caused by pathogens that infect the vascular system of plants, disrupting the transportation of water and nutrients. They can be transmitted through contaminated soil, plant debris, or infected plant materials, water and by human activity such as using contaminated tools. Conditions such as drought or poor drainage can intensify the effects of wilt diseases, making plants more prone to infection and affecting crop yields and plant health.

A table of wilt diseases, causative organism, plants and its parts affected, and symptoms is provided below.

Wilt disease	Causative organism	Plants and its parts affected	Symptoms
Fusarium Wilt	Fungus: <i>Fusarium oxysporum</i>	Tomatoes (stems, leaves) Cotton (stems, roots)	• Wilting of leaves, often starting with the lower leaves • Yellowing of leaves (chlorosis) • Stunted growth • Brown discoloration in vascular tissues when cut

Verticillium Wilt	Fungus: <i>Verticillium dahliae</i>	Eggplants (stems, leaves) Strawberries (roots, stems)	• Wilting of leaves and stems • Yellowing and browning of leaves • Stunted growth • Discoloration in the vascular system
Bacterial Wilt	Bacterium: <i>Ralstonia solanacearum</i>	Tomatoes (stems, roots) Potatoes (stems, tubers)	• Sudden wilting and collapse of plants • Yellowing of leaves • Brown discoloration in vascular tissues • Water-soaked lesions on stems



Figure 3.23: Wilt disease in maize plant

Control and Prevention

Soilborne spores can persist in the soil for years and infect plants through the roots. Spreading of the disease can occur using contaminated tools or equipment. Managing wilt diseases effectively is crucial for protecting crops and ensuring agricultural productivity. Some measure can be taken to prevent and control the disease.

- a. **Cultural Practices:** to reduces the pathogen load in the soil, rotate crops with non-host plants to break the disease cycle and plant varieties that are resistant or tolerant to specific wilt diseases. Integrate organic matter into the soil to improve soil health and structure, promoting beneficial microbial activity that can outcompete pathogens and remove and destroy infected plant debris to prevent the spread of pathogens. Regularly clean tools and equipment to avoid contamination. Avoid over-watering and ensure good drainage to reduce waterlogged conditions, which can facilitate fungal growth. Use drip irrigation to minimize leaf wetness.

- b. **Biological Control:** Introduce beneficial bacteria and fungi that can suppress wilt pathogens. These microorganisms can help protect plants by outcompeting or directly inhibiting pathogens.
- c. **Chemical Control:** use fungicides and bactericides treatments judiciously, targeting specific pathogens.
- d. **Monitoring and Early Detection:** regularly monitor plants for early signs of wilt diseases for prompt action to reduce the spread of the disease.

Animal Disease, Control and Prevention

1. Brucellosis

Brucellosis is a contagious disease of livestock caused by various bacteria of the genus *Brucella*. It affects cattle, pigs, sheep, goats, camels, horses and dogs. Brucellosis is regarded as a **zoonotic disease** because it can be transmitted from animals to humans. In animals, it is characterised by abortion, infertility and other reproductive disorders.

The principal causative species are *Brucella abortus* in cattle, *Brucella melitensis* in sheep and goats, and *Brucella suis* in pigs.

Brucellosis is typically spread when the animal aborts or gives birth with high levels of the bacteria found in the birth fluids. The bacteria also colonise the udder and contaminate the milk. The bacteria survive in the environment for several months, particularly in cool moist conditions and remain infectious to other animals which ingest the bacteria. It can also infect animals and humans through cuts in the skin, or through mucous membranes.

Symptoms: infected animal showing few signs until abortions, retention of placenta, stillbirth, birth of weak offspring or infertility occurs. There may be swelling of the testicles in males, and occasionally the bacteria are found in the joints causing arthritis. In humans, symptoms may include fever and chills, sweats, fatigue and discomfort, joint and muscle pain and headache.

Control and prevention

- a. Vaccination is often used to reduce the incidence of infection. Several vaccines are available that use modified live bacteria:
 - **Animal Vaccination:** Vaccinate livestock (especially cattle, sheep, and goats) with appropriate vaccines (e.g., *Brucella abortus* strain 19 for cattle) to reduce the incidence of infection.
 - **Human Vaccination** is currently not available, but research is ongoing.
- b. **Hygiene and Sanitation**
 - **Farm Hygiene:** Implement strict hygiene practices on farms, including regular cleaning and disinfection of facilities and equipment.
 - **PPE:** Use gloves, masks, and protective clothing when handling animals or animal products to prevent exposure.
- c. **Testing and Surveillance:** conduct routine testing of animals for *Brucella* infection. Early detection allows for prompt isolation and treatment.
 - **Quarantine Infected Animals:** Isolate and treat infected animals to prevent the spread of the disease within herds.
 - **Movement Restrictions:** Implement restrictions on the movement of animals from infected areas to prevent transmission.

d. Public Awareness and Education

- **Training for Farmers:** Educate farmers and livestock handlers about Brucellosis, its transmission, and prevention measures.
- **Community Outreach:** Raise awareness in communities about the risks of consuming unpasteurized dairy products and the importance of reporting suspicious cases.

e. Food Safety Practices

- **Pasteurization:** Promote the pasteurization of milk and dairy products to kill any potential *Brucella* bacteria.
- **Safe Handling of Animal Products:** Advise on safe practices for handling and processing animal products, including thorough cooking of meat.

2. Tuberculosis

Tuberculosis (TB) is a contagious disease caused by bacteria of the genus *Mycobacterium*, primarily *Mycobacterium bovis* in cattle and *Mycobacterium avium* in birds. It can also affect other animal species, including humans (*Mycobacterium tuberculosis*). TB is primarily spread through inhalation of airborne droplets from infected animals, direct contact with infected tissues or consumption of contaminated milk and meat.

Symptoms: in cattle and pigs, chronic cough, weight loss, fever, lethargy, swollen lymph nodes are noticed.

Control and Prevention

- Regular testing and culling of infected animals.
- Pasteurization of milk and proper meat inspection.
- Vaccination (e.g., BCG vaccine) in some regions, though not widely used in cattle.

Learning Tasks

- Investigate the symptoms and transmission of one plant and one animal disease.
- Develop a management plan for a selected disease.
- Analyse a case study of an animal disease.
- Create a strategy for an awareness campaign for a plant disease

Pedagogical Exemplars

- Field-Based Learning Approach (Experiential):** learners are taking out on a farm plantations and livestock centres within the community to observe some common diseases of plants (e.g., blight and wilt diseases by bacteria) and animal-rearing centres to observe and study animal diseases (e.g., brucellosis, tuberculosis). Learners are put into mixed-ability, all-inclusive groups to prepare group presentations. Learners obtain real world scenarios of lessons learnt in class, thereby boosting their morale.
- Collaborative Learning:** learners discuss in mixed-ability, all-inclusive groups the transmission, symptoms and effects of common diseases of plants livestock; learners, through education, obtain the requisite knowledge to educate learners, thereby being self-assured through self-confidence. Learners also learn from one another.

3. **Talk for Learning:** in mixed-ability, socially inclusive groups, learners engage in timed sessions on the prevention and cure of plant and livestock diseases; learners learn from one another through the discussions. Members in groups are socially and emotionally connected to support one another to achieve the set target within the timeframe.

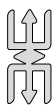
Key Assessment Level 4: Case study

1. Write a report on an investigation into one plant and one animal disease. (20 mark)
2. Reflect on the broader implications of plant and animal diseases for food security? (20 marks)
3. Analyse how climate change could potentially influence the transmission of Late Blight and Brucellosis. (20 marks)
4. A farmer in the western north region of Ghana notices symptoms of tuberculosis in his pig farm. Outline an action plan for managing this outbreak. (30 marks)

PLC Session 17

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

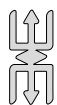
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **case study**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the case study (NTS 3k-3q).

10 minutes
Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step

- (you may be assisted by a teacher who is strong in the content area)
- all teachers in the group work through a similar problem individually for 3–4 minutes
 - the group then works through the problem together step by step
 - highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about ‘How do I teach this?’ but how do I teach it for learners to understand?*
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes

Enactment

- Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - After the enactment, ask for structured feedback from the group
 - was the concept explained in a way that a learner with no prior knowledge could follow?
 - were the examples grounded in contexts familiar to Ghanaian learners?
 - did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

- Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
- Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
- Remember to
 - transfer your chats into your learning planner template.
 - read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

Section Review

In this section, learners discussed the characteristic features and life processes of the tilapia, toad, wall gecko, and domestic fowl. The economic importance of Tilapia, frog/toad, wall gecko and domestic fowl was discussed in relation to their relevance to the livelihood of humans. Learners analysed the interdependency of living and non-living components of the environment and explained their importance to life in the ecosystem. Learners collected

and examined data on the BMI of the class and plant densities on the school compound. They brainstormed and shared valid conclusions and inferences on the analysed data to increase the understanding of and interpretations of biological data. This section concluded with learners discussing how emerging human diseases (SARS-COVID-19, Ebola, Buruli ulcer, Swine

flu/H1N1 flu and Monkeypox) are transmitted and steps to prevent and control their spread. Still in line with diseases and infections, research was done on other diseases of plants and animals and steps on how to control and prevent their spread. How these diseases impact the plants and animals on an economical level were also discussed.



MARKING SCHEMES FOR THE KEY ASSESSMENTS

WEEK 12

Question 1

Explanation of Adaptive Characteristics

- Provides a comprehensive explanation of the adaptive characteristics of both Tilapia and toads, illustrating how these traits help them survive and thrive in their environments. (4 marks)

Includes specific details such as:

Tilapia: fin structures, salinity tolerance, mouth-brooding behaviour, and omnivorous diet with relevant examples.

Toads: moisture retention, camouflage, toxic secretions, and breeding strategies.

- Offers a good explanation with three adaptive characteristics covered for both species. May lack minor details or examples but still conveys a clear understanding of how two adaptations function in their respective habitats. (3 marks)
- Mentions two adaptive characteristics but lacks depth and clarity. For instance, listing traits without explaining their significance or may focus heavily on one species while neglecting the other. (2 marks)
- Provides very limited explanation of adaptive characteristics, possibly mentioning only one trait for each species without sufficient elaboration or examples. (1 mark)

Influence on Ecosystem Roles

- Clearly articulates how two adaptive characteristics of both Tilapia and toads influence their roles in ecosystems. Includes detailed explanations such as:

Tilapia: Describes their role in controlling algae populations, enhancing water quality, and serving as a food source for larger species within the aquatic food web.

Toads: Discusses their role in regulating insect populations, their impact on agriculture, and how they serve as prey for various predators, maintaining ecological balance. (4 marks)

- Explains the influence of one adaptive characteristics on ecosystem roles for both species but may provide a less detailed explanation for the other species. Overall understanding is still evident. (3 marks)
- Provides basic information on the ecological roles of either Tilapia or toads but lacks specific examples or sufficient detail to fully illustrate their significance in ecosystems. (2 marks)
- Mentions an ecological role or influence but does so without clear explanations or connections to the adaptive characteristics. Lacks depth and detail. (1 mark)

Clarity and Organization

- The response is well-organized, with a clear introduction, logical flow of ideas, and appropriate use of paragraphs. Sentences are well-structured and easy to understand, enhancing overall readability. (2 marks)
- Some organisation is present, but the response may lack clarity in parts, making it harder to follow. There may be a mix of ideas without clear transitions. (1 mark)

Total Marks: 10

Rubric for question 2**i. Depth of Analysis**

- Provides comprehensive and insightful analysis with three relevant points. Example: how sustainable practices can improve efficiency in resource use, leading to cost savings (6 marks)
- Provides comprehensive and insightful analysis with two relevant points. Example: how sustainable practices can improve efficiency in resource use, leading to cost savings (4 marks)
- Provides analysis of two points but lacks depth or relevance. (2marks)
- Offers minimal analysis; points may be vague or not fully developed. (1mark)

Examples and Justification

- Uses specific examples to support points effectively, demonstrating understanding of the topic. For example, demonstrating a commitment to ecological concerns by preventing the depletion of wild stock of tilapia (2marks)
- Includes examples but may not fully support all points made. (1mark)

Clarity and organization

- Well-organized response with clear, logical flow of ideas. (2marks)
- Generally organised but may have minor clarity issues. (1 mark)

Total: 10 marks**i. Depth of Analysis**

- Thoroughly discusses three ecological challenges with understanding. For example, environmental conditions that are outside the company's control. (6 marks)
- Identifies and discusses two ecological challenges with understanding. (4 marks)
- Identifies two relevant challenges but lacks depth or specificity. (2 marks)
- Minimal discussion of challenges. (1 mark)

Examples and Justification

- Provides specific examples to illustrate points effectively. (2marks)
- Includes some examples, but not all points are supported. (1mark)

Clarity and Organization

- Well-organized response with clear, logical flow of ideas. (2marks)
- Generally organised but may have minor clarity issues. (1 mark)

Total: 10 marks**Question 3****Depth of Analysis**

- Provides a thorough and insightful analysis of both metamorphosis and growth processes, highlighting
 - o key stages with adaptations
 - o ecological impact on stages
 - o differences and similarities.

For example, discusses the ecological significance of metamorphosis in frogs/toads, such as how the transition from aquatic tadpoles to terrestrial adults allows them to exploit different habitats and reduce competition. (7marks)

- Offers a clear analysis but lacks some depth; one key point may be underdeveloped or missing. For example, Mentions the basic stages of metamorphosis and growth in both organisms but lack detailed exploration of their ecological roles. (5marks)
- Minimal analysis: important aspects of life cycles may be overlooked or vague. For example, briefly describes metamorphosis and growth but fails to connect these processes to broader ecological impacts. (2marks)
- Little to no analysis provided; lacks understanding of the subject matter. For example, States that frogs change and tilapia grow without elaboration or analysis. (1mark)

Use of Examples

- Effectively uses specific examples to support points, demonstrating understanding of the life processes of both organisms. For example, providing specific instances, such as how tadpoles feed on algae to control aquatic plant growth, while tilapia manage algae through their feeding habits. (2marks)
- Includes some examples, but they may not fully illustrate the points made or lack clarity. For example, mentioning that both species are important for their ecosystems lacking specific details. (1 mark)

Clarity and Organisation: well-organised response with a clear, logical flow of ideas; easy to follow the argument. (1 mark)

WEEK 13

Question 1

Depth of Analysis of adaptative characteristics and its influence on their roles in the ecosystem.

- Thoroughly identifies and explains five adaptations for each organism relating them to their role in the ecosystem. For example, the wall gecko's camouflage and sticky toe pads, enables them to access food sources such as insects on walls and ceilings, helping to control insect pest. (10 marks)
- States the adaptations but does not connect this to respective roles in the ecosystem. (5 marks)
- Provides a vague statement like "both animals are important" without specific details. (1 mark)

Use of Examples to support analysis

- Cites specific behaviours, such as how wall geckos hunt nocturnally to avoid predators, and how domestic fowl forage for insects, impacting soil health. (5 marks)
- Mentions general behaviours but lacks specific instances, such as failing to describe how geckos use their environment for hunting. (3 marks)
- Includes a vague example like "geckos eat insects" without context or explanation. (1 mark)

Clarity and Organization

- Organises the response into clear sections for each species, making it easy to follow comparisons of adaptations and their ecological roles. (5 marks)
- Generally clear but may jump between points without clear transitions, such as mixing descriptions of adaptations without linking them. (3 marks)

- Presents ideas in a disjointed manner, making it hard to see the relationships between adaptations and their roles. (1 mark)

Total: 20 marks

Question 2

Identification and Labelling

- Identifies ten or more organs correctly with precise anatomical terms. (5 marks)
- Identifies eight to eleven major organs correctly. (4 marks)
- Identifies six to eight major organs correctly. (3 marks)
- Identifies fewer than four organs correctly. (2 marks)

Organ Functions

- Comprehensive and detailed explanation of all organ functions with clear understanding of their roles. (5 marks)
- Accurate explanation of all major organ functions. (4 marks)
- Basic explanation of most organ functions with some errors. (3 marks)
- Limited or incorrect explanation of organ functions. (1 mark)

Passage of Food through the digestive system

- Excellent description with detailed understanding of processes and transitions between organs in sequence. (4 marks)
- Good description with clear understanding of sequence and basic processes. (3 marks)
- Basic description with some understanding of sequence. (2 marks)
- Minimal or incorrect description of food passage. (1 mark)

Analysis of Adaptations

- Identifies six or more adaptations with sophisticated analysis connecting structure to function and evolutionary context (where possible). (6 marks)
- Identifies five adaptations with clear connections to diet/lifestyle. (5 marks)
- Identifies four adaptations with some connection to diet/lifestyle. (4 marks)
- Identifies two basic adaptations with limited connection to diet/lifestyle. (2 mark)

Total: 20 marks

WEEK 14

Question 1: Water Hyacinth in Lake Volta (20 marks)

Understanding of Ecological Impact:

- Explanation of how water hyacinth blocks sunlight to underwater plants (1 mark)
- Description of oxygen depletion effects on fish and other aquatic life (1 mark)
- Discussion of habitat alteration for native species (1 mark)
- Explanation of disrupted food chains/webs with specific examples (2 marks)
- Description of altered symbiotic relationships (1 mark)
- Identification of specific Lake Volta species affected (2 marks)

Bioremediation Strategy:

- Clear proposal for removing/controlling water hyacinth (2 marks)
- Explanation of biological processes involved in the solution (2 marks)
- Consideration of feasibility in Ghanaian context (2 marks)

Livelihood Opportunities:

- Identification of specific job creation opportunities (2 marks)
- Explanation of how local communities could participate (2 marks)
- Consideration of economic sustainability of proposed livelihoods (2 marks)

Question 2: Rainfall Changes and Shea Trees (20 marks)**Understanding of Current Relationships:**

- Explanation of how soil microbes benefit shea trees (2 marks)
- Description of shea trees' importance to local communities (2 marks)
- Explanation of how communities affect soil health and tree populations (2 marks)

Model Development:

- Clear visual or conceptual model showing relationships (2 marks)
- Inclusion of key components (soil, microbes, trees, humans, rainfall) (2 marks)
- Logical connections between components (2 marks)
- Explanation of how the model represents real-world interactions (2 marks)

Future Predictions:

- Reasonable predictions based on climate science (2 marks)
- Specific changes to ecological relationships under altered rainfall patterns (2 marks)
- Potential adaptation strategies for communities (2 marks)

Question 3: Cocoa Agroforestry System (20 marks)**Design of Improved Cocoa Farming System:**

- Appropriate selection of companion plants/organisms (2 marks)
- Explanation of beneficial relationships (pollination, shade, pest control, etc.) (2 marks)
- Spatial arrangement and diversity of species (2 marks)
- Management practices that enhance climate resilience (2 marks)

Comparison with Conventional Methods:

- Identification of specific problems with conventional cocoa farming in Ghana (2 marks)
- Comparison of ecological benefits (2 marks)
- Comparison of economic considerations (2 marks)

Implementation for Smallholders:

- Consideration of resource requirements for small-scale farmers (2 marks)
- Discussion of knowledge/training needs (1 mark)
- Analysis of economic feasibility and transition costs (2 marks)
- Timeline and practical implementation steps (1 mark)

Question 4: Mycorrhizal Fungi in Mole National Park (20 marks)**Understanding of Mycorrhizal Relationships:**

- Explanation of how mycorrhizal fungi interact with tree roots (2 marks)
- Description of nutrient and water exchange processes (2 marks)
- Identification of specific tree species in Mole National Park that form these relationships (2 marks)

Experimental Design:

- Clear hypothesis about drought resistance (1 mark)
- Appropriate experimental setup including controls (2 marks)
- Methods for measuring seedling survival/health (2 marks)
- Methods for assessing fungal presence/activity (2 marks)
- Consideration of appropriate timeframe and local conditions (1 mark)

Conservation Strategies:

Specific protection measures for soil fungal networks (2 marks)

Integration with existing park management practices (2 marks)

Consideration of threats to these relationships (logging, fire, etc.) (2 marks)

Question 5: Mistletoe on Shea Trees (20 marks)

Negative Impacts on Shea Trees:

- Explanation of how mistletoe extracts resources from trees (2 marks)
- Description of effects on shea tree health and fruit production (2 marks)
- Economic importance of shea to local communities in northern Ghana (2 marks)

Benefits to Bird Diversity:

- Explanation of how mistletoe supports birds (habitat, food, nesting) (2 marks)
- Identification of specific bird species that benefit (2 marks)
- Ecological role of these birds in the wider ecosystem (2 marks)

Balanced Management Approach:

- Specific management recommendations (2 marks)
- Justification based on ecological principles (2 marks)
- Consideration of local community needs and traditional knowledge (2 marks)
- Practical implementation strategy with timeline (2 marks)

Question 6: Cattle Egrets and Livestock (20 marks)

Relationship Explanation:

- Description of the commensalistic relationship (2 marks)
- Benefits to egrets (feeding opportunities on disturbed insects) (2 marks)
- Effects on livestock (neutral or beneficial through pest reduction) (2 marks)

Impact of Changing Practices

- Identification of specific changing farming practices in Volta Region (2 marks)
- Logical predictions about effects on the relationship (2 marks)
- Broader ecological implications for both species (2 marks)

Field Study Design:

- Clear research question(s) (1 mark)
- Appropriate methodology for data collection (2 marks)
- Sampling strategy and study sites (2 marks)
- Methods for analysing results (1 mark)
- Consideration of practical constraints in the Ghanaian context (1 mark)
- Application to agricultural policy (1 mark)

Question 7: Fungal Waste Management (20 marks)

System Design:

- Selection of appropriate fungal species native to Ghana (2 marks)
- Description of decomposition processes (2 marks)
- Physical setup of the waste management system (2 marks)
- Integration with existing waste collection methods (2 marks)

Environmental Benefits:

- Reduction in landfill requirements (1 mark)
- Decreased pollution compared to burning/dumping (1 mark)
- Production of useful by-products (compost, soil amendments) (2 marks)
- Other environmental benefits (reduced methane emissions, etc.) (2 marks)

Economic Analysis:

- Setup and operating costs in Ghanaian context (2 marks)
- Potential revenue streams or savings (2 marks)
- Comparison with costs of conventional methods (2 marks)

Question 8: Epiphytic Orchids Investigation (20 marks)

Understanding of Plant Relationships:

- Explanation of epiphytic relationship (2 marks)
- Description of how orchids grow on trees without soil (2 marks)
- Examples of specific orchid species in Ghanaian forests (2 marks)

Investigation Design

- Clear research question(s) (1 mark)
- Hypothesis about potential mutualistic benefits (2 marks)
- Hypothesis about potential mild parasitism (2 marks)
- Appropriate methodology and measurements (2 marks)
- Controls and variables (2 marks)
- Feasibility in Ghanaian forest conditions (1 mark)
- Expected Outcomes and Implications (4 marks)
- Predicted possible findings (2 marks)
- Implications for forest conservation and management (2 marks)

WEEK 15**FOCAL AREA 1****Question 1****Application to School Areas**

- Identifies three distinct areas (e.g., shaded, sunny, disturbed) and links sampling methods to each (1 mark)
- Considers differences in vegetation structure or plant density across areas (1 mark)
- Notes challenges such as accessibility, student traffic, or soil condition (1 mark)

Analysis of Environmental Factors Affecting Distribution

- Identifies light availability as a factor and links it to observed plant types (1 mark)
- Considers soil moisture, pH, or fertility and their impact (1 mark)
- Notes human activity (e.g., foot traffic, maintenance) as an influence (1 mark)
- Includes biotic factors such as competition or canopy cover (1 mark)
- Demonstrates integration of how these factors shape plant patterns (1 mark)

Recommendations to Improve Biodiversity

- Suggests increasing native species planting or reducing monocultures (1 mark)
- Recommends use of compost or soil enrichment to support plant health (1 mark)
- Advocates control of trampling or fencing off sensitive areas (1 mark)
- Proposes student involvement (e.g., biodiversity clubs, gardening) (1 mark)
- Mentions use of monitoring and maintenance plans for long-term outcomes (1 mark)

Scientific Communication and Clarity

- Uses appropriate ecological terminology throughout (1 mark)
- Presents ideas in a logical, coherent structure (1 mark)
- Demonstrates clear sentence construction and paragraphing (1 mark)

Question 2**Identification of Methodological Problems**

- Use of inaccurate or analogue equipment (e.g., non-digital scales) (1 mark)
- Lack of standardisation in height/weight measurement techniques (1 mark)
- No adjustment for clothing, footwear, or time of day (1 mark)
- Ignores ethnic and developmental body composition differences (1 mark)

Effects on Accuracy and Interpretation

- BMI misclassifies muscular or differently-built ethnic students (1 mark)
- Measurement error affects classification into underweight/overweight categories (1 mark)
- Lack of reference to age/gender-adjusted charts reduces clinical value (1 mark)
- Misinterpretation could lead to inappropriate health interventions (1 mark)

Design of Improved Protocol

- Specifies use of calibrated digital scale and portable stadiometer (1 mark)
- Recommends morning measurement, light clothing, no shoes for consistency (1 mark)
- Introduces use of BMI-for-age percentile charts suited for Ghanaian adolescents (2 marks)
- Acknowledges ethnic body composition variance, e.g., higher muscle mass, and suggests waist-to-height ratio as a supplement (1 mark)
- Includes protocol for data privacy and informed consent (1 mark)

Design of Data Collection Form and Equipment

- Form includes fields for name/code, age, sex, height, weight, BMI, notes (1 mark)
- Includes BMI classification range specific to adolescents (1 mark)
- Lists all required equipment and basic guidelines for use (1 mark)
- Improvement in Accuracy and Interpretation
- Justifies more reliable and culturally appropriate data through protocol (1 mark)
- Allows better targeting of health programmes or counselling (1 mark)
- Encourages student health awareness and data-driven decision making (1 mark)

Total: 20 marks

Question 3

Justification of Methods

- Selects appropriate method for measuring plant density (e.g., quadrat sampling, point-frame) and explains suitability. (1 mark)
- Describes how student BMI and other health indicators (e.g., absenteeism, self-reported stress) are obtained ethically and systematically. (1 mark)
- Provides justification for linking green cover to health outcomes based on prior evidence or ecological logic. (1 mark)
- Mentions strategies to reduce bias (e.g., randomisation, control of confounding variables like age, class level) (1 mark)

