Biology

Senior High

Grade 11

Teacher Guide

Standards-Based

Department of Education

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Issued free to schools by the Department of Education

Published in 2020 by the Department of Education

ISBN 978-9980-906-16-8

Graphic Designed and Layout by Michael John - Graphics, CDD

Contents

Acknowledgements

The Grade 11 Biology Teacher Guide for was developed by the Curriculum Development Division of the Department of Education and was coordinated by Moses Hatagen Koran and with assistance from the Subject Curriculum Group (SCG) and the writing team.

High school teachers, Teacher College lecturers, University Lecturers and other educational experts are acknowledged for their input in the development of this Teacher Guide through many workshops, meetings, and consultations.

The department also acknowledges Dr Arnold Kukari as a consultant in the realignment and the development of SBC including this Teacher Guide.

Subject Advisory Committee (SAC) and Board of Studies (BoS) are acknowledged for their recommendations and endorsements of this Teacher Guide.

Acronyms

AAL	Assessment As Learning
AFL	Assessment For Learning
AOL	Assessment Of Learning
ARS	Audience Response System
BoS	Board of Studies
CDD	Curriculum Development Division
CP	Curriculum Panel
CRS	Classroom Response System
DA	Diagnostic Assessment
HOD	Head of Department
IHD	Integral Human Development
MTDG	Medium Term Development Goal
NGO	Non-Government Organisation
PBA	Performance Based Assessment
PNG	Papua New Guinea
SAC	Subject Advisory Committee
SBC	Standards-Based Curriculum
SBE	Standards Based Education
SCG	Subject Curriculum Group
SRS	Student Response System
STEAM	Science, Technology, Engineering, Arts and Mathematics

Secretary's Message

The aims and goals of the SBC identify the important knowledge, skills, values, and attitudes that all students are expected to acquire and master in order to effectively function in society and actively contribute to its development, students' welfare and enable them to acquire and apply 21st Century knowledge, skills, values, and attitudes in their life after Grade 12.

The realignment of Biology will provide learners with a range of competencies important in the world of work and in a knowledge-based society. It is envisioned that the realignment of the subject will develop in students the scientific knowledge, skills, attitudes and values of the 21st Century. The 21st knowledge skills attitudes and values learnt will equip them to be scientifically, technologically, and environmentally literate and productive members of society who will be critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision makers and effective communicators of this resourceful nation

Thus, students will be able to learn to make informed decisions, problem – solving and management knowledge, skills, values and attitudes in Biology. This will enable them to function effectively in the work and higher education environments as productive and useful citizens of a culturally diverse and democratic society in an interdependent world.

Teachers are encouraged to use the Teachers Guide in conjunction with the Syllabus and other relevant resources to generate creative teaching and learning activities to deliver the Biology content. Ensure that safety measures are taken at all cost to avoid injuries.

I commend and approve this Grade 11 Biology Teacher Guide to be used by teachers in all Senior High Schools throughout Papua New Guinea.

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UKE. W KOMBRA, PhD
Secretary for Education

Introduction

Nature has endowed Papua New Guinea with a diverse and a unique natural environment. The rugged mountain ranges, deep ocean floor, flourishing and diverse flora and fauna, the winds, and the fast flowing rivers provide a fertile ground for scientific inquiry. But how does one go about inquiring and addressing the problems that nature presents if one is not trained to ask the right questions? This is where the knowledge, skills, values and attitudes of science become necessary.

The 21st Century is a time of rapid change. New knowledge, tools and ways of doing and communicating continue to emerge and evolve and impact our lives in many different ways. Life style diseases have also taken a toll in the lives of many Papua New Guineans.

The realignment of Biology will provide learners with a range of competencies important in the world of work and in a knowledge-based society. It is envisioned that the realignment of the subject will develop in students the scientific knowledge, skills, attitudes and values of the 21st Century. The 21st knowledge skills attitudes and values learnt will equip them to be scientifically, technologically, and environmentally literate and productive members of society who will be critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision makers and effective communicators of this resourceful nation.

This course will further deepen students' understanding of advanced biological knowledge in the processes that occur in biological systems. Students will study theory and conduct investigations in the areas of biodiversity; body systems, evolution; genetic processes; the structure and function of animals; and the anatomy, growth, and function of plants. Teachers are encouraged to engage students in learning realistic contexts for increased and better understanding of learning concepts.

Time allocation for Biology is **240** minutes per week. Teachers are urged to fully utilise the allocated time.

Structure of the Teacher Guide

There are four main components to this teacher guide. They provide essential information on what all teachers should know and do to effectively implement the Science curriculum.

Part 1 provides generic information to help the teachers to effectively use the teacher guide and the syllabus to plan, teach and assess students' performance and proficiency on the national content standards and grade-level benchmarks. The purpose of the teacher guide, syllabus and teacher guide alignment, and the four pillars of PNG SBC, which are morals and values education, cognitive and high level thinking, and 21st Century thinking skills, STEAM, and core curriculum. These are explained to inform as well as guide the teachers so that they align SBE/SBC aims and goals, overarching and SBC principles, content standards, grade-level benchmarks, learning objectives and best practice when planning lessons, teaching, and assessing students.

Part 2 provides information on the strands, units, topics and learning objectives. How topics and learning objectives are derived is explained to the teachers to guide them to use the learning objectives provided for planning, instruction and assessment. Teachers are encouraged to develop additional topics and learning objectives to meet the learning needs of their students and communities where necessary.

Part 3 provides information on SBC planning to help guide the teachers when planning SBC lessons. Elements and standards of SBC lesson plans are described as well as how to plan for underachievers, use evidence to plan lessons, and use differentiated instruction, amongst other teaching and learning strategies.

Part 4 provides information on standards-based assessment, inclusive of performance assessment and standards, standards-based evaluation, standards-based reporting, and standards-based monitoring. This information should help the teachers to effectively assess, evaluate, report and monitor demonstration of significant aspects of a benchmark.

The above components are linked and closely aligned. They should be connected to ensure that the intended learning outcomes and the expected quality of education standards are achieved. The close alignment of planning, instruction and assessment is critical to the attainment of learning standards.

Purpose of the Teacher Guide

This teacher guide describes what all teachers should know and do to effectively plan, teach, and assess Grade 11 Biology content to enable all students to attain the required learning and proficiency standards. The overarching purpose of this teacher guide is to help teachers to effectively plan, teach, assess, evaluate, report and monitor students' learning and mastery of national and grade-level expectations. That is, the essential knowledge, skills, values and attitudes (KSVAs) described in the content standards and grade-level benchmarks, and their achievement of the national and grade-level proficiency standards.

Ample information with thorough guidelines is provided for the teacher to use to achieve the essential KSVAs embedded in the set national content standards and grade level benchmarks.

Thus, the teacher is expected to;

- understand the significance of aligning all the elements of Standards-Based Curriculum (SBC) as the basis for achieving the expected level of education quality,
- effectively align all the components of SBC when planning, teaching, and assessing students' learning and levels of proficiency,
- effectively translate and align the Biology syllabi and teacher guide to plan, teach and assess different Biology units and topics, and the KSVAs described in the grade-level benchmarks,
- understand the Biology national content standards, grade-level benchmarks, and evidence outcomes,
- effectively make sense of the content (KSVAs) described in the Biology national content standards and the essential components of the content described in the grade-level benchmarks,
- effectively guide students to progressively learn and demonstrate proficiency on a range of Biology skills, processes, concepts, ideas, principles, practices, values and attitudes,
- confidently interpret, translate and use Biology content standards and benchmarks to determine the learning objectives and performance standards, and plan appropriately to enable all students to achieve these standards,
- embed the core curriculum in their Biology lesson planning, instruction, and assessment to permit all students to learn and master the core KSVAs required of all students,

- provide opportunities for all students to understand how STEAM has and continues to shape the social, political, economic, cultural, and environment contexts and the consequences, and use STEAM principles, skills and process,

- integrate cognitive skills (critical, creative, reasoning, decision-making, and problem-solving skills), high level thinking skills (analysis, synthesis and evaluation skills), values (personal, social, work, health, peace, relationship, sustaining values), and attitudes in lesson planning, instruction and assessment,

- meaningfully connect what students learn in Biology with what is learnt in other subjects to add value and enhance students' learning so that they can integrate what they learn and develop in-depth vertical and horizontal understanding of subject content,

- formulate effective SBC lesson plans using learning objectives identified for each of the topics,

- employ SBC assessment approaches to develop performance assessments to assess students' proficiency on a content standard or a component of the content standard described in the grade-level benchmark and

- effectively score and evaluate students' performance in relation to a core set of learning standards or criteria, and make sense of the data to ascertain students' status of progress towards meeting grade-level and nationally expected proficiency standards, and use evidence from the assessment of students' performance to develop effective evidence-based intervention strategies to help students' making inadequate or slow progress towards meeting the grade-level and national expectations to improve their learning and performance.

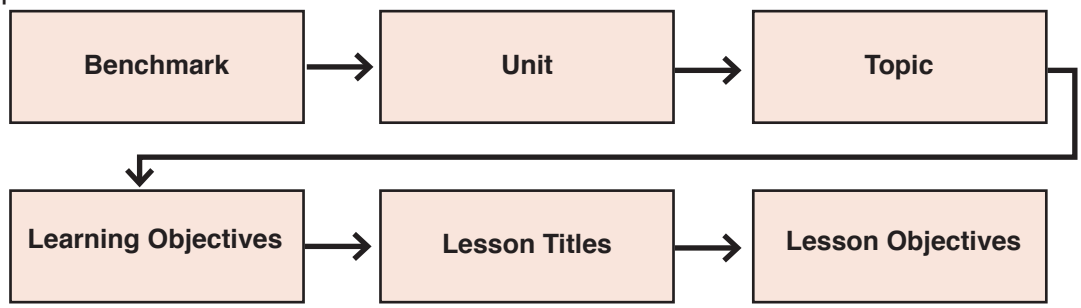
How to the use the Teacher Guide

The Teacher Guide provides essential information about what the teacher needs to know and do to effectively plan, teach and assess students learning and proficiency on learning and performance standards. The different components of the teacher guide are closely aligned with SBC principles and practice, and all the other components of PNG SBC. It should be read in conjunction with the syllabus in order to understand what is expected of teachers and students to achieve the envisaged quality of education outcomes.

The first thing teachers should do is to read and understand each of the sections of the teacher guide to help them understand the key SBC concepts and ideas, alignment of PNG SBC components, alignment of the syllabus and teacher guide, setting of content standards and grade-level benchmarks, core curriculum, STEAM, curriculum integration, essential knowledge, skills, values and attitudes, strands, units and topics, learning objectives, SBC lesson planning, and SBC assessment. A thorough understanding of these components will help teachers meet the teacher expectations for implementing the SBC curriculum, and therefore the effective implementation of Grades 11 and 12 Biology Curriculum. Based on this understanding, teachers should be able to effectively use the teacher guide to do the following:

Determine Lesson Objectives and Lesson Titles

Units, topics and learning objectives have been identified and described in the Teacher Guide and Syllabus. Learning objectives are derived from topics that are extracted from the grade-level benchmarks. Lesson titles are deduced from the learning objectives. Teachers should familiarise themselves with this process as it is essential for lesson planning, instruction and assessment. However, depending on the context and students' learning abilities, teachers would be required to determine additional lesson objectives and lesson titles Teachers should use the examples provided in this teacher guide to formulate additional lesson objectives and lesson titles to meet the educational or learning needs of their students. What is provided here is not exhaustive.



Identify and Teach Grade Appropriate Content

Grade appropriate content has been identified and scoped and sequenced using appropriate content organisation principles. The content is sequenced using the spiraling sequence principles. This sequencing of content will enable students to progressively learn the essential knowledge, skills, values and attitudes as they progress further into their schooling. What students learn in previous grades is reinforced and deepens in scope with an increase in the level of complexity and difficulty in the content and learning activities.

It is important to understand how the content is organised so that grade appropriate content and learning activities can be selected, if not already embedded in the benchmarks and learning objectives, to not only help students learn and master the content, but ensure that what is taught is rigorous, challenging, and comparable.

Integrate the Core Curriculum in Lesson Planning, Instruction and Assessment

Teachers should use this teacher guide to help them integrate the core curriculum – values, cognitive and high level skills, 21st Century skills, STEAM principles and skills, and reading, writing, and communication skills in their lesson planning, instruction and assessment. All students in all subjects are required to learn and master these skills progressively through the education system.

Integrate Cognitive, High Level, and 21st Century Skills in Lesson Planning, Instruction and Assessment

Teachers should integrate the cognitive, high level and 21st Century skills in their annual teaching programs, and give prominence to these skills in their lesson preparation, teaching and learning activities, performance assessment, and performance standards for measuring students' proficiency on these skills. Science addresses the skills and processes of sensitive, moral, ethical and environmental issues in the physical world and global industries.

Thus, students will be able to make informed decisions, problem – solving and management knowledge, skills, values and attitudes in Science. This enables them to function effectively in the work and higher education environments as productive and useful citizens of a culturally diverse and democratic society in an interdependent world.

In addition, it envisaged all students attaining expected proficiency levels in these skills and will be ready to pursue careers and higher education academic programs that demand these skills, and use them in their everyday life after they leave school at the end of Grade 12. Teachers should use the teacher guide to help them to effectively embed these skills, particularly in their lesson planning and in the teaching and learning activities as well as in the assessment of students' application of the skills.

Integrate Science Values and Attitudes in Lesson Planning, Instruction and Assessment

In sciecne, students are expected to learn, promote and use work, relationship, peace, health, social, personal, family, community, national and global values in the work and study environments as well as in their conduct as community, national and global citizens. Teachers should draw from the information and suggestions provided in the syllabus and teacher guide to integrate values and attitudes in their lesson planning, instruction, and assessment. They should report on students' progression towards internalizing different values and attitudes and provide additional support to students who are yet to reach the internalization stage to make positive progress towards this level.

Integrate Science, Technology, Engineering, Arts and Mathematics (STEAM) Principles and Skills in Lesson Planning, Instruction and Assessment

Teachers should draw from both the syllabus and teacher guide in order to help them integrate STEAM principles and skills, and methodologies in their lesson planning, instruction and assessment. STEAM teaching and learning happens both inside and outside of the classroom. Effective STEAM teaching and learning requires both the teacher and the student to participate as core investigators and learners, and to work in partnership and collaboration with relevant stakeholders to achieve maximum results. Teachers should use the syllabus, teacher guides and other resources to guide them to plan and implement this and other innovative and creative approaches to STEAM teaching and learning to make STEAM principles and skills learning fun and enjoyable and, at the same time, attain the intended quality of learning outcomes.

Identify and Use Grade and Context Appropriate, Innovative, Differentiated and Creative Teaching and Learning Methodologies

SBC is an eclectic curriculum model. It is an amalgam of strengths of different curriculum types, including behavioural objectives, outcomes, and competency. Its emphasis is on students attaining clearly defined, measurable, observable and attainable learning standards, i.e., the expected level of education quality. Proficiency (competency) standards are expressed as performance standards/ criteria and evidence outcomes, that is, what all students are expected to know (content) and do (application of content in real life or related situations) to indicate that they are meeting, have met or exceeded the learning standards. The selection of grade and contextually appropriate teaching and learning methodologies is critical to enabling all students to achieve the expected standard or quality of education. Teaching and learning methodologies must be aligned to the content, learning objective, and performance standard in order for the teacher to effectively teach and guide students towards meeting the performance standard for the lesson. They should be equitable and socially inclusive, differentiate, student-centred, and lifelong. They should enable STEAM principles and skills to be effectively taught and learned by students. Teachers should use the teacher guide to help them make informed decisions when selecting the types of teaching and learning methodologies to use in their teaching of the subject content, including STEAM principles and skills.

Plan Standards-Based Lessons

SBC lesson planning is quite difficult to do. However, this will be easier with more practice and experience over time. Effective SBC lesson plans must meet the required standards or criteria so that the learning objectives and performance standards are closely aligned to attain the expected learning outcomes. Teachers should use the guidelines and standards for SBC lesson planning and examples of SBC lesson plans provided in the teacher guide to plan their lessons. When planning lessons, it is important for teachers to ensure that all SBC lesson planning standards or criteria are met. If standards are not met, instruction will not lead to the attainment of intended performance and proficiency standards. Therefore, students will not attain the national content standards and grade-level benchmarks.

Use Standards-Based Assessment

Standards-Based Assessment has a number of components. These components are intertwined and serve to measure evaluate, report, and monitor students' achievement of the national and grade-level expectations, i.e., the essential knowledge, skills, values and attitudes they are expected to master and demonstrate proficiency on. Teachers should use the information and examples on standards-based assessment to plan, assess, record, evaluate, report and monitor students' performance in relation to the learning standards.

Make informed Judgments About Students' Learning and Progress Towards Meeting Learning Standards

Teachers should use the teacher guide to effectively evaluate students' performance and use the evidence to help students to continuously improve their learning as well as their classroom practice.

It is important that teachers evaluate the performance of students in relation to the performance standards and progressively the grade-level benchmarks and content standards to make informed judgments and decisions about the quality of their work and their progress towards meeting the content standards or components of the standards. Evaluation should not focus on only one aspect of students' performance. It should aim to provide a complete picture of each student's performance. The context, inputs, processes, including teaching and learning processes, and the outcomes should be evaluated to make an informed judgment about each student's performance, Teachers should identify the causal factors for poor performance, gaps in students learning, gaps in teaching, teaching and learning resource constraints, and general attitude towards learning. Evidence-based decisions can then be made regarding the interventions for closing the gaps to allow students to make the required progress towards meeting grade-level and national expectations.

Prepare Students' Performance Reports

Reporting of students' performance and progress towards the attainment of learning standards is an essential part of SBC assessment. Results of students' performance should be communicated to particularly the students and their parents to keep them informed of students' academic achievements and learning challenges as well as what needs to be done to enable the students' make positive progress towards meeting the proficiency standards and achieve the desired level of education quality. Teachers should use the information on the reporting of students' assessment results and the templates provided to report the results of students' learning.

Monitor Students' Progress Towards Meeting the National Content Standards and Grade-Level Benchmarks

Monitoring of student's progress towards the attainment of learning standards is an essential component of standards-based assessment. It is an evidence-based process that involves the use of data from students' performance assessments to make informed judgements about students' learning and proficiency on the

learning standards or their components, identify gaps in students' learning and the causal factors, set clear learning improvement targets, and develop effective evidence-based strategies (including preplanning and re-teaching of topics), set clear timeframes, and identify measures for measuring students' progress towards achieving the learning targets.

Teachers should use the teacher guide to help them use data from students' performance assessments to identify individual students' learning weaknesses and develop interventions, in collaboration with each student and his/her parents or guardians, to address the weaknesses and monitor their progress towards meeting the agreed learning goals.

Develop additional Benchmarks

Teachers can develop additional benchmarks using the examples in the teacher guide to meet the learning needs of their students and local communities. However, these benchmarks will not be nationally assessed as these are not comparable. They are not allowed to set their own content standards or manipulate the existing ones. The setting of national content standards is done at the national level to ensure that required learning standards are maintained and monitored to sustain the required level of education quality.

Avoid Standardisation

The implementation of Science curriculum must not be standardised. SBC does not mean that the content, lesson objectives, teaching and learning strategies, and assessment are standardised. This is a misconception and any attempt to standardise the components of curriculum without due consideration of the teaching and learning contexts, student's backgrounds and experiences, and different abilities and learning styles of students will be counterproductive. It will hinder students from achieving the expected proficiency standards and hence, high academic standards and the desired level of education quality. That is, they should not be applied across all contexts and with all students, without considering the educational needs and the characteristics of each context. Teachers must use innovative, creative, culturally relevant, and differentiated teaching and learning approaches to teach the curriculum and enable their students to achieve the national content standards and grade-level benchmarks. And enable all students to experiencesuccess in learning the curriculum and achieve high academic standards.

