MINISTRY OF EDUCATION

General Science

TEACHER MANUAL

YEAR 1 - BOOK 1

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

MINISTRY OF EDUCATION

REPUBLIC OF GHANA

General Science

Teacher Manual

Year One - Book One

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GENERAL SCIENCE TEACHER MANUAL

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INTRODUCTION

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

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

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

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

Learner-Centred Curriculum

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

Promoting Ghanaian Values

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

Integrating 21st Century Skills and Competencies

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

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

Balanced Approach to Assessment - not just Final External Examinations

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

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

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

An Inclusive and Responsive Curriculum

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

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

Social and Emotional Learning

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

Philosophy and vision for each subject

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

Philosophy: The next generation of learners can be empowered to acquire scientific knowledge and develop science process skills in scientific concepts through 21**st** Century Skills and Competencies that create opportunities that leverage practical activities in a learner-centred environment to make Science functional, leading to Global relevance.

Vision: A learner equipped with scientific knowledge through 21st Century Skills and Competencies who understands and applies scientific principles, solving daily scientific problems in an increasingly complex society.

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SCOPE AND SEQUENCE

General Science Summary

S/N	STRAND	SUB-STRAND	YEAR 1			YEAR 2			YEAR 3		
			CS	LO	LI	CS	LO	LI	CS	LO	LI
1	Exploring Materials	Science and Materials in Nature	2	2	6	1	1	3	2	2	4
2	Processes For Living	Essentials for Survival	2	3	5	2	2	6	2	2	6
3	Vigour Behind Life	Powering the future with energy forms	1	1	2	1	1	2	1	1	2
		Forces acting on substances and mechanisms	1	1	2	1	1	1	1	1	2
		Consumer Electronics	1	1	1	1	1	2	1	1	2
4	Relationships With The Environment	The Human Body and Health	3	3	3	1	1	2	2	2	4
		Technology in our Local Industries	2	2	3	1	1	2	1	1	1
TOTAL			**12**	**13**	**22**	**8**	**8**	**18**	**10**	**10**	**21**

Overall Totals (SHS 1 – 3)

Content Standards (CS)	**30**
Learning Outcomes (LO)	**31**
Learning Indicators (LI)	**61**

SECTION 1: THE CHARACTERISTICS OF SCIENCE

Strand: **Exploring Materials**

Sub-Strand: Science and Materials in Nature

Learning Outcome: *Evaluate the Characteristics of Science*

Content Standard: Demonstrate knowledge and understanding of the characteristics of science and show how they are applied in everyday life.

INTRODUCTION AND SECTION SUMMARY

This section focuses on providing learners with an understanding of the characteristics of science. Empiricism, objectivity, repeatability, and falsifiability are some of science's defining characteristics and are the foundation of the scientific process. By integrating this knowledge into project design, teachers can facilitate hands-on experiments, critical thinking, and evidence-based conclusions. Encouraging learners to create their experiments fosters curiosity and helps them acquire critical thinking abilities. Crucially, the characteristics of science are not limited to the science domain and have connections to various areas of study. Social studies offer context, Mathematics helps with data analysis, Language skills facilitate communication, and creativity is fostered by art and design. Teachers can design a comprehensive, interdisciplinary learning method that promotes students' critical thinking, problem-solving, and lifelong-learning skills by fusing the characteristics of Science with other disciplines.

The weeks covered by the section are:

- **Week 1**: Explain the characteristics of science in nature.
- **Week 2**: Design projects using the characteristics of science.
- **Week 3**: Apply the characteristics of science where appropriate.

SUMMARY OF PEDAGOGICAL EXEMPLARS

Pedagogical exemplars focusing on the characteristics of science aim to engage learners in critical thinking and practical application. To effectively teach this topic, teachers should encourage learners to reflect on the importance of science and discuss their ideas with peers thus promoting collaborative learning. Learners should then present their thoughts to the class, improving their communication skills.

Teachers should use appropriate teaching and learning resources and put learners in mixed-ability groups to discuss and explore the characteristics of science, emphasizing their meaning, significance, and real-life applications. Learners should engage in hands-on experiments to demonstrate characteristics like tentativeness, predictability, replication, and empiricism. These activities help learners grasp the practical implications of the characteristics of science.

Assessment should focus on learners' ability to articulate and apply the characteristics of science. Learners should be evaluated on their participation in discussions, performance in experiments, and poster creation, thus displaying their knowledge of the key scientific characteristics.

To cater to gifted and talented students, additional content could include more complex experiments, in-depth analysis of scientific theories, and opportunities for independent research projects to deepen their understanding and challenge their abilities.

ASSESSMENT SUMMARY

This section focuses on DoK Level 3: Formative and Summative Assessment. Formative assessment will include activities such as laboratory and practical work where the specific characteristics of science are demonstrated to enhance the science process skills of learners. Short tests, class exercises, assignments, group discussions, project work, and group presentations are incorporated. A record should be kept of progress for this range of formative assessments for all learners. Summative assessment should be done at the end of the lesson, section, and end of the semester. Refer to the Teacher Assessment Manual and Toolkits for more details as to how to assess learners. Both formative and summative assessments contribute to the cumulative records of the learners.

Week One

Learning Indicator(s): *Explain the characteristics of Science in nature.*

Theme or Focal Area: Characteristics of science in nature

Overview of Science

Science is the observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena to widen our understanding of nature and solve problems.

Some reasons why Science is important include;

- Science enhances global understanding - covering subatomic particles to huge structures.
- Scientific innovations like computers, satellites, x-rays, and cell phones have proven invaluable.
- Research boosts health, yielding medications, vaccinations, and therapies - extending lifespans and simplifying lives.
- Scientific advancements drive diverse transportation modes: automobiles, aircraft, ships, and space exploration.

Characteristics of Science and Their Meaning

Reproducibility: This means that the results of an experiment or study can be repeated by other scientists following the same methods and procedures.

Observation: Science in nature relies on careful observation of the natural world. Scientists keenly observe phenomena, organisms, and processes to gather data.

Empirical Evidence: This means information gained is through direct observation and measurement.

Precision: This is the degree of consistency and reproducibility. Precise scientific measurements consistently produce similar results over multiple trials with minimal deviation, error, or uncertainty.

Accuracy: This is the correctness or truthfulness of scientific information or measurements. When scientific findings are accurate, they reflect the true nature of the phenomenon under study, with minimal errors, bias, or distortion.

Validity: This is how well an experiment or study measures what it claims to measure. It refers to the scientific method and the conclusions that can be drawn.

Consistency: This is the ability of scientific findings to be reliable and repeatable over time. Consistency means that other scientists can replicate experimental results using the same methods and procedures and that the findings are consistent with what is already known about the phenomenon being studied.

Tentative: This means that scientific knowledge and understanding are not fixed or absolute but are subject to change and revision as new evidence, data, and insights emerge.

Verifiability: This means knowledge is based on concrete and factual data that can be tested.

Objective: This simple science relies on empirical evidence to understand natural phenomena, not prejudice, beliefs, culture, etc.

Methodical: This means scientific data/knowledge is collected (acquired) by following a step-by-step approach.

Cumulative: This means that knowledge and understanding build up over time as new discoveries are made and added to what is already known.

Replication: This means that scientific experiments are replicated several times to ensure the results are similar when identical procedures are used. Replication is necessary to allow chance results to be excluded.

Predictions: Scientists use patterns observed in nature to predict future events. These predictions are based on a logical interpretation of collected data.

Demonstration of Characteristics of Science

Experiment to show that Science is empirical.

Title: Determining the Boiling Point of Water.

Aim: To verify whether the boiling point of water remains constant at sea level.

Hypothesis: The boiling point of water at sea level is 100 degrees Celsius (°C).

Materials: Heat source (*e.g.,* Bunsen burner or electric stove), a metal pot or beaker, thermometer, water, stopwatch, or timer.

Procedure

i. Fill the beaker (or metal pot) with a fixed amount of water (*e.g.*, 500 ml). Insert the thermometer into the water without touching the bottom of the beaker – a clamp stand can be used to hold the thermometer above the beaker's bottom.

ii. Place the beaker on the heat source.

iii. Gradually increase the heat and monitor the temperature using the thermometer.

iv. When the water boils, note the temperature and start the timer

v. Continue boiling the water and monitor the temperature every 30 seconds for five minutes.

NB: Use a table to record your results and repeat the experiment to insure the reliability of results.

Expected Results: According to the hypothesis, the boiling point of water at sea level is expected to be 100°C. Therefore, during the experiment, we should observe that the water boils at or near this temperature and remains constant if it continues to boil.

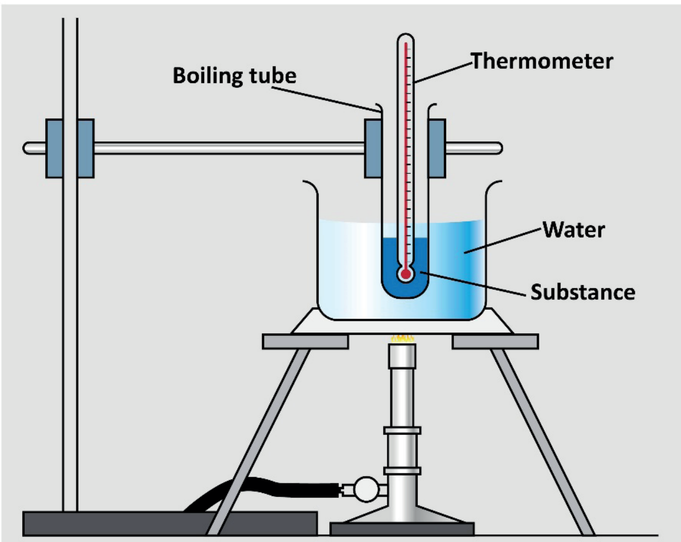

Fig 1.1: *Boiling point of water*

Conclusion: We can conclude that the boiling point of water at sea level remains constant at or near 100°C. This allows us to accept our hypothesis. As the results are collected scientifically and agree with our hypothesis, we have demonstrated the use of empirical measurement in the testing and confirmation of the scientific hypothesis as fact.

Note that some pupils may measure the boiling point consistently above or below 100; this can be explained using the term *accuracy*. School thermometers may have a precision of around plus or minus 1°C.

Experiment to show that Science is replicable.

Title: Simple experiments should be replicable.

Aim: To conduct a simple experiment involving a pendulum to demonstrate that scientific results should be replicable if the same methods are used, and variables are kept uniform.

Materials: A sturdy string or thread, a small weight (e.g., a metal ball or a stone), a ruler or measuring tape, a stopwatch or timer, and a stable point to hang the pendulum (e.g., a hook or a sturdy table edge).

Procedure:

- **i.** Attach the weight to one end of the string securely.
- **ii.** Hang the other end of the string from the stable point.
- **iii.** Measure and record the pendulum's initial length: use the ruler or measuring tape to measure the pendulum's length (from the point of suspension to the centre of the weight).
- **iv.** Hold the pendulum a measured and fixed distance away from its resting position and release it from this same starting point each time.
- **v.** Time the pendulum swinging to and fro ten times using the stopwatch or timer.
- **vi.** Record the time taken for the swings.
- **vii.** Repeat the experiment three times and compare the times taken for ten swings.

Analyse the data:

- **i.** Compare the results for each repeat of the experiment.
- **ii.** How variable are the results from the three repeats of the experiment?
- **iii.** Are the results the same? If not, what reasons could there be to account for the variability?
- **iv.** Does changing the length of the string change the time taken for 10 swings to and fro?

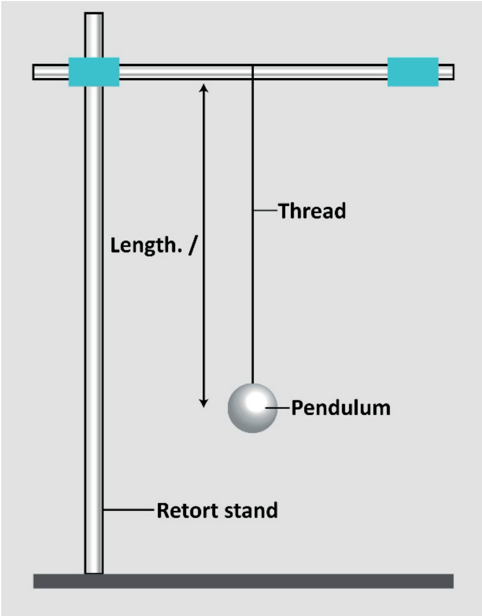

Fig. 1.2: *Replication on simple Pendulum*

Conclusion: Students should conclude that the time taken for ten swings to and fro should be very similar for the three repeats of the experiment as long as the length of the string and the point of release are kept uniform. Thus, properly designed and executed experiments are *replicable.*

Any small variability in the results will be down to errors of timing or small inconsistencies in the height of release of the experiment. Increasing the length of the pendulum string should increase the time taken for 10 swings.

Experiment to show that Science is methodical.

Title: Investigating the presence of starch in plants.

Aim: Test the presence of starch

Materials: Test tubes, test-tube stand, test-tube holder, electric kettle dropper, filter paper, iodine solution, distilled water, leaf.

Procedure:

- **i.** Gather leaves from plants exposed to sunlight for testing
- **ii.** Pour boiling water from the electric kettle into a large beaker.
- **iii.** Using forceps, immerse a leaf in the hot water for approximately three minutes.
- **iv.** Remove the leaf from the boiling water with forceps and observe any changes.
- **v.** Transfer the leaf to a labelled boiling tube, pushing it to the bottom with a glass rod.
- **vi.** Fill the boiling tube halfway with ethanol and place it in a beaker of boiling water for a hot water bath. Observe as the ethanol boils and the green chlorophyll colour is extracted from the leaf, which may take a few minutes.
- **vii.** If green colour remains after 5 minutes, replace the hot water with freshly boiled water.
- **viii.** Remove the leaf from the boiling tube using forceps, rinse it under cold water, and gently wash it with tap water.
- **ix.** Place the leaf in a petri dish on a white tile and add iodine solution, ensuring complete coverage.

Observation: Observe for a few minutes for the development of a blue-black colour indicating the presence of starch.

Conclusion: the experiment is usually failsafe and should yield consistent results (presence of starch) if the procedures are followed in a methodical manner.

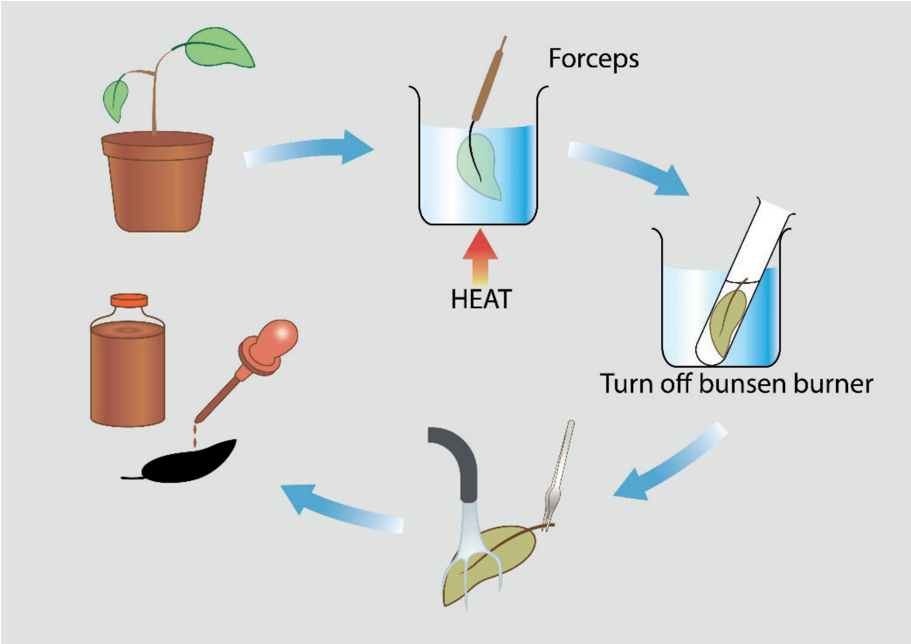

Fig 1.3: *Plant leaf contain starch*

Safety:

- Keep ethanol away from open flames to prevent accidents.
- Students must wear eye protection while handling ethanol or iodine solution.
- Exercise caution when dealing with hot liquids to avoid burns.
- Note that plant sap may cause skin irritation, so handle it with care.

Learning Task

1. Write at least three situations in life where characteristics of science are evident.
2. Identify at least four characteristics of science in nature.
3. Explain at least four characteristics of science in nature.

Pedagogical Exemplars

Collaborative learning:

1. Learners think about the importance of science and discuss their ideas with a peer. The teacher asks learners to present their ideas to the whole class. The teacher presents videos, charts, pictures, and demonstrations on the characteristics of science to learners and learners in mixed-ability groups discuss the characteristics of science, considering the meaning, importance, and real-life applications.
2. Learners in mixed ability groups perform an experiment as shown in fig. 1, 2, 3 to demonstrate the characteristics of science such as *replicability*, *predictability* (the ability of scientific

investigations to make accurate and reliable predictions about future events), empirical (relies on observations and data gathered).

3. Learners reflect and share their views of different situations in life where the characteristics of science are evident with peers for critique.
4. Group learners create a poster showing the key characteristics of science/definitions, significance, and application in daily life for a whole class gallery walk and presentation.

Key Assessment

Assessment Level 1: Identify at least four (4) characteristics of science.

Assessment Level 2: Explain four (4) characteristics of science.

Assessment Level 2: Explain at least any four (4) characteristics of science in everyday life.

Assessment Level 2: Explain the need to study the characteristics of science.

Assessment Level 2: Describe how the scientific processes can be used to make predictions.

Week Two

Learning Indicator: *Design projects using the characteristics of science.*

Theme or Focal Area(s): Designing projects using the characteristics of science.

Overview

A scientific project design is a systematic research or investigation plan that outlines the objectives, methods, procedures, and expected outcomes of a particular study or experiment.

A. Real-world example of a design project

Title: Investigating the effects of different fertilizers on plant growth.

Aim: To apply the characteristics of science to investigate the effects of different fertilizers on plant growth.

Methods

i. Select sixty (60) seedlings of the same plant species (e.g., tomato plants), all the seedlings must be of similar age.

ii. Divide them into three equal groups.

iii. Plant the seedlings into the soil.

iv. Assign each group a different fertilizer treatment. For example, Group One could receive a commercial chemical fertilizer (NPK) of $20cm^3$, Group Two - an organic fertilizer of about 1kg (equivalent to $20cm^3$ of chemical fertilizer) and Group Three - control group with no fertilizer.

NB: Ensure all groups receive the same environmental conditions e.g., light, temperature, water.

Observe: Observe, measure, and record the plants' height and number of leaves at regular intervals of three days over a set period (e.g., six weeks).

Sample table.

Day	Group One		Group Two		Group Three	
	Mean Height	Mean number of leaves	Mean Height	Mean number of leaves	Mean Height	Mean number of leaves
0						
3						
6						
9						
12						
15						

Analysis and discussion: Analyse the collected data using simple statistical methods (for example, plot average values against time on a line graph with a different line for each treatment) to compare plant growth patterns across different fertilizer treatments.

Conclusion: Draw conclusions based on the results obtained considering the effects of different fertilizers on plant growth and any significant differences observed.

NB: By designing and conducting this project, students can gain hands-on experience applying the characteristics of science and developing their skills in experimental design, data collection, analysis, and critical thinking.

A key critical point is the experimental validity – can 1kg of organic fertilizer be considered equivalent to 20cm^3 of chemical NPK fertilizer?

Examples of characteristics of Science applied in the above project.

1. **Empirical:** The project will involve conducting experiments and collecting empirical data by observing and measuring the growth of plants.
2. **Objective:** The project will follow standardised methods of experimentation to minimize bias and subjectivity. Care will be taken to ensure accurate and unbiased measurements and observations.
3. **Verifiable:** The project will formulate testable hypotheses regarding the effects of different fertilizers on plant growth. The results obtained will help determine if the hypothesis is supported or not.
4. **Replicable:** The experimental set-up and procedures will be documented to enable other researchers to replicate the study and verify the findings. The project will provide detailed instructions and guidelines for replicating the experiment.
5. **Cumulative:** The project will contribute to the cumulative body of scientific knowledge by adding new data and insights to the current understanding of the effects of fertilizers on plant growth.
6. **Tentative:** The project recognises that scientific knowledge is tentative and subject to revision. The findings will be interpreted within the context of current understanding and may lead to modifying or refining existing theories or practices.
7. **Predictive:** The project will analyse the data collected to predict the effects of different fertilizers on plant growth. These predictions can serve as a basis for further experimentation or practical applications in agriculture.

B. Real-world example of a design project

Title: Relationship between the period of a pendulum and its length.

Aim: To investigate the relationship between the period of a pendulum and its length.

Materials: string, weight (such as a metal nut or a small ball), stopwatch or timer, ruler or measuring tape

Procedure:

i. Tie the weight to one end of the string.
ii. Attach the other end of the string to a fixed point (such as a retort stand or hook).
iii. Measure the length of the string from the fixed point to the center of the weight.
iv. Pull the weight aside to a fixed angle (such as 45^o and release it allowing it to swing freely.
v. Start the stopwatch or timer as soon as you release the weight.
vi. Record the period of the pendulum (time for one complete swing).
vii. Repeat the experiment for different lengths of string, keeping other variables constant such as the angle of release and the mass of the weight.