Collection and Processing of Data

- Demonstrates consistent collection of plant density across different school zones (e.g., shaded, green, bare) (1 mark)
- Collects relevant and representative BMI/health data from a sufficient sample size (1 mark)
- Uses basic data grouping or stratification (e.g., by zone, BMI range) for clearer patterns (1 mark)
- Applies ethical considerations in student data use (anonymity, informed consent) (1 mark)

Data Analysis and Interpretation (6 marks)

- Shows attempt to correlate plant density with student BMI or other indicators (e.g., lower BMI near green areas) (2 marks)
- Identifies patterns or anomalies using summary statistics or visuals (e.g., bar graphs, scatter plots) (1 mark)
- Considers other influencing factors (e.g., food, exercise, socio-economic status) in interpretation (1 mark)

- Draws reasoned conclusions about how greenery may influence physical and/or mental health (1 mark)
- Demonstrates biological understanding of how plants impact microclimate, air quality, stress reduction (1 mark)

Proposals for Environmental Change (4 marks)

- Suggests increasing green zones in high-density or bare areas (1 mark)
- Recommends planting strategies (e.g., shade trees near sports fields, fruit trees near walkways) to encourage physical activity or nutrition (1 mark)
- Proposes student-led planting or maintenance initiatives (1 mark)
- Links environmental changes directly to improved health indicators or learning environment (1 mark)

Scientific Communication and Presentation (2 marks)

- Uses relevant biological and health terminology appropriately (e.g., “photosynthetic biomass”, “anthropometric data”) (1 mark)
- Communicates findings clearly, logically, and with appropriate formatting (1 mark)

Total: 20 marks

FOCAL AREA 2

Question 1

Data Analysis and Interpretation

- Accurate identification of the largest group (normal weight – 50%) (1 mark)
- Recognition that a significant proportion is overweight or obese (30%) (2 marks)
- Identification that 20% are underweight, showing possible malnutrition (1 mark)
- Overall conclusion on class health status (e.g., mixed picture with diet/health imbalances) (2 marks)

Comparison with National Adolescent Trends

- Reference to national data: e.g., increasing overweight/obesity in urban areas or persistent undernutrition in some regions (1–2 marks)
- Observation of similarities or differences (e.g., higher/lower than national averages) (1 mark)
- Insightful comment on urban–rural disparities or socio-economic influences in Ghana (1 mark)

Explanation of Contributing Factors

- Diet: poor eating habits, junk food access, or lack of balanced meals (2 marks)
 - Physical Activity: sedentary lifestyle, lack of sports or active play (2 marks)
 - Socio-economic Status: affordability of nutritious food or healthcare access (2 marks)
- Other acceptable factors: peer influence, health education gaps, cultural food preferences*

School-Based Action Plan

- Strategy to support underweight students (e.g., school feeding, nutrition education) (1 mark)
- Strategy to address overweight/obesity (e.g., fitness clubs, awareness campaigns) (1 mark)
- Involvement of stakeholders (teachers, parents, school nurse, canteen operators) (1 mark)
- Monitoring or follow-up method (e.g., regular BMI checks, health talks) (1 mark)

Question 2:**Identification of Methodological Problems**

- Uneven sampling methods used for different plant types (1 mark)
- Small number of quadrats for a 1-hectare area (1 mark)
- No mention of quadrat placement method for randomness/representativeness (1 mark)
- No replication or seasonal sampling to account for variability (1 mark)

Effects on Reliability of Conclusions

- Bias from non-standardised methods limits comparability between plant types (1 mark)
- Small sample size increases margin of error for grasses (1 mark)
- Over- or underestimation of species density due to unrepresentative sampling (1 mark)
- Inconsistent data could misinform conclusions about biodiversity or distribution (1 mark)

Redesign of the Study

- Use consistent and appropriate sampling methods (e.g., stratified random sampling) for all plant types (2 marks)
- Increase quadrat number or sample area for grasses for better accuracy (1 mark)
- Incorporate systematic or grid-based sampling to ensure spatial coverage (1 mark)
- Add seasonal or repeated sampling to observe variations over time (1 mark)
- Use proper tools for recording and calculating density uniformly (1 mark)

Application to Environmental Management

- Data helps identify overgrown or degraded areas needing reforestation or weeding (2 marks)
- Enables planting plans for tree or shrub increase in open spaces (1 mark)
- Assists in monitoring impact of school projects (e.g., gardens or green belts) (1 mark)
- Promotes student engagement in ecology and conservation initiatives (1 mark)
- Informs waterway protection strategies near the stream (1 mark)

WEEK 16**Question 1****Key Messages for Different Age Groups**

- Clear, age-appropriate health message for children (e.g., handwashing, avoiding sick animals) (2 marks)
- Relevant message for adults (e.g., safe animal handling, recognising symptoms) (2 marks)
- Message tailored to elderly or caregivers (e.g., early reporting, caregiving precautions) (2 marks)

Communication Methods in Rural Settings

- Identification of suitable local communication methods (e.g., community meetings, radio, town criers) (2 marks)
- Justification of chosen methods based on accessibility and reach (2 marks)
- Use of local languages and visual materials (e.g., posters, storytelling) (2 marks)

Cultural Practices and Beliefs

- Identification of cultural practices that may contribute to disease spread (e.g., bush meat consumption, communal care) (2 marks)

- Sensitivity in suggesting modifications to these practices (e.g., working with local leaders) (2 marks)
- Strategies for building trust and promoting behavioural change (2 marks)

Campaign Design and Relevance

- Overall structure, creativity, and realism of the campaign (1 mark)
- Appropriateness to rural Ghanaian context (1 mark)

Question 2:

Evaluation of Prevention Measures

- Identification of specific preventive measures (e.g., lockdowns, masks, hygiene campaigns) (2 marks)
- Assessment of their impact and limitations (e.g., enforcement challenges, rural access) (2 marks)
- Use of data or examples to support evaluation (2 marks)

Evaluation of Public Education Strategies

- Discussion of communication strategies used (e.g., national broadcasts, info centres) (1 mark)
- Assessment of reach and public understanding (1 mark)
- Consideration of misinformation or gaps (1 mark)
- Reference to role of local leaders or schools in information spread (1 mark)

Evaluation of Vaccination Programme

- Overview of vaccine rollout and access (1 mark)
- Analysis of public response and vaccine hesitancy (1 mark)
- Role of government and international partners (1 mark)
- Any inequalities in distribution or rural challenges (1 mark)

Lessons for Future Outbreaks

- Identification of relevant lessons learned (e.g., need for better surveillance, decentralised health systems) (2 marks)
- Application of lessons to Ebola or Swine flu context (2 marks)
- Emphasis on sustained investment in health infrastructure and preparedness (2 marks)

Question 3:

Hygiene Strategies

- Regular hand-washing protocols and availability of water/sanitisers (2 marks)
- Use of face masks or tissue hygiene (1 mark)
- Cleanliness of school facilities, including toilets and classrooms (2 marks)

Physical Distancing Measures

- Seating arrangements and staggered break times (2 marks)
- Limiting overcrowding in classrooms and assemblies (1 mark)
- Use of signage or student monitors (1 mark)

Health Monitoring Systems

- Daily temperature checks or symptom screening (1 mark)
- Designated isolation space or referral system for sick students (2 marks)
- Reporting and record-keeping protocols (1 mark)

Community and Parental Engagement

- Meetings or communication through PTA or local leaders (2 marks)
- Educational materials for parents on home hygiene and signs of illness (2 marks)
- Inclusion of local health authorities or clinics (1 mark)

Feasibility and Initiative

- Realistic implementation based on school context and student leadership (1 mark)
- Creativity and organisation in the plan (1 mark)

Question 4

Analysis of Causes

- Identification of environmental factors (e.g., stagnant water, poor sanitation) (2 marks)
- Possible transmission routes (e.g., contaminated soil or insect bites) (2 marks)
- Role of human activity (e.g., bathing, farming in infected areas) (2 marks)

Multi-Step Action Plan

- Involvement of local leaders in public education and support (2 marks)
- Engagement of students in hygiene promotion and community outreach (2 marks)
- Role of health workers in identifying, isolating, and treating cases (2 marks)
- Environmental officers addressing the stagnant water issue (e.g., drainage, spraying) (2 marks)
- Distribution of protective clothing or footwear (1 mark)
- Monitoring and data collection for further cases (1 mark)
- Planning for long-term community education (2 marks)

Coherence and Relevance of Plan

- Logical sequencing of steps (1 mark)
- Suitability for a rural Ghanaian village setting (1 mark)

Question 5

Comparison of Transmission Routes

- Ebola: direct contact with bodily fluids, contaminated materials, infected animals (2 marks)
- SARS-CoV-2: respiratory droplets, aerosols, surface contact (2 marks)
- Key differences in ease and mode of spread (e.g., airborne vs contact-based) (2 marks)

Urban Market Preventive Measures

- Mask use and hand sanitising stations (2 marks)
- Public announcements and posters in multiple languages (1 mark)
- Regular cleaning of surfaces and goods handling points (1 mark)
- Crowd control strategies or physical distancing (2 marks)
- Designated health checkpoint or symptom reporting area (1 mark)

Rural Farming Community Measures

- Education on avoiding bush meat and safe animal handling (2 marks)
- Training on identifying early symptoms of Ebola or COVID-19 (1 mark)
- Promoting community hygiene practices (e.g., shared tool cleaning) (1 mark)
- Encouraging early reporting to local clinics or CHPS compounds (1 mark)

Clarity and Contextual Relevance

- Appropriateness of suggestions to each setting (1 mark)
- Logical application of transmission knowledge to prevention (1 mark)

WEEK 17

Question 1

Criteria	Excellent (4-5marks)	Very Good (3marks)	Satisfactory (2marks)	Needs Improvement (1mark)
<i>Signs and Symptoms</i>	<i>Thoroughly describes specific signs and symptoms for both diseases, with detailed examples of plants</i>	<i>Clearly describes signs and symptoms for both diseases but may lack minor details</i>	<i>Provides basic signs and symptoms for both diseases, but key aspects may be missing</i>	<i>Minimal or incomplete description of signs and symptoms for one</i>
<i>Mode of Transmission</i>	<i>Clearly explains the transmission methods for both diseases, including environmental factors and vectors.</i>	<i>Good explanation of transmission modes for both diseases, but may lack details like vectors</i>	<i>Basic information on transmission modes for both diseases, but lacks depth or clarity</i>	<i>Minimal or vague explanation of transmission for one</i>
<i>Compare and Contrast Transmission Mechanisms</i>	<i>Insightful comparison of transmission mechanisms, effectively highlighting similarities and differences.</i>	<i>Good comparison made, with clear similarities and differences, but may lack depth</i>	<i>Basic comparison present, but insights are shallow or incomplete</i>	<i>One transmission mechanism mentioned with Little to no comparison; fails to identify similarities or differences effectively</i>
<i>Implications of the Disease</i>	<i>Comprehensive discussion of two implications each for agriculture and veterinary health.</i>	<i>Clear discussion of implications but may lack specific examples or depth.</i>	<i>Basic discussion of one implication each but lacks detail or clarity.</i>	<i>Minimal or vague discussion; fails to connect implications to the diseases effectively.</i>

<i>Clarity and Organization</i>	<i>Well-organised response: ideas flow logically with clear headings and subheadings</i>	<i>Generally organised; minor issues with clarity or flow, but overall understandable.</i>	<i>Some organisation present, but ideas may be mixed up or unclear at times.</i>	<i>Disorganised and difficult to follow; lacks clear structure and coherence</i>
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Total of 20 marks

Question 2

Understanding of Implications

- Comprehensive understanding of four implications of diseases on food security, with in-depth explanations. (5 marks)
- Clear understanding of four implications but may lack some depth in explanations. (4 marks)
- Basic understanding of three implications but lacks detail and clarity. (3 marks)
- Minimal understanding; fails to identify two relevant implications. (1-2 marks)

Critical Analysis

- Four insightful analyses connecting diseases to broader food security issues, including economic and health aspects. (5 marks)
- Four good analyses with connections made but may lack depth or critical insights. (4 marks)
- Three basic analyses present but limited connections or critical thinking. (3 marks)
- Little to no analysis; fails to connect two diseases to food security effectively. (1-2 marks)

Use of Examples

- Provides relevant and specific examples to support points made, enhancing the argument. (5 marks)
- Includes some examples, but they may be less specific or relevant. (4marks)
- Three examples provided, but they may not effectively support the argument. (3-2 marks)
- One example and fails to illustrate points made effectively. (1 mark)

Clarity and Organisation

- Well-organised response: ideas flow logically with clear transitions and structure. (5 marks)
- Generally organised; minor issues with clarity or flow, but overall understandable. (4 marks)
- Some organisation present, but ideas may be unclear at times. (3-2 marks)
- Disorganised and difficult to follow; lacks clear structure. (1mark)

Total of 20 marks

Question 3.

Understanding of Climate Change Effects

- Demonstrates a comprehensive understanding of how climate change can affect the transmission of both diseases, with detailed explanations. (5 marks)

- Shows a clear understanding of the effects of climate change on disease transmission but may lack some detail. (3 marks)
- Provides a basic understanding, mentioning only a few effects without much detail. (2 marks)
- Minimal understanding failing to identify relevant effects of climate change. (1 mark)

Analysis of Transmission Mechanisms

- Insightful analysis of how specific aspects of climate change (e.g., temperature, humidity) influence the transmission mechanisms of both Late Blight and Brucellosis. (5 marks)
- Good analysis with some specific connections made but may lack depth in one or both diseases. (4 marks)
- Basic analysis present, with limited connections to the transmission mechanisms. (3 marks)
- Little to no analysis; fails to connect climate change to disease transmission effectively. (1 mark)

Use of Examples and Evidence

- Provides relevant and specific examples or evidence to support points made, enhancing the analysis. (5 marks)
- Includes some examples, but they may be less specific or relevant. (4 marks)
- Few examples are provided, but they may not effectively support the analysis. (3 marks)
- Lacks examples failing to illustrate points made effectively. (1 mark)

Clarity and Organisation

- Well-organised response with ideas flowing logically with clear transitions and structure. (5 marks)
- Generally organised; minor issues with clarity or flow, but overall understandable. (4 marks)
- Some organization present, but ideas may be jumbled or unclear at times. (3 marks)
- Disorganized and difficult to follow; lacks clear structure. (1 mark)

Total of 20 marks

Question 4.

Criteria	Excellent (5 marks)	Very Good (4 marks)	Satisfactory (3-2 marks)	Needs Improvement (1 mark)
<i>Identification of Symptoms</i>	<i>Clearly identifies symptoms of TB and assesses their impact accurately.</i>	<i>Identifies symptoms with minor inaccuracies or omissions.</i>	<i>Recognizes the problem but lacks detail.</i>	<i>Vaguely identifies symptoms.</i>
<i>Immediate Actions</i>	<i>Comprehensive assessment and immediate isolation measures outlined.</i>	<i>Good immediate actions but lacks some detail.</i>	<i>Basic immediate actions mentioned but not thoroughly explained.</i>	<i>Limited immediate actions noted; lacks relevance.</i>

<i>Veterinary Consultation</i>	<i>Clearly emphasizes the importance of veterinary involvement and diagnostic testing.</i>	<i>Mentions veterinary consultation but lacks detail on diagnostics.</i>	<i>Basic mention of veterinary involvement without specifics.</i>	<i>Minimal mention of veterinary support; lacks clarity.</i>
<i>Quarantine Measures</i>	<i>Thoroughly outlines quarantine protocols and movement restrictions.</i>	<i>Includes quarantine measures but lacks specific details.</i>	<i>Basic quarantine measures mentioned but not clearly explained.</i>	<i>Few quarantine measures noted; lacks relevance.</i>
<i>Hygiene</i>	<i>Comprehensive hygiene protocols detailed.</i>	<i>Good hygiene practices included but lacks detail.</i>	<i>Basic hygiene measures mentioned but not thoroughly explained.</i>	<i>Limited mention of hygiene practices; lacks relevance.</i>
<i>Education, Training Future Prevention Strategies</i>	<i>Thoroughly discusses education, training for farm staff and discussion on vaccination and future biosecurity measures.</i>	<i>Mentions training and preventive strategies but lacks detail on implementation</i>	<i>Basic mention of education and prevention strategies without specifics.</i>	<i>Limited education strategies noted.</i>

Total of 30 marks

SECTION 4: ANIMAL AND PLANT SYSTEMS

STAND: SYSTEMS OF LIFE

Sub-strand 1: Mammalian Systems

Learning Outcome: *Explain how the mammalian respiratory, reproductive, musculoskeletal, nervous and hormonal organ systems are related in their functions to ensure the sustenance of life.*

Content Standard: *Demonstrate knowledge and understanding of mammalian systems with specific emphasis on human Respiratory, Reproductive, Musculoskeletal, Nervous and Hormonal systems and how they function to ensure sustenance of human life.*

Sub-strand 2: Plant Systems

Learning Outcome: *Describe reproduction and excretion and relate them to their importance in flowering plants.*

Content Standard: *Demonstrate knowledge and understanding of excretion and reproduction in flowering plants.*

INTRODUCTION AND SECTION SUMMARY

In earlier units, learners developed foundational knowledge of body systems, plant structures, and the roles these play in maintaining life. Building on this, the present section introduces learners to deeper biological concepts centred on the harmonious functioning of mammalian systems and the continuity of plant life. Across Weeks 18 to 24, learners will explore how the respiratory, reproductive, musculoskeletal, nervous, and hormonal systems enable mammals to survive, adapt, and maintain healthy living. They will examine these systems not as isolated structures but as interconnected networks that depend on one another for efficient functioning. Through labelled drawings, practical observations, and guided discussions, learners will gain a more concrete appreciation of form, function, and interdependence in living organisms.

The section also strengthens learners' understanding of reproductive processes in flowering plants. Learners will study sexual reproduction in plants, pollination, fertilisation, and the development of fruits and seeds. This will be followed by discussions on why reproduction in plants is essential for the continuity of life, ecosystem stability, and human survival. The unit concludes with an exploration of excretion in flowering plants, highlighting how plants remove waste to maintain internal balance. By the end of this section, learners will recognise reproduction and excretion as vital life processes comparable to those in animals, deepening their understanding of the unity of life.

The weeks covered by the section are:

Week 18: Describe with labelled drawings, how the respiratory system in mammals' functions and work with other systems to ensure healthy living.

Week 19: Describe with labelled drawings, how the reproductive system in mammals functions and works with other systems to ensure the survival of all species.

Week 20: Describe with labelled drawings, how the musculoskeletal system in mammals, functions and work with other systems to ensure healthy living.

Week 21: Describe how the nervous and hormonal systems in mammals, function and work with other systems to ensure healthy living.

Week 22: Explain the methods of reproduction in flowering plants with emphasis on sexual reproduction.

Week 23: Discuss the importance of reproduction in flowering plants for the sustenance of life.

Week 24: Discuss excretion in flowering plants.

SUMMARY OF PEDAGOGICAL EXEMPLARS

The pedagogies chosen for this section aim to make learning interactive, visual, and meaningful for all learners. To help learners understand how mammalian body systems work together (Weeks 18–21), lessons will use **labelled drawings, models, and demonstrations**. These practical activities allow learners to clearly see how organs are structured and how systems depend on one another. **Group discussions, peer explanations, and guided questioning** will deepen understanding by encouraging learners to talk through ideas, share observations, and make connections to healthy living.

In the plant reproduction and excretion lessons (Weeks 22–24), **hands-on activities and simple investigations** will help learners explore real examples from their environment. Observing flowers, fruits, and seeds will allow them to link plant structures directly to reproductive processes. **Short projects and practical demonstrations**, such as modelling pollination or tracking seed dispersal, will support curiosity and build confidence.

Across all lessons, **collaborative work** will allow learners to support one another, share diverse strengths, and learn in an inclusive environment. These approaches cater for different learning styles and ensure that complex biological concepts become clear, engaging, and relevant to everyday life.

ASSESSMENT SUMMARY

Several modes of assessment are employed in learning in this section. The tests provide a broad-based, comprehensive assessment of the learners' knowledge as advised in the Curriculum and the Teacher Assessment Manual and Toolkits. This allows consistency in evaluating learners' academic progress.

Indicator	DOK Level	Suggested Assessment Strategy and/or Mode
Describe with labelled drawings how the respiratory system in mammals functions and works with other systems to ensure healthy living.	Level 4	Group investigation and presentation (supported with labelled diagrams and a written report)
Describe with labelled drawings how the reproductive system in mammals functions and works with other systems to ensure the survival of all species.	Level 3	Case study and group presentation
Describe with labelled drawings how the musculoskeletal system in mammals functions and works with other systems to ensure healthy living.	Level 4	Practical investigation and project report

Describe how the nervous and hormonal systems in mammals function and work with other systems to ensure healthy living.	Level 4	Research project and presentation
Describe the methods of reproduction in flowering plants with emphasis on sexual reproduction.	Level 4	Practical investigation (flower dissection) with laboratory report
Discuss the importance of reproduction in flowering plants for the sustenance of life.	Level 3	Case study and argumentative essay
Discuss excretion in flowering plants.	Level 4	Experimental investigation with practical report

WEEK 18

Learning Indicator: Describe with labelled drawings, how the respiratory system in mammals functions and work with other systems to ensure healthy living

FOCAL AREA: HOW THE RESPIRATORY SYSTEM IN MAMMALS FUNCTIONS AND WORK WITH OTHER SYSTEMS TO ENSURE HEALTHY LIVING

The Respiratory System in Humans

The **human respiratory system** is responsible for breathing and the exchange of gases between the body and the environment. During inhalation, oxygen enters the lungs and diffuses into the bloodstream. During exhalation, carbon dioxide, produced by body cells during cellular respiration, diffuses from the blood into the lungs and is expelled from the body.

The oxygen transported by the blood is used by body cells during **cellular respiration** to release energy from food. Although breathing and cellular respiration are closely related, breathing refers to the movement and exchange of gases between the body and the environment, whereas cellular respiration is the chemical process by which cells release energy. The respiratory system works closely with the circulatory system to transport oxygen to body tissues and remove carbon dioxide from the body.

Breathing is an involuntary process controlled by the respiratory centres in the **medulla oblongata** and **pons** of the brain. These centres receive signals from chemoreceptors that monitor the concentration of carbon dioxide and the pH of the blood. When carbon dioxide levels increase and blood pH decreases, the respiratory centres increase the rate and depth of breathing to restore normal gas concentrations. Although humans can voluntarily hold their breath for a short period, involuntary control eventually resumes breathing to maintain normal body functions.

The human respiratory system consists of

- a. **Nasal cavity:** Air enters the body through the nostrils into the nasal cavity, where it is filtered, warmed and moistened before passing through the pharynx and larynx into the trachea.
- b. **Trachea:** A flexible tube supported by C-shaped rings of cartilage that carries air to and from the lungs.
- c. **Bronchi:** The trachea divides into two bronchi, one leading to each lung. Each bronchus branches repeatedly into smaller tubes called bronchioles.
- d. **Bronchioles:** These fine air passages distribute air throughout the lungs and terminate in clusters of alveoli.
- e. **Alveoli:** Tiny air sacs surrounded by a network of blood capillaries. Their thin, moist walls provide a large surface area for the efficient exchange of oxygen and carbon dioxide by diffusion.
- f. **Lungs:** The lungs contain the bronchi, bronchioles and alveoli and are enclosed by a double-layered **pleural membrane**. Between the two pleural membranes is **pleural fluid**, which reduces friction during breathing. The lungs are located within the thoracic cavity, which is formed by the ribs, sternum, vertebral column and diaphragm.
- g. **Diaphragm:** A dome-shaped muscular sheet separating the thoracic cavity from the abdominal cavity. Its contraction and relaxation play a major role in inhalation and exhalation.

The respiratory system works closely with the **circulatory system**, which transports oxygen from the lungs to body tissues and returns carbon dioxide from the tissues to the lungs for exhalation. Together, these systems ensure that body cells receive the oxygen needed for cellular respiration while removing carbon dioxide, thereby maintaining healthy body function.

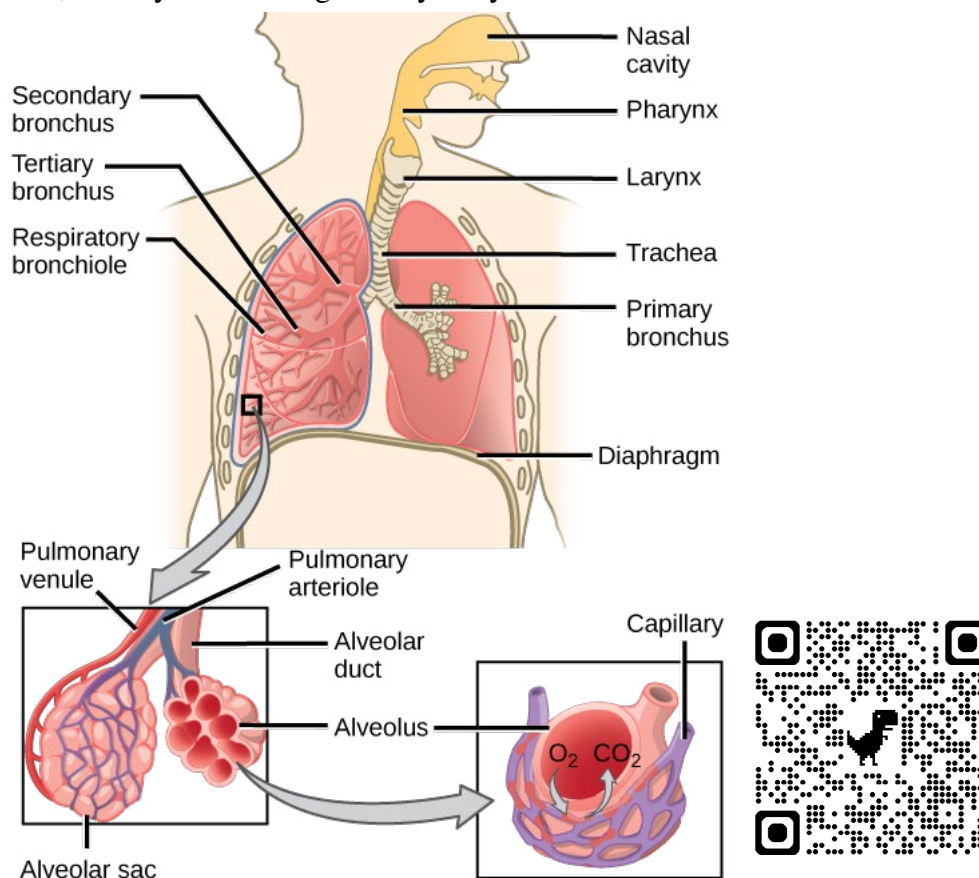


Figure 4.1: Structure of the respiratory system in humans

The parts of the respiratory system work together to ensure efficient breathing, gas exchange and the supply of oxygen for cellular respiration. The process begins with inhalation, during which air enters the lungs and reaches the alveoli. Oxygen then diffuses across the thin walls of the alveoli into the blood, while carbon dioxide diffuses from the blood into the alveoli.