What is provided in the syllabus and teacher guide are not fixed and can be changed. Teachers should use the information and examples provided in the syllabus and the teacher guide to guide them to develop, select, and use grade, context, and learner appropriate content, learning objectives, teaching and learning strategies, and performance assessment and standards. SBC is evidence-based hence decisions about the content, learning outcomes, teaching and learning strategies, students' performance, and learning interventions should be based on evidence. Teaching and learning should be continuously improved and effectively targeted using evidence from students' assessment and other sources.

Syllabus and Teacher Guide Alignment

A teacher guide is a framework that describes how to translate the content standards and benchmarks (learning standards) outlined in the syllabus into units and topics, learning objectives, lesson plans, teaching and learning strategies, performance assessment, and measures for measuring students' performance (performance standards). It expands the content overview and describes how this content identified in the content standards and their components (essential KSVAs) can be translated into meaningful and evidence-based teaching topics and learning objectives for lesson planning, instruction and assessment. It also describes and provides examples of how to evaluate and report on students' attainment of the learning standards, and use evidence from the assessment of students' performance to develop evidence-based interventions to assist students who are making slow progress towards meeting the expected proficiency levels to improve their performance.

This subject comprises of the Syllabus and Teacher Guide. These two documents are closely aligned, complimentary and mutually beneficial.
They are the essential focal points for teaching and learning the essential Science knowledge, skills, values and attitudes.

Syllabus	Teacher Guide
Outlines the ultimate aim and goals, and what to teach and why teach it	**Describes how to plan, teach, and assess students' performance**
• Overarching and SBC principles • Content overview • Core curriculum • Essential knowledge, skills, values and attitudes • Strands and units • Evidence outcomes • Content standards and grade-level benchmarks • Overview of assessment, evaluation, and Reporting	• Determine topics for lesson planning, instruction and assessment • Formulate learning objectives • Plan SBC lesson plans • Select teaching and learning strategies • Implement SBC assessment and evaluation • Implement SBC reporting and monitoring

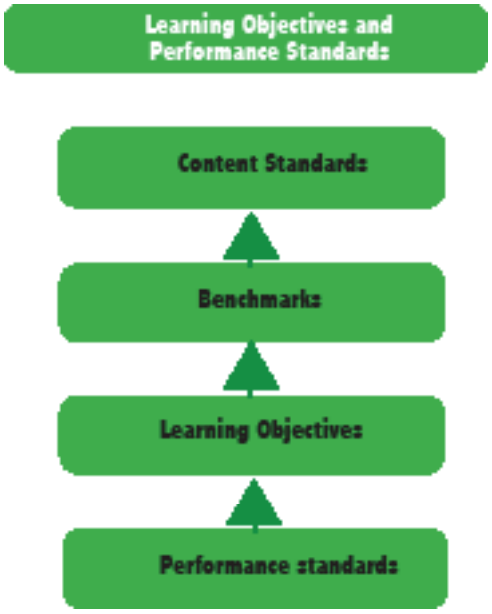
The syllabus outlines the ultimate aim and goals of SBE and SBC, what is to be taught and why it should be learned by students, the underlying principles and articulates the learning and proficiency standards that all students are expected to attain. On the other hand, the teacher guide expands on what is outlined in the syllabus by describing the approaches or the how of planning, teaching, learning, and assessing the content so that the intended learning outcomes are achieved.

This teacher guide should be used in conjunction with the syllabus. Teachers should use these documents when planning, teaching and assessing the Grade 11 Biology content.

Teachers will extract information from the syllabus (e.g., content standards and grade-level benchmarks) for lesson planning, instruction and for measuring students' attainment of a content standard as well as progress to the next grade of schooling.

Learning and Performance Standards Alignment

Content Standards, Benchmarks, Learning Objectives, and Performance Standards are very closely linked and aligned. There is a close linear relationship between these standards. Students' performance on a significant aspect of a benchmark (KSVA) is measured against a set of performance standards or criteria to determine their level of proficiency using performance assessment. Using the evidence from the performance assessment, individual student's proficiency on the aspect of the benchmark assessed and progression towards meeting the benchmark and hence the content standard are then determined.



Effective alignment of these learning standards and all the other components of PNG SBE and SBC (ultimate aim and goals, overarching, SBC and subject-based principles, core curriculum, STEAM, and cognitive, high level, and 21st Century skills) is not only critical but is also key to the achievement of high academic standards by all students and the intended level of education quality. It is essential that teachers know and can do standards alignment when planning, teaching, and assessing students' performance so that they can effectively guide their students towards meeting the grade-level benchmarks (grade expectations) and subsequently the content standards (national expectations).

Health and Safety in Science

Teachers must model safe practices at all times and communicate safety expectations to students in accordance with school board and Ministry of Education policies and Ministry of Labour regulations. Teachers are responsible for ensuring the safety of students during classroom activities and also for encouraging and motivating students to assume responsibility for their own safety and the safety of others. Teachers must also ensure that students have the knowledge and skills needed for safe participation in science activities.

To carry out their responsibilities with regard to safety, it is important for teachers to have:

- concern for their own safety and that of their students;
- the knowledge necessary to use the materials, equipment, and procedures involved in science safely;
- knowledge concerning the care of living things – plants and animals – that are brought into the classroom;
- the skills needed to perform tasks efficiently and safely.

Students demonstrate that they have the knowledge, skills, and habits of mind required for safe participation in science activities when they:

- maintain a well-organized and uncluttered work space;
- follow established safety procedures;
- identify possible safety concerns;
- suggest and implement appropriate safety procedures;
- carefully follow the instructions and example of the teacher;
- consistently show care and concern for their own safety and that of others.

Various kinds of health and safety issues can arise when learning involves field trips. Out of-school field trips can provide an exciting and authentic dimension to students' learning experiences. They also take the teacher and students out of the predictable classroom environment and into unfamiliar settings. Teachers must preview and plan these activities carefully to protect students' health and safety.

Planning Science Programs for Students with Special Education Needs

Classroom teachers are the key educators of students who have special education needs. They have a responsibility to help all students learn, and they work collaboratively with special education resource teachers, where appropriate, to achieve this goal. Special Education Transformation: The Report of the Co-Chairs with the Recommendations of the Working Table on Special Education, 2006 endorses a set of beliefs that should guide program planning for students with special education needs in all disciplines. These beliefs are as follows:

- All students can succeed.
- Universal design[2] and differentiated instruction[3] are effective and interconnected means of meeting the learning or productivity needs of any group of students.
- Successful instructional practices are founded on evidence-based research, tempered by experience.
- Classroom teachers are key educators for a student's literacy and numeracy development.
- Each student has his or her own unique patterns of learning.
- Classroom teachers need the support of the larger community to create a learning environment that supports students with special education needs.
- Fairness is not sameness.

In any given classroom, students may demonstrate a wide range of strengths and needs. Teachers plan programs that recognise this diversity and give students performance tasks that respect their particular abilities so that all students can derive the greatest possible benefit from the teaching and learning process. The use of flexible groupings for instruction and the provision of ongoing assessment are important elements of programs that accommodate a diversity of learning needs.

Learning and Performance Standards

Standards-Based Education (SBE) and SBC are underpinned by the notion of quality. Standards define the expected level of education quality that all students should achieve at a particular point in their schooling. Students' progression and achievement of education standard(s) are measured using performance standards or criteria to determine their demonstration or performance on significant aspects of the standards and therefore their levels of proficiency or competency. When they are judged to have attained proficiency on a content standard or benchmark or components of these standards, they are then deemed to have met the standard(s) that is, achieved the intend level of education quality.

Content standards, benchmarks, and learning objectives are called learning standards while performance and proficiency standards (evidence outcomes) can be categorised as performance standards. These standards are used to measure students' performance, proficiency, progression and achievement of the desired level of education quality. Teachers are expected to understand and use these standards for lesson planning, instruction and assessment.

Content Standards

Content standards are evidence-based, rigorous and comparable regionally and globally. They have been formulated to target critical social, economic, political, cultural, environment, and employable skills gaps identified from a situational analysis. They were developed using examples and experiences from other countries and best practice, and contextualized to PNG contexts.

Content standards describe what (**content - knowledge, skills, values, and attitudes**) all students are expected to know and do (how well students must learn and apply what is set out in the content standards) at each grade-level before proceeding to the next grade. These standards are set at the national level and thus cannot be edited or changed by anyone except the National Subject-Based Standards Councils.

Content Standards;

- are evidenced-based,
- are rigorous and comparable to regional and global standards,
- are set at the national level,
- state or describe the expected levels of quality or achievement,
- are clear, measurable and attainable,
- are linked to and aligned with the ultimate aim and goals of SBE and SBC and overarching and SBC principles,
- delineate what matters, provide clear expectations of what students should progressively learn and achieve in school, and guide lesson planning, instruction, assessment,
- comprise knowledge, skills, values, and attitudes that are the basis for quality education,
- provide teachers a clear basis for planning, teaching, and assessing lessons and
- provide provinces, districts, and schools with a clear focus on how to develop and organise their instruction and assessment programs as well as the content that they will include in their curriculum.

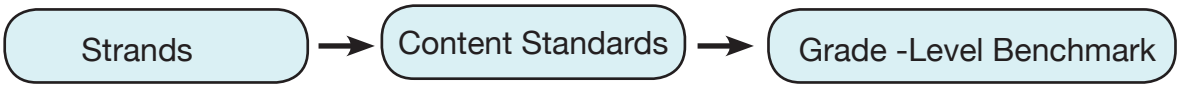
Benchmarks

Benchmarks are derived from the content standards and benchmarked at the grade-level. Benchmarks are specific statements of what students should know (i.e., essential knowledge, skills, values or attitudes) at a specific grade-level or school level. They provide the basis for measuring students' attainment of a content standard as well as progress to the next grade of schooling.

Grade-level benchmarks;

- are evidenced-based,
- are rigorous and comparable to regional and global standards,
- are set at the grade level,
- are linked to the national content standards,
- are clear, measurable, observable and attainable,
- articulate grade level expectations of what students are able to demonstrate to indicate that they are making progress towards attaining the national content standards,
- provide teachers a clear basis for planning, teaching, and assessing lessons,
- state clearly what students should do with what they have learned at the end of each school-level,
- enable students' progress towards the attainment of national content standards to be measured, and
- enable PNG students' performance to be compared with the performance of students in other countries.

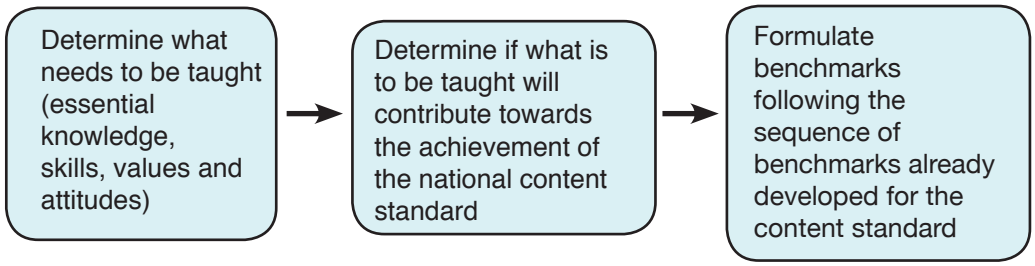
Approach for Setting National Content Standards and Grade-Level Benchmarks



Development of Additional Benchmarks

Teachers should develop additional benchmarks to meet the learning needs of their students. They should engage their students to learn about local, provincial, national and global issues that have not been catered for in the grade-level benchmarks but are important and can enhance students' understanding and application of the content. However, it is important to note that these benchmarks will not be nationally examined as they are not comparable. Only the benchmarks developed at the national level will be tested. This does not mean that teachers should not develop additional benchmarks. An innovative, reflect, creative and reflexive teacher will continuously reflect on his/her classroom practice and use evidence to provide challenging, relevant, and enjoyable learning opportunities for his/her students to build on the national expectations for students. Teachers should follow the following process when developing additional grade-level benchmarks.

Benchmark Development Process



Learning Objectives

Learning or instructional Objectives are precise statements of educational intent. They are formulated using a significant aspect or a topic derived from the benchmark, and is aligned with the educational goals, content standards, benchmarks, and performance standards. Learning objectives are stated in outcomes language that describes the products or behaviours that will be provided by students. They are stated in terms of measurable and observable student behaviour. For example, students will be able to ito compare and contrast the structure of plant and animal cells.

Performance Standards

Performance Standards are concrete statements of how well students must learn what is set out in the content standards, often called the **"be able to do"** of "what students should know and be able to do." Performance standards are the indicators of quality that specify how competent a students' demonstration or performance must be. They are explicit definitions of what students **must do to demonstrate proficiency or competency at a specific level on the content standards**.

Performance standards;

- measure students' performance and proficiency (using performance indicators) in the use of a specific knowledge, skill, value, or attitude in real life or related situations,
- provide the basis (performance indicators) for evaluating, reporting and monitoring students' level of proficiency in use of a specific knowledge, skills, value, or attitude,
- are used to plan for individual instruction to help students not yet meeting expectations (desired level of mastery and proficiency) to make adequate progress towards the full attainment of benchmarks and content standards, and
- are used as the basis for measuring students' progress towards meeting grade-level benchmarks and content standards.

Proficiency Standards

Proficiency standards describe what all students in a particular grade or school level can do at the end of a strand, or unit. These standards are sometimes called evidence outcomes because they indicate if students can actually apply or use what they have learned in real life or similar situations. They are also categorized as benchmarks because that is what all students are expected to do before exiting a grade or are deemed ready for the next grade.

Core Curriculum

A core set of common learnings (knowledge, skills, values, and attitudes) are integrated into the content standards and grade-level benchmarks for all subjects. This is to equip all students with the most essential and in-demand knowledge, skills, and dispositions they will need to be successful in modern/ postmodern work places, higher-education programs and to be productive, responsible, considerate, and harmonious citizens. Common set of learnings are spirally sequenced from Preparatory - Grade 12 to deepen the scope and increase the level of difficulty in the learning activities so that what is learned is reinforced at different grade levels.

The core curriculum includes:

- cognitive (thinking) skills (refer to the syllabus for a list of these skills),
- reasoning, decision-making and problem-solving skills,
- high level thinking skills (analysis, synthesis and evaluation skills),
- 21st Century skills, (refer to appendix 2)
- reading, writing and communication skills,
- STEAM principles and skills,
- essential values and attitudes (core personal and social values, and sustaining values), and
- spiritual values and virtues.

The essential knowledge, skills, values and attitudes comprising the core curriculum are interwoven and provide an essential and holistic framework for preparing all students for careers, higher education and citizenship.

All teachers are expected to include the core learnings in their lesson planning, teaching, and assessment of students in all their lessons. They are expected to foster, promote and model the essential values and attitudes as well as the spiritual values and virtues in their conduct, practice, appearance, and their relationships and in their professional and personal lives. In addition, teachers are expected to mentor, mould and shape each student to evolve and possess the qualities envisioned by society.

Core values and attitudes must not be taught in the classroom only; they must also be demonstrated by students in real life or related situations inside and outside of the classroom, at home, and in everyday life. Likewise, they must be promoted, fostered and modeled by the school community and its stakeholders, especially parents. A holistic approach to values and attitudes in teaching, promoting and modeling is critical to students and the whole school community to internalise the core values and attitudes and making them habitual in their work and school place, and in everyday life. Be it work values, relationship values, peace values, health values, personal and social values, or religious values, teachers should give equal prominence to all common learnings in their lesson planning, teaching, assessment, and learning interventions. Common learnings must be at the heart of all teaching and extra-curricular programs and activities.

Science, Technology, Engineering, Arts and Mathematics

STEAM education is an integrated, multidisciplinary approach to learning that uses science, technology, engineering, arts and mathematics as the basis for inquiring about how STEAM has and continues to change and impact the social, political, economic, cultural and environmental contexts and identifying and solving authentic (real life) natural and physical environment problems by integrating STEAM-based principles, cognitive, high level and 21st Century skills and processes, and values and attitudes.

Science is focused on both goals of STEAM rather than just the goal of problem-solving. This is to ensure that all students are provided opportunities to learn, integrate, and demonstrate proficiency on all essential STEAM principles, processes, skills, values and attitudes to prepare them for careers, higher education and citizenship.

Through STEAM education students will be able to:

(i) Examine and use evidence to draw conclusions about how STEAM has and continues to change the social, political, economic, cultural and environmental contexts.
(ii) Investigate and draw conclusions on the impact of STEAM solutions to problems on the social, political, economic, cultural and environmental contexts.
(iii) Identify and solve problems using STEAM principles, skills, concepts, ideas and process.
(iv) Identify, analyse and select the best solution to address a problem.
(v) Build prototypes or models of solutions to problems.
(vi) Replicate a problem solution by building models and explaining how the problem was or could be solved.
(vii) Test and reflect on the best solution chosen to solve a problem.
(viii) Collaborate with others on a problem and provide a report on the process of problem solving used to solve the problem.
(ix) Use skills and processes learned from lessons to work on and complete STEAM projects.
(x) Demonstrate STEAM principles, skills, processes, concepts and ideas through simulation and modelling.
(xi) Explain the significance of values and attitudes in problem-solving.

STEAM is a multidisciplinary and integrated approach to understanding how science, technology, engineering, arts and mathematics shape and are shaped by our material, intellectual, cultural, economic, social, political and environmental contexts. And for teaching students the essential in demand cognitive, high level and 21st Century skills, values and attitudes, and empower them to effectively use these skills and predispositions to identify and solve problems relating to the natural and physical environments as well as the impact of STEAM-based solutions on human existence and livelihoods, and on the social, political, economic, cultural, and environmental systems.

STEAM disciplines have and continue to shape the way we perceive knowledge and reality, think and act, our values, attitudes, and behaviours, and the way we relate to each other and the environment. Most of the things we enjoy and consume are developed using STEAM principles, skills, process, concepts and ideas. Things humans used and enjoyed in the past and at present are developed by scientists, technologists, engineers, artists and mathematicians to address particular human needs and wants. Overtime, more needs were identified and more products were developed to meet the ever changing and evolving human needs. What is produced and used is continuously reflected upon, evaluated, redesigned, and improved to make it more advanced, multipurpose, fit for purpose, and targeted towards not only improving the prevailing social, political, economic, cultural and environmental conditions but also to effectively respond to the evolving and changing dynamics of human needs and wants. And, at the same time, solutions to human problems and needs are being investigated and designed to address problems that are yet to be addressed and concurred. This is an evolving and ongoing problem-solving process that integrates cognitive, high level, and 21st Century skills, and appropriate values and attitudes.

STEAM is a significant framework and focal point for teaching and guiding students to learn, master and use a broad range of skills and processes required to meet the skills demands of PNG and the 21st Century. The skills that students will learn will reflect the demands that will be placed upon them in a complex, competitive, knowledge-based, information-age, technology-driven economy and society. These skills include cognitive (critical, synthetic, creative, reasoning, decision-making, and problem-solving) skills, high level (analysis, synthesis and evaluation) skills and 21st Century skills (see Appendix 4). Knowledge-based, information, and technology driven economies require knowledge workers not technicians. Knowledge workers are lifelong learners, are problem solvers, innovators, creators, critical and creative thinkers, reflective practitioners, researchers (knowledge producers rather than knowledge consumers), solutions seekers, outcomes oriented, evidence-based decision makers, and enablers of improved and better outcomes for all.