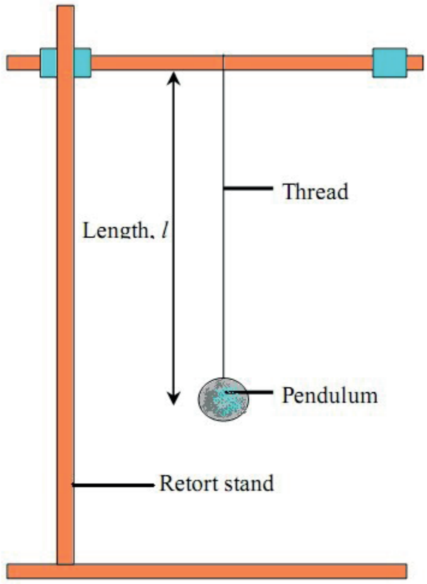

Fig. 1.4: *Investigating the relationship between the period of a simple pendulum and its length*

Analysis: Plot a graph with the length of the pendulum on the x-axis and the period of the pendulum on the y-axis. Analyze the relationship between the length and period of the pendulum. It should be concluded that as the length increases, the period also increases.

Examples of Characteristics of Science Applied in the above project.

1. **Empirical Evidence:** The experiment relies on direct observation and measurement of the relationship between pendulum length and period.
2. **Systematic Observation:** The experiment follows a systematic procedure, changing one variable (length) while keeping others constant to observe its effect.
3. **Predictive Power:** By analyzing the relationship, you can predict how changing the length of the pendulum will affect its period.
4. **Objectivity:** by ensuring the mass of the weight used is constant, the type and length of string is kept constant and there is an agreed protocol for measuring the length of the period of the pendulum, bias is removed, and the experiment can be considered objective.
5. **Testability:** The hypothesis that the period of a pendulum depends on its length is testable through experimentation. By conducting this experiment and analysing its results, you can gain a deeper understanding of the characteristics of science within the realm of physics.

C. Real-world example of a design project

Title: Investigating acid-base properties using hibiscus flower juice indicator

Aim: To demonstrate the scientific method by investigating the acid-base properties of various substances using red cabbage indicator.

Materials: Hibiscus flower leaves, distilled water, blender, strainer, various substances to test vinegar, lemon juice, baking soda, soap, etc.), test tubes, pipettes, pH strips or pH meter.

Procedure

i. Chop up a few hibiscus flowers leaves into small pieces.
ii. Blend the hibiscus flowers with distilled water until a smooth mixture is obtained.
iii. Strain the mixture to obtain the hibiscus flower juice which will serve as the indicator.
iv. Pour a small amount of the hibiscus flower indicator into each test tube.

v. Label each test tube with the substance to be tested.

vi. Add a small amount of each substance to the appropriate test tube with the indicator using a clean pipette.

vii. Observe any colour changes.

viii. Compare the colour changes to known pH values (measured using the pH paper).

NB Red cabbage leaves can be used if hibiscus flowers are not available. See https://edu.rsc.org/experiments/making-a-ph-indicator-using-red-cabbage/422.article

Data Collection and Analysis

i. Record the colour changes observed for each substance.

ii. Determine whether each substance tested is acidic, basic, or neutral based on the colour changes observed. Use pH paper to help.

iii. Discuss any limitations of the experiment and potential sources of error.

Results

- Vinegar and lemon juice should turn the indicator red/pink indicating acidity.
- Baking soda should turn the indicator green/blue indicating alkalinity.
- Soap may not show a significant colour change indicating neutrality or a slight change.

Conclusion: Using the hibiscus flower indicator, the experiment demonstrated the acid-base properties of various substances. The results align with established scientific principles regarding pH and acid-base reactions.

Note: Ensure safety precautions are followed, and proper disposal methods are employed for any chemical waste generated during the experiment.

Examples of Characteristics of Science Applied in the above project.

1. **Empirical Evidence:** The experiment relies on observable phenomena (colour changes) to conclude the acid-base properties of substances.
2. **Systematic Observation:** The experiment systematically tests various substances using a standardised indicator (red cabbage juice), allowing for consistent and comparable observations.
3. **Reproducibility:** The experiment can be repeated by others using the same materials and procedures leading to comparable results.
4. **Predictive Power:** Based on established scientific principles of acid-base chemistry, the experiment allows predictions about how different substances will react with the indicator, leading to specific colour changes.
5. **Objectivity:** The interpretation of results is based on objective observations of colour changes rather than subjective opinions or biases.
6. **Hypothesis Testing**: The experiment tests hypotheses about the acid-base properties of substances, such as whether a substance is acidic, basic, or neutral, based on the observed colour changes.

Learning Tasks

1. Identify three steps involved in designing science projects.
2. Describe how to design science-based projects using the characteristics of science.
3. Give an example of designing science-based projects where the characteristics of science can be identified.

Pedagogical exemplars

1. Provide videos, charts, diagrams, and pictures for learners on designing science-based projects using the characteristics of science in nature.
2. In mixed-ability groups, learners discuss the step-by-step science characteristics used in videos, charts, diagrams, and pictures to design the project.
3. Demonstrate how the characteristics of science (empiricism, systematic observation, objectivity, tentativity) are used in designing a project for the learners.
4. In mixed-ability groups, provide hands-on experimentation for learners on characteristics of science. Allow learners to explain the characteristics of science demonstrated in the experiment. For example, an experiment to show the empirical nature of science.
5. Learners present their findings from the experiment to the class for peer review or critique. Encourage learners to seek feedback from peers and teachers, iterate on their designs, and reflect on the iterative design process to enhance learning outcomes.

Key assessment

Assessment Level 2: Describe the characteristics of science when designing a scientific project.

Assessment Level 3: Identify three characteristics of science and discuss how each can enhance the effectiveness of a scientific project's design.

Assessment Level 3: Explain the role of empirical evidence in design.

Assessment Level 4: Why is gathering and analysing data during the design process essential? Provide examples of how empirical evidence can influence design decisions.

Week 3

Learning Indicator: *Apply the characteristics of science where appropriate.*

Theme or Focal Area(s): Application of the characteristics of science where appropriate.

The characteristics of science can be applied in the following areas:

1. Agriculture
2. Health
3. Industry
4. Education
5. Domestic Home
6. School

Agriculture

Real-world example 1: Crop breeding relies on empirical observations and data collection. Plant breeders observe and analyse the characteristics of different crop varieties, including their growth patterns, yield potential, resistance to pests and diseases, and nutritional qualities. These observations help in identifying desirable traits and understanding the genetic basis of these traits.

Fig. 1.5: *Crop breeding of seedlings*

Real-world example 2: Science emphasizes the collection of accurate and reliable data. For instance, in fertilizer application, scientists collect data on plant growth, nutrient content, soil characteristics, and environmental conditions. This data is then analysed to gain insights into the effectiveness of different fertilizers and optimise their application strategies for maximum crop productivity.

Real-world example 3: Scientific experimentation is vital in agricultural and animal production research. Controlled experiments are conducted to test hypotheses, evaluate the effectiveness of different techniques, and study the impact of many factors on crop yields and animal health. Data collected during these experiments are analysed to make evidence-based recommendations.

Domestic Home

Real-world example*:* Cooking can be considered a form of applied science to transform raw ingredients into delicious and nutritious meals. Here are some characteristics of science that apply to cooking:

1. **Observation**: Observation is an important part of cooking as it helps to identify the quality of ingredients, texture, colour, aroma, and other characteristics. Observations help to decide how long to cook, what temperature to cook and which ingredients to use for the best outcome.
2. **Hypothesis Testing**: Cooking involves testing hypotheses. For example, if you try using a different spice, you can hypothesise that the dish will get a new flavour. Through hypothesis testing, cooking can help to discover new recipes or improve old ones.
3. **Accuracy**: Accurately measuring ingredients is necessary to achieve the desired taste and texture in cooking. Using precise weights and measures is essential in following recipes and creating consistent results.
4. **Replication**: In cooking, replication is important, especially in commercial kitchens where consistency is required. Through scientific processes, recipes can be replicated with minimal variation, leading to consistent meals.
5. **Experimentation**: Cooking involves experimenting with different ingredients, cooking methods, and recipes to create or improve existing dishes. Experimentation is also useful in finding solutions to problems that may arise during cooking.

Education

1. **Observation**: It plays a vital role in education, akin to its significance in science. Teachers can observe their students' performance, behaviours, and learning preferences to pinpoint areas of strength and weakness. This valuable information enables educators to customise their teaching approaches to suit the individual needs of each student.
2. **Hypothesis testing**: In education, teachers can create hypotheses about how a particular lesson or teaching method will impact student learning. Through hypothesis testing, teachers can determine what works best for their students and adjust their teaching methods to improve student learning outcomes.
3. **Accuracy**: Accuracy is essential in education, as educators must provide accurate information to their students. They must be precise when grading assignments, giving feedback, and communicating with parents to ensure authentic assessment of student progress.
4. **Objectivity***:* Objectivity is crucial in education as it ensures consistency and fairness in grading and assessment. Teachers often use rubrics to assess student work to ensure that assignments are graded consistently across all students.
5. **Experimentation**: Teachers can experiment with different teaching and assessment methods to find the most effective strategies for their students. They can also try new technologies or instructional methods to enhance student learning.

Health

1. **Empiricism**: Medicine relies on empirical evidence obtained through observation and experimentation. Scientific methods such as clinical trials and laboratory research are used to gather data and test hypotheses. Medical professionals collect information about diseases, symptoms, treatments, and outcomes to make evidence-based decisions.
2. **Replicability**: Replicability is a fundamental principle of science that emphasizes the ability to reproduce research findings. In medicine, replicability ensures that studies and experiments can

be repeated by other researchers, enhancing the results' reliability. Replication allows for the verification and validation of scientific claims and forms the basis for evidence-based medicine.

3. **Falsifiability**: Falsifiability is the capacity of a hypothesis or theory to be proven false if it is indeed incorrect. In medicine, hypotheses and theories are tested and refined to ensure accuracy. Scientific claims are subjected to rigorous scrutiny, and if evidence emerges that contradicts a hypothesis, it can be modified or discarded. This iterative process helps refine medical knowledge over time.

4. **Peer Review**: Peer review is a critical part of the scientific process. Research papers and studies undergo rigorous evaluation by independent field experts before being published in reputable scientific journals. Peer review helps maintain the quality and integrity of scientific research and provides an added layer of scrutiny and validation.

Industry

Example 1: By conducting experiments, collecting data, and observation, industries can make informed decisions and improve operations.

Example 2: Industries employ structured methodologies to solve problems and optimise processes. This may involve defining objectives, researching, testing hypotheses, and implementing solutions step-by-step.

Example 3: Scientific inquiry is characterised by objectivity and impartiality. These characteristics are vital in ensuring un-biased evaluations, assessments, and decision-making processes in the industry. By adopting an objective approach, industries can make decisions based on evidence rather than personal biases leading to more reliable outcomes.

Example 4: Science emphasises reproducibility of experiments and findings to validate results. Industries also strive to ensure reproducibility in their processes, products, and quality control measures. By implementing standard operating procedures, rigorous testing protocols, and verification processes, industries can achieve consistent and reliable outcomes.

Learning Task

1. Explain how characteristics of science can be applied in everyday life, such as in education.

Pedagogical Exemplars

1. Put learners in mixed-ability groups. Using think-pair-share lets learners search for the applications of the characteristics of science (empirical evidence, systematic observation, objectivity, tentativity) in everyday life, such as agricultural science, health, education, and home and reflect on their findings. Learners discuss their findings on the applications of the characteristics of science in everyday life.
2. Let learners assess each other's contributions during group activities, presentations, and experiments.
3. Organise a visit or field trip to a local industry or school farm where learners can observe the applications of the characteristics of science firsthand. During field trips to local industries or school farms, teachers can monitor students' engagement, note-taking, and interactions with industry professionals to assess their understanding of the applications of the characteristics of science.
4. Learners write a summary report about what they learnt from the field trip.

Summary report on the field trip to the local industries.

Key Assessment

Assessment Level 2: Identify at least three areas where characteristics of science are applied.

Assessment Level 2: Explain how empirical evidence as a characteristic of science is applied in Agriculture.

Assessment Level 2: Explain how the characteristics of science are applied in health and school.

Assessment Level 3: Analyse at least two situations or areas where the characteristics of science can be applied.

Section Review

These lessons were structured to provide a holistic learning experience. Learners should now possess a comprehensive understanding of the characteristics of science in nature, be able to apply this knowledge in practical project design and demonstrate proficiency in applying scientific characteristics in diverse contexts. The aim is for each student to gain theoretical knowledge and develop practical skills that can be utilised in scientific activities beyond the classroom.

Additional Learning

1. Identify the characteristics of science involved in the solubility of salt experiment and explain your answer. HINT: Systematic, observation, empirical, verifiable, etc.
2. Identify any problem in your community and apply the characteristics of science to solving it. Hint: Causes, Observation/ Experimentation, and empirical data analysis.
3. Designing hands-on experiments or field trips to help students observe natural phenomena and collect data.
4. Using inquiry-based learning activities where students formulate research questions and design investigations to answer them.

References

1. Curriculum document
2. https: //evolution.berkeley.edu/nature-of-science/characteristics-of-science/
3. https: //www.sciencebuddies.org/science-fair-projects/project-ideas/list
4. Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire (VNOS): Toward valid and meaningful assessment of learners' conceptions of nature of science. Journal of Research in Science Teaching, 39, 497-521.V
5. Smith, J. K. (2002). The Empirical Nature of Science: A Comprehensive Guide. P

SECTION 2: SOLIDS AND BINARY COMPOUNDS

Strand: **Exploring Materials**

Sub-Strand: Science and Materials in Nature

Learning Outcome: *Explain the functions of solids in life.*

Content Standard: Know, understand, and identify the roles of solids in life.

INTRODUCTION AND SECTION SUMMARY

This section will examine the many types of solids and how they are used in everyday life. Understanding the characteristics of various solids is critical for understanding their functions and applications in various industries. We will look at how these solids are used in real-world applications, giving insight into the importance of material qualities in various settings. In addition, we will discuss the relationship between binary compounds, their compositions, and naming practices. This section seeks to provide a detailed overview of chemical compounds, including information on their structures and nomenclature. After completing this part, learners can categorise various solids and identify their purposes. By applying solid properties to real-world circumstances. Learners will better understand the practical significance of material qualities in everyday life. In addition, there will understanding of the relationship between binary compounds, their compositions, and the process of identifying compounds. This information will enable leaners to correctly name and analyse binary compounds, improving learners' chemical compound identification skills. Mastering these ideas will increase your learners' awareness of the importance of solids and compounds in diverse applications, laying a solid foundation for future research in science-related courses.

The weeks covered by the section are:

Week 4: Classify different solids and their uses.

Week 5: Apply the properties of solids to everyday use.

Week 6: Discuss the relationship between binary compounds, the composition of binary compounds and the names of compounds.

Week 7: Discuss the relationship between binary compounds, the composition of binary compounds and the names of compounds.

SUMMARY OF PEDAGOGICAL EXEMPLARS

Teachers should use a comprehensive approach incorporating differentiated instruction to care for diverse learning needs when designing pedagogical exemplars. Teachers should focus not just on what learners need to know and comprehend but also on providing interesting content for bright and talented learners. Teachers should use various teaching strategies and techniques to meet learners' diverse learning styles and skills in the classroom. Differentiated instruction is essential for addressing individual needs and ensuring that all learners have effective access to the focus area of study. Clearly define all learners' learning outcomes and expectations, including the fundamental knowledge, understanding, and abilities they must acquire during the learning process. Assessments should be aligned with the learning outcomes to appropriately evaluate learning progress. Give gifted and talented learners more challenges, extensions, and enrichment opportunities to help them learn more effectively. This could include more challenging coursework, independent research projects, or opportunities for creative expression outside of the traditional curriculum. By employing these strategies, teachers can foster a supportive learning environment that encourages academic improvement for all learners while also giving advanced chances for gifted and talented learners to attain their full potential.

ASSESSMENT SUMMARY

This section's assessments may be formative, summative, or differentiated. Formative assessment will involve laboratory work demonstrating certain science aspects to improve learners' science process abilities. Short exams, class exercises, assignments, group discussions, group projects, and group presentations also exist. Written examinations, interviews, observations, or performance assignments based on assessment indicators are delivered, along with graded outcomes. Students could be issued with a list of the learning outcomes for each section, and they could review their learning by coding each learning outcome red (not understood). Amber (understood but not yet secure) and green (securely understood). Summative assessments are due at the end of every lesson, section, and semester. However, both formative and summative exams contribute to learners' cumulative records.

To foster a positive assessment environment, ensure learners are given clear instructions. Maintain consistency in administering the evaluation across all participants to ensure fairness. To foster a positive assessment environment, ensure learners are given clear instructions. Maintain consistency in administering the evaluation to all participants to ensure fairness and impartiality.

Transcript recording requires relevant information such as the learner's characteristics, assessment date, components, and scores. Include any additional observations or notes that may provide valuable insights into the evaluation results. Refer to the Teacher Assessment Manual and Toolkits for more detail on how to assess learners.

Differentiated assessment focuses on learners' needs, strengths, and interests. Teachers should adjust assessment questions to different levels of readiness, learning styles, and preferences so that all students have an equal opportunity to demonstrate their competencies.

Week 4

Learning Indicator(s): *Classify different solids and their uses.*

Theme or Focal Area(s): Metals, non-metals, and semi-metals.

The three broad categories of elements based on their chemical and physical properties are metals, nonmetals, and semi-metals. These categories are used to classify elements in the periodic table.

The periodic table organises elements based on their atomic number. Elements in the same vertical column, known as a group or family, share similar chemical properties as they have the same valence electrons. Valence electrons are the electrons in the outermost energy level of an atom. Elements in the same group have the same valence electrons leading to similar chemical behaviors. Elements in the same horizontal row, known as a period, have the same principal energy level but different numbers of valence electrons. As you move across a period, the properties of elements change gradually.

Groups are labeled with numbers and specific names. For example, Group 1 elements (alkali metals) share similar properties such as high reactivity due to having one valence electron. Group 17 elements (halogens) are highly reactive nonmetals with seven valence electrons. The semi-metals are found in the middle of the periodic table. They have varying numbers of valence electrons and exhibit a wide range of chemical behaviours.

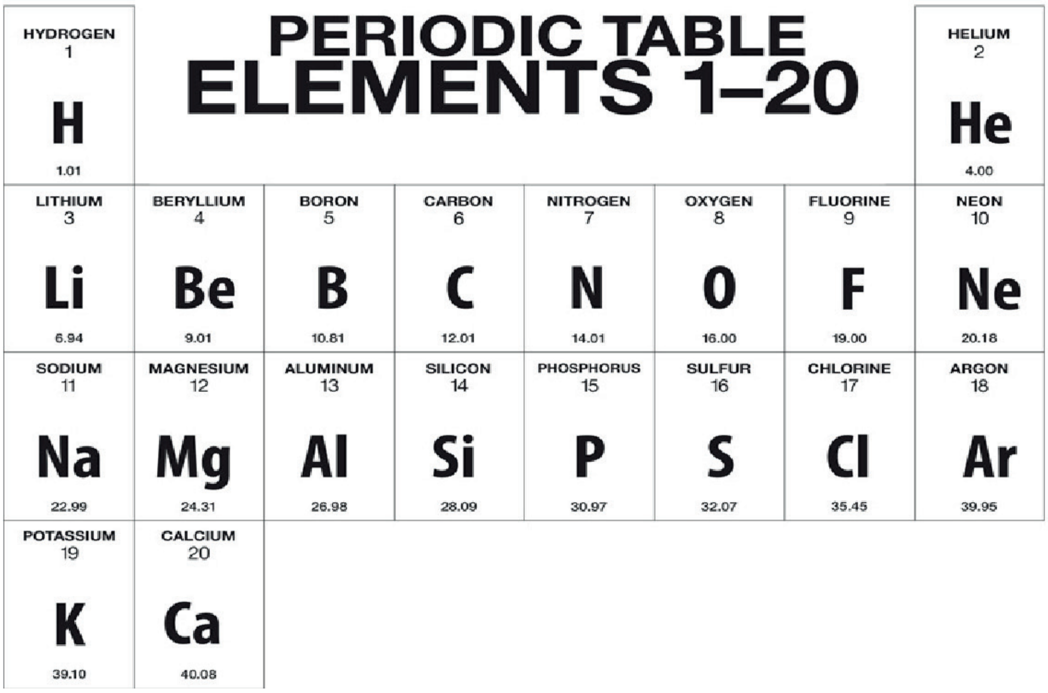

Fig. 2.1: *Peroidic Table on the first twenty element.*

Metals

Metals are found on the left-hand side of the periodic table. They are elements that donate electrons in a chemical reaction to form cations. *Eg*. Li, Na, K, Be, Mg and Ca.

Fig. 2.2: *Different metals*

Physical properties of metals

Physical State: Metals are solids at room temperature except mercury and gallium which are liquids at room temperature.

Lustre: Metals have the quality of reflecting light from its surface and can be polished *e.g.* gold, silver, and copper.

Malleability: Metals have the ability to be hammered into different shapes without breaking into pieces.

Ductility: Metals can be drawn into flexible wires.

Hardness: All solid metals are hard except sodium, rubidium, caesium, lithium, and potassium which are soft and can be cut with a knife.

Valency: Metals have 1 to 3 electrons in the outermost shell of their atoms.

Conduction: Metals are good conductors because they have free electrons. Silver and copper are the two best conductors of heat and electricity. Lead is the poorest conductor of heat. Bismuth, mercury, and iron are also poor conductors.

Density: Metals are very heavy and have high densities. Iridium and osmium have the highest densities while lithium has the lowest.

Melting and Boiling Point: Metals have high melting and boiling points.

Electropositive Character: Metals are elements that tend to lose electrons and form cations.

Sonority: Some metals are sonorous - they produce a sharp ringing sound when hit by an object.

Experiment to Show Thermal Conductivity.

Aim: To investigate the thermal conduction properties of a selection of metals.

Materials needed: Bunsen burner, Vaseline, copper, iron, brass, and aluminium rods, stopwatch, drawing pins, tripod, cardboard or paper, matches.