The circulatory system transports oxygen-rich blood from the lungs to body tissues. At the tissues, oxygen diffuses from the blood into body cells, while carbon dioxide produced during cellular respiration diffuses into the blood. The blood then carries carbon dioxide back to the lungs, where it diffuses into the alveoli and is removed from the body during exhalation.

Within the cells, oxygen is used in cellular respiration to break down food molecules and release energy for life processes. Carbon dioxide produced during this process is transported back to the lungs for removal from the body.

The breathing mechanism

Inspiration/ Inhalation: during inhaling the diaphragm, (dome-shaped muscle below the lungs), contracts and moves downward, increasing the chest cavity's volume. The intercostal muscles (muscles between the ribs) also contract, pulling the ribs upward and outward, increasing the chest cavity. This expansion creates a lower pressure inside the lungs compared to the atmosphere, causing air to rush in through the nose or mouth.

Pulmonary Gas Exchange: air travels down the trachea (windpipe) into the bronchial tubes, which branch into smaller bronchioles within the lungs. These bronchioles lead to tiny air sacs called alveoli, surrounded by capillaries. Oxygen from the inhaled air diffuses across the thin walls of the alveoli and capillaries into the bloodstream and at the same time carbon dioxide, moves from the blood into the alveoli to be exhaled.

Expiration/ Exhalation: the diaphragm relaxes and moves upward, and the rib muscles relax, causing the chest cavity to decrease in volume. This increase in pressure inside the lungs forces air out through the airways and out of the body.

Gaseous Exchange

Gaseous exchange is the process by which oxygen enters the blood and carbon dioxide is removed from the blood. Oxygen is required by body cells for cellular respiration, while carbon dioxide produced during cellular respiration must be removed from the body.

During inhalation, air enters the body through the nostrils and passes through the pharynx, larynx, trachea, bronchi, bronchioles, and finally reaches the alveoli, which are tiny air sacs in the lungs. The alveoli provide the main surface for gaseous exchange.

Gas exchange occurs at two main sites:

1. In the lungs (external gaseous exchange): Oxygen diffuses from the air in the alveoli into the blood, while carbon dioxide diffuses from the blood into the alveoli to be removed during exhalation.
2. In the body tissues (internal gaseous exchange): Oxygen diffuses from the blood into body cells, where it is used during cellular respiration. Carbon dioxide produced by the cells diffuses into the blood and is transported back to the lungs.

Gas exchange occurs by simple diffusion, with oxygen and carbon dioxide moving from areas of higher concentration (or partial pressure) to areas of lower concentration.

The lungs are well adapted for efficient gaseous exchange because:

- a. The alveoli provide a large surface area for diffusion.
- b. The walls of the alveoli and surrounding capillaries are one cell thick, providing a short diffusion distance.
- c. The alveolar surface is moist, allowing gases to dissolve before diffusing.
- d. The alveoli are surrounded by a dense network of blood capillaries, ensuring a continuous blood supply.
- e. Continuous ventilation maintains a concentration gradient between the air in the alveoli and the blood, allowing diffusion to occur efficiently.

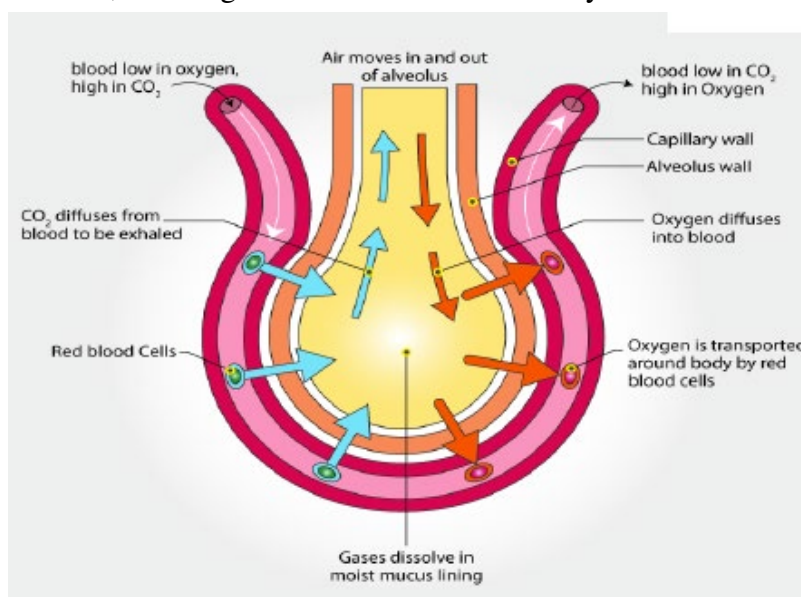


Figure 4.2: Alveolus showing how gasses are exchanged.

Internal Respiration

Although gas exchange is a continuous process, the oxygen and carbon dioxide are transported by different mechanisms in the tissues of animals.

Transport of Oxygen in the Blood

Oxygen dissolves in blood but only 1.5 percent is transported directly in this way. 98.5 percent is bound to a protein in RBCs called haemoglobin and carried to the tissues.

Haemoglobin

Haemoglobin, or Hb, is a protein molecule found in red blood cells (erythrocytes) which binds with four oxygen molecules. Molecules of haemoglobin with more oxygen bound to them are brighter red. As a result, oxygenated arterial blood where the Hb is carrying four oxygen molecules is bright red, while venous blood that is deoxygenated is darker red.

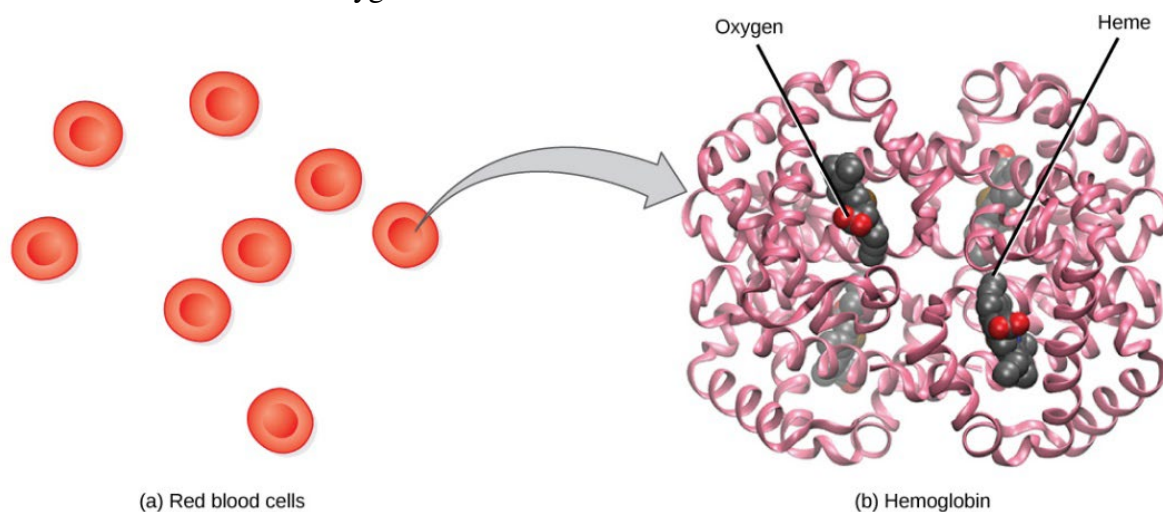


Figure 4.3: The protein inside red blood cells that transports oxygen from the lungs to body tissues is (b) haemoglobin.

It is easier to bind a second and third oxygen molecule to Hb than the first molecule. This is because the haemoglobin molecule changes its shape, or conformation, as oxygen binds, creating a higher affinity for oxygen. However, the affinity of haemoglobin for oxygen may depend on environmental conditions.

Factors That Affect Oxygen Binding to haemoglobin

The **oxygen-carrying capacity** of haemoglobin determines how much oxygen is carried in the blood. In addition, environmental factors and diseases can affect oxygen carrying capacity and delivery.

- Carbon dioxide levels and blood pH: when carbon dioxide is in the blood, it reacts with water to form bicarbonate (HCO_3^-) and hydrogen ions (H^+). As the level of carbon dioxide in the blood increases, more H^+ is produced and the pH decreases. This increase in carbon dioxide and subsequent decrease in pH reduces the affinity of haemoglobin for oxygen. Oxygen dissociates from the Hb molecule.
- Body temperature affects oxygen-carrying capacity. Increased temperature, such as from increased activity of skeletal muscle, causes the affinity of haemoglobin for oxygen to be reduced.
- Diseases like **sickle cell anaemia** and **thalassemia** decrease the blood's ability to deliver oxygen to tissues and its oxygen-carrying capacity. In sickle cell anaemia, the shape of the red blood cell is crescent-shaped, elongated, and stiffened, reducing its ability to deliver oxygen. In this form, red blood cells cannot pass through the capillaries. This is painful when it

occurs. Thalassaemia is a rare genetic disease caused by a defect in either the alpha or the beta subunit of Hb. Patients with thalassaemia produce a high number of red blood cells, but these cells have lower-than-normal levels of haemoglobin. Therefore, the oxygen-carrying capacity is diminished.

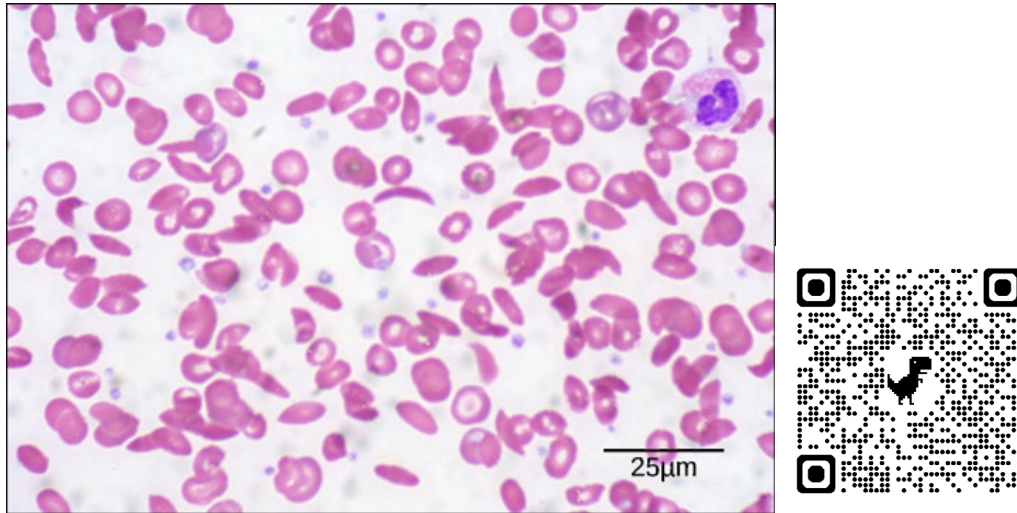


Figure 4.4: Blood sample with crescent-shaped red blood cells.

Transport of Carbon Dioxide in the Blood

Carbon dioxide molecules are transported in the blood from body tissues to the lungs by one of three methods:

- Dissolution directly into the blood, carbon dioxide is more soluble in blood than oxygen. About 5 to 7 percent of all carbon dioxide is dissolved in the plasma.
- Binding to haemoglobin and plasma proteins. This form transports about 10 percent of the carbon dioxide. When carbon dioxide binds to haemoglobin, a molecule called carbaminohaemoglobin is formed. Binding of carbon dioxide to haemoglobin is reversible. Therefore, when it reaches the lungs, the carbon dioxide can freely dissociate from the haemoglobin and be expelled from the body.
- Carried as a bicarbonate ion. Most carbon dioxide molecules (85 percent) are carried as bicarbonate ion in the blood. When the blood reaches the lungs, the bicarbonate ion is converted back into carbon dioxide and expelled through the lungs during exhalation.

Phases of Respiration in Organisms

Respiration occurs in the cytosol and around the plasma membrane in prokaryotic cells. In eukaryotic cells, respiration takes place in the mitochondria, which is also considered as the powerhouse of the cells.

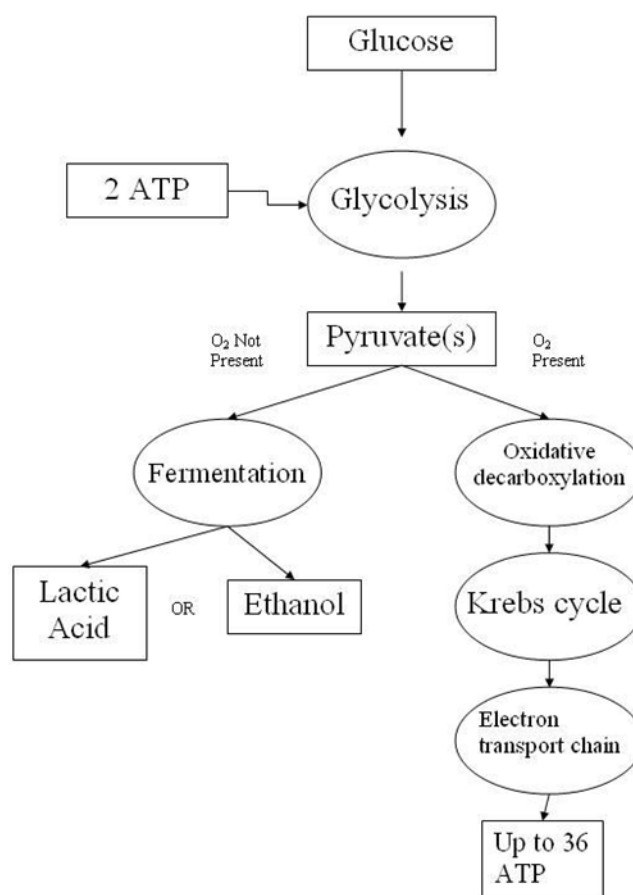


Figure 4.5: A flowchart of respiration

Glycolysis

Glycolysis is the primary phase in cellular respiration in which glucose is broken down to produce energy. It requires two APT molecules to start, and it produces two molecules of pyruvate, ATP, NADH and water. The process takes place in the cytoplasm of a cell and does not require oxygen. It occurs in both aerobic and anaerobic organisms. Glycolysis is followed by the Krebs cycle during aerobic respiration. In the absence of oxygen, the cells make small amounts of ATP as glycolysis is followed by fermentation.

PATHWAY OF GLYCOLYSIS

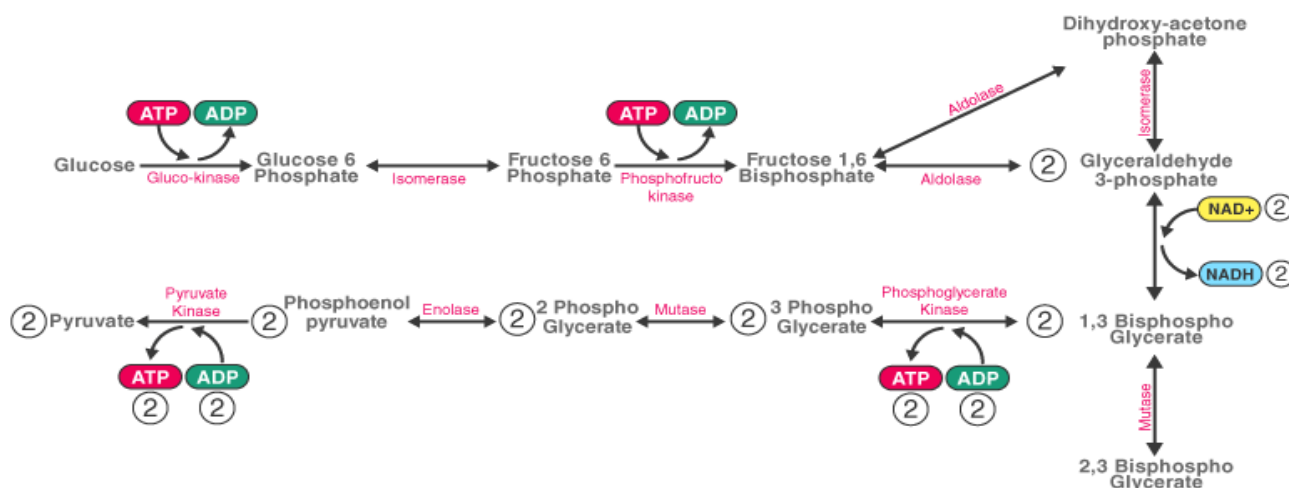


Figure 4.6: Pathway of glycolysis

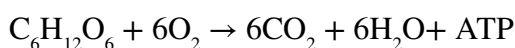
The process occurs in the following stages:

- a. A phosphate group is transferred from ATP to glucose to form glucose,6-phosphate in the cytoplasm, by the action of enzyme hexokinase.
- b. Glucose-6-phosphate is isomerised into fructose,6-phosphate by the enzyme phosphoglucumutase.
- c. The other ATP molecule transfers a phosphate group to fructose 6-phosphate and converts it into fructose 1,6-bisphosphate by the action of the enzyme phosphofructokinase.
- d. The enzyme aldolase converts fructose 1,6-bisphosphate into glyceraldehyde 3-phosphate and dihydroxyacetone phosphate, which are isomers of each other.
- e. Triose-phosphate isomerase converts dihydroxyacetone phosphate into glyceraldehyde 3-phosphate which is the substrate in the successive step of glycolysis.
- f. This stage undergoes two reactions:
 - The enzyme glyceraldehyde 3-phosphate dehydrogenase transfers 1 hydrogen molecule from glyceraldehyde phosphate to nicotinamide adenine dinucleotide to form NADH + H⁺.
 - Glyceraldehyde 3-phosphate dehydrogenase adds a phosphate to the oxidised glyceraldehyde phosphate to form 1,3-bisphosphoglycerate.
- g. The Phosphate is transferred from 1,3-bisphosphoglycerate to ADP to form ATP with the help of phosphoglycerokinase. Two molecules of phosphoglycerate and ATP are obtained at the end of this reaction.
- h. The phosphate of both the phosphoglycerate molecules is relocated from the third to the second carbon to yield two molecules of 2-phosphoglycerate by the enzyme phosphoglyceromutase.
- i. The enzyme enolase removes a water molecule from 2-phosphoglycerate to form phosphoenolpyruvate.
- j. A phosphate from phosphoenolpyruvate is transferred to ADP to form pyruvate and ATP by the action of pyruvate kinase.

Two molecules of pyruvate and ATP are obtained as the end products.

Aerobic respiration

It is a type of cellular respiration that takes place in the presence of oxygen to produce energy. It is a continuous process that takes place within the cells of animals and plants. The chemical equation for aerobic respiration is



Glucose $\longrightarrow$ Carbon dioxide + water + Energy

In the presence of oxygen, aerobic respiration progresses through pyruvate oxidation, the Krebs cycle, and the electron transport chain.

Pyruvate Oxidation

This is a crucial step that bridges glycolysis and the citric acid cycle. It occurs in the mitochondrial matrix of eukaryotic cells and involves the conversion of pyruvate into acetyl-CoA, producing NADH and carbon dioxide as byproducts.

The process occurs as follows:

- a. Pyruvate, produced during glycolysis in the cytoplasm, is transported into the mitochondria.

- b. Pyruvate is decarboxylated (a carbon atom is removed and released as CO_2), and the remaining two-carbon unit is attached to coenzyme A, to form acetyl-CoA.
- c. Electrons are removed from pyruvate during this process and transferred to NAD^+ , forming NADH (electron carrier).
- d. The acetyl-CoA then enters the citric acid cycle, continuing the process of aerobic respiration.

Citric Acid Cycle/ Krebs' cycle

Also known as the tricarboxylic acid TCA cycle or Krebs' cycle, it is the second stage of cellular respiration that occurs through a series of chemical reactions to release stored energy from the oxidation of acetyl CoA derived from carbohydrates, fats, and proteins into ATP. It occurs in the matrix of mitochondria and all the enzymes involved are soluble. Two ATP molecules are produced in each phase of the Krebs' cycle and the electrons generated move across the mitochondrial matrix.

It is an aerobic pathway because NADH and FADH_2 produced transfer their electrons to the next pathway which will use oxygen. If the transfer of electrons does not occur, no oxidation takes place. The Krebs' cycle is a closed loop with the last step regenerating the first molecule of the pathway. The following are the important steps of the Krebs' cycle:

- a. acetyl CoA combines with a four-carbon compound, oxaloacetate, and releases the CoA group resulting in a six-carbon molecule called citrate.
- b. citrate gets converted to isocitrate, an isomer of citrate. Citrate first loses a water molecule and then gains one to form isocitrate.
- c. a molecule of carbon dioxide is released leaving behind a five-carbon molecule, α -ketoglutarate. NAD^+ gets reduced to NADH. The entire process is catalysed by the enzyme isocitrate dehydrogenase.
- d. α -ketoglutarate is oxidised reducing NAD^+ to NADH and releasing a molecule of carbon dioxide. CoA is picked up by the remaining four-carbon molecules forming an unstable compound succinyl CoA. α -ketoglutarate dehydrogenase catalyses the entire process.
- e. CoA from succinyl CoA is replaced with a phosphate group. It is then transferred to ADP to make ATP. Succinate, a four-carbon molecule is produced.
- f. Succinate is oxidised to fumarate. Two hydrogen atoms are transferred to FAD to produce FADH_2 . FADH_2 transfers its electrons directly to the electron transport chain since the enzyme carrying out the reaction is embedded in the inner membrane of mitochondria.
- g. A water molecule is added to fumarate which is then converted to malate.
- h. The oxidation of malate regenerates oxaloacetate, a four-carbon compound, and another molecule of NAD^+ is reduced to NADH.

Oxaloacetate combines with acetyl CoA to generate another cycle of production of energy molecules (ATP). At the end of each cycle 6 NADH, 2 ATPs, 2 FADH_2 are produced.

Oxidative Phosphorylation/ Electron Transport Chain

Oxidative phosphorylation is the process in which ATP molecules are formed as a result of the transfer of electrons from NADH or FADH_2 to O_2 through a series of proteins (electron carriers). This process takes place in the inner membrane of the mitochondria of a cell. This releases energy used to pump protons into the intermembrane space to create a proton gradient. The difference in the protons causes a flow back into the mitochondrial matrix through ATP synthase, generating ATP. Oxygen accepts the electrons to form water. This process generates approximately 34-36 ATP and water.

Anaerobic Respiration

The pyruvate produced at the end of glycolysis in the absence of oxygen undergoes anaerobic respiration. Sometimes there is not enough oxygen around for some organisms to respire, but they still need the energy to survive. Due to lack of oxygen, they carry out respiration in the absence of oxygen to produce the energy they require, which is referred to as anaerobic respiration. This process is also referred to as fermentation.

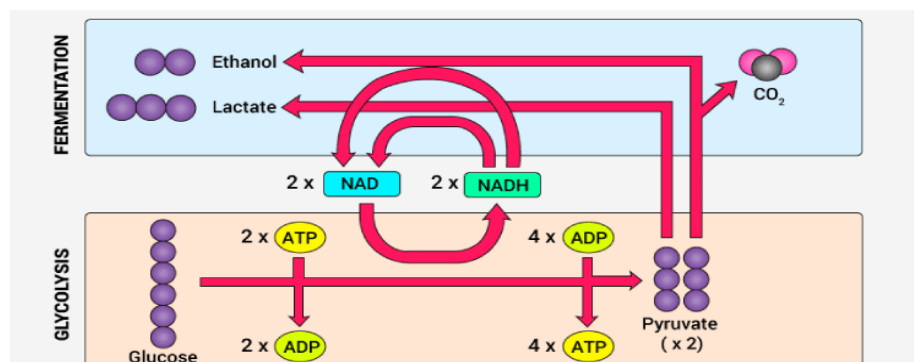
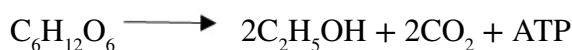


Figure 4.7: Anaerobic respiration/fermentation

Anaerobic respiration usually occurs in lower plants and microorganisms. In the absence of oxygen, the glucose derived from food is broken down into alcohol and carbon dioxide along with the production of energy. The chemical equation for anaerobic respiration is



Glucose $\longrightarrow$ Alcohol + Carbon dioxide + Energy

Anaerobic respiration also occurs in multicellular organisms as a temporary response to oxygen-less conditions. During heavy or intensive exercise such as running, sprinting, cycling or weightlifting, our body demands high energy. As the supply of oxygen is limited, the muscle cells inside our body resort to anaerobic respiration to fulfil the energy demand. Cramps occur when muscle cells respire anaerobically due to lack of oxygen, produces lactic acid and the accumulation of lactic acid causes muscle cramps. That is why a hot shower after heavy sports relieves the cramps as it improves blood circulation in the body, which in turn enhances the supply of oxygen to the cells.

Anaerobic respiration produces a relatively lesser amount of energy as compared to aerobic respiration, as glucose is not completely broken down in the absence of oxygen.