STEAM focuses on the skills and processes of problem solving. These skills and processes are at the heart of the STEAM movement and approach to not only problem solving and providing evidence-based solutions but also the development and use of other essential cognitive, high level and 21st Century skills. These skills are intertwined and used simultaneously to gain a broader understanding of the problems to enable creative, innovative, contextually relevant, and best solutions to be developed and implemented to solve the problems and attain the desired outcomes. It is assumed that by teaching students STEAM-based problem-solving skills and providing learning opportunities inside and outside the classroom will motivate more of them to pursue careers and academic programs in STEAM related fields thus, closing the skills gaps and providing a pool of cadre of workers required by technology, engineering, science, and mathematics-oriented industries.

Although, STEAM focuses on the development and application of skills in authentic (real life) contexts, for example the use of problem- solving skills to identify and solve problems relating to the natural and physical worlds, it does not take into account the significant influence values and attitudes have on the

entire process of problem solving. Values and attitudes are intertwined with knowledge and skills. Knowledge, skills, values and attitudes are inseparable. Decisions about skills and processes of skills development and application are influenced by values and attitudes (mindset) that people hold. In the same light, the use of STEAM principles, processes and skills to solve problems in order to achieve the outcomes envisaged by society are influenced by values and the mindset of those who have identified and investigated the problem as well as those who are affected by the problem and will benefit from the outcome.

STEAM Problem-Solving Processes

Problem-solving involves the use of problem-solving methods and processes to identify and define a problem, gather information to understand its causes, draw conclusions, and use the evidence to design and implement solutions to address it. Even though there are many different problem-solving methods and approaches, they share some of the steps of problem-solving, such as;

- identifying the problem,
- understanding the problem by collecting data,
- analyse and interpret the data,
- draw conclusions,
- use data to consider possible solutions,
- select the best solution,
- test the effectiveness of the solution by trialling and evaluating it, and
- review and improve the solution.

STEAM problem solving processes go from simple and technical to advance and knowledge-based processes. However, regardless of the type of process used, students should be provided opportunities to learn the essential principles and processes of problem solving and, more significantly, to design and create a product that addressed a real problem and meets a human need.

The following are some of the STEAM problem solving processes.

1. Engineering and Technology Problem Solving Methods and Approaches

Engineering and technology problem-solving methods are used to identify and solve problems relating to the physical world using the design process. The following are some of the methods and approaches used to solve engineering and technology related problems.

Parts Substitution

It is the most basic of the problem-solving methods. It simply requires the parts to be substituted until the problem is solved.

Diagnostics

After identifying a problem, the technician would run tests to pinpoint the fault. The test results would be used either as a guide for further testing or for replacement of a part, which also need to be tested. This process continues until the solution is found and the device is operating properly.

Troubleshooting

Troubleshooting is a form of problem solving, often applied to repair failed products or processes.

Reverse Engineering

Reverse engineering is the process of discovering the technological principles underlying the design of a device by taking the device apart, or carefully tracing its workings or its circuitry. It is useful when students are attempting to build something for which they have no formal drawings or schematics.

Divide and Conquer

Divide and conquer is the technique of breaking down a problem into sub-problems, then breaking the sub-problems down even further until each of them is simple enough to be solved. Divide and conquer may be applied to all groups of students to tackle sub-problems of a larger problem, or when a problem is so large that its solution cannot be visualised without breaking it down into smaller components.

Extreme Cases

Considering “extreme cases” – envisioning the problem in a greatly exaggerated or greatly simplified form, or testing using extreme condition – can often help to pinpoint a problem. An example of the extreme-case method is purposely inputting an extremely high number to test a computer program.

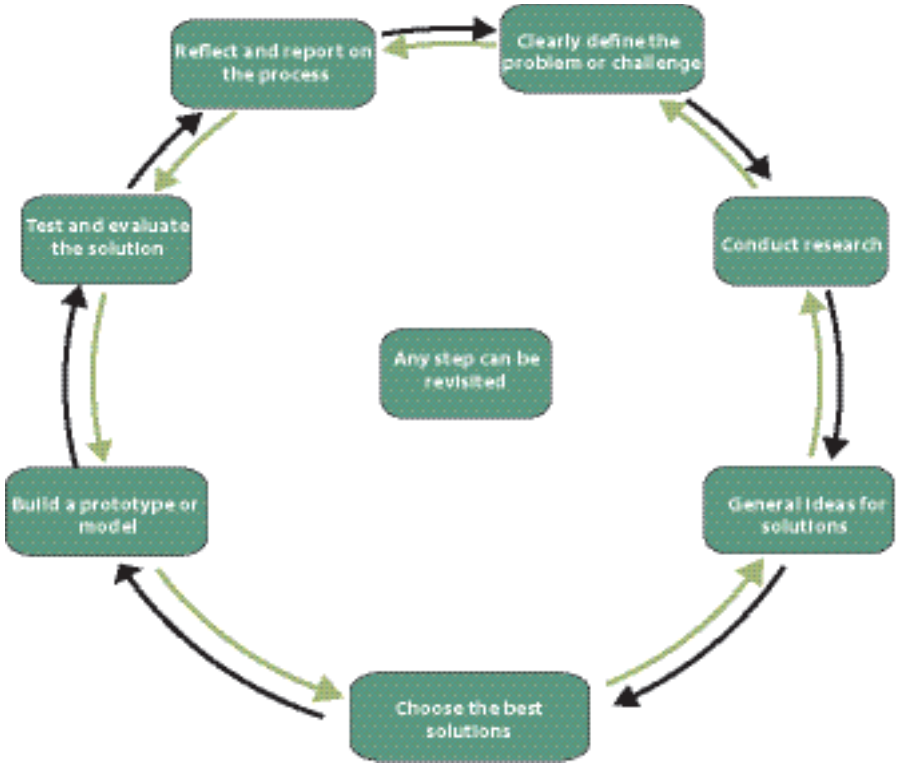
Trial and Error

The trial and error method involve trying different approaches until a solution is found. It is often used as a last resort when other methods have been exhausted.

2. Engineering Design Process

Technological fields use the engineering design process to identify and define the problem or challenge, investigate the problem, collect and analyse data, and use the data to formulate potential solutions to the problem, analyse each of the solutions in terms of its strengths and weaknesses, and choose the best solution to solve the problem. It is an open-ended problem-solving process that involves the full planning and development of products or services to meet identified needs. It involves a sequence of steps such as the following:

1. Analyse the context and background, and clearly define the problem.
2. Conduct research to determine design criteria, financial or other constraints, and availability of materials.
3. Generate ideas for potential solutions, using processes such as brainstorming and sketching.
4. Choose the best solution.
5. Build a prototype or model.
6. Test and evaluate the solution.
7. Repeat steps as necessary to modify the design or correct faults.
8. Reflect and report on the process.



STEAM-Based Lesson planning

Effective STEAM lesson planning is key to the achievement of expected STEAM outcomes. STEAM skills can be planed and taught using separate STEAM-based lesson plans or integrated into the standards-based lesson plans. To effectively do this, teachers should know how to write effective standards and STEAM-based lesson plans.

An example of a STEAM-based lesson plan is provided in the Appendix. Teachers should use this to guide them to integrate STEAM content and teaching, learning and assessment strategies into their standards-based lesson plans.

Integration of STEAM problem-solving skills into standards-based lesson plans

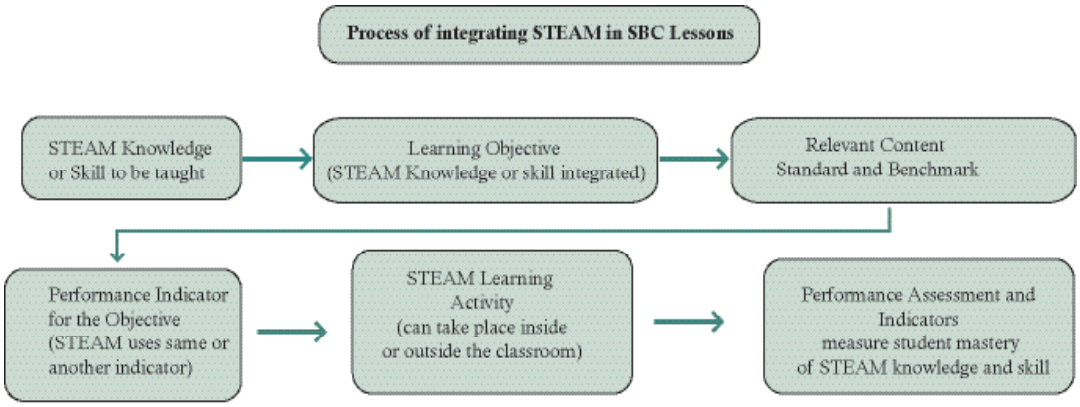
Knowing how to integrate STEAM problem-solving skills, principles, values and attitudes as well as STEAM teaching, learning, and assessment strategies into standards-based lesson plans is essential for achieving the desired STEAM learning outcomes. When integrating STEAM problem-solving skills into the standards-based lesson plans, teachers should ensure that these skills are not only effectively aligned to the learning objective and performance standards, they must also be effectively taught and assessed.

STEAM principles and problem-solving skills are integrated into the content standards and grade-level benchmarks. A list of these skills, including 21st Century skills, is provided in the syllabus. Teachers should ensure that these skills are integrated in their standards-based lesson plans, taught and assessed to determine students' level of proficiency on each skill or specific components of the skill. Teachers should use the following process as guide to integrate STEAM principles and problem-solving skills into the standards-based lesson plans.

Teachers are expected to integrate the essential STEAM principles, processes, skills, values and attitudes described in the grade 11 benchmarks when formulating their standards-based lesson plans. Opportunities should be provided inside and outside of the classroom for students to learn, explore, model and apply what they learn in real life or related situations. These learning experiences will enable students to develop a deeper understanding of STEAM principles, processes, skills, values and attitudes and appreciate their application in real life to solve problems.

Process for Integrating STEAM Principles and Problem-Solving Skills into Standards-Based Lessons

Teachers should follow the steps given below when integrating STEAM problem-solving principles and skills into their standards-based lesson plans.



Steps for integrating STEAM problem-solving principles and skills into standards-based lesson plans.

Step 1: Identify the STEAM knowledge or skill to be taught (From the table of KSVAs for each content standard and benchmark). This could already be captured in the learning objective stated in the standards-based lesson plan.

Step 2: Develop and include a performance standard or indicator for measuring student mastery of the STEAM knowledge or skill *(e.g.* level of acceptable competency or proficiency) if this is different from the one already stated in the lesson plan.

Step 3: Develop student learning activity (An activity that will provide students the opportunity to apply the STEAM knowledge or skill specified by the learning objective and appropriate statement of the standards). Activity can take place inside or outside of the classroom, and during or after school hours.

Step 4: Develop and use performance descriptors (standards or indicators) to analyse students' STEAM related behaviours and products (results or outcomes), which provide evidence that the student has acquired and mastered the knowledge or skill of the learning objective specified by the indicator(s) of the standard(s).

STEAM Teaching Strategies

STEAM education takes place in both formal and informal classroom settings. It takes place during and after school hours. It is a continuous process of inquiry, data analysis, making decisions about interventions, and implementing and monitoring interventions for improvements.

There are a variety of STEAM teaching strategies. However, teaching strategies selected must enable teachers to guide students to use the engineering and artistic design processes to identify and solve natural and physical environment problems by designing prototypes and testing and refining them to effectively mitigate the problems identified. The following are some of the strategies that could be used to utilise the STEAM approach to solve problems and coming up with technological solutions.

- *Inquiry-Based Learning*
- *Problem-Based Learning*
- *Project-based learning,*
- *Collaborative Learning*

Collaborative learning involves individuals from different STEAM disciplines and expertise in a variety of STEAM problem solving approaches working together and sharing their expertise and experiences to inquire into and solve a problem.

Teachers should plan to provide students opportunities to work in collaboration and partnership with experts and practitioners engaged in STEAM related careers or disciplines to learn first-hand about how STEAM related skills, processes, concepts, and ideas are applied in real life to solve problems created by natural and physical environments. Collaborative learning experiences can be provided after school or during school holidays to enable students to work with STEAM experts and practitioners to inquiry and solve problems by developing creative, innovative and sustainable solutions. Providing real life experiences and lessons, e.g., by involving students to actually solve a scientific, technological, engineering, or mathematical, or Arts problem, would probably spark their interest in a STEAM career path. Developing STEAM partnerships with external stakeholders e.g., high education institutions, private sector, research and development institutions, and volunteer and community development organizations can enhance students' learning and application of STEAM problem solving principles and skills.

Some examples of STEAM-related partnership experiences may include:

- *Participatory Learning*
- *Group-Based Learning*
- *Task Oriented Learning*
- *Action Learning*
- *Experiential Learning*
- *Modelling*
- *Simulation*

STEAM Learning Strategies

Teachers should include in their lesson plans STEAM learning activities. These activities should be aligned to principle or a skill planned for students to learn and demonstrate proficiency at the end of the lesson to expose students to STEAM and giving them opportunities to explore STEAM-related concepts, they will develop a passion for it and, hopefully, pursue a job in a STEAM field. Providing real life experiences and lessons, e.g., by involving students to actually solve a scientific, technological, engineering, or mathematical, or arts problem, would probably spark their interest in a STEAM career path. This is the theory behind STEAM education.

STEAM-Based Assessment

STEAM-based assessment is closely linked to standards-based assessment where assessment is used to assess students' level of competency or proficiency of a specific knowledge, skill, value, or attitude taught using a set of performance standards (indicators or descriptors). The link also includes the main components such as the purpose, the assessment principles and assessment strategies and tools.

In STEAM-based assessment, assessments are designed for what students should know and be able to do. In STEAM learning, students are assessed in a variety of ways including portfolios, project/problem-based assessments, backwards design, authentic assessments, or other student-centered approaches.

When planning and designing the assessment, teachers should consider the authenticity of the assessment by designing an assessment that relates to a real world task or discipline specific attributes such as simulation, role play, placement assessment, live projects and debates. These tasks should make the activity meaningful to the student, and therefore be motivating as well as developing employability skills and discipline specific attributes.

Effective STEAM-Based Assessment Strategies

The following are the six assessment tools and strategies to impact teaching and learning as well as help teachers foster a 21st Century learning environment in their classrooms.

1. *Rubrics*
2. *Performance-Based Assessments (PBAs)*
3. *Portfolios*
4. *Student self-assessment*
5. *Peer-assessment*
6. *Student Response Systems (SRS).*

Although the list does not include all innovative assessment strategies, it includes what we think are the most common strategies, and ones that may be particularly relevant to the educational context of developing countries in this 21st Century. Many of the assessment strategies currently in use fit under one or more of the categories discussed. Furthermore, it is important to note that these strategies also connect in a variety of ways.

1. Rubrics

Rubrics are both a tool to measure students' knowledge and ability as well as an assessment strategy. A rubric allows teachers to measure certain skills and abilities not measurable by standardized testing systems that assess discrete knowledge at a fixed moment in time. Rubrics are also frequently used as part of other assessment strategies including; portfolios, performances, projects, peer-review and self-assessment which are also elaborated in this section.

2. Performance-Based Assessments

Performance-Based Assessments (PBA), also known as project-based or authentic assessments, are generally used as a summative evaluation strategy to capture not only what students know about a topic, but if they have the skills to apply that knowledge in a "real-world" situation. By asking them to create an end product. PBA pushes students to synthesize their knowledge and apply their skills to a potentially unfamiliar set of circumstances that is likely to occur beyond the confines of a controlled classroom setting.

The implementation of performance-based assessment strategies can also impact other instructional strategies in the classroom.

3. Portfolio Assessment

Portfolios are a collection of student work gathered over time that is primarily used as a summative evaluation method. The most salient characteristic of the portfolio assessment is that rather than being a snapshot of a student's knowledge at one point in time (like a single standardized test), it highlights student effort, development, and achievement over a period of time; portfolios measure a student's ability to apply knowledge rather than simply regurgitate. They are considered both student-centred and authentic assessments of learning.

4. Self-assessment

While the previous assessment tools and strategies listed in this report generally function as summative approaches, self-assessment is generally viewed as a formative strategy, rather than one used to determine a student's final grade. Its main purpose is for students to identify their own strengths and weakness and to work to make improvements to meet specific criteria. Self-assessment occurs when students judge their own work to improve performance as they identify discrepancies between current and desired performance". In this way, self-assessment aligns well with standards-based education because it provides clear targets and specific criteria against which students or teachers can measure learning.

Self-assessment is used to promote self-regulation, to help students reflect on their progress and to inform revisions and improvements on a project or paper. In order for self-assessment to be truly effective four conditions must be in place: the self-assessment criteria is negotiated between teachers and students, students are taught how to apply the criteria, students receive feedback on their self-assessments and teachers help students use assessment data to develop an action plan.

5. Peer assessment

Peer assessment, much like self-assessment, is a formative assessment strategy that gives students a key role in evaluating learning. Peer assessment approaches can vary greatly but, essentially, it is a process for learners to consider and give feedback to other learners about the quality or value of their work. Peer assessments can be used for variety of products like papers, presentations, projects, or other skilled behaviours. Peer assessment is understood as more than only a grading procedure and is also envisioned as teaching strategy since engaging in the process develops both the assessor and assessee's skills and knowledge.

The primary goal for using peer assessment is to provide feedback to learners. This strategy may be particularly relevant in classrooms with many students per teacher since student time will always be more plentiful than teacher time. Although any single student's feedback may not be rich or in-depth as teacher's feedback, the research suggests that peer assessment can improve learning.

6. Student Response System

Student response system (SRS), also known as classroom response (CRS), audience response system (ARS) is a general term that refers to a variety of technology-based formative assessment tools that can be used to gather student-level data instantly in the classroom. Through the combination of hardware, (voice recorders, PC, internet connection, projector and screen) and software.

Teachers can ask students a wide range of questions (both closed and open ended), where students can respond quickly and anonymously, and the teacher can display the data immediately and graphically. The use of technology also includes a use of video which examines how a range of strategies can be used to assess students' understanding.

The value of SRS comes from teachers analyzing information quickly and then devising real-time instructional solutions to maximize student learning. This includes a suggested approach to help teachers and trainers assess learning.

Curriculum Integration

What is Curriculum Integration?

Curriculum integration is making connections in learning across the curriculum. The ultimate aim of curriculum integration is to act as a bridge to increase students' achievement and engage in relevant curriculum. (Susan M. Drake and Rebecca C. Burns)

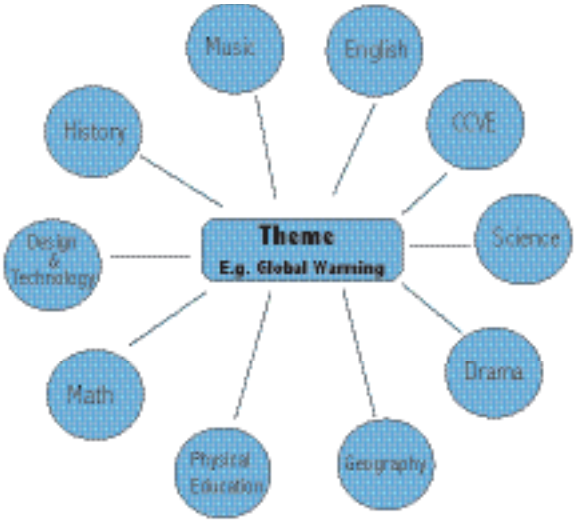
Teachers must develop intriguing curriculum by going beyond the traditional teaching of content based or fragmented teaching to one who is knowledge based and who should be perceived as a 21st Century innovative educator. Curriculum integration is a holistic approach to learning thus curriculum integration in PNG SBC will have to equip students with the essential knowledge, skills, values and attitudes that are deemed 21st Century.