Procedure

i. Stick the flat end of a drawing pin to the end of each metal rod using the Vaseline. Try to use the same amount of Vaseline for each drawing pin.
ii. Place the cardboard on the tripod (this insulates the metal rod from the metal tripod).
iii. Balance the metal rods on the cardboard so that one end is over the Bunsen burner but not too close that it catches fire.
iv. Light the Bunsen burner.
v. Using a stopwatch, time how long until each pin drops off.
vi. Record your results in the table.

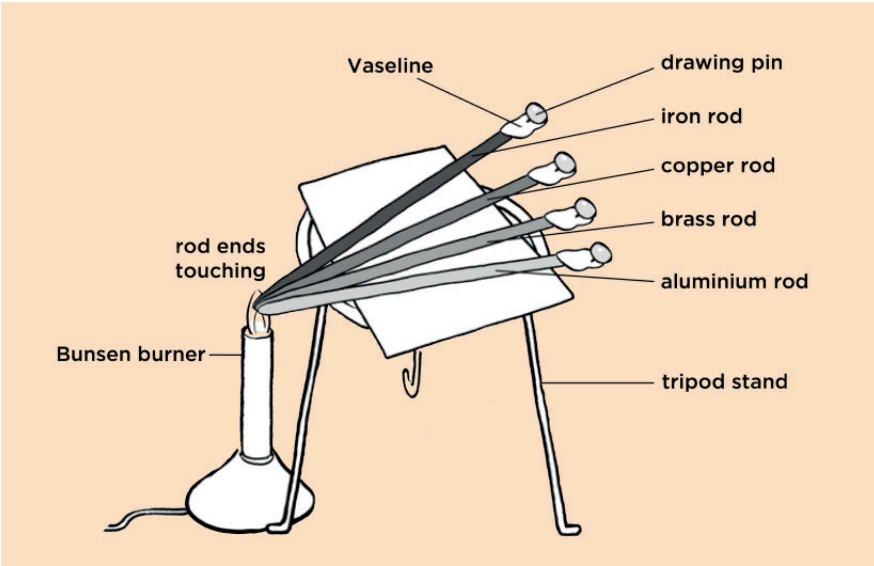

Fig. 2.3: *Testing the conductivity of metals*

Results and recording: Record your results in the following table

Type of metal	Time taken for pin to drop off (seconds)
Iron	
Copper	
Brass	
Aluminium	

Observation: The pin stuck to the copper rod should drop off first as copper is the best conductor of heat and the Vaseline will melt first.

Conclusion: Metals vary in their thermal conductivity with copper having the best in this selection.

Experiment to show that metals are malleable

Aim: to investigate the malleability of different metals by striking them with a hammer.

Materials needed: Pieces of iron, zinc, lead, and copper, hammer, an anvil, or solid block of iron to act as an anvil

Procedure

i. Note the initial shape of each piece of metal.
ii. Take a piece of iron and place it on the block of iron or anvil.
iii. Strike the piece of iron five times with a hammer.
iv. Observe and record any changes in the shape of the piece of iron.
v. Repeat the same process with pieces of zinc, lead, and copper.
vi. Record observations and note any differences in how each metal changes shape

Fig. 2.4: *Testing malleability of metal*

Observation: Metals have varying degrees of malleability and there should be a range of deformations amongst the four metals being investigated here: copper and lead are more malleable than zinc or iron.

Conclusion: metals can be hammered into different shapes.

Experiment to Show the Lustrous Nature of Metals

Aim: To compare the lustre of different metals.

Materials needed: Samples of iron, copper, aluminium, magnesium and sandpaper

Procedures:

i. Observe and note the appearance of each metal sample.
ii. Clean the surface of each sample by rubbing it with sandpaper.
iii. Observe and note any changes in appearance.

Observation: copper shines more (is more lustrous) than other metals such as iron, aluminium, magnesium.

Conclusion: Metals exhibit a shining surface known as metallic lustre, the degree of lustre varies amongst metals

Experiment to show that metals are hard

Aim: To demonstrate the hardness of metals compared with other non-metal materials

Materials: Various objects made of varied materials (e.g., metal spoon, key, rubber band, plastic ruler, piece of cloth), a coin.

Procedure: Gently try to scratch the surface of each object with the coin.

Observe: Note which objects resist scratching and which ones are easily scratched by the penny.

Conclusion: The metal objects should be difficult to scratch, whilst the softer materials should show visible scratches indicating that they are less hard.

Explanation: Metals are harder than other materials because their atoms are arranged in strong, ordered structures. This makes it difficult to deform or break the metal's surface when scratched. Softer materials have weaker atomic bonds, making them more susceptible to scratches and dents.

Chemical Properties of Metals

Reactivity: The ability of metal to undergo chemical reactions with water or acids. Metals vary in their reactivity with acids. Some metals, like zinc and aluminum, react with acids to produce hydrogen gas and a metal salt. Others are resistant to reaction. Some metals are more reactive than others and can be ordered into a reactivity series from most to least reactive (*e.g.,* the mnemonic MAZIT useful here - Mg, Al, Zn, Fe, Sn)

Corrosion: Many metals undergo corrosion, this is a chemical reaction with substances in the environment that leads to the deterioration of the metal. Iron, for example, corrodes to form rust in the presence of oxygen and water.

Formation of Alloys

Metals can form alloys which are mixtures of two or more metals. Alloying often enhances the properties of metals such as increased strength or resistance to corrosion.

Uses of metals

- Gold, silver, platinum, and copper are widely used in jewellery.
- Iron and steel (an alloy of iron) are widely used in building and home construction.
- Cooking utensils are best made from metals like steel, aluminium, and copper.
- Sodium (Na), potassium (K), magnesium (Mg), and many others are available as micro-nutrients in our body.
- Iron, steel, titanium and aluminium are used in machinery and automobile construction.

Non- Metals

Non-metals are chemical elements that do not have the properties of a metal for example, Hydrogen (H), Helium (He), Carbon (C), Nitrogen (N), Oxygen (O).

Physical properties of Non-metals

Physical state: Most non-metals exist in two of the three states of matter at room temperature: gases such as oxygen and solids such as carbon.

Low Ductility: Non-metals are usually very brittle and cannot be rolled into wires or pounded into sheets.

Poor conductivity: Non-metals are typically poor conductors of electricity and heat. However, graphite (a form of carbon) is a notable exception.

Poor lustre: Non-metals often have dull, non-reflective surfaces.

Low malleability: Solid non-metals cannot be easily hammered or pressed into different shapes without fracturing.

Chemical Properties

Reactivity: They form acidic or neutral oxides with oxygen. Non-metals tend to gain electrons in chemical reactions, making them reactive towards metals.

Electronegativity: They have higher electronegativity compared to metals, meaning they attract electrons more strongly.

Ionization: Non-metals easily gain electrons to form negative ions (anions) or share electrons to form covalent bonds.

Acidity: Many non-metals form acidic oxides when they react with oxygen, such as sulfur dioxide (SO2) and carbon dioxide (CO_2).

Hydrogen Bonding: Non-metals like oxygen and nitrogen exhibit hydrogen bonding, influencing their properties in compounds.

Uses of Nonmetals

- **Nitrogen** can be used as a food preservative and in light bulbs.
- **Sulfur** is used in making black gunpowder, matches, and fireworks.
- **Chlorine** can be used as a bleaching agent and in the treatment of water to make it safe to drink.
- **Hydrogen** fuel cells generate electricity from oxygen and hydrogen.
- **Oxygen** used in space rockets as fuel, in respiration, in welding.

Semi-metals (sometimes called metalloids)

Semi-metals are elements found along the “staircase” line in the periodic table, bordering the region between metals and non-metals. The semi-metals include boron, silicon, germanium, arsenic, antimony, and tellurium.

Semi-metals show some properties of both metals and non-metals making their classification intermediate between the two groups.

Properties

Conductivity of electricity: Partial conductivity - better than non-metals but not as good as metals.

Malleability: Intermediate between metals and non-metals

Ductility: Also intermediate between metals and non-metals.

State: All semi-metals are solid at room temperature

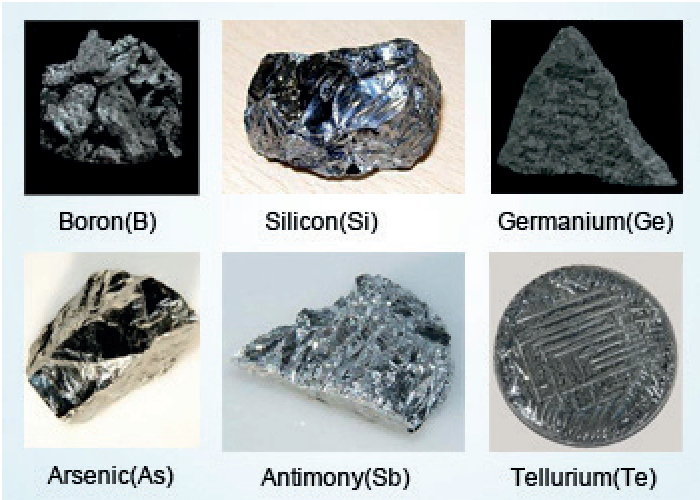

Fig. 2.5: *Different metals*

Differences between metals and non-metals

The classification into metals, non-metals, and semi-metals helps in understanding the fundamental properties and behaviours of different elements, and it provides a foundation for studying their various chemical interactions and applications.

Differences between semi-metals and non-metals

Semi-metals	Non-metals
They may be brittle like non-metals and have intermediate malleability and ductility.	They are typically brittle in solid form.
Semi-metals often have intermediate thermal conductivity.	They have low thermal conductivity making them good insulators in most cases.
Semi-metals have intermediate electrical conductivity.	They are bad conductors of electricity.

Differences between metals and semi-metals

Metals	Semi-metals
Are excellent conductors of electricity.	Have intermediate electrical conductivity.
Metals have high heat conductivity.	Have intermediate thermal conductivity.
Metals are often malleable and ductile.	Semi-metals can be brittle, making them less suitable for applications where malleability and ductility are important.
Metals tend to be reactive.	Semi-metals have intermediate reactivity.
Metals typically have a shiny, metallic lustre due to the reflection of light from their surface.	Semi-metals may have a metallic appearance but can also appear dull or non-metallic.

Corrosion

Corrosion is a natural chemical process (oxidation) that occurs when a metal reacts with oxygen/air in the presence of water to form an oxide. Rusting refers specifically to the corrosion of iron or steel (an alloy of iron). Other metals such as aluminium can also corrode.

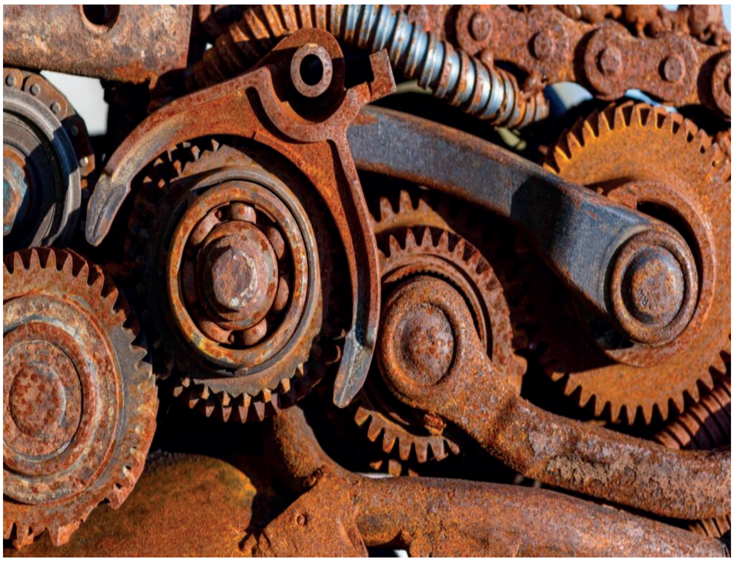

Fig. 2.6: *Rusting of metals*

The chemical reaction involved in rusting can be represented as follows:

Iron (Fe) + Oxygen (O_2) + Water (H_2O) →Hydrated Iron (III) Oxide (Rust)

$4Fe + 3O_2 + 2H_2O \rightarrow 2Fe_20_3.H_2O$

Conditions necessary for rusting to occur

1. Water (moisture)
2. Air (oxygen)

Rust is a reddish-brown coating that forms on the surface of the iron. It can weaken the metal over time, causing it to deteriorate and lose its structural integrity. This process can be accelerated in warm, saltwater, or acidic conditions.

A practical activity to show the rusting of iron

Aim: To conduct a simple experiment to demonstrate the conditions necessary for rusting of iron

Material: Test tubes, iron nails, cork, distilled water, oil, Anhydrous calcium chloride.

Procedure

i. Take three test tubes and place clean iron nails in each

ii. Label these A, B, and C.

iii. Pour some water into a test tube A and cork it. The water should cover the nails.

iv. Pour enough boiled and cooled water into test tube B to cover the nails, add about 1 ml of oil and cork it. The oil will float on water and prevent the oxygen from dissolving into the water. Boiling removes dissolved oxygen from the water.

v. Put approximately 5g of anhydrous calcium chloride in test tube C and cork it. Anhydrous calcium chloride will absorb any moisture from the air.

vi. Leave the test tubes for a week and then observe and note the results.

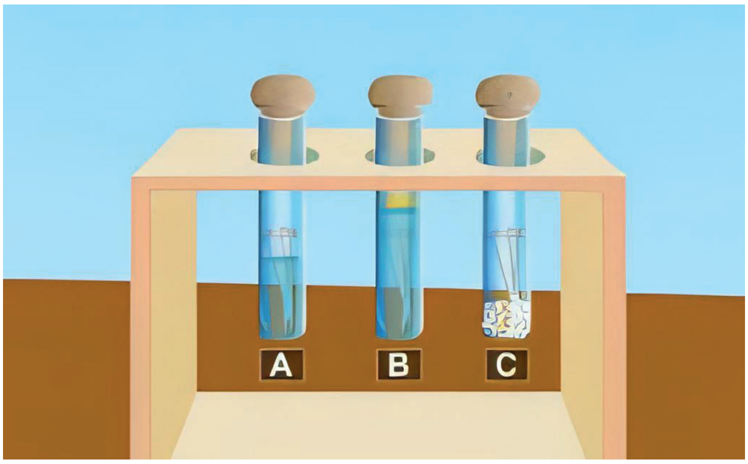

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Fig. 2.7: *Investigating the conditions under which iron rusts.*

Observation: Iron nails will rust in test tube A but they should not rust in test tubes B and C. In test tube A, the nails are exposed to both oxygen and water. In test tube B, the nails are exposed to only water, and the nails in test tube C are exposed to only to oxygen.

Conclusion: Oxygen (in air) and water are required for rusting to take place.

Methods for the prevention of corrosion include:

Painting: Paint provides a protective layer that seals the metal surface and blocks moisture and oxygen from reaching the metal.

Clear Coats and Sealants coating: Transparent coatings like lacquers and clear sealants can be used to protect metal surfaces while preserving their natural appearance.

Galvanising: Galvanising involves electro-coating the iron (or steel) with a thin layer of zinc. This has two modes of protection - the thin layer of zinc acts as a barrier to water and oxygen; and zinc is more reactive than iron and corrodes instead of the iron (called sacrificial protection).

Plating: Plating involves depositing a layer of another metal onto the surface of the base metal. This outer layer serves as a protective barrier. For example, chrome plating is commonly used for decorative and corrosion-resistant purposes.

Alloying: Alloying involves mixing two or more different metals or non-metal and a metal. This helps to improve its corrosion resistance. An example of this is stainless steel which contains chromium which reacts with oxygen to form a thin, invisible oxide layer on the metal's surface. This layer acts as a barrier, protecting the underlying metal from rust.

Keeping the metal in cool dry place: Keeping metal objects dry and clean reduces the likelihood of corrosion.

Desiccants: The use moisture-absorbing substances like silica gel packets or other desiccants when storing metal objects in enclosed spaces can reduce corrosion and is used in many commercial products within the packaging.

Learning Tasks

1. Enumerate three properties each of metals, non-metals, semi-metals
2. In tabular form, outline four differences between metals and nonmetals.
3. Explain why metal objects should be kept dry and clean.

Pedagogical Exemplars

- Learners can be grouped in mixed-gender and mixed-ability groups to explore the uses of various solid materials in different structures and substances within their community during a walk around their community (*e.g.*, buildings, vehicles, litter, glass, plastic, construction materials etc.).
- Learners can use the internet to research these different solid materials and classify them based on specific criteria using concept maps. Teacher ensures learners classify solid materials into metals, non-metals, semi-metals. Note: there will be some that cannot as they are compounds or mixtures.
- In groups, discuss the classification of solids into metals, non-metals, semi-metals using their properties. Groups can present their conclusions.
- Using samples of metals, semi-metals and non-metals, guide learners in pairs to research and distinguish between their properties such as lustre, electrical and thermal conductivity, malleability, ductility, and sonority.
- Assign learners in separate groups to perform the different practical activities. Learners can present their results to the rest of the class
- Working in small groups, learners can create a poster which shows the findings from their practical activities.

Key assessment

Assessment Level 1: Identify three substances which are solids at room temperature.

Assessment Level 2: Explain why gold and platinum do not corrode.

Assessment Level 2: Describe an experiment to explain the conditions necessary for corrosion of iron.

Assessment Level 3: Describe and explain the differences between metals and non- metals

Week 5

Learning Indicator(s):

Apply the properties of solids to everyday use

Theme or Focal Area(s): Application of properties of different solid structures in relation to their uses in life.

Solid materials

Solid materials refer to substances or objects with a definite/fixed shape and volume. Unlike liquids and gases, which can flow and change shape easily, solids maintain their shape and volume under normal conditions. Solids are characterised by strong intermolecular forces that hold their constituent particles such as atoms, ions, or molecules in a fixed arrangement.

A table showing examples of solids in different structures.

Examples of Structures	Examples of Solids in structures
Building	concrete, steel, wood, brick
Glassware	Sand is a raw material in the making of glass glass wool, glass beads
Vehicles	Metals, glass, plastics, leather, cushion, connecting wires
Gadgets (*e.g.*, computer)	Glass, plastics, , etc.
Plastic materials (*e.g.*, bottles, bowls)	Polyethylene, polyvinyl chloride (PVC)
Tables	Wood, nails. steel, plastic, glass
Sculptures	stones, marble, metal, or wood
Bridges	steel, concrete, stone

Classification of materials with reasons.

Examples of Solids	Classification	Reason(s)
Polyethylene, polyvinyl chloride (PVC)	Polymers	are large molecules made up of repeating subunits called monomers. are flexible and have a high strength-to-weight ratio.
Table salt, sugar (sucrose), diamond, quartz.	Crystalline	exhibit well-defined geometric shapes. have a highly ordered and repeating arrangement of particles (crystals).
Plastics	Polymers	do not have a well-defined shape. do not form crystals.

Solid metals

Properties of solid metals and some of their uses.

Property	Use(s)
Conductivity: They are high thermal and electrical conductors.	This property is valuable in electrical wiring, power transmission, electronics, and heating.
Magnetic properties: Iron, nickel, and cobalt exhibit magnetic properties.	This characteristic is essential for electrical motors, generators, transformers, and magnetic storage devices.
Reflectivity: particularly those with a smooth surface (e.g., Steel), have high reflectivity for light and heat.	This property is used in applications such as mirrors, reflectors, and solar panels where efficient reflection is required.
High melting and boiling points: Most metals have high melting and boiling points allowing them to withstand high temperatures.	Metals with extremely high melting points, such as tungsten and molybdenum, produce refractory materials capable of withstanding very high temperatures. Metals with high melting points are used to make crucibles and molds for casting other materials such as ceramics and alloys. The crucible or mold remains stable and does deform during casting. Other metals (such as lead) with lower melting points are used in soldering and brazing processes to join different components.
Density: The density of metals refers to how much mass is packed into a given volume of the material. In simpler terms, it is a measure of how heavy a metal is for its size. Metals tend to have high densities providing substantial mass and strength.	In military and defence applications, high-density metals like depleted uranium are used in armour-piercing ammunition due to their ability to penetrate heavily armored targets.

Experiment to demonstrate the magnetic properties of different materials

Aim: To compare the magnetic properties of various materials.

Materials: Bar magnet, iron nail, copper wire, aluminum foil, paper clips, plastic ruler, wooden stick, plastic bottle cap, Styrofoam ball and rubber band.

Procedure

i. Position the bar magnet on a level surface.

ii. Bring each substance close to the bar magnet one at a time to see if there is any attraction or repulsion between them.

iii. Repeat the process with each material.

iv. Classify each object as magnetic or non-magnetic and list these in a table.

Observations: Materials such as the iron nail, paper clips, and copper wire will be attracted to the magnet, showing magnetic properties. Materials like aluminum foil, plastic ruler, wooden stick, plastic bottle cap, Styrofoam ball, and rubber band will not be attracted to the magnet and are considered non-magnetic.

Conclusion: Certain materials exhibit magnetic properties and are attracted to a magnet whilst others do not show any magnetic response.

Experiment to show densities of various metals.

Aim: to investigate the densities of different solid materials.

Materials needed: Various metal samples such as iron, lead, aluminum, copper, iron, zinc, balance, measuring cylinder, beaker, water, forceps.

Procedure

- **i.** Start by collecting samples of the metals you want to test. Make sure they are clean and free of any dirt or debris.
- **ii.** Weigh the mass of each metal sample and record in grams.
- **iii.** Fill the measuring cylinder with a known volume of water and record
- **iv.** Carefully lower the first metal sample into the water using a pair of forceps. Make sure the metal is fully submerged.
- **v.** Measure and record the new increased volume of water after adding the metal sample. Measure volume in ml.
- **vi.** Repeat for each metal sample.
- **vii.** Calculate the volume of each metal sample by subtracting the initial volume of water from the final volume of water.
- **viii.** Use the formula: Density = Mass / Volume to calculate the density of each metal sample.
- **ix.** Record your results and compare the densities of the different metals.