Disorders Of Respiratory System

Asthma is a respiratory disease, in which a person's air passage becomes inflamed, narrow, swollen, and produces more mucus, making it difficult to breathe. Chest pain, coughing and wheezing are also experienced. This disease is caused by several factors including pollen, dust particles, cold, smoking, etc. Asthma can be treated by rescue inhalers, antibiotics and other vaccinations. The best remedy to prevent asthma is to stay away from the allergens and other triggering factors.

Bronchitis involves the inflammation of the lining of bronchial tubes, which carry air to and from the lungs. It is caused by smoking (actively or passively), exposure to pollution and other bacterial infections. Bronchitis may either be acute or chronic with swelling on the internal lining of bronchitis that causes constant coughing. The use of antibiotics, other medication and lifestyle changes can treat the condition and avoid smoking and exposure to pollutants.

Emphysema is a chronic disease, causing reduction of the respiratory surface due to the damage to the lung's alveolar walls. It is mainly caused by smoking cigarettes and other tobacco products. Other causes include inhalation of chemicals, toxins, dust and exposure to smoke. The main symptoms of emphysema include shortness of breath and cough. The use of certain antibiotics and bronchodilators are helpful to get rid of these respiratory disorders.

Lung cancer can develop in any part of the lungs. It can be caused by smoking, exposure to asbestos fibres, rubber, toxic gases, traffic fumes, etc. Difficulty in breathing, wheezing, trouble during swallowing, chest pain, etc are experienced when afflicted by lung cancer. It can be treated with surgery, chemotherapy, radiation therapy, etc. but as a **precaution**, avoid smoking and exposure to pollution and other toxic gases.

Pneumonia is a serious infection of the lungs, which affects people with weakened immune systems including infants, young children and old people. It is caused by various pathogenic bacteria, viruses and fungi. Some symptoms include shortness of breath, chest pain, cough, and nausea. To treat pneumonia, use antibiotics and vaccinate infants and children. Maintain hygiene, avoid smoking and alcohol consumption and maintain strong immunity by having a well-balanced diet to help prevent the infection.

Learning Tasks

1. Examine the respiratory system of a chosen mammal and understand the importance of each organ.
2. Discuss the forms and processes of respiration in mammals
3. Demonstrate and interpret the processes of aerobic respiration and fermentation.
4. Model a representation of the human excretory system.

Pedagogical Exemplars

1. **Group-Task-Based Learning:** in mixed ability, all-inclusive groups, examine the respiratory system in a named mammal (e.g., humans, guinea pig, Rabbit, Albino rat, etc.) and its importance from textbooks, documentary videos, improvised lab specimens, etc., and note the various organs and their functions and draw and name parts of the respiratory organs in humans: learners learn to appreciate the contribution of each member in the group and support themselves psychologically.
2. **Talk for Learning Approach:** learners in groups discuss the forms and processes of respiration in mammals, with emphasis on the two types of cellular respiration, describing the various phases involved, especially glycolysis. Details of Krebs's cycle and the respiratory chain/electron carrier system are not needed: learners learn from each other, and every member of the group is encouraged to talk, thereby improving on the learners' communication skills.
3. **Experimental/Experiential-Based Learning:** use maize/groundnut seeds soaked in water to demonstrate that heat energy is released during aerobic respiration, and yeast to show how carbon dioxide is produced as a by-product and discuss and interpret your results with a conclusion. Learners obtain real world scenarios and first-hand knowledge to boost their confidence. Learners in group tasks are socially and emotionally linked to support one another to achieve the set goals.

Key Assessment Level 4: Practice Paper 2

1. Observe the structure of the human respiratory system and evaluate how the anatomical features of each organ (e.g., trachea, lungs, diaphragm) are adapted for efficient gas exchange. In what ways do these adaptations support overall respiratory health?
2. Design an experiment to measure the impact of physical exercise on the efficiency of gas exchange in the human respiratory system. Outline the methodology, including controls, measurement techniques, and expected results. How could this experiment enhance our understanding of respiratory function during physical activity?

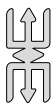
3. Formulate a hypothesis regarding how temperature affects the rate of aerobic respiration in a specific organism (e.g., yeast or muscle cells). Develop a research plan to test this hypothesis, detailing methods for data collection, analysis, and how you would draw conclusions from the results.

HINT

Conduct **Practice Paper 2**. It should cover contents taught from Year 1 to 3. Refer to the **Table of Specification and Structure of the Paper** at the end of this section. Learners' papers should be marked immediately and scores entered into the SAP.

PLC Session 12**45 minutes****Planning & Reviewing the Learning Plan**

1. Begin the session by recapping lessons from the previous session, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand.
 - b. identify three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q).
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).

**Note**

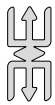
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the *Values Learning Community Handbook* and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Use your app to plan and administer the mode of assessment for the Student Assessment Portal (SAP).
 - a. The key assessment for the week is **Practice Paper 2**. Chat with your app to plan this assessment by reviewing or developing the assessment items/tasks and marking schemes/rubrics for the practice paper (NTS 3k-3q).

10 minutes**Content Exploration**

5. As a subject group, select one problem or topic/idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)

- b. all teachers in the group work through the problem individually for 3–4 minutes
- c. the group then works through it together the problem, step by step
- d. highlight the most common errors made at each step (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not ‘How do I teach this?’ but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 19

Learning Indicator: Describe with labelled drawings, how the reproductive system in mammals functions and works with other systems to ensure their survival

FOCAL AREA: HOW THE REPRODUCTIVE SYSTEM IN HUMANS FUNCTIONS AND WORKS TOGETHER WITH OTHER SYSTEMS

Reproductive System of Humans

Reproduction in mammals is sexual and requires the fusion of gametes from a male and a female to form a zygote. Mammals have separate sexes (unisexual), each with a system for production of sex cells. The male and the female reproductive systems consist of the gonads where the sex cell or gametes are formed, as well as glands that are involved in secretion of hormones and fluids essential for development and sexual process.

The reproductive system consists of the internal genitalia which are contained within the abdominal cavity and the external genitalia which are found outside the body in the groin region. It consists of specialised organs and structures in both males and females.

Parts of the Male Reproductive System and their functions

- Testes are in the scrotum and produce sperm and testosterone (a hormone). The scrotum hangs outside the body to regulate the temperature of the testes for optimum sperm health.
- Epididymis is a coiled tube where sperm mature and are stored.
- Vas Deferens transports sperm from the epididymis to the ejaculatory duct.
- Seminal Vesicles produce fluid to nourishes sperm and forms part of semen.
- Prostate Gland secretes fluid that helps protect and energise sperm.
- Bulbourethral Glands produce a pre-ejaculatory fluid that lubricates the urethra.
- Penis contains the urethra and delivers sperm to the female reproductive system. The urethra is a common duct for sperm and urine in the male therefore the penis is described as a urinogenital organ.

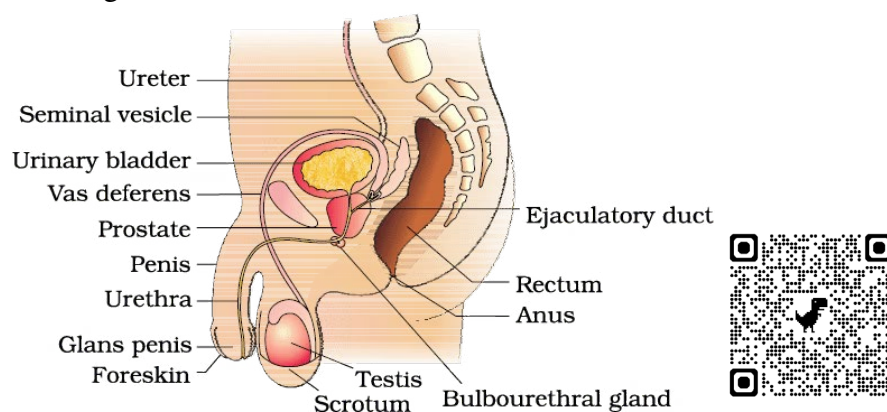


Figure 4.8: *The male reproductive system*

Parts of the Female Reproductive System and their functions

- Ovaries produce ova (eggs) and oestrogen and progesterone (hormones).
- Fallopian Tubes transport eggs from the ovaries to the uterus.

- c. The Uterus is a muscular organ where a fertilized egg implants and develops into a foetus.
- d. Endometrium is the inner lining of the uterus that thickens with blood during the menstrual cycle.
- e. Cervix is the lower part of the uterus that opens into the vagina and allows passage of sperm and menstrual fluid.
- f. Vagina: The vagina is a muscular canal that connects the external genitalia to the uterus and serves as the birth canal. In human females, the urinary and reproductive systems have separate external openings. The urethra carries urine to the outside through the urethral opening, while the vagina serves as the passage for sexual intercourse, childbirth and menstrual flow. The external genitalia, collectively known as the vulva, consist of the labia, clitoris and vaginal opening.
- g. External Genitalia (Vulva) consists of the labia, clitoris, and vaginal opening.

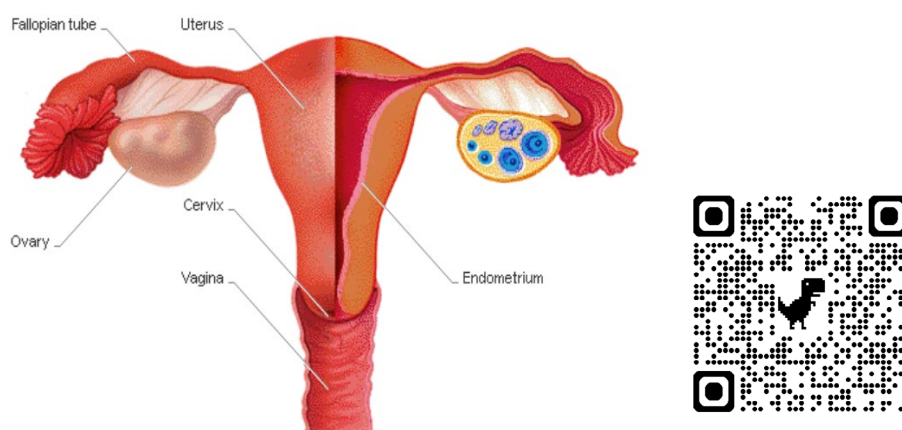


Figure 4.9: *the female reproductive system*

Human reproduction involves gametogenesis, fertilization, gestation and childbirth.

Gametogenesis

This includes the formation of egg and sperm cells in the ovaries and testes respectively.

In males, the testes (singular: testis) are the organs that produce sperm cells and the male sex hormone testosterone. Sperm are produced in the seminiferous tubules, mature in the epididymis and are stored in the vas deferens before ejaculation. Testosterone, whose production is stimulated by luteinising hormone (LH) released from the pituitary gland, regulates sperm production and the development of secondary sexual characteristics.

Secondary sexual characteristics are physical features that develop during puberty under the influence of sex hormones and distinguish males from females without being directly involved in reproduction. In males, these include the deepening of the voice, growth of facial, pubic and body hair, increased muscle mass, broader shoulders and enlargement of the larynx (Adam's apple).

In the female, the ovaries (singular, ovary) are the organs that produce gametes and sex hormones. The ovaries produce eggs/ova. At birth, about 2 million immature eggs (oocytes) are present in the ovaries. Once the female reaches puberty, luteinizing hormone triggers the production of one egg which matures approximately every 28 days inside a saclike structure in the ovary called the Graafian follicle. The female goes through a series of natural changes (reproductive/ menstrual cycle) to prepare for a potential pregnancy. It involves both ovarian and uterine changes, regulated by hormones and can last from 21 to 35 days. These phases occur to complete a reproductive/menstrual cycle:

- a. Menstruation is when the uterine lining (endometrium) sheds, resulting in menstrual bleeding and can last for 1-7days.

- b. Follicular Phase is when ovaries prepare a graafian follicle containing an egg, and the uterine lining thickens. This phase can last for 1-13 days.
- c. Ovulation occurs around Day 14, and it is when a mature egg is released from the ovary and travels through the fallopian tube into the uterus.
- d. Luteal Phase starts from day 15 and lasts through to, day 28. In this phase if the egg is fertilised, it may implant in the uterine lining but if not, then the lining of the uterus (endometrium) sheds, and the cycle begins again.

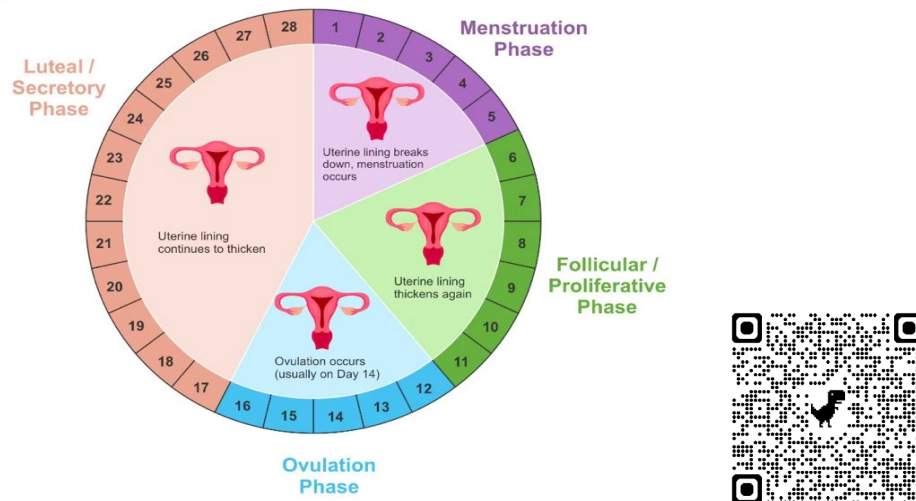


Figure 4.10: *The reproductive/menstrual cycle*

All these phases are regulated by hormones to ensure reproduction:

- a. Oestrogen produced by the ovaries is responsible stimulating the developing the follicle and thickening the uterine lining.
- b. Progesterone produced by the ovaries helps prepare the uterus for implantation and maintains the uterine lining.
- c. Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) are produced from the pituitary gland in the brain to regulate the ovarian cycle.

This monthly cycle in females continues till she reaches her 50s (and even before) when the reproductive cycle ends.

Fertilisation

This is the natural life process, that occurs by the fusion of both male and female gametes, resulting in the formation of a zygote. In humans, semen comprising thousands of sperms are inseminated into the female vagina during coitus. The sperm move towards the uterus and reach the opening of the fallopian tube. Only a few sperm will succeed in reaching the opening of the fallopian tube. The process of fertilization takes place in the fallopian tube when a sperm fuses with the egg/ovum. The sperm can live for 48-72 hours in a female reproductive system, whereas the egg can live for 24 hours. All genetic information is transferred from both the parents to their child and the gender of the child is determined. Father determines the sex of the child, i.e., if the sperm carries a Y chromosome, the child will be a boy and if sperm carries X chromosome the child will be a girl. As studied in genetics.

Once fertilization occurs, the cell starts to divide and multiply within 24 hours in the fallopian tube. This detached multi-celled structure is called a zygote. After 3-4 days it travels to the uterus and is now called an embryo. The embryo develops and undergoes various stages and gets attached to the endometrial layer of the uterus. This process of attachment is known as implantation. The embryo then develops for 9 months through gestation.

Gestation

Gestation is the period between the time a baby is conceived to when it is born. Human gestation, which lasts about nine months, is divided into three trimesters. The developing baby is called an embryo for the first eight weeks, after which it is called a foetus.

The cells of the embryo grow and divide constantly. At first, they appear similar but later develop differing structures and functions. They eventually form various specialised tissues which grow and extend in relation to each other, thus giving rise to the body organs which become easily recognizable in pregnancy. For example, the blood, blood vessel and the heart develop within a month in the developing embryo.

Conditions necessary for the development of embryo include

- The Placenta:** this is an organ formed between the developing embryo and the wall of the uterus. It has projections adhering to the uterus and is responsible for the selective exchange of materials between the mother and the developing foetus. Through the placenta, nourishment in the form of water, dissolved oxygen, nutrients, hormones and salts are obtained from the blood of the mother and waste products such as carbon (IV) oxide and urea are removed from the foetus to the mother's blood. It also produces hormones which help the mother to adapt to pregnancy.
- The Amniotic fluid** helps to protect and cushion the foetus against shock, rocking and desiccation. It also helps to maintain the internal temperature. The membranes associated with the fluid is the chorion, amnion and allantois.
- The Umbilical cord** is attached to the placenta and connects to the foetus. It contains two umbilical arteries that carry deoxygenated blood from the foetus to the placenta and the umbilical vein that transport oxygenated blood and food substances from the placenta to the foetus.

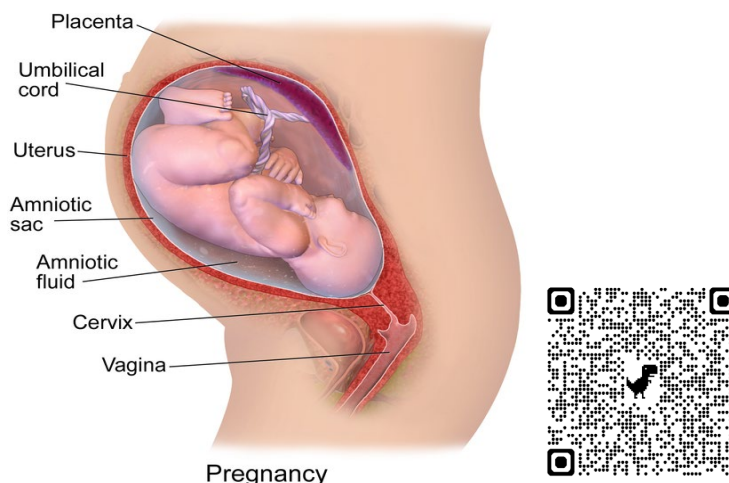


Figure 4.11: *Pregnancy*

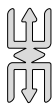
Childbirth

At the end of the nine months (about forty weeks) of pregnancy/gestation, the baby is fully formed and is ready to be born. The foetus comes to lie with its head downward just above the cervix of the uterus. The process by which the foetus is delivered from the uterus is called childbirth/ parturition.

Diseases and Problems of the Human Reproductive System

The human reproductive system may be affected by various diseases and disorders. These conditions differ in their causes, symptoms, prevention and treatment.

Disease/ Disorder	Common Causes	Common Symptoms	Prevention	Treatment
Sexually Transmitted Infections (STIs) (e.g., gonorrhoea, chlamydia, syphilis, HIV, HPV, herpes)	Infection by bacteria or viruses transmitted through unprotected sexual intercourse or infected blood	Pain during urination, abnormal discharge, sores, genital ulcers, pelvic pain	Abstinence, mutual faithfulness, correct use of condoms, screening and health education	Appropriate antibiotics or antiviral drugs depending on the infection; counselling and medical care
Reproductive Cancers (e.g., cervical, prostate and testicular cancers)	Genetic factors, infections (e.g., HPV), age, lifestyle and environmental factors	Abnormal bleeding, lumps, persistent pain, difficulty urinating or unexplained weight loss	Regular screening, HPV vaccination, healthy lifestyle and early medical check-ups	Surgery, radiotherapy, chemotherapy, hormone therapy or targeted therapy depending on the type and stage
Reproductive Disorders (e.g., erectile dysfunction, polycystic ovary syndrome (PCOS), amenorrhoea, dysmenorrhoea and menorrhagia)	Hormonal imbalance, underlying diseases, stress, lifestyle or reproductive organ abnormalities	Irregular or absent menstruation, painful or heavy menstrual flow, difficulty achieving or maintaining an erection	Healthy lifestyle, regular medical examinations and prompt treatment of underlying conditions	Medication, hormone therapy, lifestyle modification or surgery where appropriate
Hormonal Imbalances	Disorders of endocrine glands, stress, poor nutrition or disease	Delayed puberty, infertility, irregular menstruation or reduced libido	Healthy diet, exercise and regular medical check-ups	Hormone replacement therapy or treatment of the underlying cause
Infertility	Low sperm count, ovulation disorders, blocked reproductive ducts, infections or genetic factors	Inability to achieve pregnancy after prolonged unprotected intercourse	Prevention and early treatment of STIs, healthy lifestyle and reproductive health care	Medication, surgery, assisted reproductive technologies or treatment of the underlying cause
Abnormal Growths (e.g., benign prostatic hyperplasia (BPH), varicocele, endometriosis and uterine fibroids)	Hormonal changes, ageing, genetic predisposition or unknown causes	Pelvic pain, swelling, abnormal bleeding, urinary problems or infertility	Regular medical examinations and early diagnosis	Medication or surgery depending on the severity of the condition



Teaching Note

Where possible, invite a healthcare professional to discuss common reproductive health problems, their causes, symptoms, prevention and treatment. Learners should also be encouraged to seek medical attention promptly whenever they notice symptoms affecting the reproductive system.

Learning Tasks

1. Create visual maps of the functions of the parts of the reproductive system of humans.
2. Discuss reproductive health in relations to the reproductive cycle.
3. Design a campaign to promote reproductive health and create awareness on STI's
4. Model a representation of the human reproductive system.

Pedagogical Exemplars

1. **Collaborative Learning:** learners in mixed-ability, all-inclusive groups collect charts, videos, documentaries and photos on the reproductive system of humans and study it, noting the functions of its various parts: learners learn from one another and present their views constructively. Learners become emotionally and psychologically connected.
2. **Initiating Talk for Learning:** where possible, the teacher may invite a resource person to give talks on some common diseases and problems of the reproductive system of humans, their causes, symptoms, prevention and treatment: learners acquire enhanced knowledge of the reproductive system and ask questions on unclear parts of the lesson, thereby improving speaking ability: learners are also freed of some beliefs and practices associated with the reproductive system, thereby giving them emotional and psychological boost.
3. **Demonstrative Learning:** use charts/diagrams and photos to explain common reproductive diseases such as gonorrhoea and syphilis, and show how to use contraceptive devices (e.g., condoms, and recommended medications) to control birth. Allow learners to ask questions and to contribute what they have read on the lesson: learners are allowed to express themselves freely; this improves their speaking skills. Learners shed off perceptions about some reproductive diseases as they become better informed. This offers them self-confidence and emotional satisfaction.

Key Assessment Level 4: Group Discussion

1. Choose four reproductive organs (two male and two female) and explain how health issues related to these organs can affect overall reproductive health. Include specific examples of diseases or conditions.
2. Analyse the impact of hormonal regulation in the female human reproductive system.
3. Compare and contrast the gametogenesis in male and female humans.

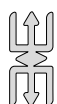
PLC Session 19

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to

- a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
- a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

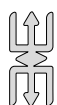
- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
- a. The key assessment for the week is **group discussion**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the discussion (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
- a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar

Ghanaian examples and how misconceptions are handled if they arise.

- b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 20

Learning Indicator: Describe with labelled drawings, how the musculoskeletal system in mammals, functions and works with other systems to ensure healthy living

FOCAL AREA: HOW THE MUSCULOSKELETAL SYSTEM IN MAMMALS FUNCTIONS AND WORKS TOGETHER WITH OTHER SYSTEMS TO ENSURE HEALTHY LIVING

Structure of the mammalian (e.g., Humans) skeleton and the importance of the various parts

The human skeleton is a complicated framework composed of bones, cartilage, ligaments, and joints, that serve various essential functions. It consists of about 206 bones. The skeleton gives shape and support to the human body, and it brings about movement of the body together with the muscles. The skeleton, especially the skull and rib cage, provides protection to vital internal organs such as the brain, lungs, and heart. The red marrow in the centre of bones produces red blood cells that carry oxygen to all parts of the body.

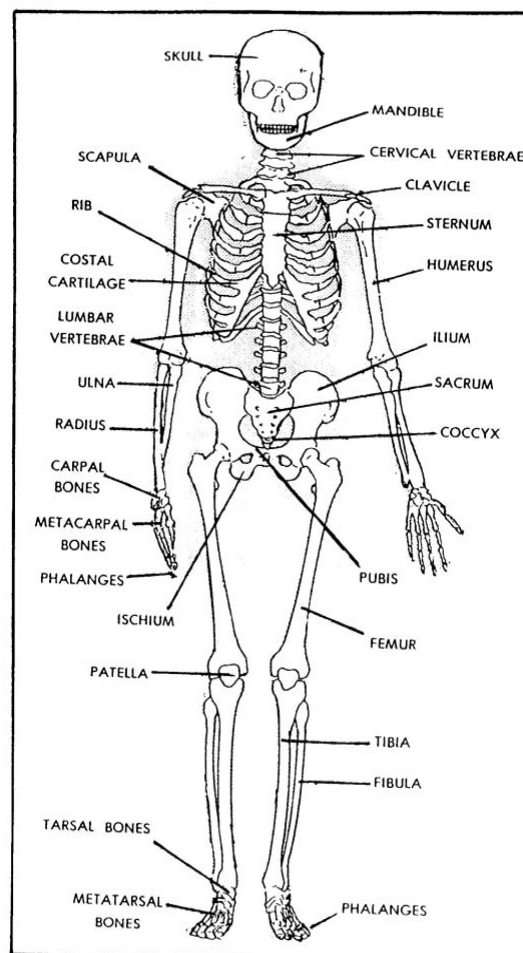


Figure 4.12: *The Human Skeleton*

It is divided into two main parts: the axial skeleton and the appendicular skeleton.

Axial Skeleton: it consists of the skull, vertebral column(spine), and rib cage. The axial skeleton protects and shields vital organs (e.g., brain, heart, lungs), provides structural support for the body and serves as an anchor for muscles to facilitate movement.

Skull: Protects the brain and houses sensory organs and is composed of cranial and facial bones.

Vertebral Column (Spine): Comprises 33 vertebrae, providing support, allowing flexibility, and protecting the spinal cord.