There are three approaches that PNG SBC will engage to foster conducive learning for all its children whereby they all can demonstrate proficiency at any point of exit. Adapting these approaches will have an immense impact on the lives of these children thus they can be able to see themselves as catalyst of change for a competitive PNG. Not only that but they will be comparable to the world standards and as global citizens.

Engaging these three approaches in our curriculum will surely sharpen the knowledge and ability of each child who will foresee themselves as assets through their achievements thus contribute meaningfully to their country. They themselves are the agents of change. Integrated learning will bear forth a generation of knowledge based populace who can solve problems and make proper decisions based on evidence. Thus, PNG can achieve its goals like the Medium Term Development Goals (MTDG) and aims such as the Vision 2050 for a happy, healthy and wealthy society whereby, all its citizens should have access and fair distribution to income, shelter, health, education and general goods and services improving the general standard of living for PNG in the long run.

1. (i) Multidisciplinary Approach

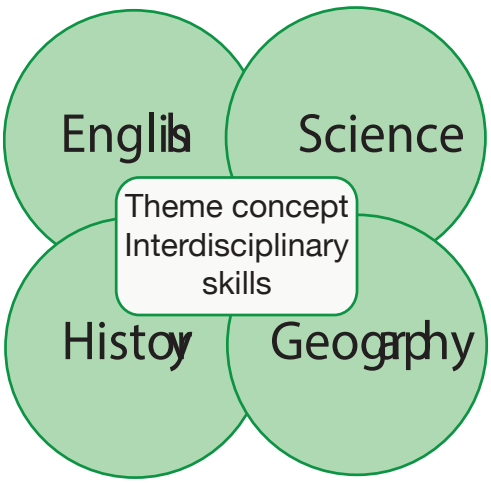
In this approach learning involves a theme or concept that will be taught right across all subject area of study by students. That is, content of a particular theme will be taught right across all subjects as shown in the diagram below. For instance, if the theme is global warming, subject areas create lessons or assessment as per their subjects around this theme. Social Science will address this issue, Science and all other subject likewise.



1. (ii) Interdisciplinary Approach

This approach addresses learning similarly to the multidisciplinary approach of integrated learning whereby learning takes place within the subject area. However, it is termed interdisciplinary in that the core curriculum of learning is interwoven into each subject under study by the students. For instance; in Social Science under the strand of geography students write essay on internal migration however, apart from addressing the issues of this topic, they are to apply the skill of writing text types in their essay such as argumentative essay, informative, explanatory, descriptive, expository and narrative essay while writing their essay. They must be able to capture the mechanics of English skills such as grammar, punctuation and so forth. Though these skills are studied under English they are considered as core skills that cut across all subjects under study. For example; if Science students were to write about human development in Biology then the application of writing skills has to be captured by the students in their writing. It is not seen as an English skill but a standard essential skill all students must know and do regardless.

Therefore, essential knowledge, skills, values and attitudes comprising the core curriculum are interwoven and provide an essential and holistic framework for preparing all students for careers, higher education and citizenship in this learning.



2. Intradisciplinary approach

This approach involves teachers integrate sub disciplines within a subject area. For instance, within the subject Social Science, the strands (disciplines) of geography, environment, history, political science and environment will all be captured studying a particular content for Social Science. For example, under global warming, students will study the geographical aspects of global warming, environmental aspect of global warming and likewise for history, political science and economics. Thus, children are well aware of the issues surrounding global warming and can address it confidently at each level of learning.

3. Trans disciplinary Approach

In this approach learning goes beyond the subject area of study. Learning is organized around students' questions and concerns. That is, where there is a need for change to improve lives, students develop their own curriculum to effect these need. The trans-disciplinary approach addresses real-life situations thus giving the opportunity to students to attain real life skills. This learning approach is more to do with Project–Based Learning also referred to as problem-based learning or place- based learning.

Below are the three steps to planning project based curriculum.

1. Teachers and students select a topic of study based on student interests, curriculum standards, and local resources.
2. The teacher finds out what the students already know and helps them generate questions to explore. The teacher also provides resources for students and opportunities to work in the field
3. Students share their work with others in a culminating activity. Students display the results of their exploration and review and evaluate the project.

For instance; students may come up with slogans for school programs such as 'Our culture – clean city for a healthier PNG'. The main aim could be to curb betel nut chewing in public areas especially around bus stops and local markets. Here, students draw up their own instructions and criteria for assessment which is; they have to clean the nearest bus stop or local market once a week throughout the year. They also design and create posters to
educate the general public as their program continues. They can also involve the town council and media to assist them especially to carry out awareness.

Studies have proven that Project based-programs have led to the following:

- Students go far beyond the minimum effort
- Make connections among different subject areas to answer open-ended questions
- Retain what they have learnt
- Apply learning to real-life problems
- Have fewer discipline problems
- Lower absenteeism

These integrated learning approaches will demand for teaches to be proactive in order to improve students learning and achievements. In order for PNG Standards-Based Curriculum to serve its purpose fully, these three approaches must be engaged for better learning for the children of Papua New Guinea now and in the future.

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Essential Knowledge, Skills, Values and Attitudes and Scientific Thinking Process

Students' level of proficiency and progression towards the attainment of content standards will depend on their mastery and application of essential knowledge, skills, values, and attitudes in real life or related situations. Provided here are examples of different types of knowledge, processes, skills, values, and attitudes that all students are expected to learn and master as they progress through the grades. These are expanded and deepen in scope and the level of difficulty and complexity are increased to enable students to study in-depth the subject content as they progress from one grade to the next.

These knowledge, skills, values and attitudes have been integrated into the content standards and benchmarks. They will also be integrated into the performance standards. Teachers are expected to plan and teach essential knowledge, skills, values and attitudes in their lessons, and assess students' performance and proficiency, and progression towards the attainment of content standards.

Types of Knowledge

There are different types of knowledge. These include;	
• Public and private (privileged) knowledge • Specialised knowledge • Good and bad knowledge • Concepts, processes, ideas, skills, values, attitudes • Theory and practice • Fiction and non-fiction • Traditional, modern, and postmodern knowledge	• Subject and discipline-based knowledge • Lived experiences • Evidence and assumptions • Ethics and Morales • Belief systems • Facts and opinions • Wisdom • Research evidence and findings • Solutions to problems

Types of Processes

There are different types of processes. These include;	
• Problem-solving • Logical reasoning • Decision-making • Reflection	• Cyclic processes • Mapping (e.g. concept mapping) • Modelling • Simulating
Science Inquiry processes include: • Gathering information • Analysing information • Evaluating information • Making judgements • Taking actions	

Types of Skills

There are different types of skills. These include:

1. Cognitive (Thinking) Skills

Thinking skills can be categorized into **critical thinking** and **creative thinking** skills.

i. Critical Thinking Skills

A person who thinks critically always evaluates an idea in a systematic manner before accepting or rejecting it. Critical thinking skills include;	
• Attributing • Comparing and contrasting • Grouping and classifying • Sequencing • Prioritising • Analysing	• Detecting bias • Evaluating • Metacognition (Thinking about thinking) • Making informed conclusions.

ii Creative Thinking Skills

A person who thinks creatively has a high level of imagination, able to generate original and innovative ideas, and able to modify ideas and products. Creative thinking skills include;	
• Generating ideas • Deconstruction and reconstruction • Relating • Making inferences • Predicting • Making generalisations • Visualizing	• Synthesising • Making hypothesis • Making analogies • Invention • Transformation • Modeling • Simulating

2. **Reasoning Skills** - Reason is a skill used in making a logical, just, and rational judgment.

3. **Decision-Making Skills** - Decision-making involves selection of the best solution from various alternatives based on specific criteria and evidence to achieve a specific aim.

4. **Problem Solving Skills** – These skills involve finding solutions to challenges or unfamiliar situations or unanticipated difficulties in a systematic manner.

5. Literacy Skills

A strong emphasis must be placed on various types of literacy, from financial to technological, from media to mathematical, from content to cultural. Literacy may be defined as the ability of an individual to use information to function in society, to achieve goals and to develop her or his knowledge and potential. Teachers emphasize certain aspects of literacy over others, depending on the nature of the content and skills they want students to learn.

The following literacy skills are intended to be exemplary rather than definitive	
• Listens, read, write, and speak with comprehension and clarity • Define and apply discipline-based conceptual vocabulary • Describe people, places, and events, and the connections between and among them • Arrange events in chronological sequence • Differentiate fact from opinion • Determine an author's purpose • Determine and analyse similarities and differences • Analyse cause and effect relationships • Explore complex patterns, interactions and relationships • Differentiate between and among various options	• Listens, read, write, and speak with comprehension and clarity • Define and apply discipline-based conceptual vocabulary • Describe people, places, and events, and the connections between and among them • Arrange events in chronological sequence • Differentiate fact from opinion • Determine an author's purpose • Determine and analyse similarities and differences • Analyse cause and effect relationships • Develop an ability to use and apply abstract principals • Explore and/or observe, identify, and analyse how individuals and/or societies relate to one another

6. High Level Thinking Skills - These skills include analysis, synthesis, and evaluation skills.

i) Analysis Skills – Analysis skills involve examining in detail and breaking information into parts by identifying motives or causes, underlying assumptions, hidden messages; making inferences and finding evidence to support generalisations, claims, and conclusions.

Key Words				
Analyse	Differences	Find	List	Similar to
Appraise	Discover	Focus	Motivate	Simplify
Arrange	Discriminate	Function	Omit	Take part in
Assumption	Discussion	Group	Order	Test for
Breakdown	Distinction	Highlight	Organize	Theme
Categorize	Distinguish	In-depth	Point out	
Cause & effect	Dissect	Inference	Research	
Choose	Divide	Inspect	See	
Classify	Establish	Isolate	Select	
Comparing	Examine	Investigate	Separate	

ii) *Synthesis Skills* – Synthesis skills involve changing or creating something new, compiling information together in a different way by combining elements in a new pattern proposing alternative solutions.

iii) *Evaluation Skills* – Evaluation skills involve justifying and presenting and defending opinions by making judgments about information, validity of ideas or quality of work based on set criteria.

Types of Values

Personal engagement and civic engagement strategies help young people to acquire and apply skills and dispositions that will prepare them to become competent and responsible citizens.

1. Personal Values (importance, worth, usefulness, etc.)

Core values	Sustaining values
• Sanctity of life • Truth • Aesthetics • Honesty • Human • Dignity • Rationality • Creativity • Courage • Liberty • Affectivity • Individuality	• Self-esteem • Self-reflection • Self-discipline • Self-cultivation • Principal morality • Self-determination • Openness • Independence • Simplicity • Integrity • Enterprise • Sensitivity • Modesty • Perseverance

2. Social Values

Core Values	Sustaining Values
• Equality • Kindness • Benevolence • Love • Freedom • Common good • Mutuality • Justice • Trust • Interdependence • Sustainability • Betterment of human kind • Empowerment	• Plurality • Due process of law • Democracy • Freedom and liberty • Common will • Patriotism • Tolerance • Gender equity and social inclusion • Equal opportunities • Culture and civilisation • Heritage • Human rights and responsibilities • Rationality • Sense of belonging • Solidarity • Peace and harmony • Safe and peaceful communities

Types of Attitudes

Attitudes - Ways of thinking and behaving, points of view	
• Optimistic • Participatory • Critical • Creative • Appreciative • Empathetic • Caring and concern • Positive • Confident • Cooperative	• Responsible • Adaptable to change • Open-minded • Diligent • With a desire to learn • With respect for self, life, equality and excellence, evidence, fair play, rule of law, different ways of life, beliefs and opinions, and the environment.

Scientific Method and Approach to Problem Solving

Scientists engage in scientific inquiry by following key science practices that enable them to understand the natural and physical world and answer questions about it. Science students must become proficient at these practices to develop an understanding of how the scientific enterprise is conducted. These practices include skills from daily life and school studies that students use in a systemic way to conduct scientific inquiry. There are six (6) basic science process skills science students have to master before they apply the science inquiry problem-solving approach. The process skills that are at the heart of the scientific inquiry and problem-solving process are:

- Observation
- Communication
- Classification
- Measurement
- Inference
- Prediction

The science practices are fundamental to all science disciplines. The eight (8) steps that are fundamental to scientific inquiry are outlined below. The steps in the process vary, depending on the purpose of the inquiry and the type of questions or hypothesis created.

The steps above should be taught and demonstrated by students separately and jointly before they implement the inquiry process. Students should be guided through every step of the process so that they can explain them, their importance and use the steps and the whole process proficiently to identify, investigate and solve problems. A brief explanations and examples of each step are provided below to assist teachers plan and teach each step. Students should be provided with opportunities to practice and reflect on each step until they demonstrate the expected level of proficiency before moving on to the next step.

Step 1: Identify and describe the problem

Problems are identified mainly from observations and the use the five senses – smell, sight, sound, touch and taste. Students should be guided and provided opportunities to identify natural and physical environment problems using their five senses and describe what the problem is and its likely causes.

Example: *Observation*

- When I turn on a flashlight using the on/off switch, light comes out of one end.

Step 2: Formulate research question

After the problem is identified and described, the question to be answered is then formulated. This question will guide the scientist in conducting the research and experiments.

Example: *Question*

- What makes light comes out of a flash light when I turn it on?

Step 3: Review literature

It is more likely that the research problem and question have already been investigated and reported by someone. Therefore, after asking the question, the scientist spends some time reading and reviewing papers and books on past research and discussions to learn more about the problem and the question ask to prepare her for his own research. Conducting literature review helps the scientist to better understand his/her research problem, refine the research question and decide on experiment/research approach before the experiment is conducted.

Example: *Literature review*

- The scientist may look in the flashlight's instruction manual for tips or conduct online search on how flashlights work using the manufacturer's or relevant websites. Scientist may even analyse information and past experiments or discoveries regarding the relationship between energy and light.

Step 4: Formulate hypothesis

With a question in mind, the researcher decides on what he/she wants to test (The question may have changed as a result of the literature review). The research will clearly state what he/she wants to find out by carrying out the experiment. He/She will make an educated guess that could answer the question or explain the problem. This statement is called a hypothesis. A hypothesis guides the experiment and must be testable.

Example: *Hypothesis*

- The batteries inside a flashlight give it energy to produce light when the flashlight is turned on.

Step 5: Conduct experiment

This step involves the design and conduct of experiment to test the hypothesis. Remember, a hypothesis is only an educated guess (a possible explanation), so it cannot be considered valid until an experiment verifies that it is valid.

Example: *Experimental Procedure*

- Remove the batteries from the flashlight, and try to turn it on using the on/off switch.
  Result: The flashlight does not produce light

- Reinsert the batteries into the flashlight, and try to turn it on using the on/off switch.
  Result: The flashlight does produce light.

- Write down these results

In general, it is important to design an experiment to measure only one thing at a time. This way, the researcher knows that his/her results are directly related to the one thing he/she changed. If the experiment is not designed carefully, results may be confusing and will not tell the researcher anything about his/her hypothesis.

Researchers collect data while carrying out their experiments. Data are pieces of information collected before, during, or after an experiment. To collect data, researchers read the measuring instruments carefully. Researchers record their data in notebooks, journals, or on a computer.

Step 6: Analyse data

Once the experiment is completed, the data is then analysed to determine the results. In addition, performing the experiment multiple times can be helpful in determining the credibility of the data.

Example: *Analysis*

- Record the results of the experiment in a table.
- Review the results that have been written down.

Step 7: Draw conclusions

If the hypothesis was testable and the experiment provided clear data, scientist can make a statement telling whether or not the hypothesis was correct. This statement is known as a conclusion. Conclusions must always be backed up by data. Therefore, scientists rely heavily on data so they can make an accurate conclusion.

If the data supports the hypothesis, then the hypothesis is considered correct or valid.If the data does not support the hypothesis, the hypothesis is considered incorrect or invalid.

Example: *Valid Hypothesis*

- The flashlight did not produce light without batteries. The flashlight did produce light when batteries were inserted.

Therefore, the hypothesis that batteries give the flashlight energy to produce light is valid, given that no changes are made to the flashlight during the experiment.

Example: *Invalid Hypothesis*

- The flashlight did NOT produce light when the batteries wereinserted. Therefore, the hypothesis that batteries give the flashlight energy to produce light is invalid.

In this case, the hypothesis would have to be modified to say something like, "The batteries inside a flashlight give it energy to produce light when the batteries are in the correct order and when the flashlight is turned on." Then, another experiment would be conducted to test the new hypothesis.

An invalid hypothesis is not a bad thing! Scientists learn something from both valid and invalid hypotheses. If a hypothesis is invalid, it must be rejected or modified. This gives scientists an opportunity to look at the initial observation in a new way. They may start over with a new hypothesis and conduct a new experiment. Doing so is simply the process of scientific inquiry and learning.

Step 8: Communicate findings

Scientists generally tell others what they have learned. Communication is a very important component of scientific progress and problem solving. It gives other people a chance to learn more and improve their own thinking and experiments. Many scientists' greatest breakthroughs would not have been possible without published communication or results from previous experimentation.

Every experiment yields new findings and conclusions. By documenting both the successes and failures of scientific inquiry in journals, speeches, or other documents, scientists are contributing information that will serve as a basis for future research and for solving problems relating to both the natural and physical worlds. Therefore, communication of investigative findings is an important step in future scientific discovery and in solving social, political, economic, cultural, and environmental problems.

Example: *Communication of findings*

- Write your findings in a report or an article and share it with others, or present your findings to a group of people. Your work may guide someone else's research on creating alternative energy sources to generate light, additional uses for battery power, etc.

Teaching and Learning Strategies

Scientific teaching emphasises and embraces the use of cognitive, reasoning, decision-making, problem solving and higher level thinking skills to teach to enhance students' understanding of inter-disciplinary concepts and issues in relation to environment, geography, history, politics and economic within PNG and globally. It aims to provide a meaningful pedagogical framework for teaching and learning essential and in demand knowledge, skills, values, and attitudes that are required for the preparation of students for careers, higher education and citizenship in the 21st Century.

Students must be prepared to gather and understand information, analyse issues critically, learn independently or collaboratively, organize and communicate information, draw and justify conclusions, create new knowledge, and act ethically.

These teaching and learning strategies will help teachers to;

- familiarise themselves with different methods of teaching in the classroom,
- develop an understanding of the role of a teacher for application of various methods in the classroom

Successful teachers always keep in view that teaching must "be dynamic, challenging and in accordance with the learner's comprehension. He/she does not depend on any single method for making his/her teaching interesting, inspirational and effective".

A detailed table of Teaching and Learning Strategies are outlined below:

STRATEGY	TEACHER	STUDENTS
CASE STUDY Used to extend students' understanding of real life issues	Provide students with case studies related to the topic of the lesson and allow them to analyse and evaluate.	Study the case study and identify the problem addressed. They analyse the problem and suggest solutions supported by conceptual justifications and make presentations. This enriches the students' existing knowledge of the topic.
DEBATE A method used to increase students' interest, involvement and participation	Provide the topic or question of debate on current issues affecting a bigger population, clearly outlining the expectations of the debate. Explain the steps involved in debating and set a criteria/ standard to be achieved.	Conduct researches to gather supporting evidence about the selected topic and summarising the points. They are engaged in collaborative learning by delegating and sharing tasks to group members. When debating, they improve their communication skills.