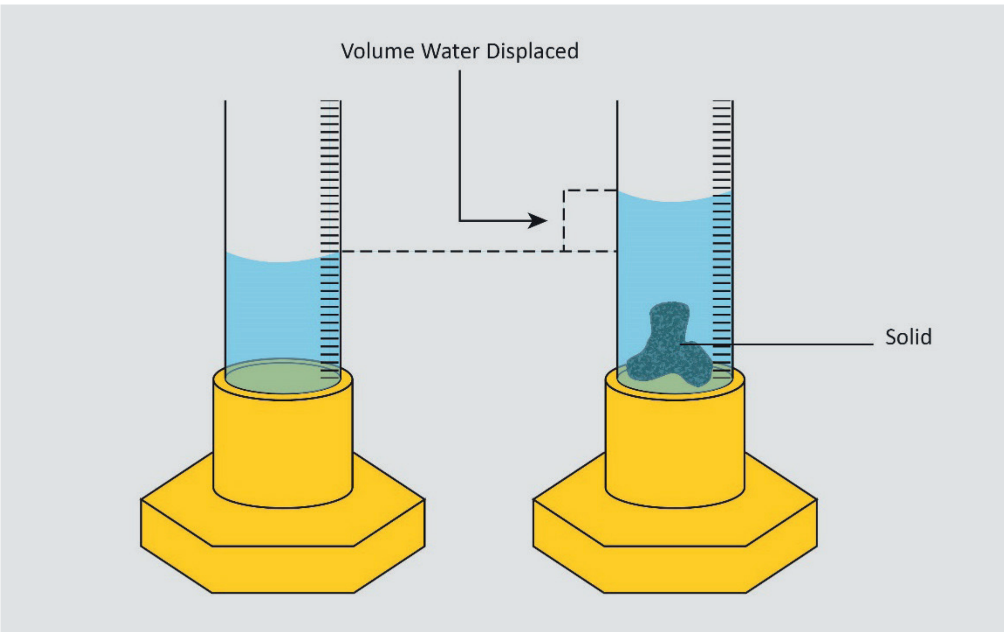


Fig. 2.8: *Investigating the density of solid materials*

Observations: different metals will have different densities. Lead should be the most dense

Conclusion: metals vary in density and have different uses *e.g.;* lead is often used in adding ballast (weight) as it is very dense and therefore heavy for its volume.

Experiment to show electricity conductivity.

Aim: to investigate the electrical conductivity of different solid materials.

Materials: Solid objects composed of a range of materials *e.g.*, metal rod, key, wooden stick, plastic ruler, graphite rod, lead pencil, etc. A simple circuit set up with a battery, LED bulb and wires.

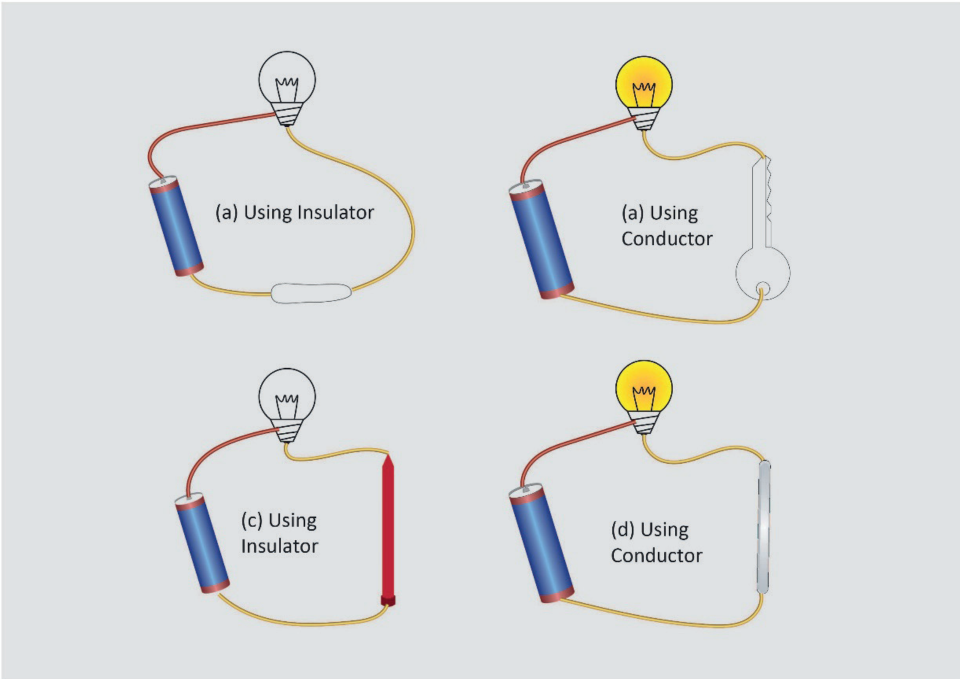


Fig. 2.9: *Testing for electrical conductivity of different solid material*

Procedure

i. Construct a simple circuit setup with a battery, LED bulb, and wires.
ii. Check the circuit conducts electricity, the battery is good, and the bulb is working by connecting the free wire ends to complete the circuit.
iii. Introduce metal rod, wooden stick, plastic ruler, graphite rod, and pencil lead into the circuit to complete it. Note: the pencil lead is in fact graphite, ensure the wires are connected to the lead of the pencil rather than the surrounding wood
iv. Does the bulb light up? Record in a table whether the object conducts electricity by observing if the bulb lights.

Observation: the metal rod, pencil lead and graphite rod will all conduct electricity (the bulb lights up) and the wooden stick and plastic ruler will not.

Conclusion: Different solid objects and materials vary in terms of electrical conductivity.

Uses of Polymers in relation to their properties.

Strength and durability properties: Many polymers show excellent strength and durability, making them suitable for applications that require robust materials. Durability is the material's ability to withstand wear, corrosion, fracture, fatigue, deformation, and exposure to a wide variety of temperatures.

*Use***:** Polyethylene (PE) and polypropylene (PP) are used in packaging, construction materials like polyvinyl chloride (PVC) in pipes, and aramid fibres used in bulletproof vests.

Flexibility and elasticity properties: Certain polymers possess high flexibility and elasticity allowing them to withstand bending and stretching without breaking.

*Use***:** These polymers find use in applications such as flexible packaging films, elastic bands, and soft-touch materials like rubber.

Thermal Stability properties: Some polymers have good resistance to high temperatures.

*Uses***:** Polyimides (PI) are used in aerospace and electronics due to their excellent thermal stability and electrical insulation properties.

Other polymers with high thermal stability can be used to manufacture textiles and fibres that can withstand extreme temperatures making them useful in producing protective clothing for firefighters and industrial workers.

Resistant properties: Many polymers are resistant to various chemicals, acids, and solvents, making them suitable for applications in corrosive environments.

*Uses***:**Chemically resistant polymers are preferred for making pipes and tubing in industries where corrosive fluids or gases are transported. They prevent leaks, corrosion, and the risk of contamination, making them suitable for applications in chemical processing plants and laboratories. These polymers are also used in coatings and paints to enhance their durability and resistance to chemical exposure and environmental factors. Polytetrafluoroethylene (PTFE) is used in chemical processing equipment whilst Polyvinylidene fluoride (PVDF) is used in chemical storage tanks.

Electrical Insulation properties: Polymers can act as excellent insulators, preventing the flow of electricity.

*Uses***:** This property is valuable in electrical applications such as insulating coatings, cables, and connectors. Examples include polyethene (PE) and polypropylene (PP).

Transparency properties: Certain polymers possess transparency or optical clarity making them suitable for applications that require see-through materials.

*Use***:** Polymethyl methacrylate, commonly known as acrylic or plexiglass, is used in products like display panels, lenses, and signage.

Water Resistance properties: Some polymers exhibit good resistance to water absorption making them ideal for applications that involve contact with moisture.

*Use***:** Polyethylene terephthalate (PET) is commonly used in beverage bottles due to its water resistance and transparency.

Biodegradability properties: Biodegradable materials can be degraded naturally by decomposers and environmental processes over time. These materials are typically made from organic resources. They can be a more environmentally friendly option to non-biodegradable materials, which can remain in the environment for a long time and contribute to pollution. Biodegradable polymers have grown in popularity as people become more concerned with sustainability. These polymers can degrade spontaneously over time lessening their negative environmental effects.

*Uses***:** Biodegradable polymers are employed in various medical devices and drug administration methods. For example, absorbable sutures constructed of biodegradable polymers disintegrate over time, removing the need for surgical removal. Biodegradable polymers can also be used for packaging purposes, notably in single-use applications that reduce plastic waste.

Bonding properties: Some polymers have adhesive properties, bonding well with various surfaces.

*Use***:** They are used in adhesives, tapes, and sealants enabling bonding in industries like construction, automotive, and electronics.

The properties and uses of crystalline solids.

Glass	Properties	Use
Soda-lime glass	Transparent. Chemical resistance - it is non-reactive. Soda-lime glass has a moderate coefficient of thermal expansion meaning it expands and contracts evenly when exposed to temperature changes.	It is used in windows, bottles, and jars and scientific glassware
Borosilicate	Exhibits high chemical resistance, high thermal resistance, and durability.	Suitable for laboratory glassware, chemical storage containers, and pharmaceutical packaging where the material needs to withstand corrosive substances. Also, cookware e.g., Pyrex and high-end lighting fixtures.
Lead crystal	It contains a significant amount of lead oxide giving it exceptional clarity, brilliance, luxurious appearance, and weight.	Often used in fine glassware, chandeliers, and decorative items.
Fused silica:	Its high purity, thermal stability, optical transparency, and chemical resistance makes fused silica is a versatile material used in a wide range of industries	It is ideal for lenses, mirrors, and precision optics in scientific instruments.
Aluminosilicate glass	Contains aluminum oxide and silica offering high strength, chemical resistance, and thermal shock resistance.	It is used in applications such as smartphone screens, armored vehicle windows, and aerospace components.

Properties and uses of marble.

Marble	Properties	Use
Glass Marble	Glass marbles are fragile and can break if dropped or subjected to pressure. They can have different surface finishes such as matte or glossy.	For games, crafts, and decorations, crafting jewelry, mosaic art, and DIY projects.
Agate Marble	This may exhibit translucency, hardness, translucency, durability, and high density	Used in jewelry, decorative arts, and collectibles.
Alabaster Marble	It has a smooth, polished surface and comes in various colours including white, cream, beige.	Decorative arts and architecture.
	Once fired, clay marbles become hard and durable with a smooth surface. Clay marbles are dense which gives them good weight and stability,	Traditional games, decorative purposes
Steel Marble	Usually made of hardened steel. Steel is a good conductor of electricity, so steel marbles can be used in electrical applications, such as electrical contacts or as conductive elements in electronic devices. Steel marbles have a high density	Furnace applications or automotive engines.
Ceramic Marble	Ceramic marbles are typically durable and resistant to wear and tear	Cooking or industrial processes.

Learning Tasks

1. State three uses of solid metals.
2. Explain the relationship between the properties of solid metals and their uses.
3. Write four properties of solid metals.
4. How will you determine the density of different solid materials.

Pedagogical Exemplars

1. Learners' research on how the features of different solids connect to their daily uses from various cultural viewpoints. Learner reflects and cross share their views.
2. Guide learners to develop concept maps to visualise the relationship between solids, their qualities, and uses.
   - Put learners into mixed ability groups to demonstrate their understanding of how various solids are employed based on their qualities through practical activities *e.g.* electrical conductivity using simple electric circuits.

3. Assign roles, based on individual strengths, such as researcher, presenter, visual maker, or group facilitator, to encourage active participation and contribution from all learners during the demonstration of practical activities.
4. Learners discuss their results with the class through a variety of presentation alternatives, such as oral presentations, poster displays, multimedia slideshows, or performances, so they can select a format that best suits their strengths and interests.

Key Assessment

Assessment Level 1: Provide examples of everyday products that use the electrical conductivity of metals.

Assessment Level 2: Explain how the high tensile strength of steel contributes to its usefulness in constructing bridges and buildings.

Assessment Level 2: Discuss the importance of corrosion resistance in selecting materials for outdoor structures and marine environments.

Week 6

Learning Indicator(s): *Discuss the relationship between binary compounds, the composition of binary compounds and the names of compounds.*

Theme or Focal Area(s): Relationship Between Binary Compounds, the Composition of Binary Compounds and the Names of Compounds.

Binary compounds

Binary compounds are chemical compounds composed of two different elements. These compounds are formed through the combination of two distinct types of atoms. The elements involved in binary compounds can be metals and nonmetals or two nonmetals. There are two main types of binary compounds: ionic and covalent compounds.

Ionic Compounds

Ionic compounds are chemical compounds composed of two elements: a metal and a nonmetal. These compounds form through ionic bonding, a type of chemical bond in which electrons are transferred from one atom to another. The metal donates electrons to become a positively charged ion (cation), and the non-metal accepts these electrons to become a negatively charged ion (anion). The resulting oppositely charged ions are held together by electrostatic forces, creating a stable compound.

Properties of Ionic Compounds

State of Matter: Most ionic compounds exist in a solid state at room temperature. The strong electrostatic forces between positively and negatively charged ions create a stable crystal lattice structure.

Melting and Boiling Points: Ionic compounds have high melting and boiling points. The strong ionic bonds require a substantial amount of energy to break, high temperatures are needed for these compounds to undergo phase changes.

Solubility in Water: Many ionic compounds are soluble in water. When placed in water, the ions separate and disperse throughout the solution due to the polar nature of water molecules. However, not all ionic compounds are equally soluble, and some may show limited solubility or are insoluble.

Conductivity in Aqueous Solutions: Ionic compounds conduct electricity when dissolved in water or in molten form. In these states, the ions are free to move and carry an electric current. However, in their solid state, ionic compounds do not conduct electricity.

Crystal Structure: Ionic compounds form a regular and repeating three-dimensional crystal lattice structure. The arrangement of positive and negative ions in this structure contributes to the stability of the compound.

Hardness and Brittleness: Ionic compounds are typically hard and brittle. The crystal lattice structure can fracture when subjected to force as like-charged ions repel each other.

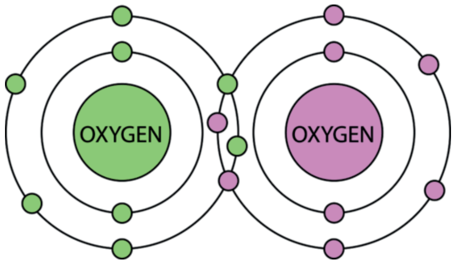
Density: Ionic compounds have high densities. The arrangement of ions in the crystal lattice contributes to the overall mass of the compound in each volume.

Colour: Pure ionic compounds are often colourless. However, certain metal ions, especially transition metals, can impart colour to the compound. For example, copper ions can give a blue or green colour to an ionic compound.

Covalent Compounds

Covalent Compounds are those whose molecules contain bonds formed through the sharing of electrons between two or more different atoms. As the name suggests, covalent compounds contain covalent bonds. Covalent bonds are formed by the sharing of electrons between atoms. Covalent bonding involves different atoms of the same element or different elements sharing electrons in their outermost shells to attain a stable electron configuration. Examples of covalent compounds are carbon dioxide (CO_2), carbon monoxide (CO_2), Water (H_2O), Ammonia (NH_3) and Methane (CH_4).

Molecules such as Hydrogen (H_2) and Oxygen (O_2) also consist of covalent bonds. In the formation of hydrogen gas, each of the two atoms of hydrogen contribute its electron to be shared with the other hydrogen atom. Sharing of electrons ensures that each hydrogen atom gains an additional electron in its valence shell (K shell). This ensures that the shell has a stable configuration.



2.10: *Formation of molecule of Oxygen Gas (O2)*

Similarly in a molecule of Oxygen Gas (O_2), the two atoms of oxygen contribute a pair of electrons each to be shared. This ensures that each of the two atoms attains an inert configuration of 8 electrons in the valence shell.

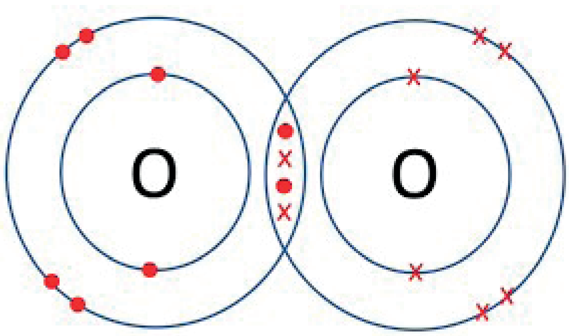


Fig. 2.11: *Formation of molecule of Oxygen Gas* (O_2)

Water is another common example of a covalent compound. It consists of atoms of hydrogen and oxygen. In the formation of a molecule of water (H_2O), two atoms of hydrogen are involved in sharing electrons with an atom of oxygen. Each atom of hydrogen contributes its electron to be shared with oxygen, the central atom. Sharing electrons with oxygen ensures that the two atoms of hydrogen both gain an extra electron to enable them to attain stability. The oxygen atom with six valence electrons gains two electrons (one from each of the two hydrogen atoms) to attain a stable octet configuration.

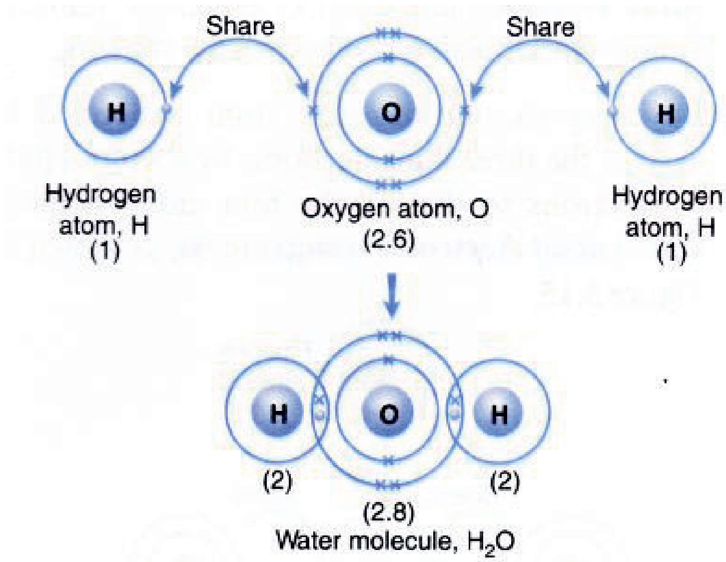


Fig. 2.12: *Formation of molecule of water*

Properties of Covalent compounds

Because they contain covalent bonds, covalent compounds exhibit the following properties:

- they normally exist as gases, liquid, or soft solids;
- their melting and boiling points are very low;
- they can be insoluble in water but soluble in organic solvents;
- they are non-conductors of electricity in solid, molten, or aqueous state;
- they have weak intermolecular forces of attraction.

Experiment: Investigating Properties of Water (H_2O)

Aim: To examine water's electrical conductivity as a representative covalent compound.

Materials: Two electrodes (e.g., copper or graphite), electrical circuit with connecting wires, ammeter, switch, batteries

Procedure

i. Set up an electrical circuit as shown by connecting two electrodes (e.g., copper or graphite) to an ammeter, switch, and battery in series.

ii. Fill a beaker with distilled water and place the electrodes into the water, ensuring they do not touch each other.

iii. Observe and record changes in the ammeter reading as the electrodes are submerged in the water.

iv. Repeat the experiment with other substances like salt (NaCl) dissolved in water and sugar (sucrose) dissolved in water.

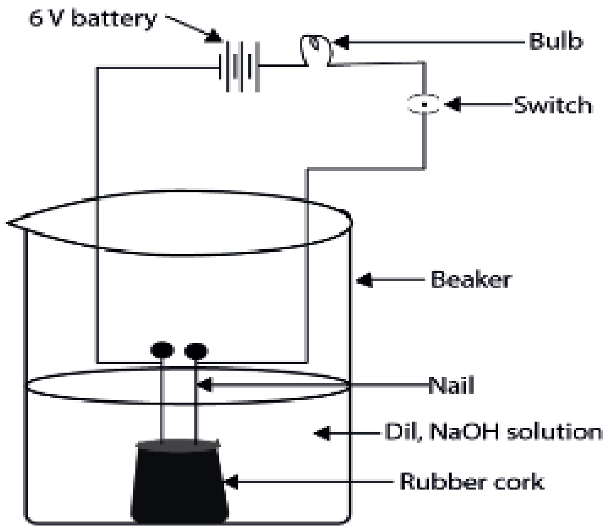


Fig. 2.14: *Testing electrical conductivity of water*

*Take **safety precautions** while conducting the experiment, such as wearing safety goggles, lab coats, and following standard laboratory practices.*

Perform each test multiple times to ensure accuracy and reliability of results.
Use distilled water to maintain consistency and reduce the influence of impurities on the experiment.

Differences between ionic and covalent compounds

Ionic compounds	Covalent compounds
1. These have high melting and boiling points because the bonds are strong due to electrostatic bonds. It takes a lot of heat energy to break the lattice.	These have low melting and boiling points because molecules are held together by weak forces that do not need much heat energy to separate them.
2. These are usually soluble in water.	These are usually insoluble in water.
3. These are insoluble in organic solvents, e.g., tetra chloromethane and petrol.	These are usually soluble in organic solvents such as tetra chloromethane and petrol.
4 They conduct electricity when they are melted or dissolved because the ions are free	These do not conduct electricity even when melted

Learning Tasks

1. Explain the chemical composition of a binary compound.
2. Give an example and explain the bonding of ionic compound.
3. Explain how the chemical formulae for binary compounds can be written.