- Cervical vertebrae consist of seven vertebrae (C1 to C7). The first vertebra, C1 or Atlas articulates with the skull. It allows the maximum movement of the neck and is responsible for the ‘yes’/nod movement of the head. The C2 and C1 joints allow the ‘no’/side to side movement of the head. It supports the weight of the head.
- Thoracic vertebrae consist of twelve vertebrae (T1 to T12). Vertebrae of the thoracic region have limited movement and provide support to the rib cage and protect the lungs and heart. Twelve pairs of rib bones articulate with the thoracic vertebrae on the posterior side.
- Lumbar vertebrae consist of five vertebrae (L1–L5). They are the largest vertebrae in the vertebral column because they support much of the body’s weight. Their large size provides strength and stability to the lower back.
- Sacral vertebrae **consist of five vertebrae (S1–S5) fused into a single bone called the sacrum. The sacrum articulates with the hip bones to form the pelvic girdle, providing stability and transmitting the weight of the upper body to the lower limbs.**
- Coccygeal vertebrae** consist of four small vertebrae fused into a single bone called the coccyx (tailbone).

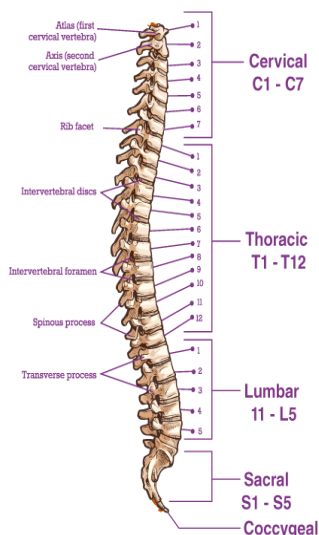


Figure 4.13: *The Vertebral Column*

The central portion of each vertebrae bone is hollow to form the spinal canal and encloses the spinal cord for protection.

Humans typically have 12 pairs of ribs, with the first seven pairs directly attached to the sternum by costal cartilage. The eighth to tenth pair are indirectly connected to the sternum by their cartilage merging with that of the seventh rib. The eleventh and twelfth ribs are floating ribs (not attached to the sternum at all and are free at the front).

Adaptive Features are

- The rib cage protects vital organs such as the heart and lungs from trauma.
- The costal cartilage allows for flexibility and expansion during breathing, enabling lung inflation and deflation.

- c. The structure aids in the mechanics of breathing by allowing the chest to expand and contract, promoting efficient airflow.

Sternum/ breastbone is a flat bone located in the centre of the chest, consisting of three parts. The upper section articulates with the clavicles and the first pair of ribs. The middle section is the central portion, to which the ribs attached. The lower section is the small, cartilaginous lower end called the xiphoid process that can ossify/turn to bone with age.

Adaptive Features are

- a. The sternum provides a stable central point for ribs to be attached, strengthening the rib cage structure.
- b. It protects the lungs, heart and major blood vessels, such as the aorta and pulmonary arteries.
- c. The articulation with ribs allows for a flexible thoracic cage that expands and contracts during respiration, enhancing lung capacity.

Appendicular Skeleton: it consists of the upper limbs, lower limbs, pectoral/ shoulder girdle and pelvic girdle. The appendicular skeleton facilitates movement, provides a base for movement and weight-bearing and allows walking, running, and other activities to occur.

Upper Limbs: Includes the humerus, radius, ulna, carpals, metacarpals, and phalanges.

Pectoral Girdle (Shoulder Girdle): Connects the forelimbs to the axial skeleton (clavicle and scapula).

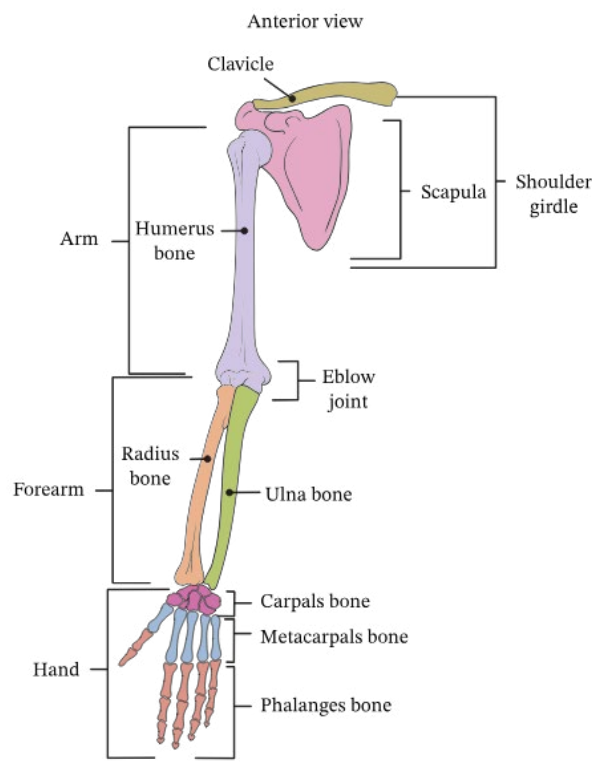


Figure 4.14: Pectoral girdle and upper limb

Lower Limbs: Comprises the femur, tibia, fibula, tarsals, metatarsals, and phalanges.

Pelvic Girdle: Connects the lower limbs to the axial skeleton, consisting of the hip bones (ilium, ischium, pubis).

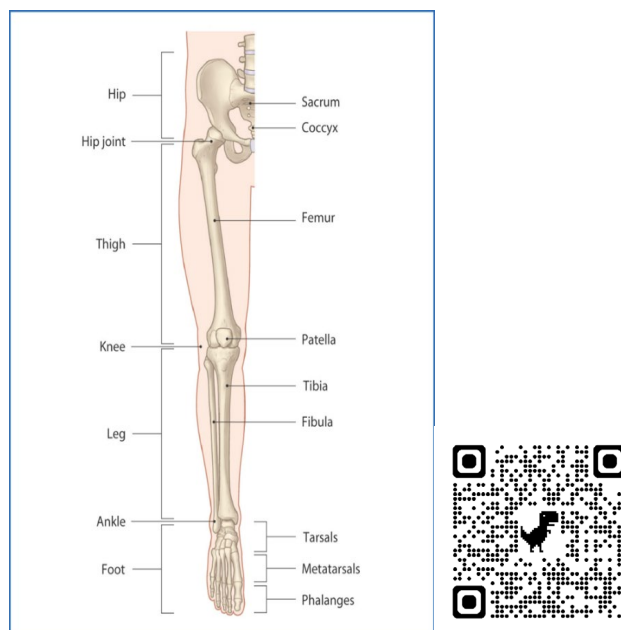


Figure 4.15: *Pelvic girdle and the bones of the lower limbs*

The appendicular skeleton is highly specialised for various functioning in the human body.

Some of these adaptations are

- a. Clavicle (Collarbone) which connects the arm to the body helps stabilize the shoulder.
- b. Scapula (Shoulder Blade) provides a broad surface for muscle attachment and allows for a wide range of motion.
- c. Humerus, Radius, and Ulna are designed for a wide range of arm movements like lifting, reaching, and throwing.
- d. The structure of the hand, with its fine motor control of muscles and opposable thumbs, allows for grasping, holding, and manipulating objects effectively.
- e. Pelvic Girdle provides a stable base for the lower limbs and supporting body weight during standing and aiding in bipedal movement.
- f. Femur (Thigh Bone) is the longest bone in the body and is adapted for weight-bearing and mobility.
- g. The Knee joint allows bending and straightening while also providing stability.

A joint is the point where two or more bones meet or are connected in the skeletal system. Joints hold bones together, provide stability and support to the skeleton, and, depending on their type, allow varying degrees of movement ranging from none to free movement.

Various Joints in the human body are

- a. Sutures: (e.g., in the skull) where bones are tightly joined with no movement allowed.
- b. Symphyses: (e.g., in the intervertebral discs and pubic symphysis) where bones are joined by fibrocartilage and are only allowed slight movement.
- c. Ball-and-Socket Joints: (e.g., in the shoulder and hip) allow for rotational movement and a wide range of motion.

- d. Hinge Joints: (e.g., in the knees and elbows) provide movement in one plane, enhancing stability and strength.
- e. Pivot Joints: (e.g., atlantoaxial joint) allow for rotation around a single axis.
- f. Condylloid Joints: (e.g., wrist joint) provide movement in two planes.
- g. Saddle Joints: (e.g., thumb joint) allow a wider range of movement.
- h. Gliding Joints: (e.g., joints between carpal bones) allow sliding movements.

How the muscles act on bones to bring about movement on body parts.

There are more than 600 muscles located almost everywhere throughout your body. Muscles are made of thousands of small fibres woven together. These stretching(relaxation) and pressing(contraction)of these fibres together is what moves the organs and the body. Muscles run in all directions and work together with the skeleton and other parts to bring about movement in the body.

There are three types of muscle tissue in the human body:

Skeletal Muscles

Skeletal muscles are attached to bones by **tendons** and, together with the skeleton, form the **musculoskeletal system**. They produce body movements, maintain posture, stabilise joints and generate heat during muscular activity. Skeletal muscles are **voluntary muscles** because their contraction is under conscious control. Some skeletal muscles, such as those controlling the fingers and eyes, contract rapidly to produce quick, precise movements, whereas others, such as the back and leg muscles, contract more slowly to maintain posture and support the body's weight.

Cardiac Muscle

Cardiac muscle, also called the **myocardium**, forms the muscular wall of the heart and is found nowhere else in the body. It contracts rhythmically and continuously to pump blood throughout the circulatory system. Cardiac muscle is **involuntary**, meaning that its contractions occur automatically without conscious control. It has its own intrinsic pacemaker but is regulated by the autonomic nervous system and hormones to meet the body's changing demands.

Smooth Muscles

Smooth muscles are **involuntary muscles** found in the walls of hollow internal organs and blood vessels. Unlike skeletal muscles, they are not attached to bones and their contractions occur automatically without conscious control.

Smooth muscles perform many essential functions, including:

- a. Producing **peristalsis**, the wave-like contractions that move food through the oesophagus, stomach and intestines.
- b. Regulating the diameter of blood vessels, thereby helping to control blood pressure and blood flow.
- c. Controlling the size of the airways (bronchioles) in the lungs during breathing.
- d. Assisting the movement of urine through the ureters and aiding the emptying of the urinary bladder.
- e. Contracting the uterus during childbirth.
- f. Controlling the size of the pupil in response to changes in light intensity.

- g. Raising body hairs during cold conditions or emotional stress through the contraction of tiny muscles attached to hair follicles (**arrector pili muscles**).

Because smooth muscles are found in many organ systems, including the digestive, respiratory, circulatory, urinary and reproductive systems, they play an essential role in maintaining normal body functions and homeostasis.

How muscles and bones work together

Muscle Contraction: when a muscle contracts, it shortens and exerts force on the attached bone through the tendons. This brings about movement (e.g. lifting a weight). When muscles relax, it lengthens while under tension (e.g., lowering a weight). The brain and spinal cord send signals through motor neurons to stimulate muscle contractions accurately and timely. Sensory receptors in muscles and joints provide feedback about body position and movement, allowing for adjustments during activities.

Agonist and Antagonist Muscles

Agonist (Prime Mover): The muscle primarily contracting for a specific movement (e.g., biceps during arm flexion).

Antagonist: The muscle that opposes the action of the agonist (e.g., triceps during arm flexion). This relationship allows for controlled movement and balance.

Synergists assist the agonist in performing a movement. They help stabilise the joint and enhance the efficiency of the primary muscle action.

Movement	Agonist Muscle	Antagonist Muscle
Flexion at the elbow	Biceps	Triceps
Extension at the elbow	Triceps	Biceps
Flexion at the knee	Hamstrings	Quadriceps
Extension at the knee	Quadriceps	Hamstrings

Figure 16: Agonist and antagonist muscles involved in elbow and knee movements.

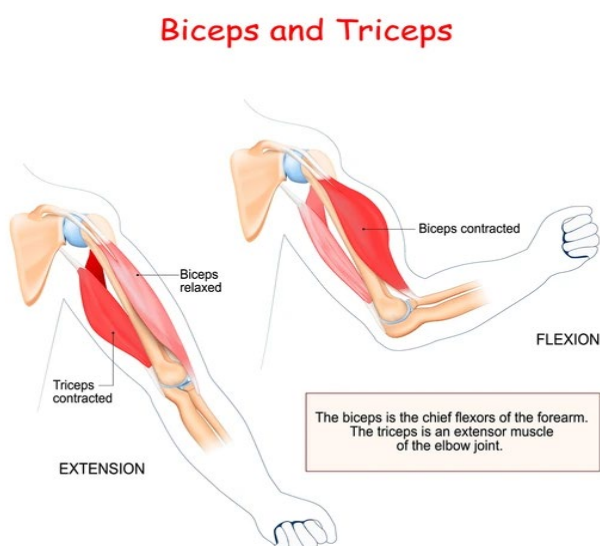


Figure 4.16: Biceps and triceps

Learning Tasks

1. Create an improvised model of the human skeleton.
2. Identify and draw the structures, (the skull, vertebrae, the limbs with their girdles and the ribs with the sternum) with annotations on specific functions.
3. Demonstrate how muscles act on bones (e.g., antagonistic movements of biceps and triceps on the limbs)

Pedagogical Exemplars

1. **Differential Task-Based Learning:** in mixed-ability, all-inclusive groups, learners create an improvised structure of the mammalian skeleton (e.g. humans) and point out the various parts and discuss their importance in group presentation: Differential learning allows each member of the group to perform one task or another, thereby recognising the importance of each member in the group. Learners are also connected emotionally as they seek to achieve set goals in the group.
2. **Creative and Imaginative Learning:** learners in mixed ability groups identify the major parts of the skeletal system and draw the structures, (the skull, vertebrae, the limbs with their girdles and the ribs with the sternum) with annotations on specific functions and adaptive features and discuss the drawings: learners acquire the skills of observation and exactness. Learners acknowledge the skills of peers and learn from them.
3. **Demonstrative Learning:** show how muscles act on bones (e.g., antagonistic movements of biceps and triceps on the limbs) to bring about movements on body parts and prepare a general presentation on the lesson: learners can emotionally connect with the lessons through demonstrations.

Key Assessment Level 4: Practical Investigation and Project Report

1. Draw an annotated diagram of the pectoral girdle.
2. How does understanding muscle-bone interactions help in physical activities? Provide at least two examples. (5 marks)
3. Explain the adaptive features of the ribs and their importance in the skeletal system. (5 points)

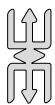
PLC Session 20

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)

- c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- *Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.*
- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

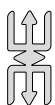
4. Plan the week's key assessment with your app

- a. The key assessment for the week is **practical investigation and project report**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the report (NTS 3k-3q).

10 minutes

Content Exploration

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
- use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - all teachers in the group work through a similar problem individually for 3–4 minutes
 - the group then works through the problem together step by step
 - highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes

Enactment

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
- Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - After the enactment, ask for structured feedback from the group
 - was the concept explained in a way that a learner with no prior knowledge could follow?
 - were the examples grounded in contexts familiar to Ghanaian learners?
 - did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

7. Reflect and share your views on the session. One thing that worked well, what did not work well

and what you will do differently. (NTS 1a, 1b).

8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 21

Learning Indicator: Describe how the nervous and hormonal systems in mammals function and work with other systems to ensure healthy living

FOCAL AREA 1: HOW THE NERVOUS AND HORMONAL SYSTEMS IN MAMMALS FUNCTION AND WORKS TOGETHER WITH OTHER SYSTEMS TO ENSURE HEALTHY LIVING

Structure of the nervous and hormonal systems in mammals and how the parts relate to their functions

Humans require sophisticated control systems to coordinate body functions and respond to changes in both the internal and external environment. The **nervous system** and the **endocrine system** are the two major communication and control systems of the body. The nervous system produces rapid, short-lived responses through electrical nerve impulses, whereas the endocrine system produces slower, longer-lasting responses through chemical messengers called **hormones**. Together, these systems maintain **homeostasis** and coordinate the activities of all body organs.

The **endocrine system** is a network of glands that secrete hormones directly into the bloodstream. These hormones regulate growth, metabolism, reproduction, development and many other body functions.

The Nervous System

The nervous system coordinates and controls the body's activities, including movement, sensation, perception, learning, memory and behaviour. It receives information from the environment, processes that information and coordinates appropriate responses.

The nervous system is divided into two main parts:

- **Central nervous system (CNS)** – consists of the brain and spinal cord.
- **Peripheral nervous system (PNS)** – consists of all nerves outside the brain and spinal cord. It is further divided into the **somatic nervous system** (voluntary control) and the **autonomic nervous system** (involuntary control), which includes the **sympathetic** and **parasympathetic** divisions.

1. The Central Nervous System

The central nervous system receives, processes and integrates information from different parts of the body and coordinates both voluntary and involuntary activities. It consists of the **brain** and the **spinal cord**.

Brain

The brain is the body's control centre and is divided into three major regions:

Cerebrum

The cerebrum is the largest part of the brain. It is responsible for conscious thought, intelligence, memory, learning, language, emotions, voluntary movement and interpretation of sensory information.

The outer layer of the cerebrum is called the **cerebral cortex**. It contains specialised areas responsible for sensory perception, voluntary movement, language, reasoning and higher mental functions.

Cerebellum

The cerebellum coordinates voluntary muscle activity, maintains posture and balance, and ensures that movements are smooth and precise.

Brainstem (including the Medulla Oblongata)

The brainstem connects the brain to the spinal cord. The **medulla oblongata**, which forms the lower part of the brainstem, controls vital involuntary functions such as breathing, heartbeat, blood pressure, swallowing and coughing.

Hypothalamus

The **hypothalamus** is located beneath the cerebrum and links the nervous and endocrine systems. It regulates body temperature, hunger, thirst, water balance, sleep and other homeostatic functions by controlling the pituitary gland.

Spinal Cord

The spinal cord is a long bundle of nervous tissue extending from the brain through the vertebral column. It conducts nerve impulses between the brain and the rest of the body and serves as the centre for many reflex actions.

2. Peripheral Nervous System (PNS)

This is part of the nervous system which transmits and receives signals to enable communication between the CNS and the body's muscles, sensory receptors and organs. This is made up of nerves that connect the central nervous system to the rest of the body.

Somatic nervous system (Voluntary nervous system)

This is the part of the peripheral nervous system that controls voluntary movements through the motor neurons to skeletal muscles.

Autonomic nervous system (ANS)

The **autonomic nervous system (ANS)** is a division of the **peripheral nervous system** that regulates involuntary body functions such as heart rate, breathing, digestion, blood pressure and glandular secretion. It controls the activities of smooth muscles, cardiac muscle and glands without conscious effort.

The autonomic nervous system has two divisions that work together to maintain homeostasis.

Sympathetic Nervous System

The **sympathetic nervous system** prepares the body for physical activity, stress or emergency situations (the **fight-or-flight response**). Its effects include:

- a. Increased heart rate and blood pressure.
- b. Dilation of the pupils.
- c. Dilation of the airways.
- d. Reduced digestive activity.
- e. Increased release of glucose into the bloodstream for energy.

Parasympathetic Nervous System

The **parasympathetic nervous system** promotes relaxation, recovery and the conservation of energy (the **rest-and-digest response**). Its effects include:

- a. Decreased heart rate and blood pressure.
- b. Constriction of the pupils.

- c. Increased digestive activity and secretion of digestive enzymes.
- d. Stimulation of urination and defecation.
- e. Restoration of normal body functions after stress.

Neurones (Nerve Cells)

Neurones are specialised cells that receive, process and transmit information through electrical impulses and chemical messengers called neurotransmitters. They are the functional units of the nervous system.

A typical neurone consists of:

- a. **Cell body (soma):** Contains the nucleus and controls the activities of the neurone.
- b. **Dendrites:** Receive nerve impulses from other neurones or receptors.
- c. **Axon:** Conducts nerve impulses away from the cell body.
- d. **Myelin sheath:** An insulating layer that increases the speed of nerve impulse transmission.
- e. **Axon terminals:** Release neurotransmitters that transmit signals to another neurone, muscle or gland.

The three main types of neurones are:

- a. **Sensory neurones** – transmit impulses from receptors to the central nervous system.
- b. **Motor neurones** – transmit impulses from the central nervous system to muscles and glands.
- c. **Interneurones (relay neurones)** – connect sensory and motor neurones within the central nervous system.

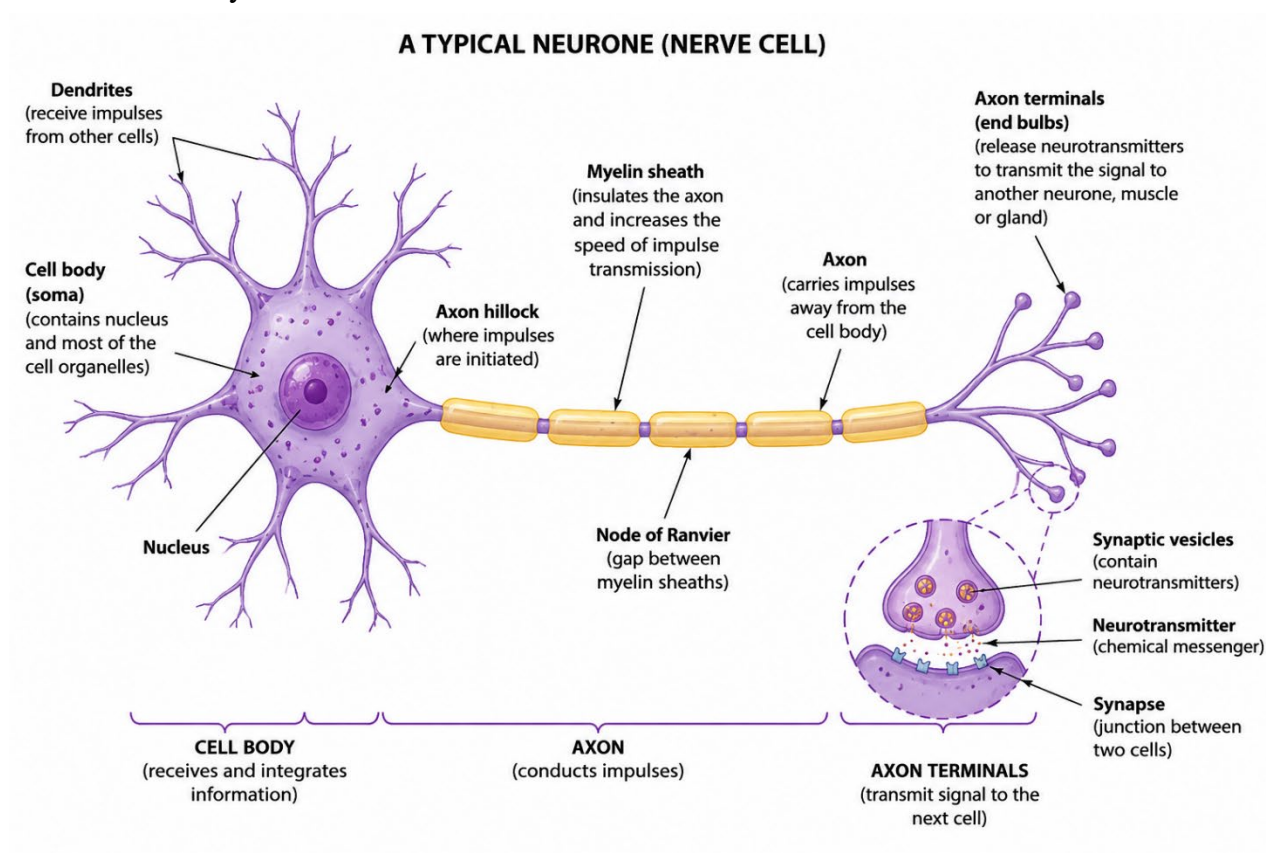


Figure 4.17: Nerve Cell

The Endocrine System

The **endocrine system** is a network of glands that produces and secretes **hormones** directly into the bloodstream. Hormones are chemical messengers that regulate growth, metabolism, reproduction, development, water balance and many other body functions. Unlike nerve impulses, hormonal responses are generally slower but last longer.

Major Endocrine Glands and Their Hormones

Pituitary Gland

The **pituitary gland**, often called the **master gland**, lies beneath the hypothalamus. It secretes several hormones that regulate the activities of other endocrine glands and many body functions.

Some important pituitary hormones include:

- a. **Growth hormone (GH):** Stimulates growth of bones and muscles.
- b. **Prolactin:** Stimulates milk production after childbirth.
- c. **Follicle-stimulating hormone (FSH):** Stimulates egg development in females and sperm production in males.
- d. **Luteinising hormone (LH):** Triggers ovulation in females and stimulates testosterone production in males.
- e. **Thyroid-stimulating hormone (TSH):** Stimulates the thyroid gland to produce thyroid hormones.
- f. **Adrenocorticotrophic hormone (ACTH):** Stimulates the adrenal cortex.

Thyroid Gland

The **thyroid gland** is located in the neck below the larynx.

It secretes:

- a. **Thyroxine (T_4) and triiodothyronine (T_3):** Regulate metabolism, growth and development.
- b. **Calcitonin:** Helps lower blood calcium levels.

Parathyroid Glands

The **parathyroid glands** are four small glands located on the posterior surface of the thyroid gland.

They secrete:

Parathyroid hormone (PTH): Increases blood calcium concentration and regulates calcium and phosphate balance.

Adrenal Glands

The **adrenal glands** are located on top of each kidney.

They secrete:

- a. **Adrenaline (epinephrine):** Prepares the body for emergencies by increasing heart rate and blood glucose.
- b. **Noradrenaline (norepinephrine):** Helps regulate blood pressure.
- c. **Cortisol:** Regulates metabolism and the body's response to stress.
- d. **Aldosterone:** Regulates sodium, potassium and water balance.

Pancreas

The endocrine cells of the pancreas (Islets of Langerhans) secrete:

- a. **Insulin:** Lowers blood glucose concentration.
- b. **Glucagon:** Raises blood glucose concentration.

Together these hormones regulate blood sugar levels.

Gonads

The **gonads** are the reproductive glands.

- a. **Testes** produce **testosterone**, which stimulates sperm production and the development of male secondary sexual characteristics.
- b. **Ovaries** produce **oestrogen** and **progesterone**, which regulate the menstrual cycle, pregnancy and female secondary sexual characteristics.

Pineal Gland

The **pineal gland** secretes **melatonin**, which regulates the body's sleep-wake cycle (circadian rhythm).

Thymus

The **thymus gland** secretes **thymosin**, which promotes the development and maturation of T-lymphocytes involved in immunity.