DISCUSSION The purpose of discussion is to educate students about the process of group thinking and collective decision.	The teacher opens a discussion on certain topic by asking essential questions. During the discussion, the teacher reinforces and emphasises on important points from students responses. Teacher guide the direction to motivate students to explore the topic in greater depth and the topic in more detail. Use how and why follow-up questions to guide the discussion toward the objective of helping students understand the subject and summarise main ideas.	Students ponder over the question and answer by providing ideas, experiences and examples. Students participate in the discussion by exchanging ideas with others.
GAMES AND SIMULATIONS Encourages motivation and creates a spirit of competition and challenge to enhance learning	Being creative and select appropriate games for the topic of the lesson. Give clear instructions and guidelines. The game selected must be fun and build a competitive spirit to score more than their peers to win small prices.	Go into groups and organize. Follow the instructions and play to win
OBSERVATION Method used to allow students to work independently to discover why and how things happen as the way they are. It builds curiosity.	Give instructions and monitor every activity students do	Students possess instinct of curiosity and are curious to see the things for themselves and particularly those things which exist around them. A thing observed and a fact discovered by the child for himself becomes a part of mental life of the child. It is certainly more valuable to him than the same fact or facts learnt from the teacher or a book. Students Observe and ask essential questions Record Interpret
PEER TEACHING & LEARNING (power point presentations, pair learning) Students teach each other using different ways to learn from each other. It encourages; team work, develops confidence, feel free to ask questions, improves communication skills and most importantly develop the spirit of inquiry.	Distribute topics to groups to research and teach others in the classroom. Go through the basics of how to present their peer teaching.	Go into their established working groups. Develop a plan for the topic. Each group member is allocated a task to work on. Research and collect information about the topic allocated to the group. Outline the important points from the research and present their findings in class.

PERFORMANCE-RELATED TASKS (dramatization, song/lyrics, wall magazines) Encourages creativity and take on the overarching ideas of the topic and are able to recall them at a later date	Students are given the opportunity to perform the using the main ideas of a topic. Provide the guidelines, expectations and the set criteria	Go into their established working groups. Being creative and create dramas, songs/lyrics or wall magazines in line with the topic.
PROJECT (individual/group) Helps students complete tasks individually or collectively	Teacher outline the steps and procedures of how to do and the criteria	Students are involved in investigations and finding solutions to problems to real life experiences. They carry out researches to analyse the causes and effects of problems to provide achievable solutions. Students carefully utilise the problem-solving approach to complete projects.
USE MEDIA & TECHNOLOGY to teach and generate engagement depending on the age of the students	Show a full movie, an animated one, a few episodes form documentaries, you tube movies and others depending on the lesson. Provide questions for students to answer before viewing	Viewing can provoke questions, debates, critical thinking, emotion and reaction. After viewing, students engage in critical thinking and debate

Strands, Units and Topics

The strand, units and topics are connected and aligned. The topics for each unit were derived from the grade level benchmarks. Unlike the units, the topics differ in grade levels. There are several topics for each unit depending on the content.

Strand 1: Science Inquiry

Strand 1: Science as Inquiry	
Units	**Topics**
11.1 Scientific Inquiry	1. Introduction to Biology 2. Scientific Method
Strand 2: Life	
Units	**Topics**
11. 1 Living Things	1. Cells 2. Classification Principles 3. Origion and Diversity
11.2 Microbiology	1. Microbes 2. Occurrence and Behaviours 3. Impacts on Host Species 4. Prions and Viroids 5. Treatment & Preventions of Diseases caused by Microbes
11.3 Nutrition	1. Autotrophic Nutrition 2. Heterotrophic Nutrition
11.4 Respiration and Circulation	1. Gas Exchange in Plants 2. Circulation and Gas Exchange in Animals
11.5 Support Systems	1. Tropism in Plants 2. Defence System 3. Reproduction System 4. Nervous System 5. Endocrine System

Strand:	Unit	Topic	Lesson Titles
1. Science as Inquiry	Scientific Inquiry	Scientific Inquiry	Introduction to Biology
			Scientific Method
			International System of Units
			Scientific Tools
			Tools used by Life Scientists
2. Life	Diversity of Living Things	Cells	Cell Structures and Functions
			Comparison Between Plant and Animal Cells
			Processes in cells and organisms
			Experiment on Pakchoi Leaf in coloured (food dyed) solution to understand diffusion
			Types of cells & Formation of Tissues, Organs & Systems
			Parts of a light microscope: Structures and Functions
			Magnification of Cells
			Experiment: Examination of Animal (Cheek) and Plant (Onion) Cell
		Classification Principles	Bryophytes or Non-Vascular Plants
			Tracheophytes or Vascular Plants
			Invertebrates
			Vertebrates
		Origin & Diversity	Origins of Life: Brief Introduction into Evolution & Diversity of Organisms
			Classification Systems & Linnaean System
			Classification Tools: Dichotomous & Cladogram
			Prokaryotes: Bacteria
			Eukaryotes: Protista & Fungi
	Microbiology	Microbes	Bacteria: Can Be Harmful or Beneficial
			FUNGI: Uses of Fungi Due to their Structures
			PROTISTA: The Benefits of Some Protista Due To Their Structures
			Experiment on observing bread mould with a magnifying glass
		Occurrence & Behaviours	Natural Habitats
			Modes of Nutrition
			Modes of Reproduction
			Ecological Interactions with other organisms
		Impacts on Host Species	Ways in which Microbes affect other hosts
			Disease & Disorders from Microbes on other living things
		Prions & Viroids	Prions - Their Effects on Humans
			Viroids - Their Effects on Plants
		Treatment & Preventions of Diseases caused by microbes	The Role of Medicine in the Management of Infectious Diseases
			a. Bacterial Diseases
			b. Fungal Diseases
			c. Protista Diseases
			d. Viral Diseases

Strand:	Unit	Topic	Lesson Titles
2. Life	Nutrition	Autotrophic Nutrition	Types of Nutrition and Main Classes of Nutrients
			Autotrophic Nutrition & Photosynthesis
			Organisms and their Structures involved in Autotrophic Nutrition
			Factors affecting Photosynthesis
		Heterotrophic Nutrition	Four Types of Heterotrophic Nutrition
			Organisms and their Structures involved in Heterotrophic Nutrition
			Feeding Adaptations
	Respiration and Circulation	Gas Exchange in Plants	Diffusion and Osmosis
			Properties of Gas Exchange Surfaces in Plants
			Types of Specialized Gas Exchange Surfaces in Plants
			Photosynthesis
			Respiration in Plants
			Factors Affecting Gas Exchange in Plants
		Circulation and Gas Exchange in Animals	Properties of Gas Exchange Surfaces in Animals
			Types of Specialized Gas Exchange Surfaces and Systems in Animals
			Types of Circulatory / Respiratory Systems In Animals
			Respiration in Vertebrates
			Experiment on Breathing Rate after Exercise
			Respiration in Invertebrates
			Components of Circulatory System
			Vertebrate Circulatory System: Human
			Invertebrate Circulatory System: Grasshopper
	Support Systems	Tropism in Plants	Plant Hormones: Structure, Function and Importance
			Types of Tropisms in Plants
			Experiment on Phototropism
		Defence System	Defence System in Plants
			Defence System in Animals
			Lymphatic System and its Role in Human Defence System
			Human Immune System: First, Second & Third lines of defence in humans
			Role of Immune System in Humans: Non-specific & Specific Immune Mechanisms
			Natural versus Acquired Immunity in Humans

Strand:	Unit	Topic	Lesson Titles
2. Life	Support Systems	Reproduction System	Modes of Reproduction
			Asexual Reproduction: Types and Occurrences
			Sexual Reproduction: Types and Occurrences
			Reproduction in Plants
			Reproduction in Animals
			Process of Reproduction in Humans: From Conception to Birth
			Hormones Associated With Reproduction in Humans
			Human Growth: Primary and Secondary Characteristics associated with Puberty
			Family Planning Methods
			Sexually Transmitted Diseases
		Nervous System	Role of Nervous System in Animals
			Components of the Human Nervous System: Structure of the Nerve Cell and Types of Nerve Cells
			Involuntary vs Voluntary Reflexes
			Central vs Peripheral Nervous systems
		Endocrine System	Role of Endocrine and Exocrine Systems in Animals
			Hormones: Definition and Types
			Elements of the Human Endocrine and Exocrine Systems
			Homeostatis: How Endocrine System interacts with the other Systems in the human body to bring balance

Grade 11 Biology

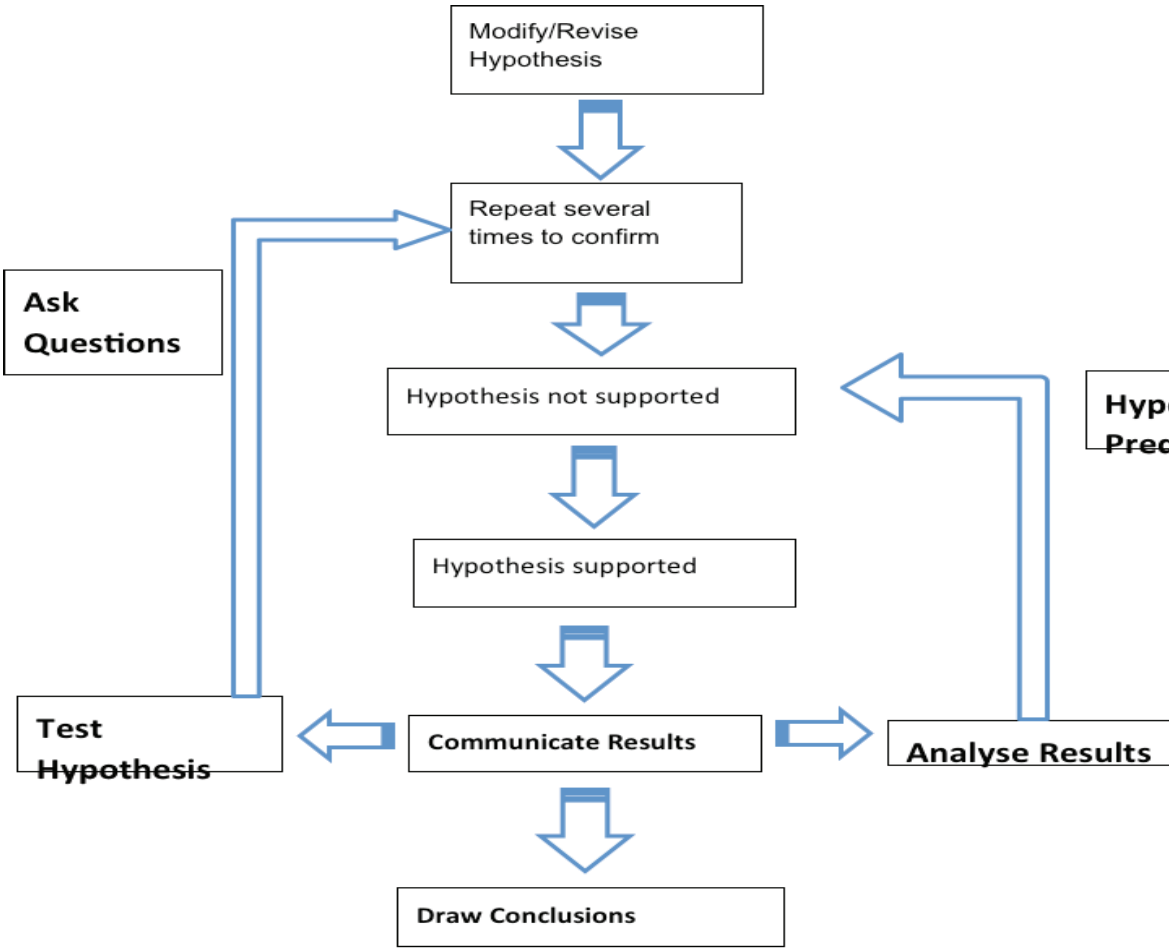
Teaching Content

What is Biology?

Biology, or life science is the study of all living organisms. In this course you will be studying a range of living organisms, the life processes they carry out, the effects that these life processes might have on our health and the responsibilities which we have towards other organisms. This will help you to understand and perhaps contribute to the biological revolution which will increasingly affect the lives of all of us.

Scientific Inquiry

As scientist study the natural world, they ask certain questions about what they observe. To find the answers to this question, they usually use certain skills or methods. It is important to know that, sometimes, not all of these skills are performed in an investigation or performed in a particular order. Scientists use the Scientific Inquiry- a process that u ses a variety of skills and tools to answer questions or test ideas about the natural world.



Results of Scientific Inquiry

There are many outcomes of scientific inquiry. The common once include the practical use of scientific knowledge especially for industrial or commercial use in technology, creating of new materials and possible explanations to answer the questions: who, what, when, where and how.

Evaluating Scientific Evidence

An important skill in scientific inquiry is critical thinking. Critical thinking is comparing what you already know with the information you are given to to decide whether you agree with it.Identifying and minimising bias is also important when conducting scientific inquiry. To minimise bias in an investigation, sampling, repetition and blind studies can be helpful.

Sampling – a method of data collection that involves studying small amounts of something in order to learn about the larger whole sampling. A sample should be a random representation of the whole.

Bias - it is important to reduce bias during scientific investigations. Bias is intentional or unintentional prejudice toward a specific outcome. Sources of bias in an investigation can include equipment choices, hypothesis formation and prior knowledge.

Blind Study - a procedure that can reduce bias is a blind study. The investigator , subject, or both do not know which item they are testing. Personal bias cannot affect an investigation if participants do not know what they are testing.

Repetition - if you get different results when you repeat an investigation, then the original investigation probably was flawed. Repetition of experiments helps reduce bias.

The International System of Units

All SI units are derived from seven base units. This is shown in the table below. A prefix can be added to a base units name to indicate either a fraction or a multiple of the base unit. The prefixes are based on powers of 10, such as 0.01 and 100.

Prefix	Meaning
Mega – (M)	1 000 000 (10^6)
Kilo – (k)	1 000 (10^3)
Hecto – (h)	100 (10^2)
Deka- (da)	10 (10^1)
Deci- (d)	0.1 (10^{-1})
Centi- (c)	0.01 (10^{-2})
Milli (m)	0.001 (10^{-3})
Micro – (μ)	0.000 001 (10^{-6})

Diversity of Living Things

Content Standard	**11.2.1** Investigate and analyse the principles of scientific classification, diversity of living organisms and the cell
Benchmarks	**11.2.1.1** Explain the fundamental principles of taxonomy and phylogeny by defining concepts of taxonomic rank and the relationship such as genus, species and taxon **11.2.1.3** Describe unifying and distinguishing anatomical and physiological characteristics of representative organisms from each of the kingdoms **11.2.1.4** Explain the key structural and functional changes in organisms as they have evolved over time.
Essential Question	1. How are scientists able to organise millions of plant and animal species into an orderly manner? 2. How does Darwin's theory of evolution by natural selection show species change over time? 3. What type of plant is thought to be the ancestor of land plants?
Learning Objective	• Explain how life started, evolved and diversified into different types of organisms • Explain the different types of classification systems and describe the taxonomic groups within the Linnaean System • Correctly identify organisms using a Dichotomous Key • Describe the evolutionary relationships of some organisms using a Cladogram.
Knowledge	• Brief introduction of the Theory of Evolution and diversification of organisms • The different types of classification systems and the orderliness of the taxonomic groups within the Linnaean System • How organisms are identified by using a Dichotomous Key and a tree diagram showing organisms' evolutionary relationships from a common ancestor
Skills	• Investigate the conditions that encouraged the emergence of new organisms • Identify organisms easily based on their characteristics • Classifying living things according to their characteristics.
Atitudes & Values	• Change Adaptability (Survival of the Fittest) • Orderliness • Appreciate the importance of details

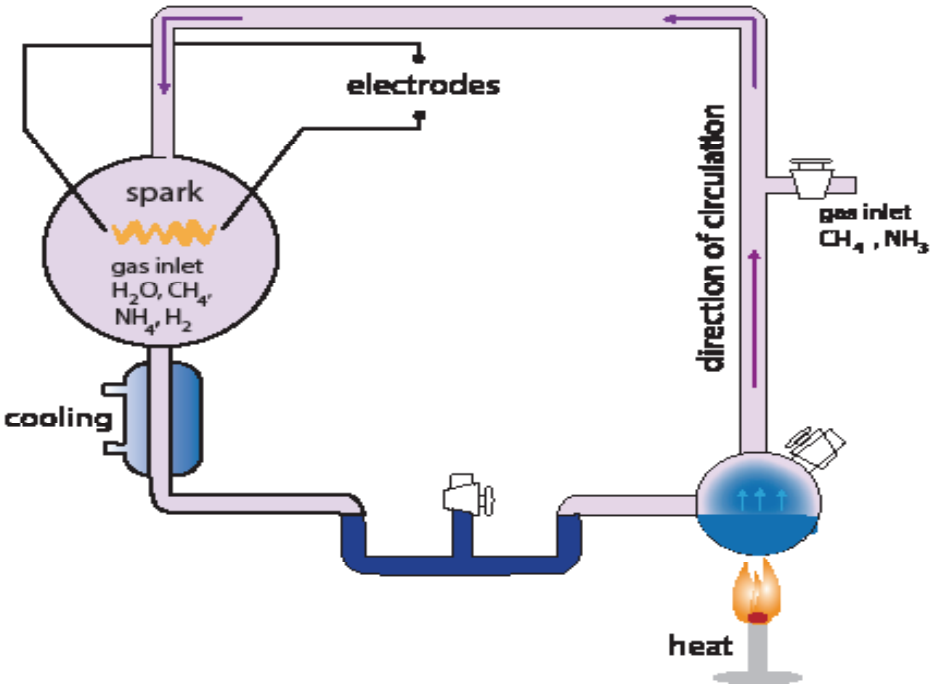
Content Background

Origins of Life: Brief Introduction into Evolution & Diversity of Organisms

Primordial Soup

It was believed that the atmosphere of the earth in the beginning of life had little to no oxygen, but had other gases like methane, hydrogen, water vapour and ammonia. These gases mixed together with other elements to form amino acids, which are the building blocks of organic molecules. The organic molecules formed could have been the precursor to life on earth.

Two scientists worked independently and came up with the idea that life started in the ocean when the energy from the lightning strikes combined with the mixture of gases in the air to form amino acids in the oceans. This idea is known as "primordial soup".
Experiments were then carried out with almost the same amount of gas mixtures as suspected to be on earth in the beginning. With a small ocean simulation done in a closed apparatus and exposed all those to constant lightning shocks, 15 % of the Carbon in the flask turned into organic building blocks, including amino acids, in a week. This proved that life on earth could have been formed from inorganic elements.



Although that experiment may have so many issues and questions about the conditions of life on earth earlier, it did prove that organic molecules, the building blocks of life, can be built from inorganic molecules.
It was believed that life started from a single celled organism, produced as a result of the conditions in the "primordial soup" and developed into much more complex multicellular organisms.

Theory of Evolution

The Theory of Evolution claims that all living things on Earth came from a single ancestor more than 3000 million years ago. From this one ancestor, natural selection allowed those that were better adapted to the conditions at those times to improve and become better while those that could not became extinct. Diversity occurred when one species divided into two or more species by geographical isolation. Due to the environment they were in, they adapted and over time developed new characteristics that made them different. They became new species as compared to the old population from which they came out from. Over time, those new species could not meet and reproduce with the rest of their former species. Thus more and more species of organisms diversified, adapted and became much better forms today.

Classification Systems & Linnaean System

To help us identify living things easily without any confusion, Scientists have come up with ways of putting them together into groups called classification systems based on certain characteristics or abilities they possess. Common names as well as scientific names are given to an organism and it becomes universally accepted. In this way, a scientist in America can converse with another scientist from another part of the world like Papua New Guinea about a bird and the two of them would never go wrong because they would both be speaking the same language. There are many systems of classification but the main one is the Linnaean System of Classification.