Pedagogical Exemplars

Using talk-for-learning approaches:

1. Guide learners to revise from the JHS curriculum B9.1.1.1.1 about the nature of compounds. Provide opportunities for students to practice respecting others as they use the talk-for-learning strategies.
2. With the aid of models, videos, charts, and the internet, learners discuss the relationship between binary compounds (such as CO_2 NO_2 etc.), their composition, and chemical equations.
3. With the help of visuals, define each term: element, molecule, ion, and compound.
4. Have learners categorise a list of chemical examples such as H_2O, NaCl, Fe, Ca^2+ under the correct headings: element, molecule, ion, or compound. Review and clarify misconceptions.
5. Explain what binary compounds are, focusing on their formation.
6. Using a Venn diagram or a chart, learners working in pairs can compare the properties of different binary chemical compounds such as solubility, conductivity, melting point.
7. Engage learners in small group discussion about why certain compounds share properties and why some are vastly different. Encourage each small group to feed back their conclusions to the class.
8. Provide learners with modeling kits or craft materials like coloured balls (for atoms) and sticks or Molymod (for bonds). Learners can practice building simple molecules.

Key assessment

Assessment Level 1: Identify at least four examples of binary compounds

Assessment Level 2 - Describe how magnesium oxide is formed.

Assessment Level 3: Explain the role of electron transfer in the formation of binary ionic compounds.

Assessment Level 3: Explain how covalent compounds are different from ionic compounds. Give precise examples to support your explanation.

Week 7

Learning indicator: *Discuss the relationship between binary compounds, the composition of binary compounds and the names of compounds.*

Theme or Focal Area(s): Naming of binary compounds

Naming of Binary Compounds

Naming compounds serves a crucial purpose in chemistry by providing a standardised way to identify and communicate the composition of compounds. The naming conventions for compounds help to convey vital information about the elements present and their respective charges. By following specific naming rules, chemists can determine the exact combination of cations (positively charged ions) and anions (negatively charged ions) within a compound. This knowledge is essential for understanding chemical reactions, predicting the behavior of substances, and effectively communicating information about the structure and properties of compounds.

Additionally, the proper naming of compounds allows for clear and unambiguous communication within the scientific community. When scientists discuss chemical compounds in written or spoken form using standardised names ensures that everyone understands the specific elements or ions involved and their respective roles in the compound.

Writing of Chemical formula for binary compounds

1. Identify the two elements present in the compound.
2. Write the chemical symbols of the two elements that combine to make up the binary compound. In an ionic compound, the atom that forms a positive ion is written first followed by the anion.
3. Then determine the valency of each of the atoms. Valency is the combining power of an element. It refers to the number of electrons that an atom loses or gains to form a compound with a different element. Valency has no charge. However, knowing the charge on an atom gives an important clue about its valency. E.g., Mg^{2+} has a valency of 2, Na^{+} has a valency of 1, O^{2-} has a valency of 2 and Cl^{-} has a valency of 1.
4. Exchange the valencies of the two different elements and write them as subscripts at the right-hand side of the chemical symbol of each atom. In the example below, the cation of Magnesium ($Mg2^{+}$) has a valency of 2 which is exchanged with the valency of the anion of Chlorine (Cl^{-}) which is one (1).
5. Simplify the subscripts by finding the common factor. This step is often skipped if the values are already simplified. Additionally, if the valency is one (1), it is not written.

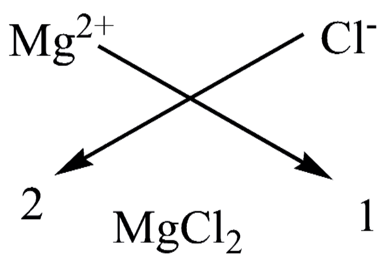


Fig. 2.15: *Formation of Magnesium chloride*

For example, let us consider the compound formed between calcium (Ca) and oxygen (O):
Calcium is a metal and forms cations with a charge of +2. Oxygen is a non-metal and forms anions with a charge of -2.

Based on their charges, it can be inferred that each of these atoms has a valency of 2.

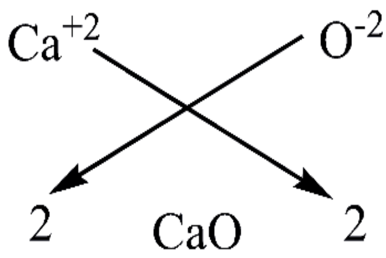


Fig. 2.16: *Formation of Calcium oxide*

The valencies of the two atoms are exchanged as shown above.
Because 2 is a common factor to the two subscripts, the subscripts are simplified by dividing each of them by two, giving us the chemical formula of the compound as CaO.

Another example is provided showing how to write the chemical formula of Aluminium chloride.

As is always the case the chemical symbols of the two elements are written, beginning with the metallic element (Al).

Afterwards we infer the valencies of the two elements based on the charges on their ions (Al^{3+} and Cl^{-}).

The valencies are then exchanged to give us the chemical formula of the compound Aluminium Chloride as $AlCl_3$.

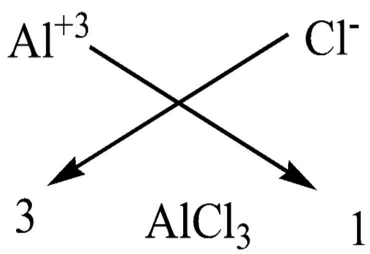


Fig. 2.17: *Formation of Aluminium chloride*

Learning Tasks

A compound is formed by burning magnesium in the air.

1. What is the chemical name of the resulting compound and its chemical formula?
2. Explain how the compound is formed.

Pedagogical Exemplars

1. Discuss with learners on the basic concepts of binary compound naming. Use leading questions to engage students in conversations about the patterns and rules involved in naming binary compounds. Encourage them to share their prior knowledge and build on it collaboratively.
2. Create a concept map on the board illustrating the connections between elements, ions, and naming conventions for binary compounds. Encourage students to contribute to the map throughout the lesson.
3. Provide models representing different elements and ions, demonstrating how they combine to form binary compounds. Use interactive simulations or animations to illustrate the formation and naming processes.
4. Incorporate real-world examples, such as common household compounds, to illustrate the application of naming rules. For example, table salt, caustic soda, and baking soda.
5. In mixed groups, learners can research and prepare short presentations on specific aspects of binary compound naming.
6. Provide a set of binary compounds for learners to name, encouraging them to work through the naming rules independently or in groups. Offer feedback and discuss solutions collectively to reinforce learning.

Key Assessment

Assessment Level 1: Write the chemical formula of one compound formed between each of the following elements:

- **i.** Magnesium and chlorine
- **ii.** Sodium and bromine
- **iii.** Carbon and oxygen

Assessment Level 3: Compare a compound formed between Sodium and Chlorine with one formed between Hydrogen and Nitrogen. Use this information to answer the question below:

- **a.** Write down the name of each compound.
- **b.** Write the chemical formula for each of the compounds you have named above.
- **c.** Identify the type of bond in each compound and three differences between the compounds.

Section Review

Having completed the teaching session on the identification and practical applications of different types of solids, along with exploring binary compounds and compound naming practices, learners should have gained a comprehensive understanding of these fundamental concepts. Through the initial assessment segment, learners should have successfully demonstrated their ability to categorise solids and articulate their purposes, displaying a solid grasp of how various characteristics define a solid's utility in the real world. This phase not only evaluated their knowledge of solid features but also encouraged critical thinking regarding practical applications.

Moving forward to the subsequent section, students are now tasked with applying their understanding of solid properties to real-life scenarios, displaying their proficiency in translating theoretical knowledge into practical contexts. Furthermore, the exploration of binary compounds and compound naming practices has deepened their comprehension of chemical structures and nomenclature essentials, emphasising the significance of these concepts in scientific studies.

By participating in this comprehensive evaluation, learners are not only enhancing their understanding of solids and compound compositions but are also developing vital skills that they can apply in their daily lives. This knowledge will enable them to make informed decisions, solve problems effectively, and approach scientific challenges with confidence and proficiency in various scientific domains.

Extension Learning Suggestions

1. Create a visual presentation or poster board displaying various types of solids (e.g., crystalline, amorphous, polymers) and their characteristics.
2. Conduct a hands-on experiment to identify unknown solids based on their physical properties such as density, conductivity, and solubility.
3. Design and build a model demonstrating the properties of solids in construction materials (e.g., bridges, buildings).
4. Investigate the thermal conductivity of different solids and the practical implications in insulation materials.
.5. Develop a guide on naming rules for binary compounds (ionic and covalent) with examples and practice exercises.
6. Create a board game or flashcards to help reinforce the naming conventions of binary compounds through interactive learning.
7. Research professions that use knowledge of solids and binary compounds in their operations.

Resources

1. Internet resources such as Massive Open Online Courses (MOOCs), for example www.youtube.com/watch?v=N4MdZx1fgbA;
2. www.youtube.com/watch?v=ZcF8E8aAOGs;
3. www.youtube.com/watch?v=vTq4sgGd2QU)
4. Data projector
5. Charts/pictures/drawings showing different solids.
6. Solid substances such as iron nails, plastic bottles, stones etc.,
7. Simulations/You Tube videos.
8. Connecting wires, ammeter, switch, beaker, electrodes, batteries, distilled water, Bunsen 8 burner or hot plate, thermometer.
9. Wood, plastic, aluminum, steel, etc., glass beaker, and a balance.
10. Vaseline copper, iron, brass and aluminium rod, stopwatch, drawing pins, tripod, cardboard, matches.

Models for teaching chemical compounds such as Molymod https://molymod.com/

References

1. General science curriculum for Senior High Schools
2. https://tinyurl.com/2r82hv9m
3. https://tinyurl.com/zarca4ee
4. The Molecular Nature of Matter and Change (Silberberg)
5. Smith, W. F., & Hashemi, J. (2006). Principles of Materials Science and Engineering. McGraw-Hill Education.

6. Callister Jr., W. D., & Rethwisch, D. G. (2017). Materials Science and Engineering: An Introduction (10th ed.). Wiley.

7. Revie, R. W., & Uhlig, H. H. (2008). Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering (4th ed.). Wiley

SECTION 3: DIFFUSION AND OSMOSIS

Strand: **Processes for Living**

Sub-Strand: Essentials for Survival

Learning Outcome: *Appreciate the movement of substances in biotic and abiotic media.*

Content Standard: Demonstrate understanding, appreciation and model the movement of substance in biotic and abiotic media.

INTRODUCTION AND SECTION SUMMARY

In this section, we explore the fundamental concepts of diffusion and osmosis, revealing their significance in both scientific principles and everyday life. Diffusion, the spontaneous movement of particles from high to low concentration, influences various natural phenomena from gas behaviour in physics to cellular processes in biology. Its applications are omnipresent from the scent of flowers to culinary arts, enhancing our understanding of biological systems and atmospheric interactions. Interdisciplinary connections abound, with diffusion's implications extending to physics, biology, and environmental science.

Osmosis, a special form of diffusion, involves the movement of water molecules across selectively permeable membranes. We model and explain osmosis, emphasising its applications in maintaining cellular balance and impacting daily life - from preserving vegetable crispness to cellular functions. Teachers can highlight the interdisciplinary relevance of osmosis in chemistry, healthcare, and beyond. Together, we unravel the mysteries of diffusion and osmosis, appreciating their profound impact on the world and the interconnectedness of scientific concepts across various disciplines.

The weeks covered by the section are:

Week 8: *Concepts of diffusion and its application in life.*

Week 9: *Design, model and explain the osmosis process and indicate its application to everyday life.*

SUMMARY OF PEDAGOGICAL EXEMPLARS

Teachers are advised to adopt a collaborative and differentiated teaching approach for diffusion. Grouping learners based on ability and gender with assigned positions promotes inclusive collaboration and ensures equitable participation. The essential learning objectives encompass understanding diffusion principles, observing compound changes over time, employing the think-pair-share strategy, and engaging in discussions comparing diffusion rates. Assessment criteria include effective communication of understanding, documentation of observations, and active participation in collaborative discussions.

Learners are expected to summarise key concepts and explore real-world applications of diffusion. Additional opportunities for gifted and talented students include exploring advanced diffusion principles, conducting independent experiments, leading discussions, and presenting in-depth findings. Various avenues, such as written reports, oral presentations, or multimedia projects, are provided for learners to deliver their findings according to their preferences. The conclusion encourages learners to summarise key points and apply their understanding to real-world scenarios, ensuring a comprehensive grasp of the diffusion concept through diverse and inclusive teaching methods.

ASSESSMENT SUMMARY

This section's assessments will be formative, summative, and differentiated. Formative assessment will involve laboratory work, practically demonstrating certain science aspects to improve learners' science process abilities. Short exams, class exercises, assignments, group discussions, group projects, and group presentations also exist. Written examinations, interviews, observations, or performance assignments based on assessment indicators should be delivered along with graded outcomes. Students should be issued with a list of the learning outcomes for each section and could review their learning by coding each learning outcome red (not understood), amber (understood but not yet secure) and green (securely understood). Summative assessments are due at the end of every lesson, section, and semester. However, both formative and summative examinations contribute to learners' cumulative records.

To foster a positive assessment environment, ensure learners are given clear instructions. Maintain consistency in administering the formative assessment across all participants to ensure fairness and impartiality.

Differentiated assessment focuses on learners' learning needs, strengths, and interests. Teachers should adjust assessment questions to different levels of readiness, learning styles, and preferences so that all students have an equal opportunity to demonstrate their competencies.

Week 8

Learning Indicator(s): *Appreciate the movement of substances in biotic and abiotic media.*

Theme or Focal Area(s): Concepts of diffusion and its application in life.

Concepts of Diffusion

Diffusion refers to the movement of molecules from an area of high concentration to an area of low concentration until the molecules are evenly distributed. The driving force behind diffusion is the concentration gradient, which is the difference in concentration between two regions. Diffusion always tends to equalise the concentration gradient leading to a uniform distribution of molecules and equal concentration throughout space or solution.

Demonstration of diffusion of potassium permanganate

Title: Demonstrating the spread of permanganate ions in solution.

Aim: The purpose of this demonstration is to show how particles move from an area of high concentration to an area of low concentration - the process of diffusion.

Materials needed: Beaker, water, potassium permanganate crystal and spatula.

Procedure

1. Fill the beaker with water.
2. Put a piece of potassium permanganate crystal into the bottom of the beaker containing water using a spatula. Be careful so the water is not overly disturbed and that the crystal is positioned at the bottom of the beaker without much mixing.
3. Observe what happens over a few minutes.

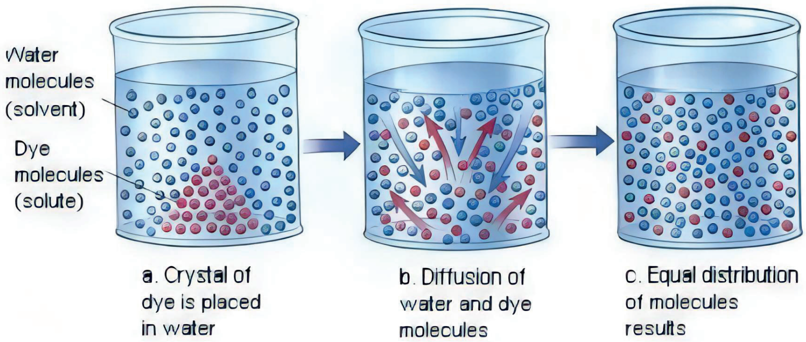


Fig. 3.1: *diffusion using potassium permanganate crystal.*

Observation: when potassium permanganate crystal is placed in water, the crystal dissolves and the permanganate ions are concentrated in one area.

As the crystal dissolves in the water, a net movement of permanganate ions occurs throughout the beaker of water.

The water and the permanganate ions are eventually equally distributed throughout the beaker.

Conclusion: Permanganate ions move from an area of high concentration to an area of low concentration until the ions are evenly distributed.

NOTE:

The teacher could repeat the experiment with the potassium permanganate crystal in a beaker of cold water and compare the rate of diffusion with a similar sized crystal in hot water. Diffusion should be faster in hot water as the ions will be moving faster.

Demonstration of diffusion in gases using perfume.

Title: Observing Gas Diffusion

Aim: To investigate the diffusion of perfume molecules through air.

Material Needed: a bottle of inexpensive perfume.

Procedure:

1. Learners should be spread throughout the classroom;
2. Pour or spray a small volume of perfume onto a piece of tissue and leave it in one corner of the classroom.
3. Learners should raise their hands when they can smell the perfume.

Observation: over a few minutes, the perfume will be smelled by pupils increasingly distant from the perfume bottle as the perfume molecules diffuse throughout the classroom.

Conclusion: Diffusion of gas particles also occurs as the perfume evaporates forms a cloud of high perfume concentration and diffuses throughout the classroom until at equal concentration throughout.

Factors that Affect Diffusion

Concentration gradient: The concentration gradient is the difference in concentration between two regions. The greater the concentration gradient, the faster diffusion will occur.

Temperature: Temperature directly affects particle kinetic energy. Higher temperatures increase the kinetic energy, causing particles to move more vigorously. As a result, diffusion happens at a faster rate in higher temperatures. Conversely, lower temperatures lead to slower diffusion due to reduced particle movement.

Particle size/molecular weight: Smaller particles diffuse more quickly than larger particles. Collisions with other particles hinder smaller particles. Larger particles, on the other hand, have more mass and experience greater resistance, leading to slower diffusion rates.

Nature of matter/substances: Diffusion occurs faster in less dense or viscous media. For example, it occurs more rapidly in air than in a thick liquid.

Surface area: The available surface area for diffusion can affect the diffusion rate. A larger surface area allows more particles to contact the interface, facilitating faster diffusion. This is especially relevant in processes like gas exchange in the lungs or the transfer of nutrients across cell membranes.

Distance of Diffusion: The distance over which diffusion occurs also plays a role. The greater the distance, the longer it takes for particles to diffuse across it.

Pressure: gases at low pressure have less density of particles, and therefore, the movement of particles is less hampered by collision than similar gases at higher pressure. Diffusion is faster in low-pressure situations than in high-pressure situations.

Application of Diffusion in Everyday Life

Perfume/Cologne: When you spray perfume or cologne onto the skin, the scent particles evaporate from the skin and diffuse through the air spreading from an area of high concentration (your skin) to an area of low concentration (the surrounding space).

Cooking: During cooking, food particles diffuse through the kitchen and sometimes beyond, allowing you to smell the food even if you are not standing directly over the stove. The food particles' movement in the air gives the food its aroma.

Room Fresheners: Air fresheners or diffusers release fragrance into the air. The fragrance molecules disperse and diffuse throughout the room, creating a pleasant scent.

Tea/Coffee Brewing: When you place a tea bag or coffee grounds in hot water, the flavour compounds diffuse from the concentrated source into the surrounding liquid resulting in a flavoured beverage.

Oxygen and Carbon Dioxide Exchange: In the human body, diffusion is vital for gas exchange in the lungs. Oxygen from the inhaled air diffuses from the lungs into the bloodstream, while carbon dioxide diffuses into the lungs to exhale.

Learning Tasks

1. Explain diffusion in everyday life.
2. Give at least three examples of diffusion in everyday life.
3. How does temperature affect the rate of diffusion?
4. How does diffusion play a role in biological systems?

Pedagogical Exemplars

Collaborative Learning

1. Group learners based on mixed-ability and gender to encourage collaborative learning. Assign roles within each group to ensure equitable participation.
2. Introduce the concept of diffusion and explain its use in domains such as chemistry, biology, and physics.
3. Give each group a transparent container/beaker half-filled with water and potassium permanganate crystals.
4. Let learners drop potassium permanganate crystals into the beaker containing water and observe what happens. Ensure all learners actively participate in the activity and support learners with difficulties.
5. Ask learners to reflect and cross share their findings for discussion through peer review.
6. Encourage groups to use the think-pair-share strategy to explain the diffusion process.
7. Ask learners to repeat the experiment using hot water, different sizes of potassium permanganate crystals and compare the factors that may affect diffusion.
8. Guide learners to write their findings and present them to class for discussion.
9. Provide guided questions or prompts to facilitate the learning process and encourage gifted learners to examine advanced diffusion principles or conduct their own experiments to learn more about diffusion.

10. Learners present findings in various ways, such as written reports, presentations, or multimedia (PowerPoint).
11. Let learners in their groups explore the applications of diffusion in everyday life and present their work using charts, concept maps, posters, and mind maps.
12. To conclude the lesson, guide learners in summarising the important points covered and exploring real-world applications of diffusion.

This link is especially useful in showing diffusion https://www.youtube.com/watch?v=SWByFMo32Qg

Key Assessment

Assessment Level 2: How does temperature affect the rate of diffusion?

Assessment Level 3: How does the molecular weight of particles influence the diffusion rate?

Assessment Level 4: In a lab experiment, two identical containers are filled with water, and a drop of ink is added to each container. Container A is kept at room temperature while Container B is placed in a refrigerator. Predict and explain the difference in the diffusion rate between the two containers.

Week 9

Learning Indicator(s): *Design, model and explain the process of osmosis and indicate its application to everyday life.*

Theme or Focal Area(s): Osmosis and its application in our daily life.

Explanation of Osmosis

Osmosis is defined as the movement of water molecules from an area of high-water concentration to an area of low water concentration across a s*emi-permeable* membrane. Osmosis does not require energy from the cell to occur. It takes place naturally to ensure the concentration of water molecules on both sides of a semi-permeable membrane are equal.

The direction and rate of osmosis depend on the relative concentration of solutes on either side of the membrane. If compartment A had a higher solute concentration than compartment B, water would move from compartment B to compartment A until equilibrium is reached. Equilibrium simply means the same concentration of water molecules in the two compartments. The diagram below shows that there is a higher concentration of water molecules (small blue circles) on the right-hand side than on the left-hand side. Therefore, the water will move from right to left until the concentration of water molecules is equal on both sides.