Hormone Action

- a. **Chemical messengers:** These travel via bloodstream to target cells.
- b. **Receptor binding:** Hormones bind to specific receptors on/in target cells. Only cells with matching receptors respond.
- c. **Feedback mechanisms:** **Negative feedback** is a regulatory mechanism that helps maintain a stable internal environment (**homeostasis**) by reversing changes from the normal level. When the level of a hormone or another body condition becomes too high or too low, the endocrine system responds by reducing or increasing hormone secretion until normal conditions are restored. For example, when blood glucose levels rise after a meal, the pancreas secretes **insulin**, which lowers blood glucose levels. As the blood glucose returns to normal, insulin secretion decreases. Conversely, when blood glucose levels fall, the pancreas secretes **glucagon**, which raises blood glucose levels. This continuous adjustment helps maintain a relatively constant internal environment.

The hypothalamus of the brain serves as the primary link between nervous and endocrine systems. Both systems cooperate in stress response (fight-or-flight). Both contribute to homeostatic regulation of temperature, blood glucose, water balance, etc. These two systems function together to coordinate growth, reproduction, metabolism and behaviour.

Sensory Organs and Coordination in Mammals

Mammals interact with their environment through an array of sensory organs that detect external stimuli and convert them into nerve impulses. These impulses are then integrated by the central nervous system, which coordinates appropriate responses. This sensory-integration-response pathway enables mammals to navigate their surroundings, locate food, avoid predators, find mates, and maintain homeostasis.

Sensory Receptors and Organs

The Human Eye

The **human eye** is the organ responsible for vision. It detects the intensity and wavelength (colour) of light entering the eye and converts it into nerve impulses that are interpreted by the brain as images.

The main structures of the eye include the **cornea**, **aqueous humour**, **iris**, **pupil**, **lens**, **vitreous humour**, **retina**, **optic nerve** and **sclera**. The retina contains specialised photoreceptor cells called **rods** and **cones**. Rods are responsible for vision in dim light, while cones detect colour and provide sharp vision in bright light.

Light enters the eye through the cornea and follows this pathway:

- a. Cornea
- b. Aqueous humour
- c. Pupil
- d. Lens
- e. Vitreous humour
- f. Retina
- g. Optic nerve
- h. Visual cortex of the brain

The brain interprets the nerve impulses as the images that we see.

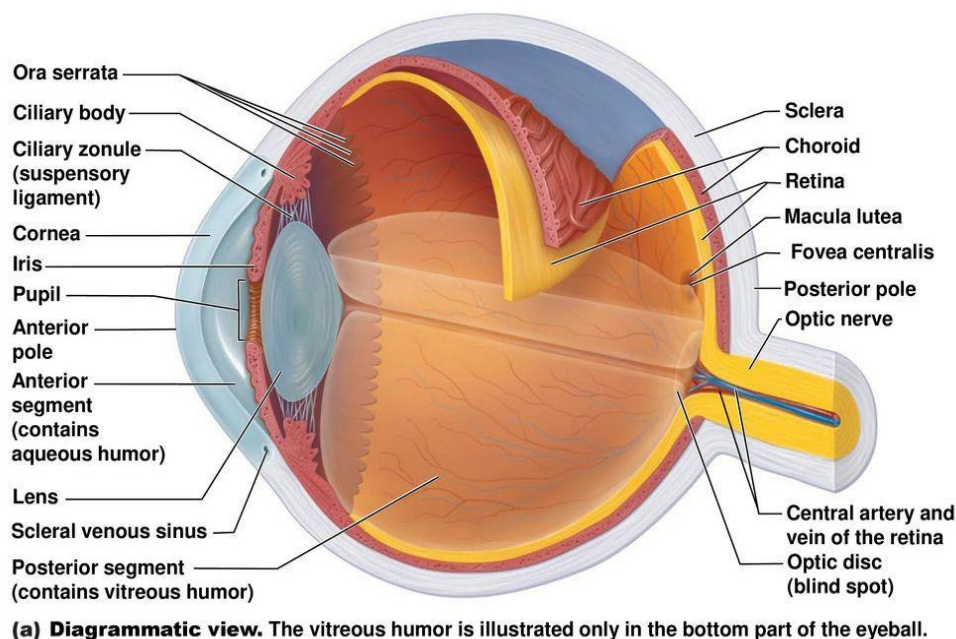


Figure 4.18: *Labelled longitudinal section of the human eye*

The Ear

This detects sound waves (auditory) and maintains balance. The outer ear is made up of the pinna, auditory canal. The middle ear consists of the eardrum and the ossicles while the inner ear comprises the cochlea and semicircular canals. The mechanism for hearing is as follows:

- Sound waves collected by the pinna travels to the eardrum.
- The eardrum vibrates and transmit the wave through the ossicles (middle earbones).
- The vibrations enter the cochlea, thereby stimulating the hair cells in it.
- The signals are transmitted from the hair cells to the auditory nerves.
- The auditory nerves transmit the signals to the primary auditory cortex of the brain, which interprets the signals as sound.

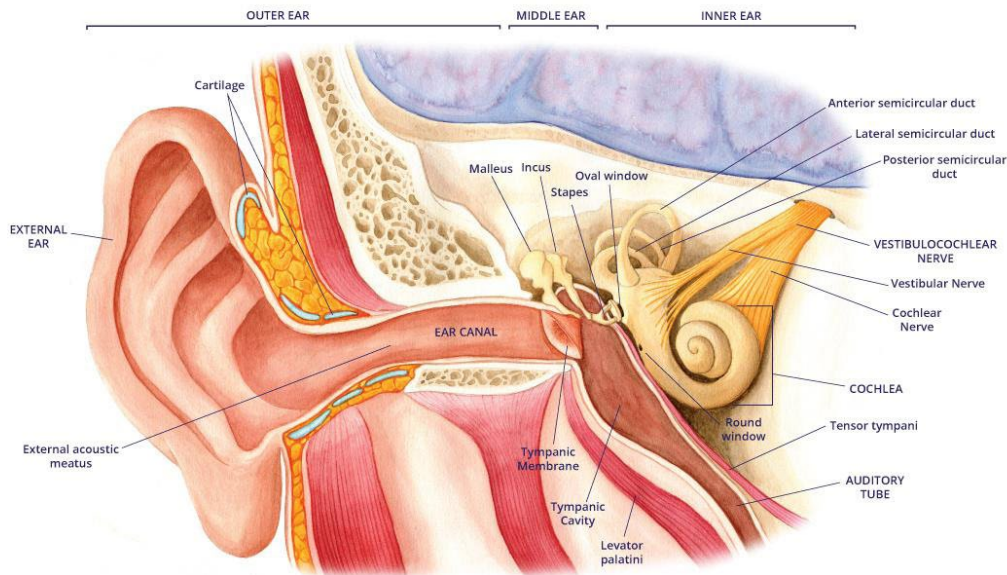


Figure 4.19: The Ear

The Nose

This is the organ that detects scent. It has many parts such as the nasal cavity, nostrils, septum, the turbinate bones, olfactory epithelium and the mucous membranes. The olfactory epithelium is the mucous membrane that lines the upper part of the nasal cavity. It contains olfactory receptors and neurones for the detection of smell. Functions of the nose include its use for breathing and the detection of smell (primary functions). Others are the filtering of air, and for warming and humidifying air.

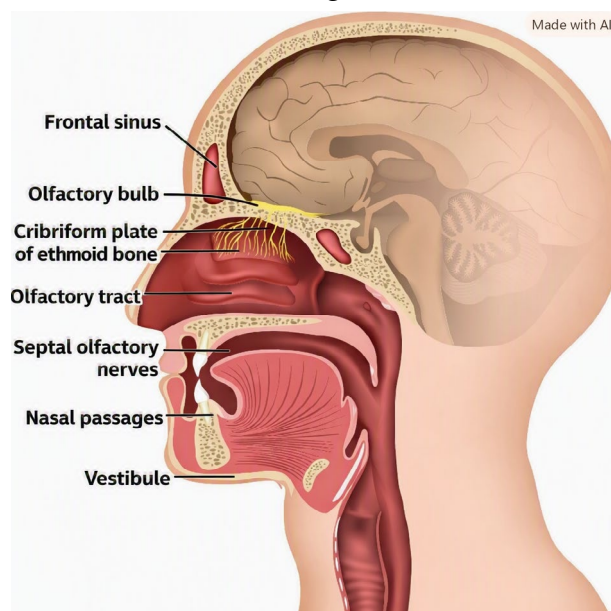


Figure 4.20: The Nose

The Human Tongue

The **human tongue** is a muscular organ in the oral cavity covered by a mucous membrane. It plays important roles in **taste, chewing, swallowing and speech**.

The tongue consists of the **tip (apex), body, dorsum (upper surface), root (base)** and the **frenulum**, which connects the underside of the tongue to the floor of the mouth.

The dorsum is covered with numerous **papillae**, most of which contain **taste buds**. Taste buds contain specialised **taste receptor cells** that detect the five basic tastes:

- a. Sweet
- b. Sour
- c. Salty
- d. Bitter
- e. Umami (savoury)

The nerve impulses generated by these receptor cells are transmitted to the brain, where the different tastes are recognised.

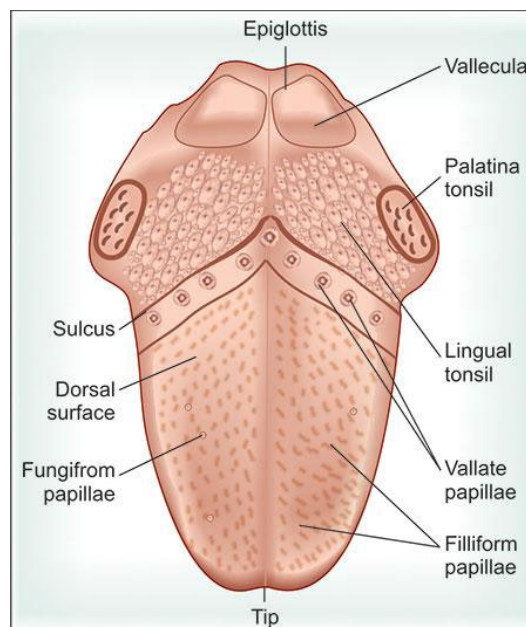


Figure 4.21: *The Human Tongue*

The Skin

This is the outermost layer of the human body that serves as a protective barrier against pathogens and external dangers (e.g., radiations and external injuries). It is made up of three layers which are the epidermis (outermost layer), dermis (middle layer) and hypodermis or subcutaneous tissue (comprising the subcutaneous fat and connective tissue). The skin detects touch, pressure temperature and pain. Receptors used for these purposes include mechanoreceptors (touch, pressure), thermoreceptors (temperature), nociceptors (pain). The network of sensory receptors and pathways that detect and process information based on touch, pressure, temperature, pain and proprioception (body position and movement) is termed as the **somatosensory pathway (or somatosensory system)**. The skin also plays important roles in excretion and synthesis (e.g., vitamin D).

Coordination of Sensory Information

- a. **Sensory processing:** This refers to how the nervous system receives, interprets and integrates sensory information from our bodies and the environment. It involves sensory inputs, signal

transmission, processing and response. The structures or components involved include sensory receptors, neural pathways, various brain regions (e.g. the visual and auditory cortices) and several neurotransmitters and hormones.

- b. **Association areas:** This integrates information from multiple sensory modalities.
- c. **Thalamus:** This acts as a relay station for sensory information (except olfaction).
- d. **Limbic system:** It links sensory information to emotional responses and memory.

Motor Coordination

- a. **Motor cortex:** This initiates voluntary movements.
- b. **Cerebellum:** It coordinates movement, posture, and balance by comparing intended movements with sensory feedback.
- c. **Basal ganglia:** It regulates movement initiation and termination.
- d. **Brainstem:** Controls reflexive movements and coordinates vital functions.

Sensorimotor Integration

- a. **Feedback loops:** This is the continuous adjustment of movement based on sensory input.
- b. **Proprioception:** This refers to the awareness of body position through muscle spindles and joint receptors.
- c. **Reflex arcs:** It is the rapid, involuntary responses to stimuli that bypass conscious processing.

Hormonal Influence on Coordination

- a. **Adrenaline and noradrenaline:** These enhance sensory perception during stress responses.
- b. **Sex hormones:** These regulate the development of reproductive organs, the production of gametes, the development of secondary sexual characteristics, and reproductive behaviours in animals.
- c. **Melatonin:** It regulates circadian rhythms affecting sensory sensitivity.

Adaptations in Different Mammalian Species

- a. Nocturnal mammals: have enhanced olfaction and hearing, specialised visual adaptations.
- b. Aquatic mammals possess modified ears for underwater hearing, echolocation in cetaceans.
- c. Bats employ echolocation using specialised auditory structures.
- d. Moles have reduced vision, enhanced tactile sense through specialised snout.

Learning Tasks

1. Identify nervous and hormonal system structures and their functions.
2. Explain coordination between nervous and hormonal systems.
3. Demonstrate how these systems maintain homeostasis.
4. Investigate sensory organ roles in mammalian coordination.

Pedagogical Exemplars

1. **Individual/Independent-Based Learning:** Learners research the structure and function of mammalian nervous and hormonal systems from textbooks and online resources. They collect information on brain regions, neuron structure, endocrine glands, and how these systems maintain homeostasis. Learners support one another emotionally while investigating complex feedback mechanisms.
2. **Talk for Learning:** In mixed-ability groups, learners discuss how the nervous system (brain, neurons) and hormonal system (pituitary, thyroid, adrenal glands) coordinate body functions. They explore how the hypothalamus links both systems during stress responses. All learners contribute, building confidence while sharing knowledge about sensory reception and hormone action.
3. **Differential Task-Based Learning Approach:** Learners choose one component (brain, pituitary gland, eye, ear) to create diagrams showing structure and function. These visuals are used for exhibition to explain human coordination. Some focus on basic structures while others explore detailed pathways, with learners supporting each other throughout the task.

Key Assessment Level 4: Research project and presentation

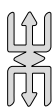
1. Design an investigation to determine how hypothalamus disruption affects multiple body systems. Include hypotheses, ethical considerations, data collection methods, and potential therapeutic applications. (20 marks)
2. Evaluate how mammals in extreme environments have adapted their nervous, hormonal and sensory systems. Develop a model explaining how these systems maintain homeostasis under environmental stress. (20 marks)
3. Analyse a disorder affecting both nervous and endocrine systems. Design and justify a comprehensive treatment approach incorporating both traditional and innovative strategies. (20 marks)

PLC Session 21

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.

- *Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.*

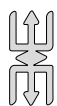
4. Plan the week's key assessment with your app

- The key assessment for the week is **research project and presentation**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the presentation (NTS 3k-3q).

10 minutes

Content Exploration

- As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - all teachers in the group work through a similar problem individually for 3–4 minutes
 - the group then works through the problem together step by step
 - highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes

Enactment

- Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - After the enactment, ask for structured feedback from the group
 - was the concept explained in a way that a learner with no prior knowledge could follow?
 - were the examples grounded in contexts familiar to Ghanaian learners?
 - did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

- Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
- Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
- Remember to
 - transfer your chats into your learning planner template.

- b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
- c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEKS 22 & 23

Learning Indicators

1. Explain the methods of reproduction in flowering plants with emphasis on sexual reproduction
2. Discuss the importance of reproduction in flowering plants for the sustenance of life

FOCAL AREA 1: METHODS OF REPRODUCTION IN FLOWERING PLANTS WITH EMPHASIS ON SEXUAL REPRODUCTION

Types of Reproduction

Reproduction in plants occurs in two main ways:

1. Asexual Reproduction

Asexual reproduction involves **only one parent** and does not require the fusion of male and female gametes. The offspring produced are genetically identical to the parent plant (except where mutations occur).

Natural methods of asexual reproduction in flowering plants include:

- a. **Runners (stolons):** Horizontal stems that produce new plants (e.g., strawberry).
- b. **Rhizomes:** Underground stems that grow horizontally and produce new shoots (e.g., ginger).
- c. **Tubers:** Swollen underground stems that store food and produce new plants (e.g., potato).
- d. **Bulbs:** Underground storage organs that develop into new plants (e.g., onion).
- e. **Corms:** Short underground swollen stems that produce new plants (e.g., cocoyam).

Artificial methods of asexual reproduction include:

- a. **Cuttings:** A portion of a stem, leaf or root is planted to produce a new plant (e.g., cassava, rose and grapevine).
- b. **Layering:** Roots are induced to develop on a stem while it is still attached to the parent plant (e.g., bougainvillea and jasmine).
- c. **Grafting:** A shoot (scion) from one plant is joined to the rooted stem (stock) of another plant (e.g., citrus and mango).
- d. **Tissue culture:** New plants are produced from small pieces of plant tissue under sterile laboratory conditions.

2. Sexual Reproduction

Sexual reproduction involves the **fusion of male and female gametes** to produce a zygote, which develops into a seed and eventually a new plant. Because gametes from two parents combine, the offspring show genetic variation.

In flowering plants, sexual reproduction involves the following stages:

- a. Pollination
- b. Fertilisation
- c. Seed formation
- d. Fruit development

- e. Seed dispersal
- f. Seed germination

Sexual reproduction promotes genetic diversity, enabling plant populations to adapt to changing environmental conditions.

Structure of a Flower

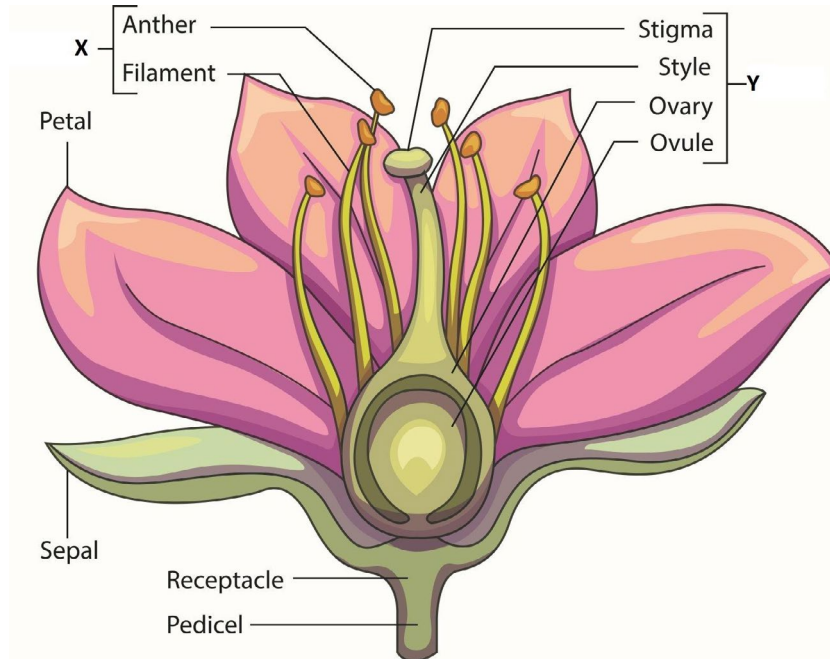


Figure 4.22: A typical flower

A typical flower consists of four main floral parts arranged in concentric whorls around the receptacle.

1. **Sepals (calyx):** Usually green structures that protect the flower while it is still a bud.
2. **Petals (corolla):** Often brightly coloured or scented to attract pollinators.
3. **Stamens (male reproductive organs):** Each stamen consists of a **filament**, which supports the **anther**, where pollen grains are produced.
4. **Carpel (pistil or female reproductive organ):** Consists of the **stigma**, which receives pollen; the **style**, which connects the stigma to the ovary; and the **ovary**, which contains one or more **ovules**. After fertilisation, the ovules develop into seeds while the ovary develops into the fruit.

Floral Formula

This is the symbolic representation of the various structures and parts of a flower using numbers and letters to give information about the morphology of the flower. Features captured in floral formula include floral symmetry sexuality (bisexual or unisexual), number and arrangement of floral parts (e.g., sepals, petals stamens and carpels), and fusion or separation of floral parts.

The floral formula of a flower can be determined by following the steps below:

1. A freshly cut flower (e.g., hibiscus or okra) is carefully dissected and separated into its parts: sepals (calyx), petals (corolla), stamens (androecium), carpels (gynoecium)
2. The number of each floral part is counted, and their arrangement is noted.
3. The position of the ovary (superior or inferior) and the symmetry of the flower (actinomorphic or zygomorphic) are also observed.

4. The floral formula is the written using the letters: **K** = Calyx (sepals), **C** = Corolla (petals), **A** = Androecium (stamens), **G** = Gynoecium (carpels)

Other symbols used are given below:

- $\oplus$ or $\otimes$ = bisexual flower
- $\uparrow$ = zygomorphic (bilateral symmetry)
- $\downarrow$ or $\oplus$ = actinomorphic (radial symmetry)
- A line under G = superior ovary
- A line over G = inferior ovary

Example (Hibiscus):

$\oplus$ K5 C5 A(∞) G1 — This shows a bisexual, actinomorphic flower with 5 sepals, 5 petals, many stamens, and one carpel with a superior ovary.

Male and Female Reproductive Parts of a Flower

The male reproductive part (stamens or androecium) of the flower is made up of the **anther** which produces the pollen grains that contain the male gametes, and the filaments, which support the anther. The female reproductive part (gynoecium/pistil/carpel) contains the **stigma** (sticky surface) to receive pollen, **style** /a **stick** a stalk that holds the stigma and connects it to the ovary, **Ovary**. It contains ovules, which develop into seeds after fertilisation.

Self – Pollination and its Adaptations

Self-pollination refers to the transfer of pollen grains from the anther to the stigma of the same flower or another flower on the same plant. Examples of self-pollinated plants are cassava, potatoes, tomatoes, pea plants, rice and wheat. Self-pollinated flowers have evolutionary developed several mechanisms to enable them to survive successfully within the environment. Some of these adaptive strategies are:

- Anthers close to stigma.
- Flowers may remain closed (cleistogamy).
- Flowers are often small and less bright.
- They produce less pollens.

Cross–Pollination and its Adaptations

Cross-pollination is the transfer of pollen grains from the anther of one flower to the stigma of another flower of the same species. Examples of cross-pollinated plants are cocoa, cashew, palm plants, sunflower and apples. Examples of adaptations for cross-pollination include the following:

- Stamens and carpels mature at different times (dichogamy).
- Structural barriers prevent self-pollination.
- Brightly coloured petals and scents to attract pollinators.
- Long stamens or styles encourage contact with pollinators.

Agents of pollination

These are the organisms or natural factors that cause or facilitate pollination in flowering plants. Living or biotic factors that cause pollination include animals such as insects, birds, bats and mammals. Non-living or abiotic agents include wind and water or rain.

Double Fertilisation in Flowering Plants

Double fertilisation refers to the occurrence of two fertilisation events in which there is the fusion of a female embryonic sac with two male sperm cells (gametes), resulting in the formation of a diploid zygote and a triploid endosperm. It is a unique feature in **angiosperms** (flowering plants). The major processes involved in double fertilisation are

- Pollen grains land on the stigma, absorbing water and nutrients to swell and germinate.
- Pollen tube grows down the style and into the ovary to reach the embryo sac.
- Pollen tube penetrates the embryo sac and releases two sperm cells.
- One sperm cell fuses with the egg cell to form a diploid zygote, while the other sperm cell fuses with the two polar nuclei to form a triploid endosperm for nourishment.

The endosperm is a nutrient-rich tissue essential for seed development and nourishment of the growing embryo. The main importance of double fertilisation is seed development and nutrient supply.

Types of Fruits

Fruits are the mature ovary of a flowering plant which contains seeds. They can be classified based on many factors such as the development of floral parts, structure and origin and the type of seed. The three main types of fruits are classified based on the structure and origin.

Fruit Classification by Structure and Origin

1. Simple fruits

They are fruits that develop from a single ovary in a flower; examples are tomatoes, mangoes, oranges, pawpaw, lime, lemon and peach fruits. The various forms of simple fruits are:

- Fleshy fruits** – These are simple fruits with soft fleshy pericarp or fruit wall. The types are **berries**, **drupes** and **pomes**.
- Dry fruits** – These are simple fruits characterised by a dry, non-fleshy pericarp. The two main types are **dry dehiscent fruits**, such as peas and beans (which open to release seeds) and **dry indehiscent fruits**, which do not open to release seeds. The types of dry dehiscent fruits are legumes, follicles and capsules, while indehiscent fruits include **nuts**, **achenes** and **caryopsis** (grain).

2. Aggregate fruits

These are fruits that develop from multiple ovaries of a single flower; examples are strawberries and raspberries.

3. Composite fruits

Composite fruits are fruits which develop from ovaries of multiple flowers; examples are pineapples and fig fruits (less known in Ghana).

Classification by Development of Floral Parts

- True fruits:** These are fruits that develop from the ovary of a flower. Examples are tomatoes and peaches.
- False fruits (Accessory fruits or Pseudocarps):** These are fruits that develop mainly from parts of the flower **other than the ovary**, especially the **receptacle** (the swollen base of the flower to which the sepals, petals, stamens and carpels are attached). In false fruits, the ovary may contribute to the fruit, but it is not the only or main part that develops into the mature fruit. Examples include **apple**, **pear** and **strawberry**.

Seeds and Their Classification

A seed is the reproductive unit of a plant that develops from the ovules in the ovary of a flower after fertilisation. It contains the embryo, and is surrounded by the seed coat. Most seeds possess food storage tissue (embryo) for germination. Two main ways of classifying seeds are the number of **cotyledons** or **seed leaves** they contain, and whether they have endosperm or not (endospermic seeds such as corn, wheat, maize, and non-endospermic seeds such as beans and peas). Based on the number of cotyledons, seeds may be considered as:

- Monocotyledonous seeds (Monocot seeds):** These are seeds that contain only one cotyledon or seed leaf. Examples are palm seeds, pawpaw, grains and cereals.
- Dicotyledonous seeds/Dicot seeds:** These are seeds with two cotyledons or seed leaves. Examples are bean seeds, peas, mangoes, oranges and sunflower seeds.