What is a Linnaean Classification System?

Linnaean Classification was developed by Carlos Linnaeus in 1735. He proposed three main groups, Plants, Animals and Minerals and called them Kingdoms. He further divided them into classes, orders, genera and species. Added to that, he gave a two naming system for each organism, which we still use today.

Binomial Nomenclature System

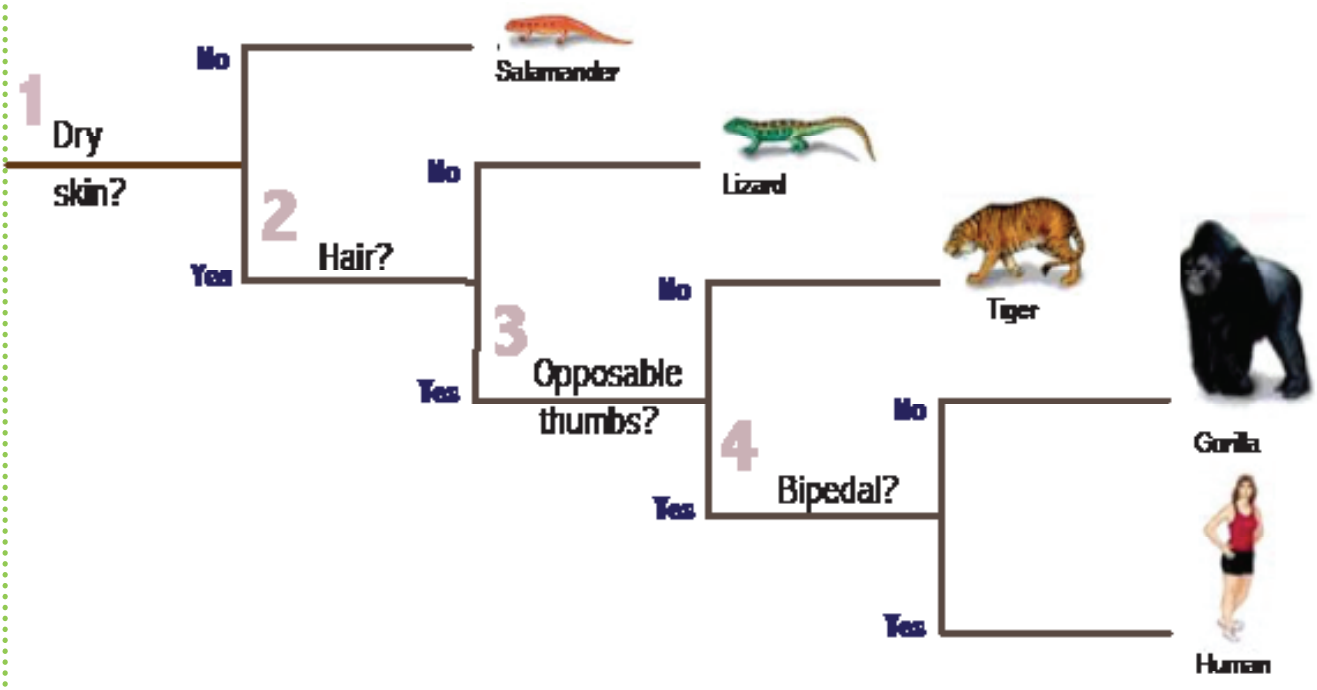
Binomial Nomenclature System is a classification system that was derived from the Linnaean Classification System and developed over time. It classifies organisms into Domains, Kingdoms, Phylums, Class, Order, Family, Genus and Species. It also gives each species a name consisting of two words. The first part of the name is the name of the genus and usually starts with the capital letter. The second part of the name is the species name and is usually written in small letter. Both names should be underlined or written in italic form.

For example, the scientific names should be written as follows, for:

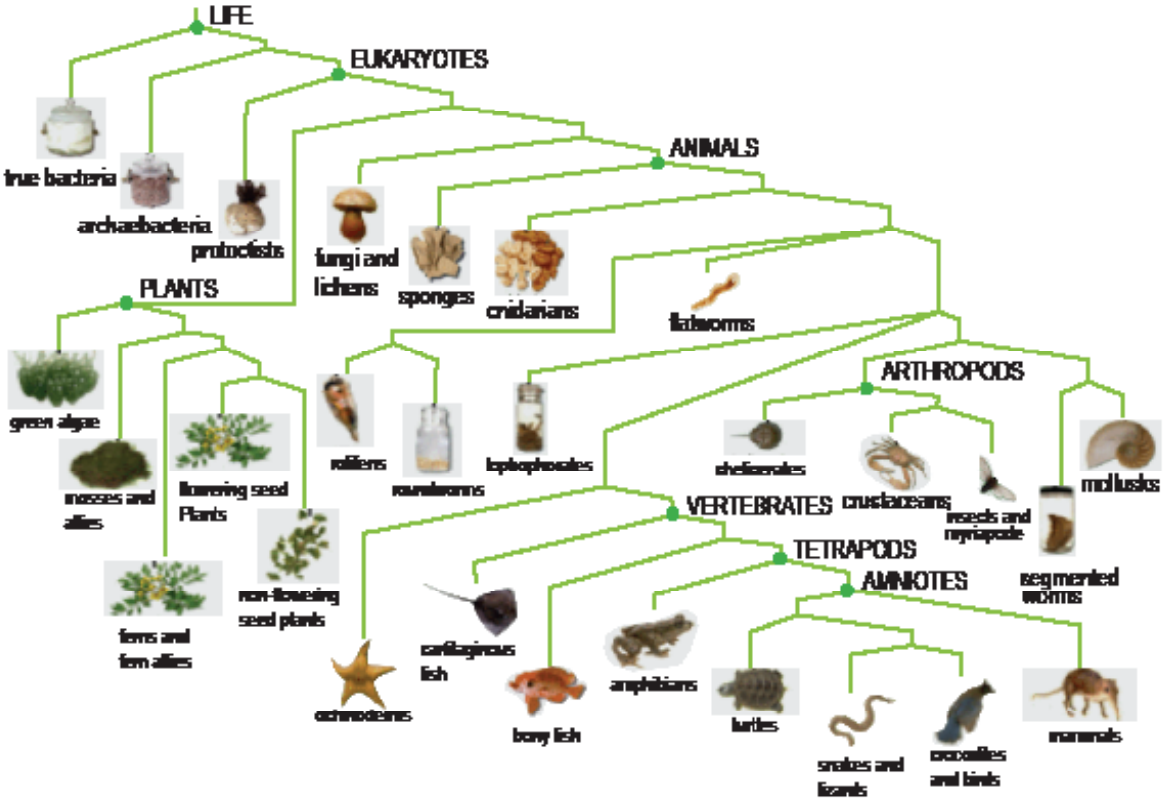
Classification level	Man	Kaukau
Domain	Eukaryote	Eukaryote
Kingdom	Animal	Plant
Phylum	Chordata (Vertebrata as the sub-phylum)	Tracheophyta
Class	Mammalia (Eutheria as the sub-class)	Angiosperm
Order	Primate (Anthropoidea as the sub-order)	Herb - perennial
Family	Hominidae	Convolvulaceae
Genus	Homo	Ipomoea
Species	Sapien	Batatas

Classification Tools: Dichotomous Key

"Dichotomous' comes from a Greek word dichotomia, which means 'a cutting into two'. A dichotomous key is a classification tool that uses a set of questions about organisms' characteristics with Yes or No answers at one time to identify a plant or an animal.
An example of a dichotomous key is shown below.



A cladogram is also a classification tool that shows, using lines branching off in different directions, relations among organisms. It is not an evolution tree because it does not show how ancestors are related to descendants. An example of a cladogram is shown below.



Cells- Fundamental of Life

Content Standard:	**11.2.1** Investigate and analyse the principles of scientific classification, diversity of living organisms and the cell
Benchmarks	**11.2.1.2** Compare and contrast the structure and function of different types of prokaryotes, eukaryotes and viruses **11.2.1.6** Describe the cell cycle in animals and explain its importance for the growth and repair of tissues **11.2.1.7** Describe the structure, function and importance of specialised cells and tissues in multi-cellular organisms **11.2.1.8** Explain cell organization by describing the link between cells, tissues, organs and systems in the body
Essential Question	1. What are the building blocks of living things and how do cells promote continuity of life? 2. How is the basic unit crucial in understanding life? 3. How are plant and animal cells similar and how are they different? 4. How do cells regulate the movement of substances into and out of themselves, and what are the implications of such movements? 5. How are cells specialised? 6. What is osmosis? 7. How does the temperature affect the rate of enzyme action? 8. How does pH affect the rate of enzyme action?
Learning Objective	• Explain the structures of a plant and animal cell and state their functions. • Compare and contrast the structure of plant and animal cells. • Explain processes that take place in a cell and organisms. • Explain the process of diffusion. • Explain the different types of cells such as the nerve cells, blood cells, muscle cells and the organs and systems that are built up from them. • Explain that the lock and key concept hypothesis can be used to explain how enzymes work • Explain the properties of enzymes
Knowledge	• Structures of a plant and animal cell and their functions. • Difference between a plant and animal cell. • Processes like diffusion, osmosis, active transport and respiration (cellular and physical) take place in a cell and organisms. • The different types of cells (nerve cells, blood cells, muscle cells, etc.) and the organs and systems that are built up from them. • Enzymes are protein produced by living cells • Enzymes function as biological catalyst • Enzymes control every chemical reaction that takes place in living cells
Skills	• Draw the structures of the plant and animal cell and label them. • Differentiate between a plant and an animal cell due to cell shape as well as the presence of some organelles in plant cells and absence in animal cells. • Differentiate between diffusion, osmosis and active transport as well as cellular and physical respiration. • Demonstrate the process of diffusion. • Identify the different types of cells based on structure and the kind of tissues, organs and systems they build. • Identify the properties of enzymes
Atitudes & Values	• Appreciate the wonders of our bodies where many different types of cells work together effectively

Content Background

History: Discovery of Cells

All living things are made of cells and the material produced by cells. Some organisms consist of just one cell while others are multicellular. Within the bodies of these multicellular organisms, cells communicate and cooperate with one another so that their individual activities are integrated. The functions of an organism are the result of the activities of its cells. It is believed that bacteria were the first cells to evolve. These cells have a simple structure that lacks internal compartments. They are called **prokaryotic cells** (from the Greek, *'pro'* which means 'before' and *'karyon'*, which means 'nucleus'. Their heredity material, a single strand of DNA, lies free within the cell and they have no membrane-bound structures. During evolution, the internal complexity of cells increased rapidly. The more complex cells that arose from their bacterial ancestors are termed **eukaryotic cells** (from the Greek '*eu',* which means 'proper' and *'karyon'* which means nucleus. One of the most distinguishing features of eukaryotic cells is their possessions of internal membrane-bound structures called **organelles.** The most important of these is the **nucleus**, the control centre of the cell and the compartment that houses the heredity material DNA.

Robert Hooke discovered cells in 1665. Aided by the microscope, a new invention in the seventeenth century, he examined a thin slice of cork bark that he had cut from a tree and saw hundreds of tiny box-like structures. He named them 'cells'. Anton van Leewenhoek than advanced this discovery of dead cork cells to living cells such as sperm and blood cells.

In the nineteenth century, largely due to work of Mathias Schleiden (on plant tissues) and Theodor Schwann (on animal tissues), there was wide acceptance of the theory that all organisms were composed of cells and that all cells came from a pre-existing cell through cell division.

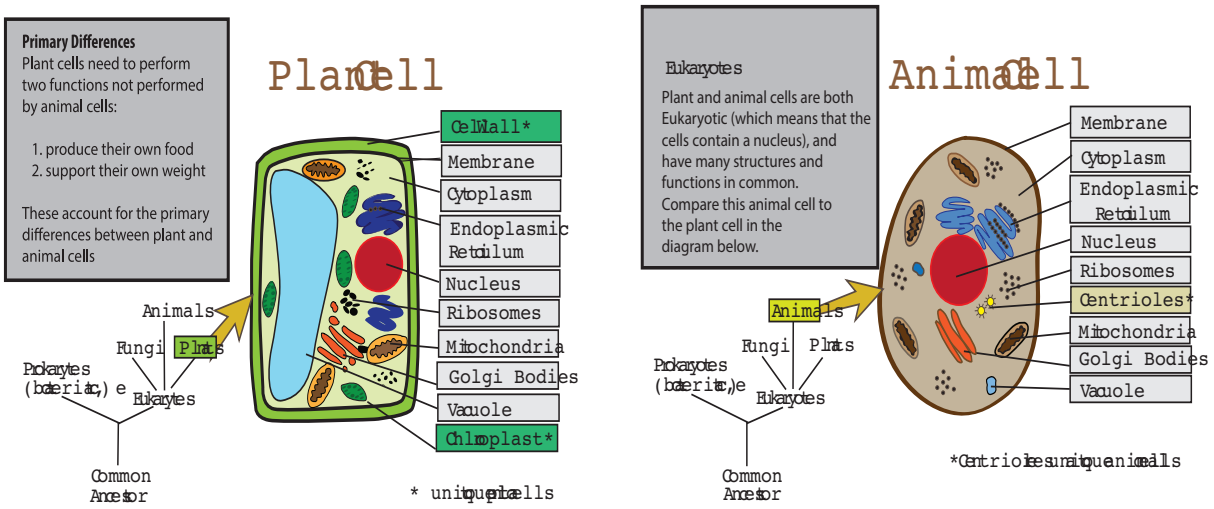
The invention of electron microscope in the twentieth century opened up avenues for the development of new techniques for studying the minute organelles found in eukaryotic cells. Therefore, through observations and discoveries made by scientists over a number of centuries, the cell theory was formulated. The cell theory states that:

- All organisms are made of cells and the products of cells
- All cells come from a pre-existing cells
- The cell is the smallest organisational unit.

Living things are able to survive and perform all the seven characteristics because they contain cells.

What is a cell?

A cell is a basic fundamental unit of life. It contains organelles or specialised structures that perform to keep the cell and therefore the organism alive. To understand what a cell looks like, let us consider the cell structures of a plant and an animal cell.



The presence (✓) and/or absence (x) of organelles in plant and animal cells and their functions are further clarified below.

Name of Organelle	Function	Animal Cell	
Cell membrane	A cell membrane is a thin semi-permeable membrane that surrounds the cytoplasm of the cell. Its main function is to protect the content of the cell by only allowing helpful substances into the cell and keeping the harmful ones out	✓	✓
Nucleus	The nucleus is found only in eukaryotic cells, such as plant and animal cell and it contains all the genetic material of the cell called DNA (deoxyribonucleic acid), which controls a cell's growth, function and reproduction. The nucleus is sometimes referred to as the "brain" of the cell.	✓	✓
Cytoplasm	Cytoplasm is the largest part of the cell that has colourless jelly-like liquid. It contains all the organelles, proteins, water, food reserves and metabolic wastes that surround the nucleus. It is a jelly-like substance which usually forms the bulk of the cell in which numerous life processes occur. It also gives the cell its structure.	✓	✓
Golgi body	Golgi body or apparatus is an organelle that is made up of a series of flattened, stacked pouches called cisternae. It is responsible for packaging and transporting protein products to their destinations.	✓	✓
Lysosome	Lysosomes are small, membrane bound sacs that contain enzymes. They are abundant in liver and kidney cells and in leaves, they are responsible for digesting particles and therefore acts as a gabbage bag or known as the waste management system of a cell. They are also responsible for destroying a cell after it has died.	✓	✓
Vacuole	Vacuole is a fluid-filled enclosed structure within the cytoplasm that has a variety of functions depending on which organism it occurs in. In plants, it has many functions. One of them is turgor pressure control. When contents of the cell push the plasma membrane against the cell wall, it exerts a force on the cell wall. This force is called turgor pressure. The vacuole then exerts pressure on the cell wall to help plant structures remain rigid and erect.	✓ Present but smaller in size and not	✓

Name of Organelle	Function	Animal Cell	Plant Cell
Ribosome	Ribosomes are cell organelles that can be found floating in the cytoplasm or attached on the endoplasmic reticulum. They consist of two sub units: one can read the instructions from the RNA while the other joins the amino acids to form polypeptide chains. Thus, ribosomes are responsible for assembling the proteins of a cell.	✓	✓
Mitochondria	Mitochondria (plural for mitochondrion) are small organelles found within the cells that are responsible for generating energy in the form of ATP (Adenosine triphosphate). This energy is used by the cells to carry out various functions. Thus, mitochondria are referred to as the "powerhouse" of the cell.	✓	✓
Rough Endoplasmic Reticulum	The rough endoplasmic reticulum (rER) is a network of flattened sacs and tubules called cisternae. They synthesize, fold, modify and transport proteins to their targeted destinations. They are rough because of the presence of ribosomes attached on them.	✓	✓
Smooth Endoplasmic Reticulum	Smooth endoplasmic reticulum (sER) does not contain ribosomes therefore they have a different function from that of the rER. They perform many functions, one of them being the production of lipids, carbohydrates including cholesterol and phospholipid, which are used to build new cellular membrane.	✓	✓
Starch Grain	Most plants cells convert excess sugar produced during photosynthesis into starch and then store the starch in the form of starch grains. Animal cells do not have starch grains. Instead animal cells store surplus carbohydrates in the form of glycogen granules.	X	✓
Centriole	Centrioles are cylindrical organelles that contain proteins called tubulin. They have two main functions: They help in cell division by forming spindles fibres that separate chromosomes during mitosis. They also help in the formation of cilia and/or flagella.	✓	X
Chloroplast	Chloroplasts are organelles that are found in plants and they contain chlorophyll, which is the green pigment that captures light energy to make food in the process of photosynthesis. They are referred to as the "food producers" of the cell.	X	✓
Cell wall	A cell wall is the rigid outer layer of plant cells that provide protection, structure and support.	X	✓

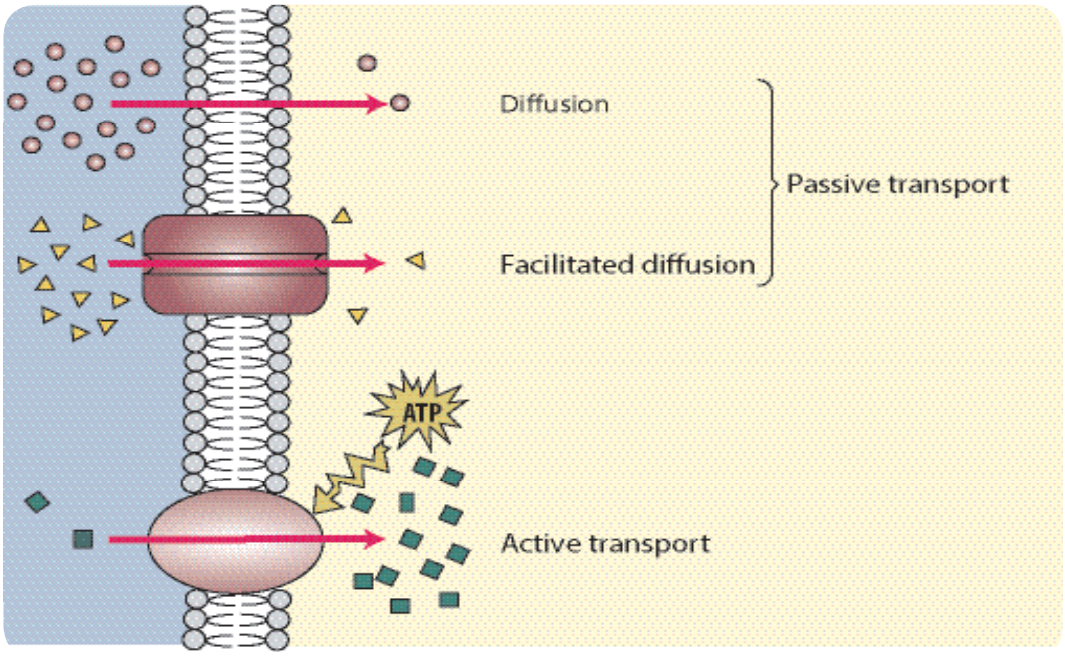
Comparison between Plant and Animal Cells

1. Plants cells are regularly shaped while animal cells are irregularly shaped.
2. Plant cells have cell walls while animal cells do not have cell walls.
3. Plant cells contain chloroplast while animal cells do not contain chloroplasts.
4. Animal cells contain centrioles while plant cells do not contain centrioles.