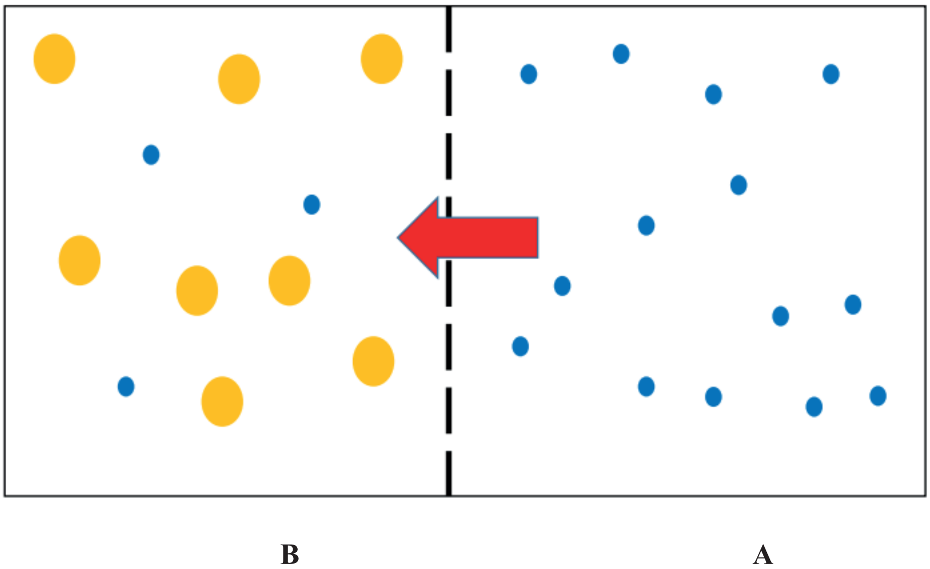


Fig. 3.2: *Diffusion demonstration*

Osmosis Model

Experiment: To investigate osmosis in a model cell using Visking tubing.

Title: Investigating osmosis in model cells with different internal water concentrations bathed in pure water.

Aim: The aim of this investigation is to investigate the process of osmosis on model cells with different internal water concentrations bathed in pure water. The model cells are made using Visking tubing which is selectively permeable.

Materials needed: beakers, 3 solutions of sucrose; 5%, 10%, 15% (w/v), water, Visking tubing, funnel, measuring tape (or string and a ruler).

Procedure

1. Almost fill each beaker with pure water.
2. Cut equal lengths of Visking tubing about 12 cm long.
3. Tie one end of each piece of Visking tubing.
4. Use a funnel to pour pure water into the first piece of tubing. Tie the other end.
5. Measure the circumference of the filled tubing using string and the ruler.
6. Place this model cell into beaker 1.
7. In the same way fill the next piece of visking tubing with 5% sucrose solution and place in beaker 2.
8. Repeat for 10% sucrose and 15% sucrose solutions and place into beaker 3 and 4.
9. Leave for 24 hours and re-measure the circumference of the model cells and feel the hardness of the model cell. Record in the table below.

The model cells have different sucrose solutions and therefore different water concentrations. 0% sucrose has the highest water concentration and 15% sucrose the lowest water concentration. Water can move freely into or out of the Visking tubing but sucrose cannot.

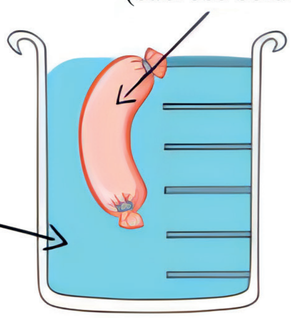


Fig. 3.3: *Investigating osmosis in a model cell using Visking tubing.*

Results:

A sample table is shown below.

Beaker	Visking tubing containing	Circumference at start	Circumference after 24hrs/mm	Firmness of model cell.
1	Water			
2	5% Sucrose			
3	10% sucrose			
4	15% sucrose			

Conclusion: The Visking tubing acts as a semi-permeable membrane akin to a cell membrane. If the water concentration is higher in the beaker than inside the model cell, the water will move through the tubing and the model cell will increase in circumference. If the water concentration is higher inside the model cell than the surrounding water, water will move out of the model cell and the circumference will reduce. If the water concentration is the same, then there will be no net movement and therefore no change in circumference.

Experiment to investigate osmosis in plant tissue (living tissue)

Aim: To investigate osmosis in plant tissue

Materials needed: Potato, borer/knife, 3 different concentrations of sucrose solution, beakers, measuring cylinder, ruler, weighing balance.

Procedure

- **i.** Make up four concentrations of sucrose solution: for example, 0%, 5%, 10%, 15% (w/v)
- **ii.** Pour 50cm^3 of pure water into beaker 1, 50cm^3 of 5% sucrose solution into beaker 2, 50cm^3 of 10% sucrose solution into beaker 3 and 50cm^3 of 15% sucrose solution into beaker 4.
- **iii.** Use the borer to remove cylinders of potato from the whole potato
- **iv.** Cut the potato cylinder into 3cm pieces and dry with a paper towel
- **v.** Measure the mass, diameter, and length of each potato piece.
- **vi.** Record the results.
- **vii.** Place one potato cylinder into each beaker.
- **viii.** Leave for 24 hours.
- **ix.** Record the mass, diameter, and length of each potato cylinder.

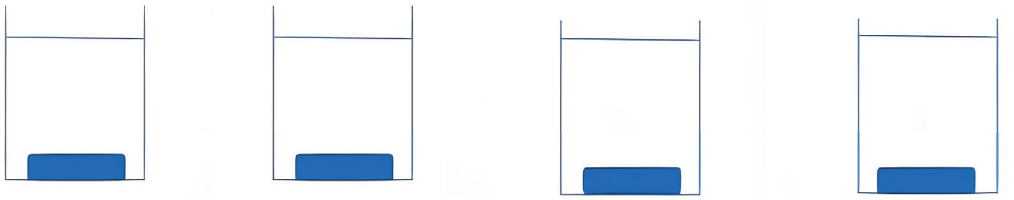


Fig. 3.4: *Investigating osmosis in plant tissue*

Results: Record the results in a suitable table such as shown below

BEAKER	solution	Length/mm			Mass/g			Diameter/mm		
		Start	After 24hrs	Change	Start	After 24hrs	Change	Start	After 24hrs	Change
1	water									
2	5% sucrose									
3	10% sucrose									
4	15% sucrose									

The results from this investigation should be further analysed by calculating the percentage change in mass, length, or diameter of the plant tissue. A line graph can also be drawn to present the results with sucrose concentration on the X-axis and percentage change in mass (or length or diameter) on the Y-axis.

Conclusion: The potato cell membrane acts as the semi-permeable membrane. There is a difference in the concentration of water in the cells making up the potato tissue and the concentration of water in the solution. In beaker 1 the highest concentration of water is outside the cell in the beaker. So, water will move into the potato tissue. The cells will expand. Therefore, we should notice an increase in the length, mass, and diameter of the potato cylinder.

In the next 3 beakers, the water will either move into the potato, increasing the measurements, or out of them, decreasing them. If there is no change in the measurements, then water has not moved because the concentrations on either side of the semi-permeable membrane are already equal.

Application of Osmosis in Everyday Life.

Food Preservation: Osmosis is utilised in food preservation techniques such as pickling and curing. In these processes, salt or sugar is used to create a high concentrated solution, which draws water out of the food and the microorganisms present in the food. This removal of water inhibits the growth of bacteria and other spoilage-causing organisms, thus extending the shelf life of the food.

Kidney Function: Osmosis is integral to the functioning of the kidneys, which filter waste products from the blood and regulate water and electrolyte balance. The movement of water and solutes across the renal tubules occurs through osmosis, allowing the kidneys to concentrate urine and reabsorb necessary substances back into the bloodstream.

Brining: Brining is a process used to enhance the flavour and juiciness of meat, poultry, and fish. It involves soaking the food in a solution of salt and water. During brining, osmosis occurs as the salt concentration in the brine is higher than the concentration of salt in the meat or fish. Water moves from the meat or fish into the brine, resulting in decreased moisture content and improved flavour.

Learning Tasks

1. Define osmosis.
2. Describe how osmosis is apparent in everyday life.
3. Design an experiment to investigate osmosis.

Pedagogical Exemplars

Research and Discussion

a. Put learners into pairs and assign them the task of researching osmosis from books/internet/ science journals etc. Facilitate student research on osmosis through guiding questions and reliable sources.

b. Encourage discussions on the meaning and significance of osmosis based on their findings.

c. Facilitate a whole-class discussion to consolidate key points and address any queries.

d. Encourage participation and collaboration among students, ensuring diverse perspectives are valued.

Activity-based learning/ Collaborative learning

a. Put learners in mixed-ability groups and guide them to design an experiment investigating osmosis.
b. Provide support and resources for students to plan and execute their experiments.
c. Encourage students to document their experimental procedures, observations, and results.
d. Organise mixed-sex and mixed-ability groups to prepare presentations on the practical applications of osmosis. Offer feedback and evaluation of student presentations to reinforce learning outcomes.
e. Emphasise the involvement of female students in key roles during the presentation.
f. Encourage discussions on how osmosis is utilised in everyday scenarios like cooking, plant hydration, or medical processes.

Key Assessment

Assessment Level 2: Explain three factors that affect osmosis.

Assessment Level 2: Describe three ways osmosis can be applied in the domestic setting.

Assessment Level 3: Design a model to explain the process of osmosis and report on it.

Additional Reading:

1. Read further other experiments to explain process of diffusion and osmosis.
2. Identify and incorporate educational technology tools or resources (such as interactive simulations or virtual labs) to enhance students' comprehension and engagement with diffusion and osmosis concepts.
3. Research and compile examples of diffusion and osmosis in real-life situations, such as biological processes, environmental phenomena, or industrial applications, and create case studies or presentations for students.

Resources

1. Beaker, water, potassium permanganate crystals, spatulas, bottle of perfume, tea, coffee
2. Beakers, 3 solutions of sucrose; 5%, 10%, 15%, water, Visking tubing, funnel, string, Visking tubing
3. Potatoes, borer/knife, 3 different concentrations of sucrose solution, beakers, measuring cylinder, ruler, paper towel.
4. Charts, videos, simulations, pictures, diagrams, posters showing osmosis and diffusion.

References

1. Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2006). Transport Phenomena (2nd ed.). Wiley.
2. NewPath Learning. (2014). Osmosis and Diffusion Science Learning Guide. Life Science Learning Guides. NewPath Learning

SECTION 4: REPRODUCTION IN PLANTS AND HUMANS

Strand: Processes for Living

Sub-Strand: Essentials for Survival

Learning Outcome: *Illustrate the principles of reproduction.*

Content Standard: Demonstrate knowledge and understanding of the principles of reproduction and their application in addressing sexually related societal problems.

INTRODUCTION AND SECTION SUMMARY

This section focuses on providing learners with an understanding the concept of reproduction in plants and humans; to understand and explain the concept of the menstrual cycle; how to calculate the menstrual cycle, and the application of this knowledge to address reproduction-related issues.

The weeks covered by the section are:

Week 10: Explain reproduction in plants and humans.

Week 11: Explain reproduction in plants and humans.

Week 12: Explain the female menstrual cycle and show how that can be used to address reproduction-related issues.

SUMMARY OF PEDAGOGICAL EXEMPLARS

Teachers should lead students on a nature walk to observe various plants and identify their reproductive parts. Using project-based learning approaches, put learners in mixed-ability groups to present on sexual reproduction in plants using resources such as videos on pollination, fruits and seeds formation and seed germination, and asexual reproduction in plants using vegetative parts such as corm, rhizome, suckers, stem cuttings and bulbs.

Using models, videos, pictures, or charts of the male and female reproductive system, let learners in mixed-ability groups describe the structure and explain the function of the parts of the structure. Stereotypes should be addressed when using representatives of the human reproductive system.

Put learners into mixed ability groups and guide them to calculate the menstrual cycle using calendar/pictures/charts/videos. Finally, using talk-for-learning strategies and reflections from Internet resources/books, learners can compare global best practices of menstrual hygiene.

Assessment should focus on the understanding the concept of reproduction in plants and humans, explaining the concept of the human menstrual cycle, how to calculate the menstrual cycle and its application to address reproduction-related issues. Furthermore, it should also focus on hands-on demonstration of artificial vegetative propagation practices such as budding, grafting and layering.

ASSESSMENT SUMMARY

This section focuses on DoK Level Three: strategic reasoning. Assessment will include formative and summative approaches. Formative assessment during delivery of the lessons within the session will include activities such as short tests, class exercises, assignments, group discussions, and project work where marks are awarded and recorded. Summative assessment should be done at the end of the lesson, section, and end of the semester.

Moreover, learners also should be evaluated on their participation in discussions, project work and presentations. However, both formative and summative assessments contribute to the cumulative records of the learners.

To cater for gifted and talented learners, additional content could include demonstrations on vegetative propagation practices such as budding and grafting, in-depth analysis of the menstrual cycle, and opportunities for independent research projects to deepen their understanding and challenge their abilities.

Week 10

Learning Indicator(s): *Explain reproduction in plants and humans.*

Theme or Focal Area(s): Reproduction in plants

Reproduction

This is the process by which living things give rise to new individuals of their kind. Reproduction in plants is a fundamental biological process that allows plants to propagate and ensure the continuation of their species. Through these mechanisms plants can produce offspring, disperse their genetic material, and colonize new habitats. There are two types of reproduction: sexual reproduction and asexual reproduction.

Sexual reproduction

Sexual reproduction in plants involves the fusion of male and female reproductive cells or gametes. It allows for genetic diversity and adaptation as it introduces new combinations of genetic material. The key processes involved in sexual reproduction in plants are pollination, fertilisation, seed production and dispersal, germination, and subsequent growth.

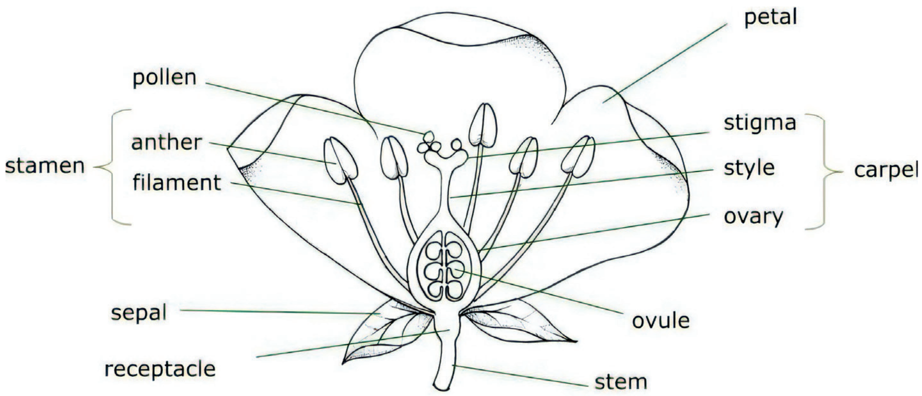


Fig. 4.1: *Structure of a Flower*

In flowering plants, male and female reproductive structures can often be found in the same individual plant. The organ of a sexual reproduction is the flower.

Parts of a flower	Structure	Function
Sepals	The sepals are the outermost whorl which is small and green in colour.	Brightly coloured sepals attract pollinators to pollinate the flower and Green sepals manufacture food for the plant. They protect the delicate flower bud before it opens.
Petals	Petals are large, brightly coloured and often scented to attract pollinators	Produces scent to attract pollinators. Produces nectar to attract insect pollinators.

Parts of a flower	Structure	Function
Stamens	This is male organ of the plant and consists of the anther and the filament. The anthers produce pollen which can be considered the male gametes of the plant. The filament holds the anthers.	The male sex organs which produce pollen grains and help distribute them.
Stigma	The stigma is on the top of the style connected to the ovary. The stigma, style and ovary can be considered the female parts of the flower.	Stigma collects pollen grains
Ovary	A carpel has three parts; ovary, style, and stigma. The ovary is the enlarged base of the carpel. It contains one or more ovules. The ovary is where the female gametes are located. The ovules can be considered the female gametes.	Produces ovules which will develop into seeds once fertilised. The ovary develops into a fruit at the same time.

Pollination

Is the transfer of pollen grains from mature anthers to a mature stigma of flower.

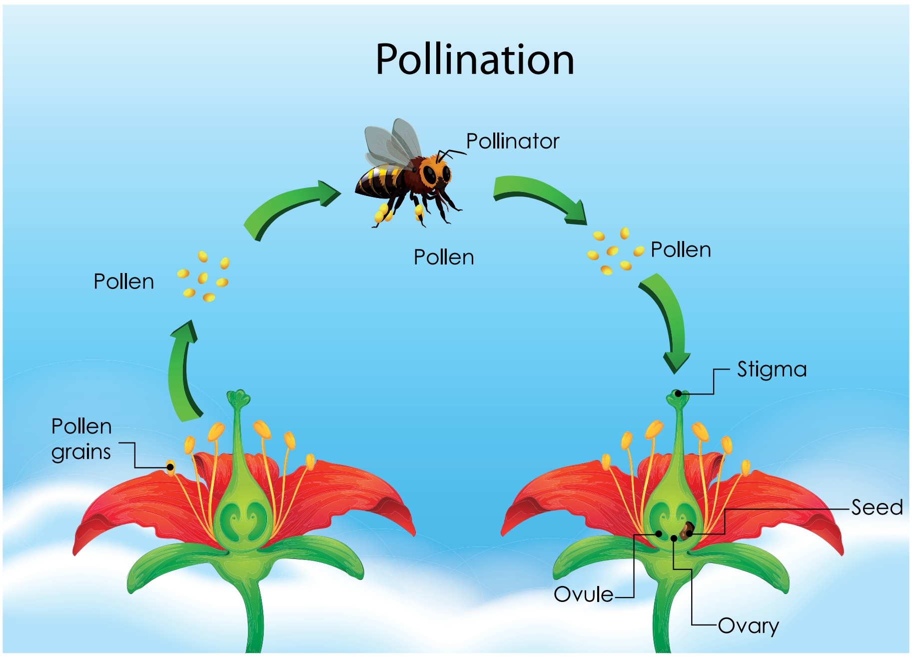


Fig. 4.2: *Pollination of a flower*

Agents of Pollination

Pollination requires some agents or vectors to help transfer pollen from one flower to another. The agents can be insects, other invertebrates, wind, bats, birds, mammals, birds, reptiles, and water. Insects and wind are the major agents of pollination.

Importance of Wind Pollination

Wind pollination is highly efficient for plants in environments where other pollinators are scarce or less reliable. Since wind is omnipresent, plants relying on wind pollination do not have to wait for specific pollinators to visit.

Wind can carry pollen over significant distances, facilitating pollination between plants that might be quite far apart. This is particularly useful in sparse or isolated populations, where insect pollinators might not reach.

Wind pollination does not depend on the availability of specialised pollinators, making it advantageous for plants in areas where pollinator populations are limited or unpredictable.

Wind-pollinated plants often exhibit specific adaptations to maximise their reproductive success. These adaptations include producing large quantities of lightweight pollen grains that are easily carried by the wind.

Unlike insect-pollinated flowers, wind-pollinated flowers often lack nectar, scent, or bright colors since they do not need to attract insects. This saves the plant energy that would otherwise be spent on producing these attractants.

While some plants rely heavily on specific pollinators (like bees or butterflies), wind-pollinated plants are less vulnerable to fluctuations in pollinator populations or changes in the environment that might affect certain pollinators.

Importance of Insect Pollination

- Insect pollination efficiently facilitates plant reproduction by relying on specialised pollinators.
- It promotes cross-pollination as insects transport pollen between flowers during foraging.
- Plants attract insects with nectar, scent, and vibrant colors, enhancing pollination success.
- Insect-pollinated flowers often have specific structures to facilitate pollen transfer by insects.
- This strategy ensures reproductive success through mutualistic relationships with pollinating insects.
- Insect pollination has evolved as a highly effective reproductive strategy especially in diverse ecosystems.

Characteristics/Adaptations of Insect and Wind Pollinated Flowers Compared

Insect-pollinated flowers	Wind pollinated flowers
Petals are brightly coloured to attract insects	Petals, if present, are dull in colour
Flowers are scented	Flowers are not scented
Have sticky stigma	Have feathery stigma
Have short and stout filaments	Have long filaments
Produces less pollen grains	Produce abundant pollen grains

Fertilisation

Fertilisation is the fusion of the nucleus of a male gamete with the nucleus of a female gamete to form a zygote. Fertilisation takes place in the ovule, which contains the female gamete - the ovum. Ovules are found inside the ovary. Each ovule contains an egg. When a mature pollen grain lands on a mature stigma, it absorbs water and nutrients from the stigma and swells up. The wall of the pollen grain ruptures, and a pollen tube protrudes which penetrates the stigma and grows through its tissues into the style. This is the germination of the pollen grain. The pollen tube nucleus moves to the tip of the pollen tube. The pollen tube enters the ovule through the area called the micropyle. The pollen grain travels to the egg and fuses with it resulting in fertilisation. The fertilisation results in zygote formation which later develops into a seed. Following fertilisation, the zygote starts to divide, and it eventually turns into an embryo within the seed. The embryo is kept latent in a seed capsule until the right environmental factors allow it to germinate and grow into a new plant.

Following fertilisation, the ovary swells and forms the fruit. The role of fruit is in seed dispersal. Fruit can be considered the mobile stage in a plant's life cycle. Some fruits are carried by the wind, others are explosive and fire seeds far from the mother plant, others are attractive to animals are eaten and the indigestible seeds are transported and deposited in animal faeces, other fruits are sticky and transported after sticking to animal's fur.