Seeds may also be classified as **endospermic seeds** when they possess endosperm (typical examples are rice, maize, wheat, castor seeds, etc.), and **non-endospermic seeds** (examples are peas, beans, soya bean, cowpea and barley).

Fruit and Seed Dispersal

This is the process by which plants spread their seeds to new locations, allowing them to colonise new habitats and spread in different locations. There are several mechanisms or methods by which this is achieved. These include:

- Wind:** Seeds light, winged or with hairs (e.g., dandelion, maple).
- Water:** Seeds have air spaces or fibrous husks for floating (e.g., coconut).
- Animals:** Fleshy fruits eaten and seeds dispersed in droppings (e.g., mango), or seeds attach to fur (e.g., burdock).
- Explosive Mechanism:** Fruit bursts open to scatter seeds (e.g., balsam).

Fruit and seed dispersal is important among plants because the process reduces competition with parent plant, allows colonisation of new areas and increases the chances of survival among plant species.

Seed Germination and Its Requirements

Seed germination is the stage in seeds when the seed begins to grow and develop into a seedling. The requirements or conditions necessary for germination are:

- Water** to rehydrate (soften the seed coat) and activate enzymes.
- Oxygen** for aerobic respiration to produce energy for the developing seed.
- Warmth** for enzyme activity (most seeds germinate within the range of 15°C to 30°C).
- Light or Darkness.** Some seeds such as lettuce and tobacco require light for germination, while others, including onion and cucumber germinate best under darkness.
- Viable seeds**, which are seeds capable of germinating and growing into healthy plants under the right conditions.

Investigation

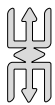
Carry out different experiments to investigate the effects of each of the factors or conditions required for germination.

Types of Germination

There are two main types of germination. These are:

- Epigeal germination** – This is the type of germination where the cotyledons come above the soil. The stem below the cotyledon is called the **hypocotyl**. This elongates to push the cotyledon above the soil. Examples of this epigeal germination are found in plants such as cocoa, beans, peas, tomatoes and sunflower.

2. **Hypogeal germination** – It is the type of germination where the cotyledons stay below the soil. The stem that grows above the cotyledon is called the **epicotyl**. The epicotyl elongates and pushes out of the ground, while the cotyledon remains in the soil. Examples of this type of germination is found in maize, sorghum, millet, rice, coconut, grasses



Note

Although monocot seeds are mainly hypogeal, dicot seeds show both epigeal and hypogeal germinations.

Learning Tasks

1. Identify parts of a flower and their functions.
2. Collect flowers from the environment, dissect them, and record their floral formulae.
3. Compare the floral parts and explain how differences in structure might affect their method of reproduction.
4. Compare self- and cross-pollination adaptations.
5. Describe double fertilisation and its outcomes.
6. Investigate germination and vegetative propagation.

Pedagogical Exemplars

1. **Collaborative Learning Approach:** in mixed-ability, social-inclusive groups, learners research the two main types of reproduction in plants and take notes on lessons learnt: learners in a group learn from other members and build teamwork confidence.
2. **Experiential Learning Approach: learners go on a tour** in floral gardens around the school compound or an area of choice to study various forms of flowering plants to identify the whorls/ floral parts (calyx, corolla, androecium and gynoecium); this offers the learner real-world scenarios, hence first-hand information of lessons.
3. **Initiate Talk for Learning Approach:** in mixed-ability, all-inclusive groups, learners discuss with examples, various adaptations of flowering plants for self-pollination and cross pollination; learners analyse and make annotated diagrams of double fertilisation in flowering plants, types of fruits, and discuss seeds and fruit dispersal: learners learn to accept one another's view and develop tolerance through discussions.
4. **Differential Task-Based Learning:** Learners in their groups set up experiments to investigate the various factors necessary for seed germination and prepare a PowerPoint slide for class presentations and discussions: Laboratory and field experiments offer the learner first-hand experiences to understand lessons better. Learners boost confidence and obtain emotional satisfaction.

Key Assessment Level 4: Case study and argumentative essay

1. A farmer in the Northern Region notices that some of his okra plants produce many seeds while others produce few. Design an investigation to identify which floral structures or reproductive processes might be affecting seed production. Explain how your findings could help improve his crop yield. (20 marks).
2. Design an investigation to compare the success of self-pollination and cross-pollination in a local flowering plant, and explain how your results could support conservation of native species.

3. Create a model or diagram showing double fertilisation in a flowering plant; explain how each fertilisation event contributes to survival of the embryo in Ghanaian farming conditions.
4. Evaluate the advantages and disadvantages of wind, animal, and water seed dispersal for plants growing in different parts of Ghana (e.g. savannah vs. rainforest).
5. Devise a plan to grow crops using both asexual and sexual reproduction methods; justify your choices based on climate, soil type, and farming practices in your community.

FOCAL AREA 2: IMPORTANCE OF REPRODUCTION IN FLOWERING PLANTS FOR THE SUSTENANCE OF LIFE

Importance of Reproduction in Flowering Plants

Reproduction is essential for the survival and continuity of flowering plant species. It enables plants to produce offspring, maintain populations, increase genetic diversity through sexual reproduction, and ensure the continued functioning of ecosystems. The importance of reproduction in flowering plants includes the following:

1. **Ensures continuity of plant species:** Reproduction allows flowering plants to produce new generations, preventing species from becoming extinct.
2. **Promotes genetic diversity:** Sexual reproduction produces genetically varied offspring, increasing the ability of plant populations to adapt to changing environmental conditions, pests and diseases.
3. **Produces seeds and fruits:** Reproduction results in the formation of seeds and fruits, which protect the developing embryo, aid seed dispersal, and serve as important sources of food for humans and other organisms.
4. **Facilitates the spread of plants:** Seeds and fruits are dispersed by wind, water, animals or humans, enabling flowering plants to colonise new habitats and reduce competition with the parent plant.
5. **Maintains ecosystem stability:** The continued reproduction of flowering plants ensures the availability of food, shelter and habitats for many organisms, thereby supporting biodiversity and ecosystem balance.
6. **Supports agriculture and the economy:** Successful reproduction enables the production of crops, fruits, vegetables and seeds that provide food, raw materials, employment, income and export opportunities, thereby contributing to economic development.

Learning Tasks

1. Investigate how the structure of the hibiscus flower helps it reproduce successfully in your local environment. Present your findings using a labelled diagram, floral formula, and a short explanation.
2. Design and carry out a simple experiment to compare how often insects visit two types of flowering plants in your school garden or community, and explain how this affects seed formation.
3. Create a plan for restoring a piece of degraded land in your area using flowering plants. Include the types of plants, how they reproduce, and how they will help other life forms survive.

Pedagogical Exemplars

1. **Individual Project-Based Learning:** Each learner is tasked to read, summarise, and present notes on how plant reproduction is important to the survival of other forms of life, especially animals. Learners build self-confidence and emotional satisfaction when they work independently on assignments or projects. This approach encourages the development of critical reading and summarising skills. Learners also learn from one another when they share and compare their findings during class discussions, promoting peer learning.
2. **Talk for Learning:** Learners form mixed-ability groups to discuss the importance of reproduction in plants, emphasising on how plant reproduction is important to the survival of other forms of life, especially humans and other animals. Contributing to discussions develop the confidence of each learner.
3. **Project-Based Learning:** Based on the group research, learners develop flow charts on the importance of reproduction in flowering plants. Through this approach, learners develop creativity, explore diverse methods of completing tasks, learn from one another, and build self-confidence through teamwork and shared success.

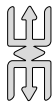
Key Assessment Level 4: Case study and argumentative essay

1. A group of students working on a school project in Cape Coast find that certain plants in the area seem to rely more on insect pollinators than wind for reproduction. Develop a plan for how they could confirm this through observation and simple experiments, and explain how their findings could support biodiversity conservation in the area. (20 marks)
2. Imagine a community in the Volta Region wants to replant degraded land using flowering plants that can provide food for both people and animals. Propose a combination of plant species, explaining the role of their reproductive parts and seed formation in supporting the ecosystem. (20 marks)

PLC Session 22 & 23

45 minutes
Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

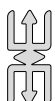
4. Plan the week's key assessment with your app

- The key assessment for the week is **case study and argumentative essay**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessment (NTS 3k-3q).

10 minutes

Content Exploration

- As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - all teachers in the group work through a similar problem individually for 3–4 minutes
 - the group then works through the problem together step by step
 - highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).



Note

- This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?
- If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.
- Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.

30 minutes

Enactment

- Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - After the enactment, ask for structured feedback from the group
 - was the concept explained in a way that a learner with no prior knowledge could follow?
 - were the examples grounded in contexts familiar to Ghanaian learners?
 - did any misconceptions surface and if so, how were they addressed?

5 minutes

Reflection

- Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).

8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

WEEK 24

Learning Indicator: Discuss excretion in flowering plants

FOCAL AREA 1: EXCRETION IN FLOWERING PLANTS

Structures Involved in Excretion in Flowering Plants

Excretion is the process by which living organisms remove metabolic waste products from the body. Metabolic waste products are substances produced during normal cellular activities that are no longer needed and may become harmful if they accumulate.

In flowering plants, common waste products include oxygen (produced during photosynthesis), carbon dioxide (produced during respiration), excess mineral salts, resins, latex, gums, tannins, alkaloids, terpenes, phytoliths and glycosides. Unlike animals, flowering plants do not possess specialised excretory organs. Instead, they remove, store or isolate waste products using ordinary plant structures and tissues.

The main structures and methods involved include:

1. **Stomata:** Tiny pores found mainly on leaves that allow the exchange of gases. Oxygen produced during photosynthesis and carbon dioxide produced during respiration diffuse through these openings.
2. **Lenticels:** Small openings in the bark of woody stems and branches that permit gaseous exchange between internal tissues and the atmosphere.
3. **Leaf abscission:** Some waste products accumulate in ageing leaves. When these leaves fall, the stored wastes are removed from the plant.
4. **Bark shedding:** Waste products may accumulate in older bark. As the bark peels off naturally, these wastes are discarded.
5. **Storage in vacuoles and specialised tissues:** Some wastes are stored safely in vacuoles or specialised tissues where they do not interfere with normal plant activities.
6. **Storage as insoluble substances:** Some wastes are converted into harmless substances such as calcium oxalate crystals or stored as gums, resins and latex.

Methods by Which Different Types of Flowering Plants Remove Metabolic Waste Products

Although all flowering plants lack specialised excretory organs, they remove or store metabolic waste products in different ways depending on their structure and habitat.

1. **Herbaceous plants (soft-stemmed plants):** These mainly remove gaseous metabolic waste products such as oxygen and carbon dioxide through the stomata. Carbon dioxide produced during respiration and oxygen produced during photosynthesis diffuse through these pores.
2. **Woody plants (trees and shrubs):** In addition to using stomata, woody plants exchange gases through lenticels in their bark. They may also remove stored metabolic wastes by shedding leaves and peeling old bark.
3. **Aquatic plants (water plants):** These remove gaseous metabolic waste products such as oxygen and carbon dioxide directly into the surrounding water by diffusion.

4. **Succulent plants (e.g., cacti):** These often store certain metabolic waste products as harmless crystals or other insoluble substances within specialised tissues or vacuoles, preventing them from damaging living cells.

Metabolic Waste Products in Flowering Plants

Flowering plants produce metabolic waste products during normal physiological processes. Some of these are released into the environment, while others are safely stored within plant tissues.

1. **Oxygen (O₂):** Oxygen is produced during photosynthesis and diffuses out of the plant mainly through the stomata and lenticels. The oxygen released is essential for the respiration of animals, humans and many other organisms.
2. **Carbon dioxide (CO₂):** Carbon dioxide is produced during respiration and diffuses out of the plant through the stomata and lenticels. During daylight, some of the carbon dioxide produced may be reused by the plant during photosynthesis.
3. **Storage of Metabolic Waste Products:** Some metabolic waste products are converted into harmless, insoluble substances and stored in specialised tissues or vacuoles where they do not interfere with normal cellular activities. Examples include:
 - o Calcium oxalate crystals
 - o Silica bodies (phytoliths)
 - o Tannins
 - o Certain alkaloids

These substances may remain stored throughout the life of the plant or be removed when leaves, bark or other plant parts are shed.

Protective Secretions Produced by Flowering Plants

In addition to metabolic waste products, flowering plants produce several secretions that protect them from injury, pests and diseases. These substances are not metabolic waste products but play important roles in plant defence.

1. **Resins:** Resins are secreted to seal wounds and protect plants against insects and pathogens.
2. **Gums:** Gums are produced following injury and help seal damaged tissues while reducing water loss.
3. **Latex:** Latex is a milky secretion that deters herbivores and insects and helps seal damaged tissues after injury.

These protective secretions contribute to the survival and defence of flowering plants but are not regarded as metabolic waste products.

Pedagogical Exemplars

1. **Project-Based/Observational Learning:** Take the class on an educational walk around the school compound to identify and observe plant structures involved in the removal or storage of metabolic waste products. Learners should identify features such as **stomata (using prepared microscope slides or leaf peels), lenticels on woody stems, peeling bark, fallen leaves, and resin or gum exudates**. Each group should record their observations, sketch or photograph the structures where possible, discuss how each structure contributes to waste removal or storage, and present their findings to the class.

2. **Talk-for-Learning Approach Discuss:** In their respective mixed-ability groups, learners discuss the importance of some named plant waste products (e.g., resins, latex, gum, carbon dioxide, water, oxygen, etc.) and how they are excreted. Groups discuss why, unlike animals, plants generally lack specialised excretory organs and structures for removing waste materials from their bodies.

Key Assessment Level 4: Experimental investigation with practical report

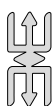
1. During a school garden project, your class discovers that some old mango trees have large patches of peeling bark. Design an investigation to determine whether bark peeling in these trees helps remove plant waste products. Explain how you would collect and present your data. (20 marks)
2. A student in your class claims that aquatic plants do not need stomata because they excrete waste directly into water. Develop an argument, using evidence and examples, to support or challenge this claim. (20 marks)
3. Imagine you are advising a farmer who wants to plant trees that produce useful waste products such as gums or resins. Propose two suitable tree species and explain how their waste products are excreted, and how they benefit both the plant and the farmer. (20 marks)
4. Your community plans to plant trees along a river to reduce erosion. Create a plan that links the excretory structures of the chosen plants (such as stomata or lenticels) with how they will support the ecosystem. (20 marks)

PLC Session 24

45 minutes

Planning & Reviewing the Learning Plan

1. Begin the session by recapping lessons from the previous year/session/week, focusing on how learning was applied.
2. Use your subject specific app to explore the content before planning. Ask the app to
 - a. explain the week's concepts in a practical way that will make it easier for learners to understand
 - b. identify two or three common misconceptions learners may have on the week's content and how to address them using contexts familiar to Ghanaian learners. (NTS 3a, 3g and 3m).
3. Use your subject specific app to plan your lesson. Ask the app to
 - a. suggest the most effective method for teaching the week's concepts to learners with diverse backgrounds.
 - b. suggest learning activities, differentiation and essential questions based on the method of teaching (NTS 3a-3q)
 - c. review your prepared learning plan and address any challenging issues you may have identified in your subject area (NTS 3a-3c).



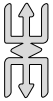
Note

- Take note of the recap topics linked to Years 1 and 2 while preparing for your lesson.
- Refer to the Values Learning Community Handbook and link the values for the week in your lesson to ensure that learners are applying what they learn.

4. Plan the week's key assessment with your app
 - a. The key assessment for the week is **experimental investigation with practical report**. Chat with your app to plan this assessment, indicating what you and your learners will do before, during and after the assessment (NTS 3k-3q).

10 minutes**Content Exploration**

5. As a subject group, select one problem or idea/term in the week's content that is challenging (not a routine procedural question, but one that requires conceptual understanding) and then
 - a. use the app, ask it to solve the problem step by step and explain the reasoning behind each step (you may be assisted by a teacher who is strong in the content area)
 - b. all teachers in the group work through a similar problem individually for 3–4 minutes
 - c. the group then works through the problem together step by step
 - d. highlight the most common errors made at each step and discuss (NTS 1c, 1e, 2c, 2e, 3e-3j).

**Note**

- *This part is not just about 'How do I teach this?' but how do I teach it for learners to understand?*
- *If the group still shares the same content gap, use the app: ask it to solve the problem step by step and explain the reasoning behind each step.*
- *Problems/ideas discussed should be sourced from the Teacher Manual content, not invented separately. This keeps the content exploration directly connected to what teachers will deliver.*

30 minutes**Enactment**

6. Enact a teaching activity based on your learning plan (NTS 1a-1b, 1e-1g, 2c, 2e, 2f, 3c-3j and 3o).
 - a. Colleagues observe with specific attention to clarity of concept explanation, use of familiar Ghanaian examples and how misconceptions are handled if they arise.
 - b. After the enactment, ask for structured feedback from the group
 - i. was the concept explained in a way that a learner with no prior knowledge could follow?
 - ii. were the examples grounded in contexts familiar to Ghanaian learners?
 - iii. did any misconceptions surface and if so, how were they addressed?

5 minutes**Reflection**

7. Reflect and share your views on the session. One thing that worked well, what did not work well and what you will do differently. (NTS 1a, 1b).
8. Identify a critical friend to observe and provide feedback on your lesson in relation to the PLC Session conducted (NTS 1f, 1g).
9. Remember to
 - a. transfer your chats into your learning planner template.
 - b. read your Teacher Manual and related Learner Material in preparation for the next session. Take note of the recap weeks, which are linked to Years 1 and 2 (NTS 3a).
 - c. integrate National Values, GESI, SEL, and 21st century skills into your learning activities, assessment tasks, and rubrics/mark schemes.

Section Review

In this section, learners explored the structure and functions of key mammalian body systems and how these systems work together to maintain healthy living. Through labelled drawings and guided discussions, learners described how the respiratory, reproductive, musculoskeletal, nervous, and hormonal systems operate and support one another. They examined how efficient breathing supports muscular activity, how hormones regulate body processes, and how the reproductive system ensures the survival of species.

Learners also deepened their understanding of plant biology by studying sexual reproduction in flowering plants. They described the roles of floral parts in pollination and fertilisation and discussed the importance of plant reproduction for food supply, ecosystem balance, and continuity of life. The section further enabled learners to explain excretion in plants, highlighting how plants remove waste products to maintain internal balance and support healthy growth.

Across these lessons, learners engaged in observations, simple investigations, and group discussions that strengthened their ability to interpret biological structures and processes. By the end of the section, learners gained a broader understanding of how both animals and plants sustain life through coordinated systems, reproduction, and effective waste management.



MARKING SCHEMES FOR THE KEY ASSESSMENTS

WEEK 18

Question 1 (Total: 20 Marks)

Identification of Structures (5 marks)

- Clearly identifies all five key structures (trachea, bronchi, lungs, alveoli and diaphragm) with accurate and detailed descriptions. *(5 marks)*
- Identifies most structures with good descriptions. *(4 marks)*
- Identifies some structures but descriptions lack detail or accuracy. *(3 marks)*
- Identifies only a few structures with limited descriptions. *(2 marks)*
- Identifies one relevant structure with little or no description. *(1 mark)*
- **No relevant structures identified. (0 marks)**

Evaluation of Adaptations (5 marks)

- Thoroughly explains how each structure is adapted for efficient gaseous exchange with clear scientific reasoning and relevant examples. *(5 marks)*
- Explains most adaptations clearly but lacks some detail or examples. *(4 marks)*
- Provides a basic explanation of several adaptations but lacks depth. *(3 marks)*
- Gives a limited explanation with minimal connection between structure and function. *(2 marks)*
- Mentions one adaptation with little explanation. *(1 mark)*
- **No explanation of adaptations provided. (0 marks)**

Support for Respiratory Health (5 marks)

- Clearly explains how the adaptations support efficient respiration and healthy functioning of the respiratory system with relevant examples. *(5 marks)*
- Gives a good explanation but lacks some detail or examples. *(4 marks)*
- Provides a basic explanation of how adaptations support respiration. *(3 marks)*
- Gives only a limited explanation with little scientific detail. *(2 marks)*
- Makes only a brief mention of respiratory health. *(1 mark)*
- **No explanation provided. (0 marks)**

Clarity and Organisation (5 marks)

- Response is well organised, logical and scientifically accurate with minimal language errors. *(5 marks)*
- Response is organised and mostly clear with only minor errors. *(4 marks)*
- Response shows some organisation but lacks clarity in places. *(3 marks)*
- Response is poorly organised and difficult to follow. *(2 marks)*
- Response has very limited organisation and is difficult to understand. *(1 mark)*
- **No response or completely irrelevant response. (0 marks)**

Total: 20 Marks

Question 2

Objective and Hypothesis:

- Clearly states the objective and formulates a relevant hypothesis. E.g. The objective is clearly stated: “To measure how different intensities of physical exercise affect the efficiency of gas exchange in the human respiratory system.” A relevant hypothesis is implied (gas exchange efficiency will increase with exercise intensity). (5 marks)
- States the objective but lacks a clear hypothesis. (4 marks)
- Basic objective stated, but unclear or no hypothesis. (3 marks)
- Vague objective and hypothesis. (2 marks)
- No objective or hypothesis provided. (1 mark)

Methodology:

- Comprehensive outline of methodology including detailed steps and participant selection. E.g. The methodology: “Participants will rest for 5 minutes to establish baseline values...”, “Participants will perform three different exercise intensities...”, and “Use a spirometer to measure tidal volume (TV) and respiratory rate (RR)...”. Participant selection is also mentioned: “A group of healthy adult volunteers (e.g., 20 participants aged 18-30).” (5 marks)
- Clear methodology but lacking some details. (4 marks)
- Basic methodology present but lacks clarity or detail. (3 marks)
- Limited methodology with significant omissions. (2 marks)
- No methodology provided. (1 mark)

Measurement Techniques and Controls:

- **Thoroughly explains appropriate measurement techniques and experimental controls used in the investigation.** Examples include measuring breathing rate by counting chest movements per minute, using a stopwatch to record exercise duration, and, where available, using a spirometer to measure lung volumes. Clearly identifies appropriate control variables such as exercise intensity, duration, room temperature, participant age and fitness level. (5 marks)
- **Clearly explains most measurement techniques and control variables but lacks some detail or clarity.** (4 marks)
- **Provides a basic explanation of measurement techniques and identifies some control variables.** (3 marks)
- **Provides limited explanation of measurement techniques or control variables.** (2 marks)
- **Mentions one relevant measurement technique or control variable with little explanation.** (1 mark)
- **No relevant measurement techniques or control variables described.** (0 marks)

Expected Results and Analysis:

- Clearly outlines expected results with logical reasoning. E.g. Results: “It is expected that gas exchange efficiency (measured by VO_2 and VCO_2) will increase with higher exercise intensity...”, “A higher tidal volume and respiratory rate should be observed during moderate and high-intensity exercises compared to baseline measurements.” The reasoning is also present: “...reflecting an increased demand for oxygen and enhanced respiratory function.” (5 marks)

- States expected results but lacks detailed reasoning. (4 marks)
- Basic expected results stated but lacks clarity. (3 marks)
- Vague expected results with little reasoning. (2 marks)
- No expected results provided. (1 mark)

Impact on Understanding Respiratory Function:

- Provides a comprehensive explanation of how the investigation improves understanding of respiratory function. Clearly explains the relationship between physical activity and respiratory responses, supports the explanation with appropriate scientific principles, and discusses at least two practical applications of the findings. **(5 marks)**
- Provides a clear explanation of how the investigation improves understanding of respiratory function. Explains the relationship between physical activity and respiratory responses and discusses at least one practical application. **(4 marks)**
- Provides a basic explanation of how the investigation relates to respiratory function but gives limited scientific reasoning or practical application. **(3 marks)**
- Provides only a brief or partially correct explanation of the investigation's relevance to respiratory function. **(2 marks)**
- Makes only a simple statement about respiratory function with little or no explanation. **(1 mark)**
- No relevant explanation provided. **(0 marks)**

Question 3

Hypothesis Formulation:

- Clearly states a testable hypothesis regarding the effect of temperature on the rate of aerobic respiration. E.g. "In yeast, an increase in temperature will increase the rate of aerobic respiration up to a certain optimum temperature, beyond which the rate will decline." (5 marks)
- States a hypothesis but lacks clarity or specificity. (4 marks)
- Basic hypothesis stated but not fully testable or specific. (3 marks)
- Vague hypothesis with minimal connection to temperature and respiration. (2 marks)
- No hypothesis provided. (1 mark)

Research Plan:

- Comprehensive outline of the research plan, including detailed steps for testing the hypothesis. E.g. "The experiment will involve measuring carbon dioxide production in yeast at various temperatures (e.g., 15°C, 25°C, 35°C, and 45°C) using a respirometer." (5 marks)
- Clear research plan but lacking some details or specifics. (4 marks)
- Basic research plans are present but lacks clarity or detail. (3 marks)
- Limited research plan with significant omissions. (2 marks)
- No research plan provided. (1 mark)

Methods for Data Collection:

- Thorough explanation of methods for data collection, including equipment and procedures. E.g. "Use a respirometer to measure the volume of carbon dioxide produced over a fixed time period for each temperature." (5 marks)

- Clear explanation but lacks some detail regarding data collection methods. (4 marks)
- Basic explanation of methods present but not comprehensive. (3 marks)
- Limited explanation with minimal connection to data collection. (2 marks)
- No mention of data collection methods. (1 mark)

Analysis and Interpretation:

- Clearly describes how data will be analysed and conclusions drawn from results. E.g., “Data will be analysed by comparing the rates of carbon dioxide production at each temperature, using statistical methods to determine significance.” (5 marks)
- States analysis methods but lacks detailed explanation. (4 marks)
- Basic analysis methods stated but lacks clarity. (3 marks)
- Vague mention of analysis with little reasoning. (2 marks)
- No mention of analysis or interpretation methods. (1 mark)

Clarity and Organization:

- Well-organized response with clear, logical flow; minimal errors. E.g., The response is structured with clear headings and logical progression through hypothesis, research plan, data collection, and analysis. (5 marks)
- Organized response with minor errors; generally clear. (4 marks)
- Some organisation present but lacks clarity in parts. (3 marks)
- Poor organization; difficult to follow; many errors. (2 marks)
- Unclear and disorganized response. (1 mark)

Total 25 marks

WEEK 19

Question 1 (Total: 20 Marks)

Identification of Reproductive Organs (2 marks)

- Correctly identifies two male and two female reproductive organs. (2 marks)
- Identifies two or three correct organs. (1 mark)
- Identifies one or no correct organs. (0 marks)

Description of Functions (6 marks)

- Accurately explains the functions of all four organs using correct biological terminology and appropriate detail. (6 marks)
- Explains the functions of most organs with minor omissions. (4–5 marks)
- Gives basic descriptions of some organ functions. (2–3 marks)
- Gives very limited or inaccurate descriptions. (1 mark)
- No relevant description. (0 marks)

Example

The testes produce sperm cells and the hormone testosterone, while the ovaries produce ova and the hormones oestrogen and progesterone.