Processes in cells and organisms

To sustain life, many substances need to be transported out of, into and between cells. These can be achieved either by **Passive Transport** or **Active Transport.** Passive transport is where there is no energy required to move things in and out of a cell while active transport needs energy to move things from a region of low concentration to a region of high concentration, against the concentration gradient. That energy is derived from ATP, which is produced by cellular respiration.

The diagram below summarises these processes.



Passive Transport

There are two types of passive transport.

i. Diffusion

Diffusion is the movement of water, ions or molecules in and out of a cell through its cell membrane, from a region of high concentration to a region of low concentration to reach equilibrium. Just like perfume when it is sprayed, it is heavily concentrated as you can tell by the smell. Over time, the smell reduces as the gases have spread out evenly to occupy all the spaces. A good example of simple diffusion is seen when a pak choi leaf is placed in a coloured (food dyed) solution. After a while, you would find patches of the colours up in the leaves as they follow the white stem up.

Some common examples of simple diffusion occur in:

a. The lungs where carbon dioxide and oxygen exchanges. Oxygen from the air diffuses into the blood while carbon dioxide from the blood diffuses out into the air.
b. Gas exchange in photosynthesis where carbon dioxide from the air diffuses into the leaf and oxygen from the leaf diffuses out into the air.

Diffusion can either be **simple diffusion** or **facilitated diffusion**. Simple diffusion is explained above. Facilitated diffusion, however, uses a protein carrier molecule to allow fat-soluble substances to diffuse through a cell membrane since these substances cannot diffuse through a cell membrane on their own. Other substances that move by this form of diffusion is glucose and amino acids.

ii. Osmosis

Osmosis is the diffusion of water into or out of a cell. Cells will gain water and swell or burst if they are placed in a hypotonic solution, for example, placing an egg in distilled (pure) water. On the other hand, cells will lose water and shrivel if they are placed in a hypertonic solution, for example, placing an egg in syrup.

Active Transport

Active transport is used by both plant and animal systems to bring in molecules that are of a lower concentration outside their cells, that is, against the concentration gradient. Because the molecules actually need to move against the concentration gradient, active transport requires energy in the form of ATP. Active transport is useful to living systems and is used in a number of processes occurring within organisms. This include the absorption of dissolved mineral salts by the root hair, as well as the absorption of glucose by the epithelial cells in the small intestines of humans.

Respiration

There are two types of respiration:

i. Cellular Respiration

Cellular Respiration takes place in the mitochondria of a cell whereby glucose is broken down to release energy in the form of ATP, which is needed for active transport and other processes. It can occur in two ways:

a. *Aerobic Respiration* – in the presence of oxygen
b. *Anaerobic Respiration* – in the absence of oxygen

ii. Physical Respiration

Physical respiration is the gas exchange that takes place by simple diffusion during the breathing process.

Enzymes

In the human body, numerous chemical reactions are happening every second. Each of the reactions may take hours and even days if takes place without enzymes. In fact all reactions and the processes that occur in a living organism, from digestion to production of tissues, and growth are catalysed by enzymes.

Enzymes are usually named by adding the suffix ‘ase’ to the name of the chemical that the enzymes acts on the substrate. For example, the enzyme lipase acts as lipids and the enzymes sucrase acts on sucrose. Enzymes which break down proteins usually end with ‘in’ are also found intracellularly and extracellularly.

Class	Function	Example
Oxidoreductase	Catalyse redox reactions (oxidation/reduction)	• Oxidases: cause oxidation of substrate • Reductase: case reduction of substrate
Hydrolases	Catalyse bond breaking with the introduction of water	Mostly digestive enzymes, such as: • Proteases like pepsin and trypsin which break down proteins to amino acids. • Lipases which breakdown lipids/fats to fatty acids and glycerol. • Carbohydrases such as amylase which breaks down starch to sugar.
Ligases/Synthetases	Catalyse reactions joining together two molecules	• DNA ligase which joins pieces of DNA together

Properties of enzymes:

- Highly specific: a particular enzyme only catalyses one substrate
- Remain chemically unchanged at the end of the reaction
- Required in minute quantities
- Denatures at high temperatures
- Rate is affected by temperature and pH
- Lower activation energy

Lock-and-Key Hypothesis

Imagine enzyme as a key used to open a lock, in this case is the substrate. If the key is positioned correctly, it can be turn easily. if the key is positioned wrongly or if the lock is not aligned to the key, it will not work. Similarly, it applies to enzymes. The substrate must be at the enzyme's binding site and attach itself to the site before the reaction can proceed. If the substrate is anywhere else around the enzyme, no reaction will occur.

In the lock-and -key hypothesis, the same key can be used to turn hundreds of similar locks without anything happening to the key. This is the same in enzyme action. The same enzyme can be used to catalyse hundreds of the same substrates. As a result, only a minute quantity of enzymes is required. The enzyme is also chemically unchanged at the end of every reaction.

This analogy also mirrors the specificity of enzymes. Enzymes are very specific. A lock can only be opened by one type of key and a specific reaction is only catalysed by a specific enzyme.

Types of Cells & Formation of Tissues, Organs and Systems

There are many different types of plant and animal cells that form tissues and organs, which work together to form a system. Some of them include:

Nerve Cells or Neurons

Neurons are nerve cells that relay information to and from the Central Nervous System in the form of electrical impulses. The structure of a neuron is made up of a cell body which contains a nucleus, dendrites and axon. Dendrites conduct impulses towards the cell body while axons conduct impulses away from the cell body.

There are two different types of nerve cells:

Motor Neuron or Afferent Neuron

These types of neurons pick up the stimuli from the skin, eyes, nose and muscles and relay the message to the Central Nervous System.

Effector Neuron or Efferent Neuron

These types of neurons transmit impulses from the brain and spinal cord to parts of the body that needs to respond. For example, to a muscle to contract or a gland to secrete hormones.

Muscle Cells

Muscle cells or fibres are made up of minute thread-like structures called myofibril. These cells combine to form muscle tissue, which is characterised by the ability to contract. There are three types of muscle cells:

Smooth Muscle

Smooth Muscle is made up of spindle-shaped cells, each having a nucleus and does not have cross striations but exhibit faint longitudinal striations in its structure. It is found in the skin, internal organs, reproductive system, major blood vessels and excretory system. It is an involuntary muscle because the stimulus for its contraction is mediated by the autonomic nervous system.

Skeletal or Striated Muscle

Skeletal Muscle is made up of elongated, sausage-shaped cells, having many nuclei and clearly display longitudinal and cross striations in its structure. This muscle is attached to the bone by connective tissue called tendons. Its contractions serve purposely to move the skeleton, which then moves the body since this muscle forms most of the underlying flesh, mainly of human and other vertebrates. Skeletal muscle is supplied with nerves from the central nervous system, and because it is partly under conscious control, it is also called voluntary muscle.

Cardiac Muscle

Cardiac Muscle tissue composes most of the vertebrate heart. It has a centrally placed nucleus and shows both longitudinal and imperfect striations in its structure. Although it receives nerves from the autonomic nervous system, the autonomic impulses merely speed or slow its action and are not responsible for the continuous rhythmic contraction characteristic of living cardiac muscle.

Skin Cells

Epithelial cells have nuclei and have three types of shapes: columnar, squamous and cuboidal. These cells form layers called epithelium that serves a protective covering over a surface such as the outside of an organ or the lining of the cavity wall in the body. The skin contains several layers of epithelial cells. Many secretory glands and some of the endocrine glands are also composed of these cells.

Reproductive Cells

They are the gametes or sex cells that contain half the number of chromosomes in a human being. The male sex cell or spermatozoa unites with the female sex cell or oocyte during sexual reproduction and the number of chromosomes get restored when fertilization takes place.

Blood Cells

Blood is a connective tissue made up of red blood cells, white blood cells, platelets and plasma. Red and white blood cells differ in structure and function. The red blood cell is biconcave in structure and it functions mainly by transporting oxygen to the body cells while removing carbon dioxide from those cells. White blood cells on the other hand irregularly shaped and its main function is to defend the body against infection.

Types of Tissues

Multicellular organisms comprise of millions of cells. These cells are grouped at different levels to enable the biological and chemical activities in the organism to occur harmoniously. The xylem vessel is an example of how a group of similar cells are grouped together to perform a special function. Such is a group of cells is called a simple tissue. Tissue is a group of associated, similarly structured cells that perform specialised functions for the survival of the organism. There are four types of tissues found in humans and animals.

Epithelial Tissues

An example of a tissue is the epithelial tissue. Epithelial tissues are the topmost group of cells that cover the internal and external surfaces of organs, tubules, vessels and the body. These tissues include the skin and the inner surfaces of the body, such as those of the lungs, stomach, intestines and blood vessels. Its main function is to protect the body from injury and infection.

Connective Tissues

Connective tissue connects different parts of an organ or organs together. The main function of these tissues is to support and hold parts of the body together. It is made up of:

a. Fibrous tissues - which supports blood vessels, nerves and other organs.
b. Elastic tissues - are found in the ligaments, trachea and the arterial walls.
c. Adipose (Fatty) Tissue - contains and store fat
d. Cartilage and Bones - which support the skeletal system

Muscle Tissues

Other examples of tissues are muscle tissues. They form a group of muscle cells working together that contract and relax to bring about movement; nervous tissue; bone tissue and connective tissue.The tissues, which contract and relax, comprise the striated, smooth and cardiac muscles.

Nerve Tissues

These highly complex group of cells, called ganglia (nerve nuclei), transfer information from one part of the body to another. Each neuron or nerve cell, consists of a cell body with branching dendrites and one long fibre, or axon. The dendrites connect one neuron to another and transmit information towards the centre of the neuron; the axon transmits impulses to an organ or tissue.

These cells and the tissues they form develop into organs, which play important roles in so many of our body systems. For example, the blood vessels are made up of epithelial cells to provide protection to the blood. Blood is made up of red blood cells and white blood cells, besides platelets and plasma, and together, they play a role not only in the circulatory system but also the digestive system, reproductive system, even the skeletal system where the red and white blood cells are made. Can you think of other examples?

The above example connects well with the Cell Theory, which states that:

1. All living things are composed of cells,
2. Cell is the smallest unit of life, and
3. All living cells arise from pre-existing cells.

An organ is a group of different tissues working together to enable the organ to perform its function. The heart for example, has different types of tissue working together: it has muscle tissues to pump blood; blood vessels to supply the muscle cells with oxygen and nutrients for its action; nervous tissue to regulate the heartbeat and connective tissues to connect other tissues.

Similarly in plants, the stem has different tissues working together; epithelial tissues are used for protection and to take in oxygen and carbon dioxide; xylem tissues are used for transport of water and mineral salts; phloem tissues are used to transport manufactured food substances.

Several organs working together for a specific function form an organ system. The heart, arteries and veins make up the blood circulatory system. Other examples include the respiratory system, digestive system and nervous system. It is important to keep in mind that these systems do not just exist as individual units. The final unit of these cooperating systems is called the body. Each system depends on other systems either directly or indirectly to keep the body function normally. All of the organ systems together make up the entire organism.

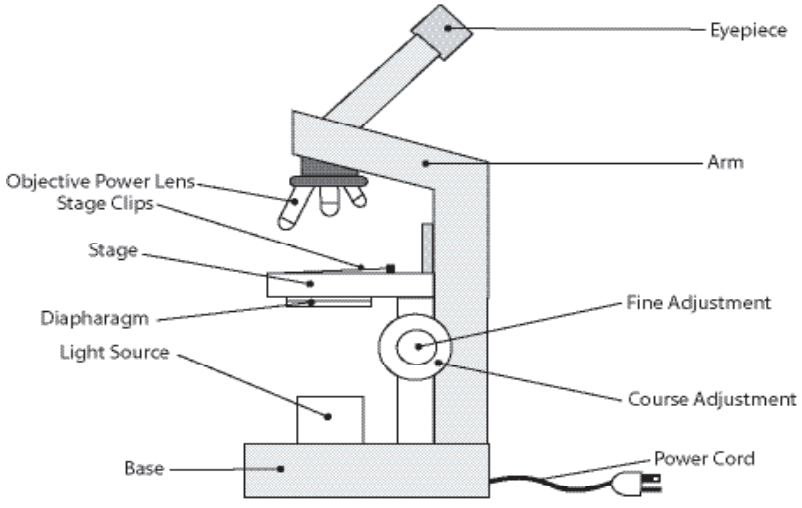
Microscopy

Content Standard:	**11.2.1** Investigate and analyse the principles of scientific classification, diversity of living organisms and the cell
Benchmarks	**11.2.1.2** Compare and contrast the structure and function of different types of prokaryotes, eukaryotes and viruses
Essential Question	1. Can you see cells with your naked eyes? 2. What characteristics are common in plants and animals cells? 3. What is a microscope made up of? 4. How do you handle a microscope?
Learning Objective	• Identify the parts of light microscope and explain their functions. • Learn the process of setting up the microscope • Calculate the size of an organism or a cell given the value of the lenses.
Knowledge	• The microscope consists of different parts. Each part has its own functions. • The structures of cells and microorganisms under different magnifications. • The size of an organism or a cell can be calculated given the value of the lenses.
Skills	• Draw and label the parts of a light microscope. • Demonstrate how to magnify a specimen, sharpen the focus, etc. • Identify the structures of a cell in detail. • Calculate the size of an organism or a cell.
Atitudes & Values	• Appreciate that cell structures and microorganisms that be viewed and studied easily by means of increasing the magnification of a microscope. • Respect their friends opinion

Content Background

Parts of a Light Microscope: Structures and Functions

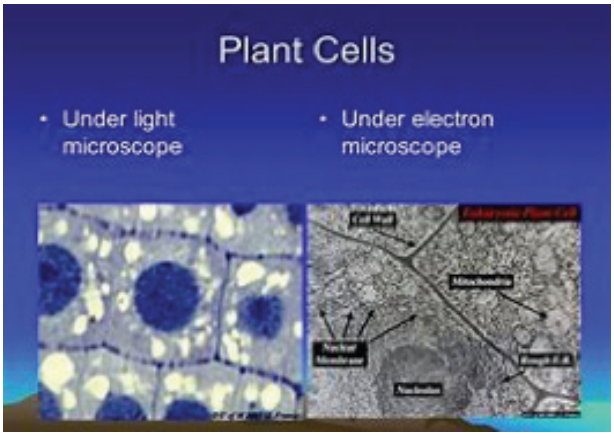
A light microscope is a valuable tool for examining specimens that are too small for you to see without magnification. It is very important that you set up the microscope properly, otherwise you may find it hard to see or find anything on high power. Light microscopes can be used to examine live organisms or cells (cheek cells), whole (or part) mounts of dead organisms (for example, a flea) or selectively stained tissue. A microscope may have an inbuilt light or it may have a mirror that will reflect light from an outside source.

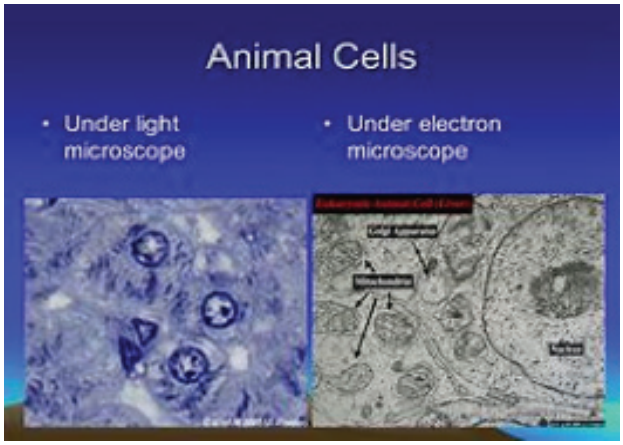


Structure	Function
Eyepiece	For viewing the image. It usually has a power of X10 written on it
Arm	Supports the body tube
Fine Adjustment	Sharpens the image
Coarse Adjustment	Focuses images
Objective Power Lens	Magnifies the image. There are three of them. The short one has the power of X4 (Extra Low Power lens) , the medium is X10(Low Power lens) and the big one is X40 (High Power lens)
Revolving Nosepiece	Rotates the objective lenses
Stage Clips	Holds the slide in place
Stage	Holds the slide in place
Diaphragm	Regulates amount of light
Light Source (or Mirror)	Provides light for viewing the slide
Power Cord	Allows power to flow through
Base	Supports and stabilizes the microscope

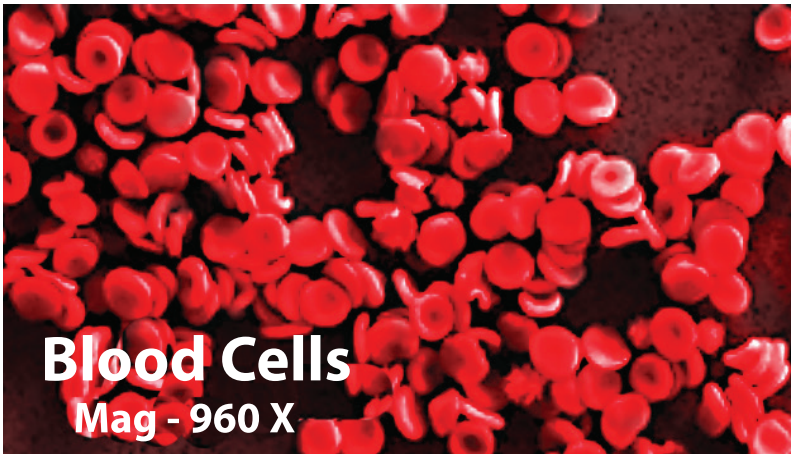
To calculate magnification, multiply the power of the ocular (eyepiece) lens (10) by the power of the objective lens (4, 10 or 40).

The light microscope has the capacity to magnify up to 1000x. However, it cannot reveal much more structures in detail. Hence, further modifications and developments were made in improving the technology. The electron microscope, which is a much more higher form of the light microscope was built as a result. It has the capacity to magnify an organism to up to about 1000000X. With magnifications as big as this, it is possible to view cell structures or images clearly.





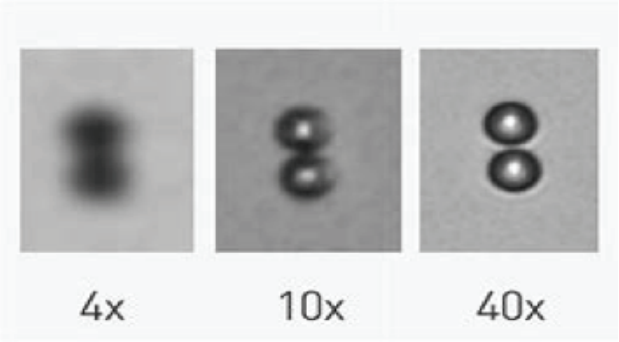
The images below are from the same animal and plant cells but viewed with different microscopes. Many new structures can be seen in the cytoplasm that are not seen using a light microscope.