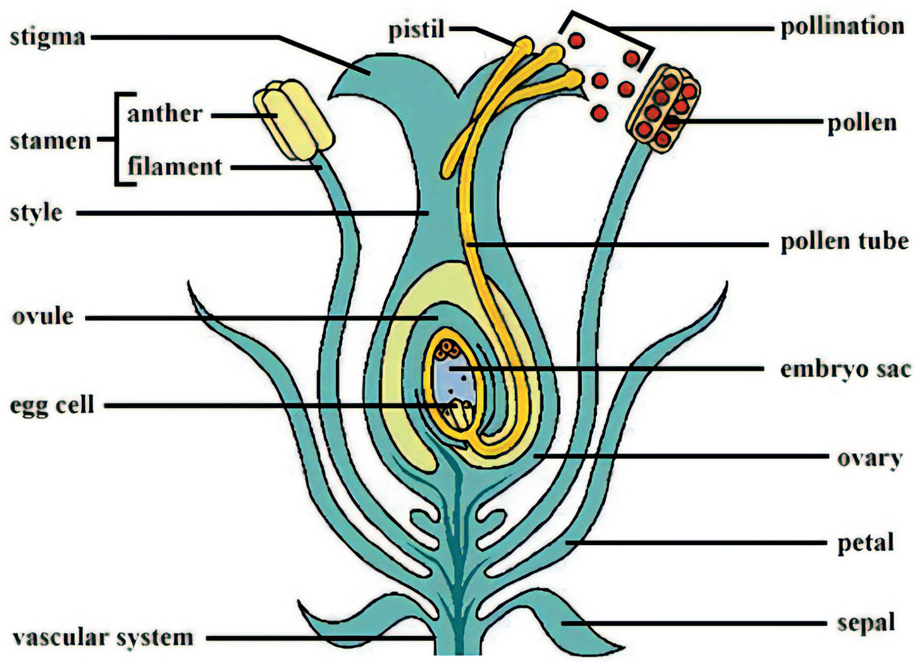


Fig. 4.3: *Fertilization in flowering plants*

Advantages of Sexual Reproduction in Plants

Sexual reproduction leads to offspring with genetic diversity. Each parent contributes half of their genetic material, resulting in unique combinations of traits in the offspring. Some individuals may have advantageous traits that enable them to thrive in specific conditions, ensuring the survival of the species.

Evolutionary Advantage: sexual reproduction accelerates the process of evolution by creating new genetic combinations that can be subjected to natural selection. It enables plants to evolve and adapt to new ecological niches over time.

Genetic diversity within a population makes it less susceptible to widespread diseases or pests.

Seed Dispersal: sexual reproduction produces seeds that can be dispersed over wide areas, increasing the chances of colonisation in new habitats, and facilitating the establishment of new plant populations.

Disadvantages of Sexual Reproduction in Plants

Sexual reproduction in plants demands more energy and resources compared to asexual reproduction.

Many plants rely on pollinators, such as bees, butterflies, or other animals, to transfer pollen between flowers. If pollinators are scarce or absent, sexual reproduction may be limited or entirely hindered.

The process of sexual reproduction, involving pollination, fertilisation, and seed development, can be time-consuming. This slow reproduction rate may be a disadvantage in rapidly changing or unstable environments.

Asexual Reproduction

Asexual reproduction is the mode of reproduction that does not involve the fusion of male and female gametes and produces individuals genetically identical to the parent. Asexual plant reproduction occurs through many modes including suckers, runners, bulbs, tubers, and layering. No flowers are required for this method. Asexual reproduction in plants is often termed vegetative propagation and can take place naturally or artificially.

Natural Asexual Reproduction

Natural asexual reproduction, also known as vegetative reproduction, is a fascinating process observed in various plants and organisms across the natural world. This method of propagation enables plants to reproduce without the need for seeds or the involvement of external agents like pollinators. Instead, new individuals are generated from specialised plant parts such as roots, stems, bulbs, or leaves.

Advantages of Natural Asexual Reproduction in Plants

1. Asexual reproduction in plants is efficient, as it does not require the time and energy needed for pollination or the production of seeds.
2. Offspring produced through asexual reproduction are genetically identical to the parent plant, ensuring consistency in desirable traits such as disease resistance or fruit quality.
3. Rapid propagation of plants with favorable traits occurs without the need for genetic recombination.
4. Asexual reproduction allows plants to colonise new environments rapidly, enabling them to spread even from a single individual.
5. Some plants can reproduce asexually under adverse conditions such as drought or nutrient scarcity, serving as a survival strategy.
6. Genetic purity is maintained as there is no mixing of genetic material from different plants, preserving specific traits that are well-adapted to environments.

Natural Methods of Asexual Reproduction

There are several mechanisms by which plants reproduce asexually.

Runners and Stolons: Some plants produce horizontal stems called runners or stolons that grow along the soil surface. At certain intervals, nodes along these stems develop into new plants, forming clones of the parent plant. Examples include strawberries and spider plants.

Rhizomes: Rhizomes are underground stems that extend horizontally and give rise to new shoots and roots at nodes along their length. Plants like ginger and bamboo propagate through rhizomes, allowing them to spread and colonize large areas.

Bulbs and Tubers: Bulbous and tuberous plants store nutrients in specialised underground structures like bulbs (e.g., onions) or tubers (e.g., potatoes). These structures can give rise to new plants through budding or the growth of daughter bulbs or tubers.

Fragmentation: In fragmentation, a plant breaks into parts, and each can grow into a new individual. For instance, pieces of certain succulent plants like aloe vera or jade plants can develop roots and shoots when placed in suitable conditions.

Runners: These stems usually grow in a horizontal position above the ground. They have the nodes where the buds are formed. These buds usually grow into a new plant.

Roots: When a new plant is developed from modified roots called tubers. Example: sweet potato

Leaves: In some plants, detached leaves from the parent plant can be used to grow a new plant. They promote the growth of small plants, called plantlets on the edge of their leaves. Example: *Bryophyllum.*

Artificial Propagation

Artificial propagation refers to the deliberate human intervention in the reproductive processes of plants and animals to produce offspring under controlled conditions. These methods are employed in various fields such as agriculture, aquaculture, horticulture.

Advantages of Artificial Propagation

Artificial propagation methods ensure the consistency of desirable cultivars' traits, such as flower color and disease resistance.

Techniques like tissue culture enable swift production of large numbers of uniform plants from a single tissue sample.

Artificial methods offer the only means of multiplying sterile or hybrid plants that do not produce viable seeds.

Artificial propagation allows for continuous plant production regardless of seasonal variations, ensuring a steady supply.

Endangered plant species can be conserved through artificial propagation, preserving genetic diversity, and preventing extinction.

Propagation methods like tissue culture start with sterilised plant material thus reducing the risk of introducing pathogens and allowing to produce disease-free stock.

Artificial Propagation Methods

Cuttings: Portions of stems or roots are cut and planted in suitable conditions to grow into new plants. Typically, cuttings are obtained from healthy, established plants while they are actively growing. Rooting hormone is then applied to the cutting to promote the formation of roots. The cutting is placed in a growing medium to facilitate further growth after the roots have formed.

In horticulture and agriculture, this technique is frequently employed to grow plants that have desired traits, like disease resistance, flower colour, or fruit quality. It is useful for maintaining and propagating plant kinds with special or exceptional qualities. Stem cuttings from these plants are used to cultivate a variety of plants including sugarcane, roses, Bougainvillea, Croton, Coleus, and money plants. These plants can even be grown from cuttings in water where they will generate adventitious buds and roots.

Advantages of Cuttings

Cuttings root quickly and can establish themselves as new plants in a short time.

Cuttings produce plants that are genetically identical to the parent plant, ensuring desirable traits are maintained.

Cuttings allow for precise control over the size and growth habits of the resulting plants.

Cutting propagation is often cost-effective as it requires minimal materials and equipment.

Disadvantages of Cutting

Cuttings are more prone to disease and rot since they lack a developed root system and are more vulnerable to environmental stress.

Some plant species are challenging to propagate from cuttings due to low rooting success rates.

Newly rooted cuttings may experience transplant shock when moved to a new environment, requiring extra care and attention.

Grafting: Grafting is a technique in which the parts of two separate plants are connected so that they develop as a single plant. During grafting, the stems of two separate plants are cut and joined together in such a way that they grow as a single plant. One of the two cut stems has roots and is referred to as stock. The other stem, known as the scion, is cut without roots. Scion and stock cut surfaces are fitted and stitched together with a piece of cloth before being covered with a polythene cover. It guards the stem against infections and other issues. Soon, the stock and scion combine to form a new plant. This is often done where the delicate fruit bearing variety is grafted onto a hardier root stock.

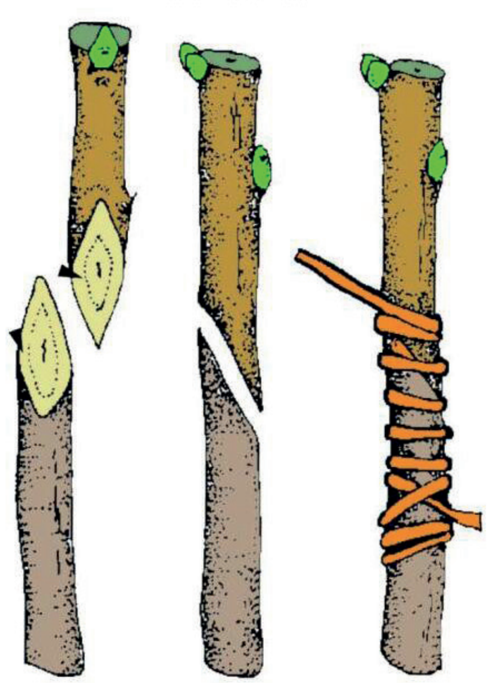


Fig. 4.4: *Grafting.*

Advantages of Grafting

Grafting allows for the combination of different plant varieties or species, enabling the creation of plants with desirable qualities such as disease resistance, improved yield, or unique characteristics.

Grafted plants often exhibit faster growth rates and earlier fruiting compared to plants propagated by other methods.

Grafted plants can benefit from the root system of a vigorous rootstock, providing improved nutrient uptake, drought resistance, and overall resilience.

Grafting can be used to repair damaged plants or rejuvenate old or weak specimens by incorporating them into a new, healthier root system.

Disadvantages of Grafting

Grafting success depends on genetic compatibility between the scion (upper portion) and the rootstock leading to potential incompatibility issues.

Grafting can be a labour-intensive process requiring specialised skills and equipment leading to higher production costs compared to other propagation methods.

Grafting can potentially transmit diseases from the rootstock to the scion especially if proper sanitation practices are not followed.

Layering: This technique involves bending a lower branch of a plant and covering it with damp soil leaving the developing tip exposed. Before the stem is bent down, a ring of bark is sometimes removed. When it has rooted, it can be separated from the parent plant and grown as an independent plant. In some species, long branches emanating from the tree trunk or bush stem can touch the surrounding soil surface (or are pinned to the ground) and soon start to develop roots which anchor the branch to the soil and start to draw water and nutrients. Once established, the layered branch detaches (or can be cut) from the mother trunk and the rooted branch becomes an independent plant. For instance, grapevine, strawberries, bougainvillea, and jasmine.

Advantages of Layering

Layering is a delicate and non-invasive method of growing new plants since it resembles natural plant growth techniques.

Having established roots prior to being split off from their parent plant, layered plants have a better chance of establishing themselves.

Layering encourages branching and general plant vigor, which results in stronger, healthier plants.

Plant species that are challenging to reproduce by cuttings can benefit from layering.

Disadvantages of Layering

Compared to cuttings, layering may result in established plants more slowly because roots need time to grow while still connected to the parent plant.

In general, layering produces fewer young plants at a time than cutting propagation techniques.

To accommodate the expanding branches, layering might need additional room in the nursery or garden.

Fig. 4.5: *Layering*

Micropropagation (Tissue Culture): Involves the growth of plant cells, tissues, or organs in a sterile nutrient medium under controlled conditions. A little portion of tissue, an organ, or even just one cell is removed from the plant and placed in an aseptic, sterile container with nourishing medium. The tissue quickly becomes an unorganized lump known as a callus. There is no limit to how long the callus can persist and grow. Plantlets, or tiny plants, are created when little amounts of tissue are transplanted to a different specialised media containing hormones. This process drives differentiation. The plantlets are grown into mature plants and can be gradually transplanted into pots or soil.

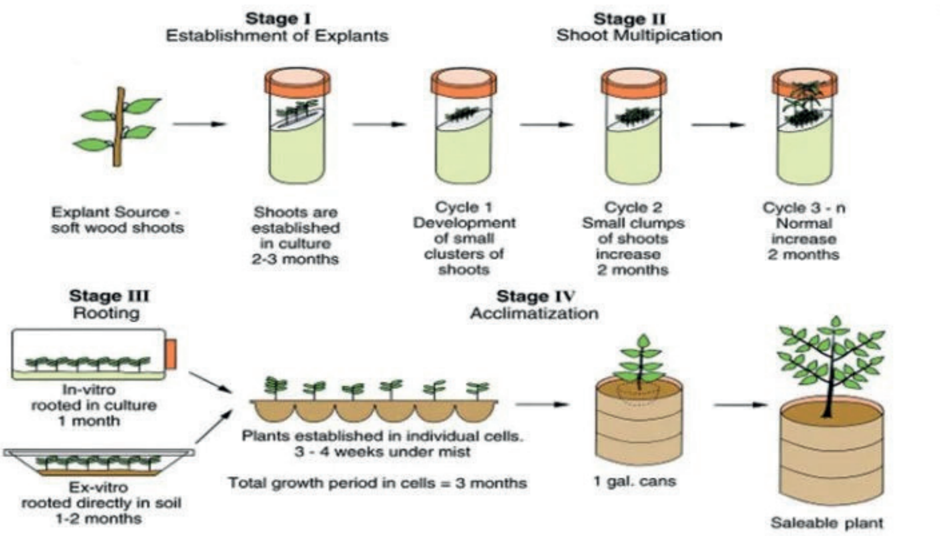


Fig. 4.6: *Steps involved in micropropagation*

Advantages of Micropropagation

Micropropagation enables the rapid production of many plants from a small amount of plant material making it an efficient method for commercial plant production.

Micro-propagated plants are grown in sterile conditions, reducing the risk of disease transmission, and producing healthy stock free from pathogens.

Micropropagation preserves the genetic integrity of plant varieties, ensuring the propagation of true-to-type plants with desired traits.

Micropropagation allows for continuous production of plants regardless of seasonal limitations, providing a consistent supply of plant material.

Disadvantages of Micropropagation

Micropropagation can lead to genetic uniformity among propagated plants, which may result in reduced genetic diversity and increased susceptibility to pests and diseases.

Setting up and maintaining a tissue culture facility can be expensive, making micropropagation a costly method of plant propagation.

Micro-propagated plants may require care and acclimatization post-propagation to transition successfully from sterile laboratory conditions to outdoor environments.

Learning Tasks

1. Analyse the differences between the types of reproduction in plants.
2. Describe the stages of sexual reproduction in flowering plants.
3. Describe vegetative propagation practices such as layering, grafting, cutting etc. using hands-on experiment.

Pedagogical Exemplars

Research and Collaborative Method

a. Put learners in groups to research and discuss the meaning of reproduction and types of reproduction in plants.

b. Encourage reflection and sharing of findings with the class for a discussion on different reproductive strategies in plants. Facilitate research activities, discussions, and presentations within mixed-ability groups.

Nature Walk and Observations

a. Lead students on a nature walk to observe various plant species and identify reproductive parts.

b. In groups, students can write down their observations and discuss their findings with the class, focusing on the diversity of plant reproductive structures. Provide guidance during the nature walk and encourage meaningful observations.

Research method

a. Put learners in mixed-ability groups to search for information on sexual reproduction in plants, including pollination and its role in plant reproduction.

b. Learners cross-share findings through presentations and facilitate group discussions to reflect on key themes and encourage critical thinking about pollination and sexual reproduction in plants. Encourage critical thinking, reflection, and peer interaction during group discussions.

c. Utilise a research-based learning approach where learners research and present on asexual reproduction in plants using vegetative parts like corms, rhizomes, suckers, stem cuttings, and bulbs.

Activity-based Learning Approach

Engage students in hands-on activities related to asexual reproduction to reinforce learning through active participation. Support hands-on activities and promote engagement through experiential learning.

Key Assessment

Assessment Level 1: Explain the importance of reproduction.

Assessment Level 2: Describe the process of fertilisation in flowering plants.

Assessment Level 3: write a report on a hand-on activity of at least two artificial propagation methods from the lesson.

Week 11

Learning Indicator(s): *Reproduction in plants and animals*

Theme or Focal Area(s): Female reproductive system

The female reproductive system is responsible for the production of eggs (ova), the reception of sperm for fertilisation, and the support of embryo development. It consists of several structures each with unique functions contributing to the reproductive process.

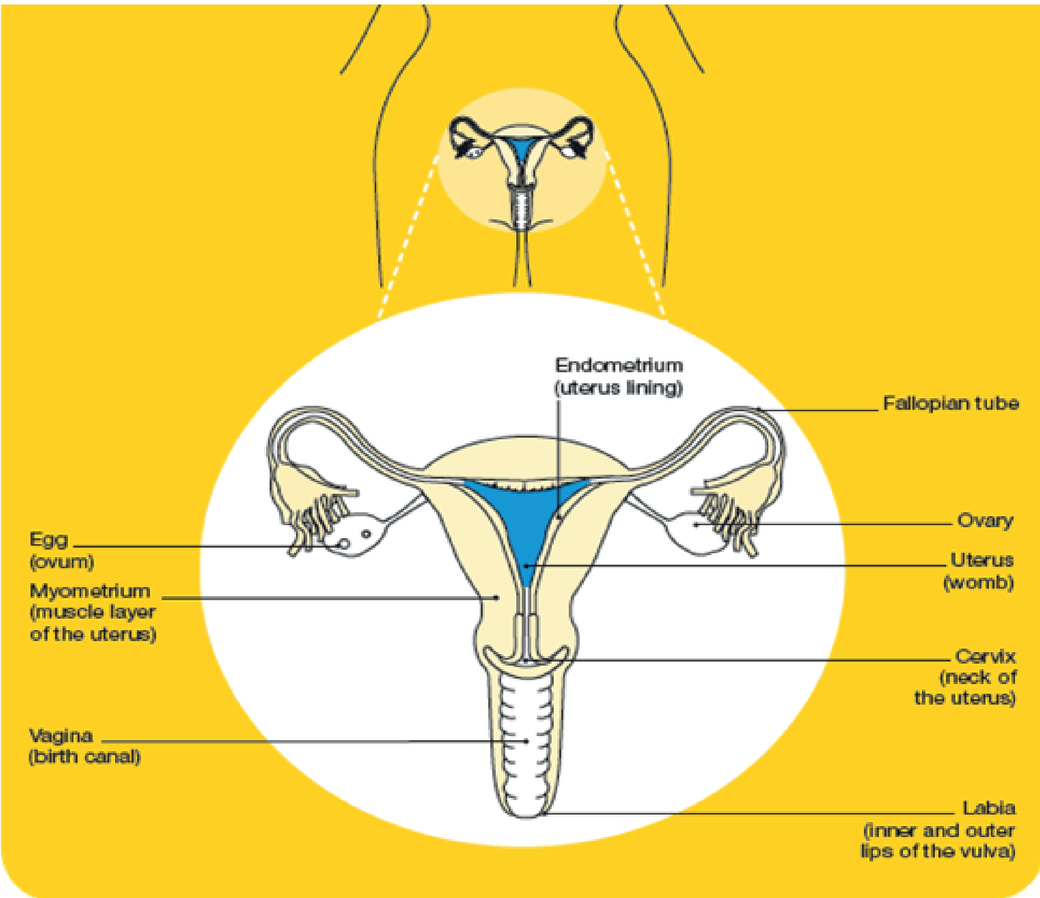


Fig. 4.7: *Structure of female reproductive system*

Processes of reproduction in humans

Copulation: Also known as sexual intercourse, copulation involves the insertion of the erect penis into the vagina. During this process, semen is ejaculated into the vagina.

Fertilisation: Fertilisation is fusion of male and female sex cells in the oviduct.

This forms a zygote, the single-cell embryo with a complete set of chromosomes from both parents.

Implantation: Implantation is the attachment of embryo to the uterine wall for nourishment.

After fertilisation, the zygote undergoes several divisions to form a blastocyst. The blastocyst moves down through the oviduct until it enters the uterus, it then implants itself into the lining of the uterus (endometrium), where it continues to grow and develop.

Foetal Development: Following implantation, the blastocyst develops into an embryo, and then into a fetus. During foetal development, organs and systems begin to form and differentiate. This stage spans three trimesters (each three months long), with distinct milestones such as the development of limbs, organs, and the nervous system.

Role of the Placenta: The placenta forms from tissues of both the embryo and the mother. It serves as the interface between the maternal and foetal circulatory systems facilitating the exchange of nutrients, oxygen, and waste products. Moreover, toxins such as nicotine and alcohol can cross the placenta from the mother's blood stream and damage the foetus. The placenta also produces hormones essential for pregnancy maintenance.

Birth: Labour is the process by which a foetus is expelled from the uterus through the birth canal (vagina). It involves uterine contractions coordinated by hormonal signals. After birth, the umbilical cord is typically clamped and cut, separating the newborn from the placenta.

Breastfeeding: Breastfeeding is the process of feeding a newborn with breast milk produced by the mother's mammary glands. Breast milk provides essential nutrients, antibodies, and other factors crucial for the baby's growth, development, and immune system function. It also fosters bonding between the mother and infant.

The main reproductive structures and their functions in the female reproductive system:

Ovaries: The ovaries are a pair of small, almond-shaped organs in the pelvic cavity.

Functions

1. Egg Production
2. Hormone Production

Oviducts: The oviduct**s** are two narrow tubes that extend from the ovaries to the uterus.

Functions

1. The oviduct is the site of fertilisation where the egg meet sperm;
2. The oviduct subsequently carries the fertilised egg (zygote) to the uterus

Uterus: The uterus, or the womb, is a hollow, muscular organ in the pelvis. It is lined with tissue with an enhanced blood supply called the **endometrium**.

Functions

1. Site for implantation
2. The uterus wall supplies nourishment and oxygen to the developing foetus
3. Provides protection and support to the developing foetus

Cervix: The cervix is the lower part of the uterus that connects it to the vagina.

Functions

1. Muscular entrance and exit of the uterus
2. Allows the entry of sperm and the exit of menstrual blood, and through which the baby passes from the uterus to the vagina in childbirth

Vagina: The vagina is a muscular canal that serves as the birth canal during childbirth and as the site for sexual intercourse.