Health Issues Associated with Each Organ (8 marks)

- Correctly identifies appropriate health issues and clearly explains how each condition affects the organ and reproductive health. (7–8 marks)
- Identifies appropriate health issues and provides adequate explanations for most organs. (5–6 marks)
- Identifies some health issues with basic explanations. (3–4 marks)
- Gives limited or inaccurate explanations. (1–2 marks)
- No relevant response. (0 marks)

Example:

Endometriosis causes tissue similar to the uterine lining to grow outside the uterus, leading to pain, inflammation and possible infertility.

Clarity and Organisation (4 marks)

- Response is well organised, logically presented and uses correct biological terminology. (4 marks)
- Generally, well organised with minor errors. (3 marks)
- Some organisation but lacks clarity. (2 marks)
- Poorly organised. (1 mark)
- No meaningful response. (0 marks)

Total: 20 Marks**Question 2 (Total: 20 Marks)****Description of Key Hormones (4 marks)**

- Correctly identifies and describes the major reproductive hormones and their sources. (4 marks)
- Identifies most hormones with adequate descriptions. (3 marks)
- Identifies some hormones with limited descriptions. (2 marks)
- Identifies one hormone only. (1 mark)
- No relevant response. (0 marks)

Example:

Oestrogen is produced mainly by the ovaries and promotes the development of female secondary sexual characteristics and regulates the menstrual cycle.

Roles of Hormones in Reproduction (6 marks)

- Clearly explains how hormones regulate the menstrual cycle, ovulation, pregnancy and reproductive health. (6 marks)
- Gives a good explanation with minor omissions. (4–5 marks)
- Gives a basic explanation. (2–3 marks)
- Gives limited explanation. (1 mark)
- No relevant response. (0 marks)

Hormonal Imbalances (6 marks)

- Clearly explains common hormonal disorders and their causes, symptoms and effects on reproductive health. (6 marks)
- Explains most disorders adequately. (4–5 marks)
- Gives basic explanations. (2–3 marks)
- Gives limited explanation. (1 mark)
- No relevant response. (0 marks)

Example:

Polycystic Ovary Syndrome (PCOS) is characterised by hormonal imbalance that may cause irregular menstruation, ovarian cysts and reduced fertility.

Real-World Applications (2 marks)

- Clearly explains how understanding hormones supports reproductive health decisions and disease prevention. (2 marks)
- Gives a basic explanation. (1 mark)
- No relevant response. (0 marks)

Clarity and Organisation (2 marks)

- Response is well organised, logically presented and uses appropriate biological terminology. (2 marks)
- Response shows limited organisation. (1 mark)
- No meaningful response. (0 marks)

Total: 20 Marks**Question 3 (Total: 30 Marks)****Accurate Description of the Products of Spermatogenesis and Oogenesis (10 marks)**

- Accurately identifies and describes the products of both spermatogenesis and oogenesis, including their chromosome number, structure and function. (9–10 marks)
- Correctly describes most features of both products with minor omissions. (7–8 marks)
- Gives a basic description of both products but lacks important details. (5–6 marks)
- Gives limited or partially correct descriptions. (2–4 marks)
- Gives very little or no relevant description. (0–1 mark)

Example:

Spermatogenesis produces four genetically distinct haploid sperm cells, each adapted for movement and fertilisation. Oogenesis produces one large functional haploid ovum and three polar bodies, which usually degenerate. The ovum contains abundant cytoplasm and nutrients to support early embryonic development.

Comparison and Contrast (6 marks)

- Clearly compares and contrasts the products of spermatogenesis and oogenesis with respect to number produced, size, structure, motility and function. (6 marks)
- Compares most characteristics with minor omissions. (4–5 marks)
- Gives a basic comparison of some characteristics. (2–3 marks)

- Gives very limited comparison. (1 mark)
- No relevant comparison. (0 marks)

Example:

Both sperm cells and ova are haploid gametes produced by meiosis. However, spermatogenesis produces four small, motile sperm cells, whereas oogenesis produces one large, non-motile ovum with abundant cytoplasm and three polar bodies.

Analysis and Critical Thinking (5 marks)

- Provides a well-reasoned explanation of how the differences between sperm and ova contribute to successful fertilisation and reproduction. (5 marks)
- Explains most aspects with adequate reasoning. (4 marks)
- Gives a basic explanation with limited analysis. (2–3 marks)
- Gives minimal explanation. (1 mark)
- No relevant explanation. (0 marks)

Example:

The production of many small, motile sperm increases the probability of fertilisation, while the large nutrient-rich ovum provides the resources needed to support the embryo during its early stages of development.

Real-World Applications (5 marks)

- Clearly explains the significance of these differences in relation to fertility, reproduction and reproductive health. (5 marks)
- Explains the significance with minor omissions. (4 marks)
- Gives a basic explanation. (2–3 marks)
- Gives limited explanation. (1 mark)
- No relevant explanation. (0 marks)

Example:

Understanding the differences between sperm and ova helps explain the causes of infertility, supports assisted reproductive technologies such as in vitro fertilisation (IVF), and informs reproductive health education and family planning.

Clarity and Organisation (4 marks)

- Response is well organised, logically presented and uses correct biological terminology throughout. (4 marks)
- Generally well organised with minor language or organisational errors. (3 marks)
- Some organisation but lacks clarity in places. (2 marks)
- Poorly organised with limited use of appropriate terminology. (1 mark)
- No meaningful response. (0 marks)

Total: 30 Marks

WEEK 20**Question 1**

Criteria	marks	Description
Completeness of Diagram	10	Diagram includes all major components of the pectoral girdle (clavicle, scapula, and associated joints).
Accuracy of Structure	10	Each part of the pectoral girdle is accurately represented in shape and proportion.
Annotations	15	- Clarity: Annotations are clear and legible. Annotations should be easy to read and well-placed, connecting directly to the relevant parts of the diagram. Functionality: Each part is described with its function. Each labelled structure should include a brief explanation of its role in the pectoral girdle, such as stabilisation, movement, or connection. - Detail: Includes additional features such as muscle attachments, blood vessels, or nerves when relevant.
Clarity and Neatness	5	The diagram is well-organised, neat, and visually appealing, making it easy to understand.
Total	40	

Question 2

- **Clarity of Explanation:** The response clearly explains the concept of muscle-bone interactions and their relevance to physical activities. 2 marks
- **Relevance to Physical Activities:** Provides at least two relevant examples demonstrating how this understanding enhances performance or safety in physical activities. 2 marks
- **Depth of Insight:** Shows a deeper understanding of the implications of muscle-bone interactions (e.g., injury prevention, improved performance). 1 mark

Question 3

- Clearly describes the curved and flexible nature of the ribs and its role in respiration. 2 marks
- Explains how the rib cage protects the heart, lungs, and other vital organs. 1 mark
- Identifies the ribs as attachment points for muscles, particularly those involved in respiration. 2marks
- Discusses how the ribs contribute to posture and stability in the upper body. 2 marks
- Describes the role of the ribs in the mechanics of breathing, including their impact on lung expansion. 3 marks

Total 10 marks

WEEK 21**Question 1****Hypothesis Formulation**

- Clear statement of primary hypothesis about hypothalamus disruption (1 mark)

- Specific prediction about effect on nervous system regulation (1 mark)
- Specific prediction about effect on hormonal system regulation (1 mark)
- Specific prediction about effect on body temperature regulation (1 mark)
- Logical connection between hypothalamus function and predicted outcomes (1 mark)

Experimental Design (6 marks) • Appropriate animal model or alternative method selection (1 mark)

- Clear independent and dependent variables identified (1 mark)
- Appropriate control groups specified (1 mark)
- Consideration of confounding variables (1 mark)
- Timeline for data collection justified (1 mark)
- Sample size and statistical approach outlined (1 mark)

Ethical Considerations (3 marks) • Discussion of specific ethical issues in hypothalamus research (1 mark)

- Proposed methods to minimize harm/suffering (1 mark)
- Justification for why the research benefits outweigh risks (1 mark)

Data Collection Methods (3 marks) • Specific techniques to measure nervous system function (1 mark)

- Specific techniques to measure hormonal system function (1 mark)
- Physiological parameters to monitor (e.g., temperature, metabolism) (1 mark)

Therapeutic Applications (3 marks) • Identification of specific medical conditions relevant to findings (1 mark)

- Explanation of how results could inform treatment approaches (1 mark)
- Discussion of limitations in translating to human applications (1 mark)

Question 2: Extreme Environment Adaptations (20 marks)

Nervous System Adaptations (5 marks) • Identification of specific nervous system adaptation (1 mark)

- Explanation of adaptation's physiological mechanism (1 mark)
- Connection to environmental challenge (e.g., temperature, pressure) (1 mark)
- Comparison with non-adapted mammals (1 mark)
- Example of specific mammalian species showing this adaptation (1 mark)

Hormonal System Adaptations (5 marks) • Identification of specific hormonal adaptation (1 mark)

- Explanation of how hormone levels/receptors are modified (1 mark)
- Connection to environmental challenge (e.g., water availability, hibernation) (1 mark)
- Metabolic consequences of the adaptation (1 mark)
- Example of specific mammalian species showing this adaptation (1 mark)

Sensory System Adaptations (5 marks) • Identification of specific sensory adaptation (1 mark)

- Structural modifications in the sensory organ (1 mark)
- Processing adaptations in the brain (1 mark)
- Behavioural advantages conferred by the adaptation (1 mark)

- Example of specific mammalian species showing this adaptation (1 mark)

Homeostasis Model (5 marks) • Clear illustration/description of system interactions (1 mark)

- Explanation of feedback mechanisms between systems (1 mark)
- Energy conservation strategies in the model (1 mark)
- Response to acute environmental changes (1 mark)
- Long-term adaptation mechanisms (1 mark)

Question 3: Nervous–Endocrine Disorder Treatment (20 marks)

Disorder Analysis (6 marks) • Accurate identification of a relevant disorder (1 mark)

- Primary nervous system components affected (1 mark)
- Primary endocrine system components affected (1 mark)
- Explanation of disrupted feedback mechanisms (1 mark)
- Symptoms resulting from nervous system dysfunction (1 mark)
- Symptoms resulting from hormonal imbalance (1 mark)

Traditional Treatment Approaches (5 marks) • Identification of standard pharmaceutical intervention (1 mark)

- Explanation of mechanism of action (1 mark)
- Identification of standard non-pharmaceutical approach (1 mark)
- Limitations of traditional treatments (1 mark)
- Evidence for effectiveness of traditional approaches (1 mark)

Innovative Treatment Strategies (5 marks) • Description of novel pharmaceutical or technological approach (1 mark)

- Scientific basis for the innovation (1 mark)
- Targeting of specific physiological mechanism (1 mark)
- Consideration of personalized medicine aspects (1 mark)
- Potential advantages over traditional approaches (1 mark)

Treatment Justification (4 marks) • Integration of traditional and innovative approaches (1 mark)

- Addressing both nervous and endocrine components (1 mark)
- Consideration of side effects and contraindications (1 mark)
- Long-term management strategy (1 mark)

WEEK 22 & 23

FOCAL AREA 1

Question 1: Investigation of Floral Structures Affecting Seed Production (20 marks)

Investigation Design

- Clear statement of aim (1 mark)
- Identification of floral structures to examine (e.g. anther, stigma, ovary) (1 mark)
- Description of method to compare flowers (e.g. count pollen, examine stigma for pollen grains) (1 mark)

- Mention of sample size or repeats (1 mark)
- Description of controls (e.g. same soil, water, sunlight) (1 mark)
- Suggestion of data recording method (e.g. table, chart) (1 mark)
- Plan for comparing seed numbers from different flowers (1 mark)
- Statement on how to handle or analyse data (e.g. calculate average seed set) (1 mark)

Interpretation and Application

- Link between floral structure and seed production (1 mark)
- Link between pollination type and seed production (1 mark)
- Statement on expected findings (e.g. flowers with more pollen on stigma produce more seeds) (1 mark)
- Suggestion for improving pollination (e.g. attract more pollinators) (1 mark)
- Suggestion for improving yield (e.g. selective breeding) (1 mark)
- Mention of limitation or possible error in the investigation (1 mark)

Application to Farming

- Explanation of how findings could inform better farming practices (2 marks)
- Example of local action the farmer could take (e.g. plant more pollinator-friendly crops nearby) (1 mark)
- Suggestion for improving crop management (e.g. timing of planting to match pollinator activity) (1 mark)
- Link to food security or local economy (2 marks)

Question 2: Investigate Self- and Cross-Pollination Success (20 marks)

Investigation Design (8 marks)

- Clear statement of aim (1 mark)
- Identification of local flowering plant species (1 mark)
- Description of method for self-pollination (1 mark)
- Description of method for cross-pollination (1 mark)
- Identification of variables to measure (e.g. fruit set, seed count) (1 mark)
- Description of control of conditions (e.g. same soil, water) (1 mark)
- Mention of sample size or repeats for reliability (1 mark)
- Description of data recording method (e.g. table, chart) (1 mark)

Data Analysis and Interpretation

- Suggestion of how to compare results (e.g. average seed number) (1 mark)
- Statement on expected outcome for self-pollination (1 mark)
- Statement on expected outcome for cross-pollination (1 mark)
- Link between genetic variation and cross-pollination (1 mark)
- Link between self-pollination and reduced diversity (1 mark)
- Identification of limitation or possible error (1 mark)

Application to Conservation

- Explanation of how data could inform plant conservation (2 marks)
- Example of a native species that could benefit (1 mark)
- Suggestion of a farming or ecological practice based on findings (1 mark)
- Connection to Ghanaian biodiversity preservation (2 marks)

Question 3: Double Fertilisation and Embryo Survival (20 marks)**Model/Diagram Accuracy (8 marks)**

- Correct path of pollen tube shown (1 mark)
- Entry of two male gametes labelled (1 mark)
- Fusion with egg cell shown (1 mark)
- Fusion with polar nuclei shown (1 mark)
- Zygote correctly labelled (1 mark)
- Endosperm nucleus correctly labelled (1 mark)
- Ovule or embryo sac labelled (1 mark)
- Ovary or ovule wall labelled (1 mark)

Functional Explanation

- Zygote forms embryo (1 mark)
- Endosperm nourishes embryo (1 mark)
- Advantage of double fertilisation for seed development (2 marks)
- Role in rapid seed development in tropical conditions (1 mark)
- Link to successful crop production in Ghana (1 mark)

Local Application

- Example of Ghanaian crop with double fertilisation (e.g. maize) (1 mark)
- Link to survival in poor soil or drought conditions (1 mark)
- Contribution to food security (1 mark)
- Link to yield or seed quality (1 mark)
- Suggestion for farmer practice (e.g. seed selection) (1 mark)
- Identification of risk if fertilisation fails (1 mark)

Question 4: Seed Dispersal Methods in Ghana (20 marks)**Dispersal Method Evaluation**

- Advantage of wind dispersal (1 mark)
- Disadvantage of wind dispersal (1 mark)
- Advantage of animal dispersal (1 mark)
- Disadvantage of animal dispersal (1 mark)
- Advantage of water dispersal (1 mark)
- Disadvantage of water dispersal (1 mark)
- Another advantage of any method (1 mark)
- Another disadvantage of any method (1 mark)
- Link between wind dispersal and savannah environment (1 mark)
- Link between animal dispersal and rainforest environment (1 mark)
- Link between water dispersal and riverine/coastal areas (1 mark)
- Reference to explosive dispersal and a relevant Ghanaian plant (1 mark)

Environmental Links and Judgement (8 marks)

- Comparative evaluation: which method suits savannah best (2 marks)
- Comparative evaluation: which method suits rainforest best (2 marks)
- Impact on plant distribution in Ghana (1 mark)
- Impact on competition reduction (1 mark)
- Suggestion of how dispersal helps in land restoration (1 mark)
- A potential limitation of dispersal method for farming (1 mark)

Question 5: Crop Production Plan Using Sexual and Asexual Reproduction (20 marks)

Method Selection and Justification (12 marks)

- Identification of asexual method (1 mark)
- Example of crop suitable for asexual method (1 mark)
- Identification of sexual method (1 mark)
- Example of crop suitable for sexual method (1 mark)
- Climatic reason for choosing asexual method (1 mark)
- Climatic reason for choosing sexual method (1 mark)
- Soil condition linked to asexual method (1 mark)
- Soil condition linked to sexual method (1 mark)
- Link to local farming practice (1 mark)
- Stated advantage of combining both methods (1 mark)
- Additional advantage of either method (1 mark)
- Mention of a traditional or cultural farming practice supporting choice (1 mark)

Challenges and Solutions (8 marks)

- Identification of challenge for asexual method (1 mark)
- Solution to challenge for asexual method (1 mark)
- Identification of challenge for sexual method (1 mark)
- Solution to challenge for sexual method (1 mark)
- Environmental risk considered (e.g. pests) (1 mark)
- Strategy to minimise risk (1 mark)
- Link to sustainable farming (2 marks)

FOCAL AREA 2

Question 1: Hibiscus Diagram, Floral Formula, and Function (20 marks)

Diagram and Labelling

- Clear, accurate diagram of hibiscus flower (2 marks)
- Correct labelling of sepals (1 mark)
- Correct labelling of petals (1 mark)
- Correct labelling of stamens (1 mark)
- Correct labelling of carpel parts (stigma, style, ovary) (2 marks)
- Label of ovules or pollen grains (1 mark)

Floral Formula (4 marks)

- Correct use of symbols (e.g. $\oplus$, K, C, A, G) (1 mark)
- Correct numbers in the formula (1 mark)
- Indication of superior ovary (1 mark)
- Indication of bisexual flower (1 mark)

Functional Explanation and Local Link

- Explanation of role of stigma in pollen reception (1 mark)
- Explanation of role of anther in pollen production (1 mark)
- Explanation of ovary function (1 mark)
- Link between bright petals and attraction of pollinators (1 mark)
- Link between hibiscus features and success in local environment (2 marks)
- Mention of relevance to local farming or gardens (1 mark)
- Explanation of how floral structure supports reproduction success (2 marks)

Question 2: Pollinator Observation Plan and Biodiversity Link (20 marks)**Plan Design**

- Clear aim of study stated (1 mark)
- Suggestion of what to observe (e.g. insects visiting flowers, time of visit) (1 mark)
- Suggestion of how to record data (e.g. tally of insect visits) (1 mark)
- Suggestion of simple experiment (e.g. cover flowers with mesh and compare seed set) (2 marks)
- Mention of repeat observations (1 mark)
- Control of conditions (e.g. same type of plant, time of day) (1 mark)
- Statement of how results will be compared (1 mark)

Data Interpretation

- Link between insect visits and seed or fruit production (1 mark)
- Statement on expected outcome if insects excluded (1 mark)
- Explanation of how data could show pollinator dependence (2 marks)
- Mention of possible error or limitation (1 mark)
- Suggestion of how to improve accuracy (1 mark)

Conservation Link

- Explanation of how findings could inform conservation (2 marks)
- Example of how biodiversity could be supported locally (e.g. planting flowering hedgerows) (1 mark)
- Link to local ecosystem health (1 mark)
- Suggestion for community action (1 mark)
- Link to importance of pollinators for food security (1 mark)

Question 3: Plant Proposal for Land Restoration (20 marks)**Plant Choice and Reproductive Role (10 marks)**

- Identification of a plant for human food (e.g. maize, okra) (1 mark)
- Identification of a plant supporting animals (e.g. mango, palm) (1 mark)
- Statement of how sexual reproduction contributes (e.g. seed dispersal) (2 marks)
- Statement of how asexual reproduction might help (e.g. rapid ground cover) (2 marks)
- Description of reproductive parts key to seed formation (e.g. ovary forms fruit) (1 mark)
- Description of role of stamens in seed formation (1 mark)
- Link to dispersal aiding land cover (1 mark)
- Link to plant survival in poor soils (1 mark)

Ecosystem and Community Link (10 marks)

- Statement of how plants support animals (1 mark)
- Link to soil improvement (e.g., leaf litter, roots) (1 mark)
- Link to preventing erosion (1 mark)
- Suggestion for community involvement (1 mark)
- Link to local food security (1 mark)
- Suggestion of a challenge (e.g. pests, drought) (1 mark)
- Suggestion of a solution (1 mark)
- Link to sustainable farming (2 marks)
- Link to biodiversity preservation (1 mark)

WEEK 24**Question 1: Investigation of Bark Peeling as Excretion (20 marks)****Investigation Design (10 marks)**

- Clear statement of aim (1 mark)
- Identification of waste materials possibly stored in bark (e.g. resins, tannins, gums) (1 mark)
- Description of how to observe and record bark peeling (e.g. note area, frequency) (1 mark)
- Suggestion to compare with younger trees or trees without peeling bark (1 mark)
- Description of how to collect samples safely (1 mark)
- Plan to note other visible signs (e.g. gum or resin at peeling sites) (1 mark)
- Suggestion to observe other excretory structures like lenticels (1 mark)
- Mention of data recording method (e.g. table, sketches, photos) (1 mark)
- Suggestion of repeats or sample size (1 mark)
- Statement of how findings will be analysed (e.g. compare amount of bark loss to gum production) (1 mark)

Interpretation and Application (10 marks)

- Link between bark peeling and removal of stored wastes (2 marks)
- Explanation of how the process may protect the tree (1 mark)
- Suggestion of how the data might show differences between trees (1 mark)
- Link between excretion and plant health (1 mark)
- Link to environmental conditions (e.g. dry season may increase gum excretion) (1 mark)
- Possible limitation of investigation (1 mark)
- Suggestion of how to address limitation (1 mark)
- Link to usefulness for farming or forestry (2 marks)

Question 2: Argument about Aquatic Plant Stomata (20 marks)**Development of Argument (10 marks)**

- Clear statement of position (supporting or challenging the claim) (1 mark)
- Explanation that some aquatic plants still have stomata on floating leaves (1 mark)
- Example of aquatic plant with stomata (e.g. water lily) (1 mark)
- Explanation that submerged plants may rely on diffusion through body surface (1 mark)
- Statement on role of stomata in gas exchange beyond waste removal (1 mark)
- Explanation that stomata help balance oxygen and carbon dioxide in photosynthesis and respiration (1 mark)
- Link between habitat type (floating/submerged) and stomatal presence (2 marks)
- Mention of any environmental factor affecting stomatal function (e.g. water pollution) (1 mark)
- Statement about the role of lenticels in aquatic stems (1 mark)

Use of Evidence and Examples (10 marks)

- Inclusion of evidence from plant structure (1 mark)
- Inclusion of evidence from waste type (e.g. gas exchange) (1 mark)
- Example of aquatic plant waste removal process (1 mark)
- Statement on importance of diffusion in water plants (1 mark)
- Connection to adaptation to habitat (1 mark)
- Link to survival and efficiency of excretion (2 marks)
- Reference to plant health or growth (1 mark)
- Mention of possible disadvantage if stomata were absent (1 mark)
- Conclusion that links argument clearly to plant function (1 mark)

Question 3: Proposal for Trees Producing Useful Waste Products (20 marks)**Species Selection and Justification (10 marks)**

- Identification of first suitable tree species (e.g. acacia) (1 mark)
- Identification of second suitable tree species (e.g. rubber tree) (1 mark)
- Explanation of gum or resin production in first species (1 mark)
- Explanation of latex or resin production in second species (1 mark)
- Description of how waste is excreted (e.g. through cracks, wounds) (2 marks)
- Link between gum or resin and plant protection (1 mark)
- Link to use by humans (e.g. gum arabic, rubber tapping) (1 mark)
- Explanation of where waste is stored before excretion (1 mark)
- Mention of how the farmer could harvest it (1 mark)

Link to Benefits and Ecosystem (10 marks)

- Description of how waste products protect plant from pests (1 mark)
- Description of how waste products seal wounds (1 mark)
- Link to economic benefit for farmer (2 marks)
- Link to sustainability (1 mark)
- Link to biodiversity support (1 mark)
- Mention of challenge in harvesting (1 mark)
- Suggestion of solution to challenge (1 mark)
- Link to local environmental conditions (e.g. drought-resistant species) (1 mark)
- Statement on long-term value to community (1 mark)

Question 4: Tree Planting Plan for Erosion Control (20 marks)**Plant Choice and Excretory Link (10 marks)**

- Identification of suitable tree type (e.g. mangrove, neem) (1 mark)
- Link between stomata and transpiration supporting local water cycle (1 mark)
- Link between lenticels and gas exchange helping tree survival (1 mark)
- Explanation that leaf fall removes stored waste and enriches soil (2 marks)
- Explanation of how tree roots stabilise soil (1 mark)
- Link between transpiration and cooling local environment (1 mark)
- Suggestion of spacing or planting pattern (1 mark)
- Mention of how waste products (e.g. gums, tannins) deter pests (1 mark)
- Link between excretion and tree health (1 mark)

Ecosystem and Community Link (10 marks)

- Explanation of how plants support animal life (1 mark)
- Link between tree planting and reduction of erosion (2 marks)
- Link to long-term soil improvement (1 mark)
- Suggestion for community involvement in planting (1 mark)
- Mention of a possible risk (e.g. over-harvesting of tree products) (1 mark)
- Suggestion of how to manage risk (1 mark)
- Link to food security or livelihood (2 marks)
- Statement on contribution to biodiversity (1 mark)

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