Functions

1. Accepts the penis during sexual intercourse
2. Allows the exit of menses during menstruation
3. The birth canal allowing the baby to pass through into the outside World

Vulva: the external parts of the female reproductive system comprised of the labia majora, labia minora, and clitoris. Labia minora are folds of skin protected by the outer labia. The clitoris is the main site of female sexual pleasure located above the urethra.

Functions

1. The labia protect the opening of the urethra and vagina.
2. The labia and clitoris provide sexual sensations making sex pleasurable.

Structure of the Male Reproductive Organs

The male reproductive system is responsible for the production and delivery of sperm which are necessary for the fertilisation of the egg.

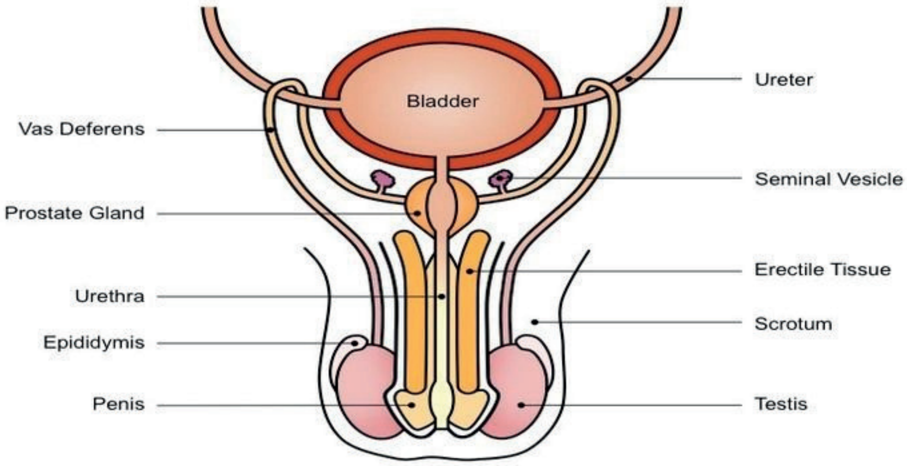


Fig. 4.7: *Structure of Male reproductive system*

The male reproductive system consists of organs that work together to produce, store, and deliver sperm. Key components include the testes, where sperm and testosterone are produced; the epididymis, where sperm mature and are stored; the vas deferens, which transports sperm from the epididymis to the urethra; the seminal vesicles, prostate gland, and bulbourethral glands, which produce fluids that mix with sperm to form semen; and the penis, which delivers semen into the female reproductive tract during sexual intercourse. Hormones such as testosterone play a crucial role in regulating the male reproductive system's functions.

Testes: The testes, or testicles, are the primary reproductive organs in males.

Functions

1. Sperm Production
2. Hormone Production – especially testosterone.

Epididymis

The epididymis is a coiled tube located on the surface of each testis. It functions as a storage and maturation site for sperm cells.

Functions

1. Sperm Maturation
2. Temporary storage of sperm

Vas Deferens: The vas deferens is a muscular tube that connects the epididymis to the ejaculatory duct.

Functions

1. Sperm Transport.
2. Provides sensation.

Seminal Vesicles, Prostate Gland, and Bulbourethral Glands:

These accessory glands produce fluids that combine with sperm to form semen.

Function: The seminal vesicles and glands produce a fluid rich in fructose and other nutrients that provide energy for sperm. The fluid also contains prostaglandins, which help in sperm motility and fertility. They make up a significant volume of semen.

Learning Tasks

1. Draw the structure of male reproductive system and label at least five parts.
2. Describe the structure of female reproductive system and give at least **one** function of at least five parts.
3. Describe the processes of reproduction in humans from copulation to birth

Pedagogical Exemplars

Talk for Learning.

1. Engage learners to observe models, videos, pictures, or charts of female and male reproductive systems. Encourage learners to document their observations.
2. Assign roles within the mixed-ability groups to help learners present their observations from the videos, pictures, and charts. Use open-ended questions through talk for learning to encourage all learners to participate actively.
3. Offer scaffolding or additional support for learners who may struggle with vocabulary or concepts.
4. Let learners describe the parts of the female and male reproductive systems, provide visual aids and diagrams to help learners visualise the parts.
5. Ask learners to explain the function of each part in pairs and share their ideas.
6. Encourage learners to think critically about why each part is important for the structure to work properly.
7. Ask each group to identify any potential issues or concerns related to the structure and function. Have learners in groups present their findings to the class and discuss how these concerns can be addressed or improved.

   i. For learners who need extra support, provide simplified objects with fewer parts to describe and explain. For gifted and talented learners, challenge them to analyse more complex structures with difficult parts and functions. Offer additional resources such as videos or supplementary reading materials for learners to deepen their understanding.

Key Assessment

Assessment Level 2: Draw and label the structure of female reproductive system.

Assessment Level 2: Describe any 3 parts of female reproductive system and their function.

Assessment Level 2: Describe the structure of male reproductive system and it function.

Week 12

Learning Indicator: *Explain the female menstrual cycle and show how that can be used to address reproduction-related issues.*

Theme or Focal Area(s): Menstrual cycle

Overview of the Menstrual Cycle

The menstrual cycle consists of natural changes that occur in a reproductive- age woman's body every month. It involves a series of hormonal, physiological and behavioural changes the body that prepare it for potential pregnancy. Menstruation starts at puberty between 8 and 15 (average age of 12). It usually begins two years after breasts and pubic hair start to develop and ends at menopause. However, the cycle stops while a woman is pregnant.

The menstrual cycle typically lasts around 28 days although it can vary from woman to woman between 20 and 40 days and cycle to cycle. It is counted from the first day of a period (appearance of vaginal bleeding) to the first day of the next period. The menstrual cycle is regulated by the complex interplay of hormones which are produced by the ovaries and pituitary.

Fig. 4.8: *Menstrual cycle chart*

Significance in Reproduction

The menstrual cycle plays a crucial role in reproduction as it regulates ovulation and the release of an egg from the ovaries. Additionally, the menstrual cycle prepares the uterus for potential pregnancy by thickening its lining. If fertilisation occurs, this lining provides a nourishing environment for the embryo to implant and develop. If fertilisation does not occur, the lining is shed during menstruation making way for a new cycle to begin.

Phases of the Menstrual Cycle

The female reproductive system includes a cycle of events called the menstrual cycle. There are four key phases of the menstrual cycle: follicular phase, ovulation, the luteal phase, and menstruation It is tightly controlled by the release and interplay of four main hormones.

Hormones are chemical messengers produced by glands in the endocrine system and released into the bloodstream. They regulate various physiological functions in the body, including growth and development, metabolism, mood, sexual function, and reproduction. Hormones interact with specific target cells or organs, where they exert their effects by binding to hormone receptors.

Hormones involved in the menstrual cycle

Follicle-stimulating hormone (FSH): FSH stimulates the growth and development of follicles (fluid-filled sacs) in the ovaries. Within each follicle is an immature egg. FSH is produced in the pituitary.

Oestrogen: As the ovarian follicles grow and mature, they produce increasing amounts of oestrogen. Oestrogen plays a key role in thickening the uterine lining (endometrium) in preparation for potential implantation of a fertilised egg.

Luteinising hormone (LH): LH surge triggers ovulation, the release of a mature egg from the ovary. LH is also produced in the pituitary.

Progesterone: After ovulation, the ruptured follicle transforms into a structure called the corpus luteum which produces and secretes progesterone. Progesterone helps maintain the uterine lining and prepares it for implantation of a fertilised egg. If fertilisation does not occur, the corpus luteum breaks down, leading to a decline in progesterone levels.

Menstruation: The cycle begins with menstruation which is the shedding of the endometrium (uterine lining) with other secretions from the body through the vagina. This phase lasts an average of 3-7 days, but this could change from month to month and depending on each woman. The endometrium thickens in readiness for pregnancy and if this does not occur, the endometrium breaks down to form the menses or blood released in menstruation.

Follicular phase: Start on first phase of the menstrual cycle, typically lasting around 10-14 days. It begins on the first day of menstruation when the endometrium sheds. During this phase, follicle-stimulating hormone (FSH) is released from the pituitary, stimulating the development of a follicle in one of the ovaries. FSH stimulates growth and development of the follicle. The follicle produces oestrogen, which thickens the uterine lining (endometrium) in preparation for implantation.

Ovulation: The term "ovulation" indicates the release of a mature egg from the follicle into the oviduct. Ovulation occurs midway through the menstrual cycle, usually around day 14 in a 28-day cycle. Peak levels of oestrogen stimulate a surge in Luteinising hormone (LH) from the pituitary. This causes the mature egg to be released from the follicle into the oviduct.

Luteal phase: After ovulation, the ruptured follicle forms the corpus luteum, which secretes progesterone. Progesterone is a hormone which promotes further development of the endometrium for potential implantation of a fertilised egg. If pregnancy does not occur, the corpus luteum degenerates, progesterone levels decrease, and menstruation begins.

Hormonal Regulation

Hormone levels are controlled by the pituitary and ovaries. Progesterone and oestrogen are produced in the ovaries whilst Luteinising Hormone (LH) and Follicle Stimulating Hormone (FSH) are produced in the pituitary.

Importance of Ovulation

Ovulation is crucial in the menstrual cycle because it marks the release of a mature egg from the ovary, making pregnancy possible. Tracking ovulation is essential for those trying to conceive or avoid pregnancy as it indicates the most fertile window of the cycle.

Methods of Tracking the Menstrual Cycle

Such methods include monitoring basal body temperature, monitoring cervical mucus (vaginal discharge) and ovulation predictor kits to identify the fertile window.

Tracking basal body temperature (BBT): Tracking BBT can be useful for monitoring ovulation patterns and fertility. To do this, you would measure your temperature first thing in the morning just after waking. Consistent tracking over time can help predict ovulation and optimise chances of conception if that is your goal. There are various apps available to help track BBT and the menstrual cycle.

Cervical mucus changes: Hormonal variations cause the consistency of cervical mucus to fluctuate during the menstrual cycle. During most of the menstrual cycle, cervical mucus is very thick and viscous and forms a plug blocking the cervix. As ovulation draws near, the cervical mucus becomes runnier, thinner, and much less viscous (like egg white) as the cervical mucus plug breaks down potentially allowing sperm to enter the uterus. This less viscous cervical mucus promotes sperm motility and survival which makes conception easier. It gets thicker and less abundant again after ovulation. It is possible to anticipate ovulation and fertility by monitoring these changes in the vaginal discharge (which is cervical mucus).

Ovulation Predictor Kits: Ovulation predictor kits (OPKs) are tools used to predict ovulation to maximise the chances of pregnancy. They work by detecting levels of luteinising hormone (LH) in urine which surges just before ovulation. OPK's can help women identify their most fertile days aiding in conception or in contraception. It is essential to follow the instructions carefully and consider other fertility signs for accurate predictions.

How to use the ovulation predictor kits (OPKs)

Understand your cycle: Determine the length of your menstrual cycle. Typically, ovulation occurs around 14 days before your next period starts, but this can vary.

Start testing: Begin testing a few days before you expect to ovulate based on your cycle length. For example, if you have a 28-day cycle, start testing around day 10.

Choose the time of day: Most kits recommend testing with your first morning urine, as the LH surge (which indicates ovulation is about to occur) is usually most concentrated then.

Follow the instructions: Read the instructions provided with your OPK carefully. They typically involve either urinating on a stick or dipping it into a cup of urine.

Interpret the results: Look for the appearance of a test line. If it is as dark or darker than the control line, it indicates a positive result meaning you are likely to ovulate within the next 12-36 hours.

Time intercourse: Plan to have intercourse over the next couple of days after receiving a positive result to maximise your chances of conception.

Continue testing: Keep testing daily until either you detect ovulation or your cycle ends. Some kits come with multiple strips to cover your entire fertile window.

Record your results: Keep track of your results and the days you had intercourse to better understand your fertility pattern over time.

Contraception

Contraception refers to methods or techniques used to prevent pregnancy. There are many methods used to prevent pregnancy from hormonal pills, inter-uterine devices, condoms, and hormonal implants. The above methods of tracking ovulation (OPKs, cervical mucus monitoring and BBT) can also be used to plan periods of sexual abstinence when fertilisation is most likely. This can be used as a method of contraception though it is unreliable in younger women when periods are unpredictable and vary from month to month.

Menstrual Disorders

Issues affecting a woman's regular menstrual cycle are referred to as menstrual disorders, these come in a variety of forms. Issues can vary from painful, heavy periods to no periods at all. Menstrual patterns vary widely, but women should be concerned if their periods continue longer than 10 days or if they occur less frequently than 21 days or more. Such occurrences could be a sign of ovulation issues or other illnesses. Below are some examples of menstrual disorders:

Dysmenorrhea: dysmenorrhea is severe, frequent cramping during menstruation. Pain occurs in the lower abdomen but can spread to the lower back and thighs.

Menorrhagia: the medical word for noticeably heavier periods is menorrhagia. There are numerous reasons for menorrhagia. An average woman sheds 30 ml of blood during a typical menstrual cycle and changes her sanitary items three to five times a day.

Amenorrhea: amenorrhea is the absence of menstruation and can result from malnutrition or from heavy sustained exercise. Many female athletes have periods of amenorrhea

Oligomenorrhea and **Hypomenorrhea:** the disorder known as oligomenorrhea causes menstrual cycles to be irregular and spaced apart by more than 35 days. Early adolescence is a common time for it to occur, and it typically does not signify a medical issue. Before menopause and in the first years following menarche, light, or insufficient flow (hypomenorrhea) is also typical.

Premenstrual Syndrome (PMS): PMS is a collection of behavioural, emotional, and physical symptoms that often appear a week before menstruation in the final week of the luteal phase. Usually, the symptoms do not appear until at least day 13 of the cycle and go away four days after the bleeding starts.

Reproductive Health Issues

Reproductive health refers to the state of physical, mental, and social well-being in all matters relating to the reproductive system. It encompasses a broad range of issues, including fertility, contraception, sexually transmitted infections (STI's), menstrual health, pregnancy, childbirth, and reproductive cancers. It is crucial to address these issues through education, access to healthcare, and support services to ensure individuals can make informed decisions and maintain their reproductive health.

Good menstrual health and hygiene practices can prevent infections, reduce odours, and help stay comfortable during your period. Some menstrual products that can be used to absorb or collect blood during your period, including sanitary pads, tampons, menstrual cups and menstrual discs, The following tips can be used to promote good health using menstrual products, in addition to instructions that come with the product:

1. Wash your hands before and after using the restroom and before using a menstrual product.
2. Discard used disposable menstrual products properly: wrap them with toilet paper, a tissue, or other material and then toss it in a trash bin. Do not flush menstrual products down the toilet.
3. Sanitary pads: Change sanitary pads every few hours, no matter how light the flow. Change them more frequently if your period is heavy.
4. Tampons: Change tampons every 4 to 8 hours. Do not wear a single tampon for more than 8 hours at a time.
5. Use the lowest-absorbency tampon needed. If you can wear one tampon for up to 8 hours without changing, the absorbency may be too high.
6. Sanitise menstrual cups after your period is over by rinsing them thoroughly and then placing them in boiling water for one to two minutes.
7. Wear lightweight, breathable clothing (such as cotton underwear). Tight fabrics can trap moisture and heat, allowing germs to thrive.
8. Change your menstrual products regularly. Trapped moisture provides a breeding ground for bacteria and fungi. Wearing a pad or period underwear for too long can lead to a rash or an infection.
9. Keep your genital area clean. Wash the outside of your vagina (vulva) and bottom every day. When you go to the bathroom, wipe from the front of your body towards the back, not the other way. Use only water to rinse your vulva. The vagina is a self-cleaning organ. Changing the natural pH balance of your vagina by washing or using chemicals to cleanse out the vagina can be harmful and may result in a yeast infection or bacterial vaginosis.
10. Use unscented toilet paper, tampons, or pads. Scented hygiene products can irritate the skin and impact your natural pH balance.
11. Drink enough liquids. This can help wash out your urinary tract and help prevent infections, like vaginal candidiasis.
12. Track and monitor your period. Your menstrual cycle is a valuable marker for your overall health. Irregular periods can be a sign of conditions like diabetes, thyroid dysfunction, and celiac disease. You can track your period on a calendar or with an app on your phone designed for this purpose.
13. Talk to a doctor if you experience a change in odour, have extreme or unusual pain, or have more severe period symptoms than usual (such as a heavier flow or longer period).
14. Avoid using chemical products.
15. Try to avoid a pad rash: A heavy flow can cause a pad rash. This will happen as the pad can be wet for a longer time. Try to change the pad by staying dry and using an ointment, as suggested by an expert after a bath and before bed, this will heal the rash. Pad lining may cause irritation to sensitive skin too. If rashes persist, the skin can be sensitive and indicate high blood sugar or allergy to the product.
16. Do not forget to take a shower: Take a shower at least twice a day. This can help you to keep yourself clean, stay fresh, get rid of that unpleasant odour down there, and prevent infections.

Adolescent Reproductive Health.

It is essential to understand the menstrual cycle to understand reproductive health. Menstrual cycle irregularities may indicate underlying medical conditions such thyroid abnormalities, polycystic ovarian syndrome (PCOS), or hormone imbalances. Recognising the menstrual cycle facilitates conception or family planning by enabling the prediction of fertile periods.

Understanding the menstrual cycle contributes to awareness of the value of safe sexual behaviours.

Teenagers who are aware of the menstrual cycle are better equipped to choose suitable contraception methods. Learners should be informed of the many forms of birth control and their efficacy. Emphasis should be given to the importance of using contraception consistently and appropriately particularly during the days in the menstrual cycle where conception is most likely. Medical professionals can be engaged to provide advice on contraception.

Menstrual cycle education should be a part of any school program for reproductive health education. Talk about issues like menstruation cleanliness, fertility awareness, reaching out for reproductive healthcare services, and puberty. To guarantee inclusivity and accessibility, provide education that is both age and culturally appropriate.

Education and access to care might be hampered by societal stigmas and cultural taboos regarding menstruation and reproductive health. Encourage candid conversation and dispel common misconceptions about the menstrual cycle. Encourage the adoption of policies within the school that de-stigmatise reproductive health concerns and advance menstruation fairness.

Access to resources for reproductive health, healthcare, and education is impacted by gender disparities. Encourage learners to speak up in favour of initiatives that advance gender parity and provide female learners with the freedom to make their own decisions regarding their bodies and reproductive health.

Learning Tasks

1. Explain menstrual cycle and identify at least two stages involved.
2. Describe the phases of menstrual cycle
3. Describe at least three (3) ways reproduction-related issues can be addressed by an understanding of the menstrual cycle.
4. Analyse the differences among the phases of menstrual cycle

Pedagogical Exemplars

Think-Pair-Share

- Provide charts, diagrams, videos/ animations illustrating and explaining the menstrual cycle.
- Use color-coded calendars to represent separate phases of the menstrual cycle.
- Present a scenario related to menstrual health and hygiene to the entire class.
- Have learners individually respond to the scenario. Pair learners to discuss their ideas and perspectives. Learners share understandings and solutions with the larger group, fostering cross-learning and peer learning.

Gallery Walk

- Display various visual aids, articles, and resources around the classroom related to menstrual health and hygiene.
- Encourage learners to engage with the materials and share insights and reflections gathered from the gallery walk. Invite a health professional to share experiences with the learners on

good menstrual hygiene practices. Encourage males to play leading roles in supporting female experiences and participate fully in the activities for menstrual hygiene day

- Ask learners to write summaries or reports on global best practices in menstrual hygiene.

Key Assessment

Assessment Level 1: Briefly explain the menstrual cycle.

Assessment Level 2: Explain the term menstrual hygiene.

Assessment Level 2: Describe at least four (4) ways good menstrual hygiene can be practiced.

Assessment Level 2: Describe how menstrual cycle can be determined using ovulation predictor kits.

Assessment Level 3: Compare and contrast luteal phase and follicular phase of menstrual cycle.

Section Review

These lessons were structured to provide a holistic learning experience. Learners should now possess a comprehensive understanding the concept of reproduction in plants and humans and explain the concept of menstrual cycle, how to calculate the menstrual cycle and its application to address reproduction-related issues. The aim is for each student to have not only gained theoretical knowledge but to apply in real-life situation and solve societal problems.

Additional Reading

- Determination of menstrual cycle using ovulation predicting kits, reproductive health-related issues.
- Organise debates or role-playing scenarios where learners discuss different approaches to menstrual hygiene.

Resources

1. Charts/videos/pictures /diagrams, posters, or images of menstrual cycle.
2. Internet resources such as https://www.webmd.com/baby/healthtool-ovulation-calculator; https://www.always.com/en-us/period-calculator
3. Charts/videos/pictures of menstrual cycle.
4. https://www.bbc.co.uk/bitesize/subjects/zhstqp3
5. Internet resources such as https://www.webmd.com/baby/healthtool-ovulation-calculator; https://www.unfpa.org/resources/adolescent-sexual-and-reproductive-health; https://www.youtube.com/watch?v=lBHRwkZPNac
6. Journals on reproductive health

References

1. Curriculum document
2. https://www.always.com/en-us/period-calculator
3. https://www.bbc.co.uk/bitesize/subjects/zhstqp3
4. Internet resources such as https://www.webmd.com/baby/healthtool-ovulation-calculator; https://www.unfpa.org/resources/adolescent-sexual-and-reproductive-health; https://www.youtube.com/watch?v=lBHRwkZPNac
5. https://crickethillgarden.files.wordpress.com/2013/07/bt-base.jpg
6. Tortora, G. J., & Derrickson, B. H. (2017). Principles of Anatomy and Physiology (15th ed.). Wiley.
7. Ramawat, K. G., Merillon, J.-M., & Shivanna, K. R. (2016). Reproductive Biology of Plants. CRC Press.
8. Jones, R. E. (1997). Human Reproductive Biology, Second Edition (2nd ed.). Academic Press.