Images of a mosquito and red blood cells, when viewed under an electron microscope.

Magnification of Cells

Below is a diagram showing the different images of the same specimen at different magnification.



Step 1: Eyepiece is X10

Step 2: Objective lens is X4

Step 3: Magnification = 10 X 4 = X40

Note: Magnification is always written with an X in front.

Hence your answer should be X40 and not just 40

The light microscope has the capacity to magnify up to 1000x. However, it cannot reveal much more structures in detail. Hence, further modifications and developments were made in improving the technology. The electron microscope, which is a much more higher form of the light microscope was built as a result. It has the capacity to magnify an organism to up to about 1000000X. With magnifications as big as this, it is possible to view cell structures clearly.

Procedure for Setting up the Microscope

The following steps must be followed each time you use the microscope:

1. Check that the microscope and all its optical parts are clean.
2. Rotate the nosepiece until the middle-sized OBJECTIVE lens is in the vertical position. This is the objective lens with the '10X' engraved on it.
3. Adjust the position of the NOSEPIECE (using the adjustment knobs) so that the lens of the '10X' objective is about 1.5cm above the stage.
4. Position the microscope in front of you with the ARM towards you and the BASE at the right angles to the edge of the bench.
5. Place the slide to be examined in the clips on the microscope stage.
6. Place a small lamp in front of the microscope about 10cm away from the mirror so that the light shines onto the mirror (REMEMBER to use a FLAT mirror if your microscope has a condenser.)if no lamp is available, position microscope on a window bench to get good light, but DO NOT have the sun shining directly into the mirror.
7. Remove the eyepiece and look down the body tube: while you are looking down the tube, adjust the mirror so that the greatest amount of light comes through. Replace the eyepiece.
8. Look down the eyepiece, and rotate the disc diaphragm. Notice that with the largest disc, the intensity of light is increased, and will decrease as you use smaller discs of the diaphragm. Try this 3 or 4 times then leave the largest discs in position.
9. Focusing. Using the coarse adjustment, and watching from the side of the microscope, very carefully lower the BODY TUBE until the slide is 2mm from the objective. Now keeping BOTH eyes open, look, look through the eye piece and slowly rack the BODY TUBE upwards using the coarse adjustment until the object comes into focus. If you do not find the object the first time, go back and repeat from the beginning of step 6 after checking that the object on the slide is in the centre of the stage opening. (i.e. directly beneath the objective lens.
10. Finally, rotate the DISC DIAPHRAGM. Looking through the eyepiece, experiment with rotating the disc diaphragm until the image is as clear as possible.

Smaller discs affect definition (sharpness of the image) as well as cutting down on the light intensity. Practice focusing under low power until you can do it quickly and easily, following the 10 steps above.

SETTING UP THE MICROSCOPE FOR HIGH POER EXAMINATION (H.P)

1. Always begin an examination of a slide under low power. This enables you to adjust your microscope correctly and to find a suitable area of the object for more detailed study.

2. Make certain that the object or part of the object that you wish to study is in the exact centre of the low power field of view

3. When the object is in focus under low power, swing the H.P. (x40) objective gently into the vertical position, watching carefully from the side to make sure the H.P. objective will not touch the stage or the slide.

4. Using the fine adjustment screw only, bring the object into focus. (as the object has a very short working distance from the slide, never use the coarse adjustment with this objective unless you are watching from the side to make certain the lens does not touch the slide.)

5. When studying an object under high power, keep your fingers on the fine adjustment screw and move it backwards for short distances. By doing so you can bring all parts of the object into focus.

6. Adjust the disc diaphragm again as you did for low power. The disc of the diaphragm needs to be much larger for H.P. than for L.P. study

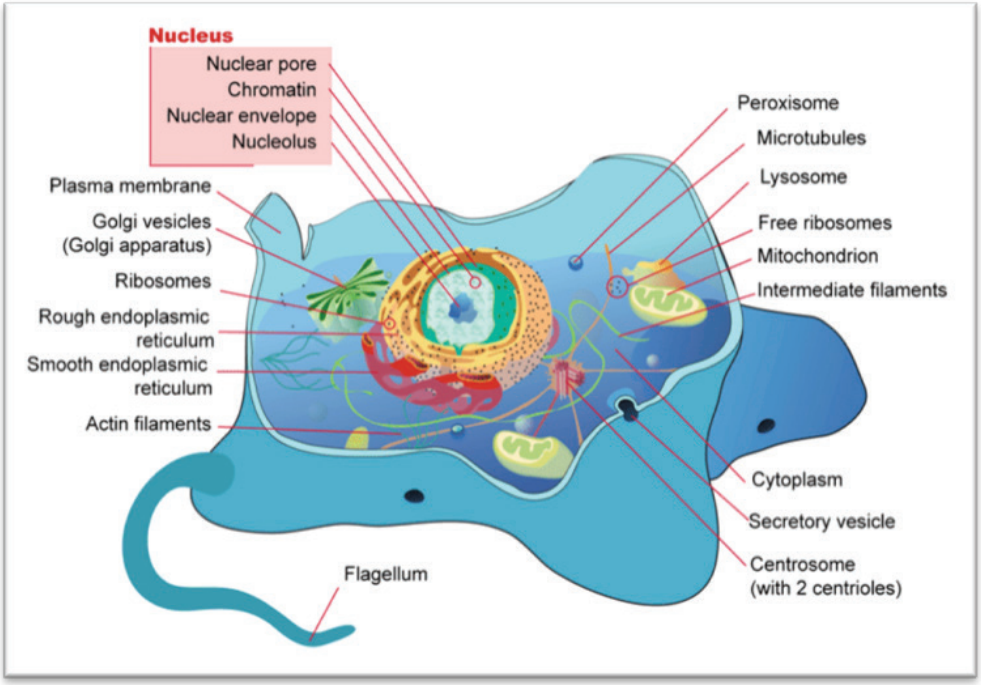
Types of Cells

Prokaryotic Cells

It is believed that bacteria were the first cells to evolve. These cells have a simple structure that lacks internal compartments. They are called prokaryotic cells (from the Greek, 'pro' which means before and 'karyon' which means 'nucleuses. Their heredity material, a single strand of DNA, lies free within the cell and they have no membrane-bound structure. Their control system of the cell is the cytoplasm.

Eukaryotic cell

During evolution, the internal complexity of cells increased rapidly. The more complex cells that arose from their bacterial ancestors are termed eukaryotic cells (from the Greek, 'eu' which means proper and 'karyon' which means 'nucleus'. One of the main distinguishing features of the eukaryotic cells is their possession of internal membrane-bound structures called organelles. The most important of these is the nucleus, the control centre of the cell and the compartments that houses the hereditary material DNA. Eukaryotes include fungi, algae, plants and animals. They range from a single-celled organism, such as Amoeba to larger and more complex plants and animals.
Eukaryotic cells are usually larger than prokaryotic cells and they are found mainly in multicellular organisms. They contain other organelles besides the nucleus. An organelle is a structure within the cytoplasm that performs a specific job in the cell


Nucleus
Nuclear pore
Chromatin
Nuclear envelope
Nucleolus
Plasma membrane
Golgi vesicles
(Golgi apparatus)
Ribosomes
Rough endoplasmic
reticulum
Smooth endoplasmic
reticulum
Actin filaments
Flagellum
Peroxisome
Microtubules
Lysosome
Free ribosomes
Mitochondrion
Intermediate filaments
Cytoplasm
Secretory vesicle
Centrosome
(with 2 centrioles)

Classification of Plants

Content Standard:	**11.2.1** Investigate and analyse the principles of scientific classification, diversity of living organisms and the cell
Benchmarks	**11.2.1.2** Compare and contrast the structure and function of different types of prokaryotes, eukaryotes and viruses **11.2.1.3** Describe unifying and distinguishing anatomical and physiological characteristics of representative organisms from each of the kingdoms

Essential Question	1. How are plants classified? 2. How are nonvascular and vascular seedless plants alike? How are they different? 3. What characteristics are common in bryophytes? 4. How are the leaves, flowers, stem and seeds of monocots different from those of dicots? 5. What is transpiration? What factors affect transpiration
Learning Objective	• Identify the different types of bryophytes as well as state the characteristics and classification of their different groups. • Identify the different types of tracheophytes as well as state the characteristics and classification of their different groups. • Explain what a monocotyledon is by the distinct characteristics of its stem, leaves and flowers • Explain what a dicotyledon is by the distinct characteristics of its stem, leaves and flowers • Explain how water is transported in plants
Knowledge	• Non-vascular Plants (Bryophytes) can be classified into Mosses, Liverworts and Horn worts and their characteristics • Vascular Plants (Tracheophytes) can be classified into Angiosperms and Gymnosperms and their characteristics • Characteristics of stems, leaves and flowers of Monocotyledons and Dicotyledons • Water is transported from the roots to the leaves through the xylem vessels • Plants absorb water into their roots by osmosis • The greatest amount of water absorption occurs in the zone of maturation in the root tip • Transpiration is the loss of water in the form of water vapour from the leaves as a consequence of gaseous exchange. • Wilting is the loss of turgidity in plant tissue, where the intake of water is insufficient to replace that lost by transpiration or other means, causing a deflation of the plant cell • The rate of transpiration is affected by the following factors; light,temperature,humidity, air movements/wind • The translocation of food occurs in the phloem
Skills	• Differentiate between an angiosperm and a gymnosperm • Differentiate monocotyledon from a dicotyledon by its stem, leaf or flower • Outline the pathway by which water is transported from the roots to the leaves through the xylem vessels. • Describe how transpiration occurs in plants • Describe the factors that affect the rate of transpiration
Atitudes & Values	• Appreciate the knowledge of bryophytes • Be responsible and take care of plants

Content Background

Plants are eukaryotes and they are divided into two main groups called the Bryophytes and the Tracheophytes.

Bryophytes

These are the non-vascular plants. They do not have a vascular bundle for transporting water, dissolved mineral nutrients and food.

Bryophytes is a division of the plant phyla and can be divided into three classes:

1. Mosses

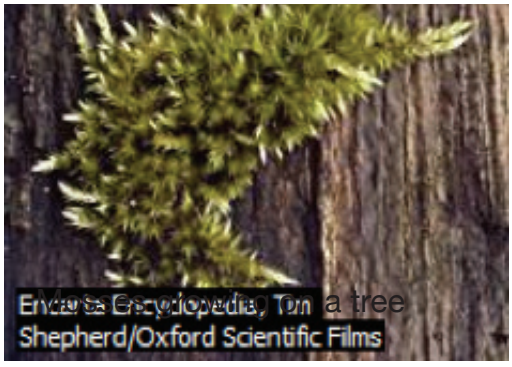
Plants that consists of small, slender stalks and leaves. They do not have true roots but have filamentous structures called rhizoids that carry out conduction of water, nutrients and food. They grow on soil, rocks, bark of tress and shallow streams. They reproduce by spores.

2. Liverwort

Group of plants with the thalli (plant bodies) similar to the structure of the liver in some species. They have gametophytes, which are leafless, flattened structures. The lower surface of the gametophytes produces root-like structures which serve for attachment and external water transport. They reproduce by spores.

3. Hornwort

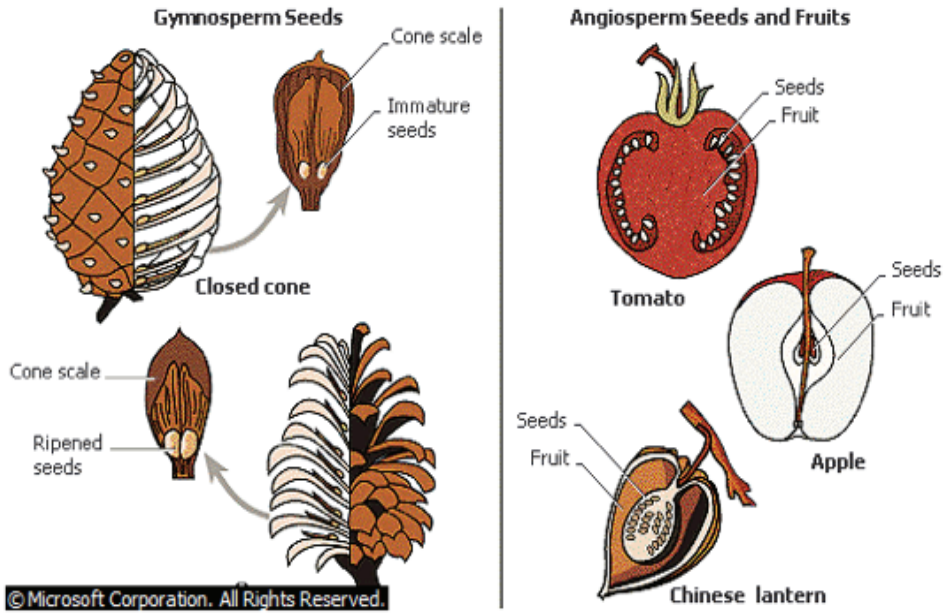
Group of plants with an elongated, horn-like structure called a sporophyte. Their gametophyte is a flattened structured plant body, similar to the other two classes of bryophytes. They grow in damp or humid places. They reproduce by spores.



Tracheophytes

These are vascular plants. They have a vascular bundle for transporting water, dissolved mineral nutrients and food. There are two kinds of conducting tissues: The xylem, responsible for conduction of water and dissolved mineral nutrients, and the phloem, responsible for conduction of food. The xylem also stores food and helps to support the plant.

Tracheophytes are a division of the plant phyla and can be divided into three classes based on the presence and absence of seed. They are the Seedless Vascular Plants and the seeded plants known as Gymnosperms and Angiosperms. Gymnosperms are identified by their naked or exposed seeds such as a pine tree. Angiosperms on the other hand are all the flowering plants where their seeds are enclosed within a fruit.



1. The Seedless Vascular Plants

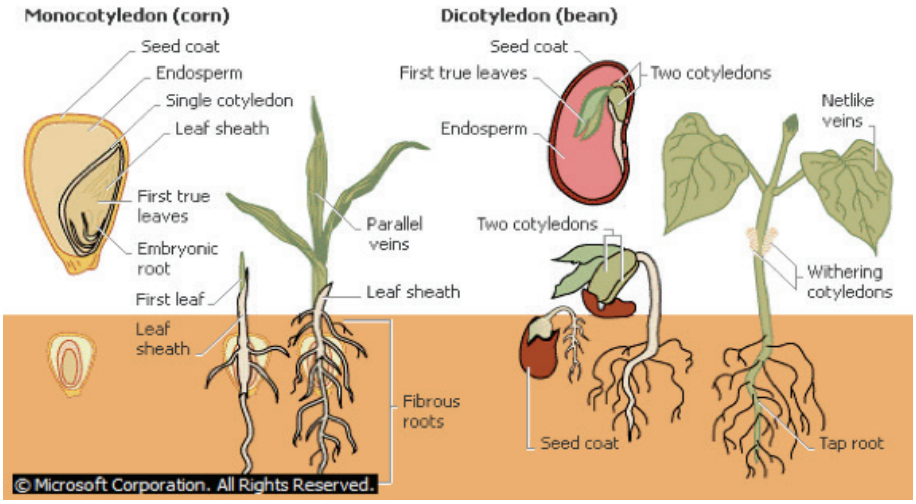
This is the spore – producing vascular plants. Fern belongs to this group.

2. The Gymnosperms

These are the seed-bearing vascular plants without flowers. They are woody plants, either shrubs, trees or vines. Eg. Sago palm and cedar tree

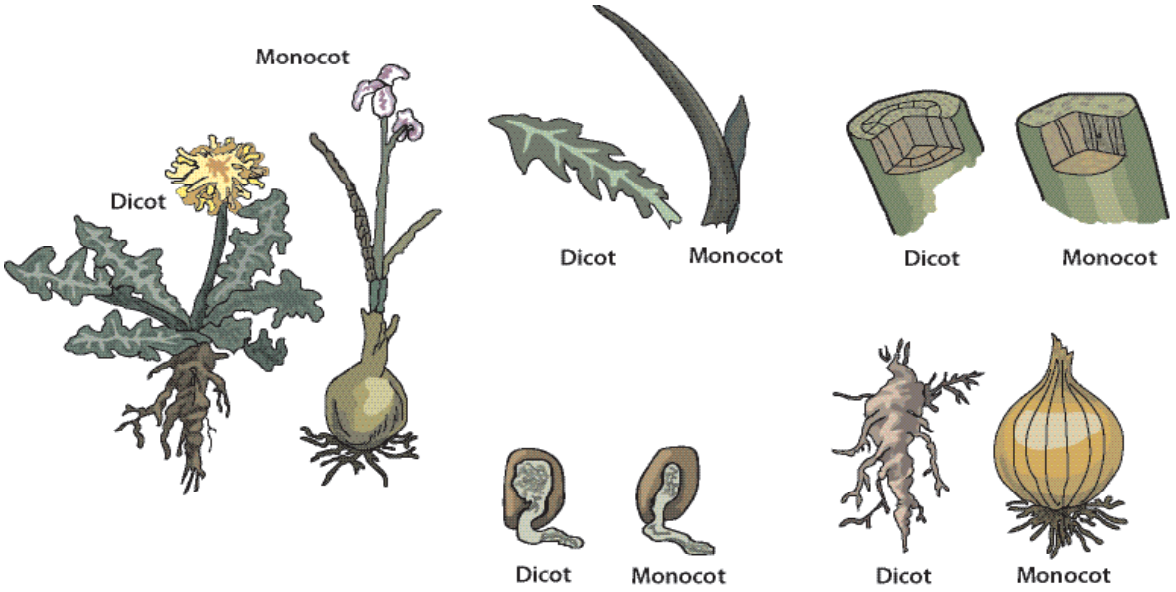
3.The Angiosperms

This group contains all the flowering plants and can be sub-divided into two groups again called the Monocotyledons and the Dicotyledons. The monocot seed has one cotyledon which remains below the ground when the seeds germinate, absorbing nutrients from the endosperm and transporting them to the developing seedling. A dicot seed on the other hand contains two cotyledons which emerge above the ground during germination. They absorb and store the nutrients from the endosperm before the seed germinates and transport them to the developing seedling when they emerge above the ground. The cotyledons serve in photosynthesis but wither and die when true leaves develop.



They also vary greatly in the way their steam, leaves and flowers are arranged, as summarised in the table below with further illustrations.

Differences Between a Monocot and a Dicot		
Structure	Monocotyledon	Dicotyledon
Leaves	Parallel veins	Network of veins
Stem	Multiples of three	Multiples of four and five
Seed	Vascular tissue (xylem and phloem) are scattered	Vascular tissue arranged in a ring
Roots	Stem and roots do not show secondary growth	Stem and roots expand and show secondary growth
Examples	Corn and Bamboo	Mango and Guava



Transport in Plants

Before learning about how plants transport water and other important substances, you need to understand the problems and limitations that plants face in transportation of substances.

Firstly plants need sunlight and carbon dioxide and sunlight. The reason why many trees are so tall is that they compete with each other to maximise their intake of sunlight.

However, the water and mineral salts that they also need are found in the soil and this is one of their limitations. Their transport vessels need to be able to send water against gravity to greater heights. So how do plants overcome this problem?

Plants need to transport water up to the leaves and also transport manufactured food from leaves to the rest of the plant. How do plants overcome this need of having a transport system that allows movements in two directions?

Most plants have transport structures that are generally similar, but there are slight variations. To have a better understanding of the transport mechanism of plants, it is necessary to know that the million species of plants in the world are classified according to similar transport mechanisms.

Differences	Monocots	Dicots
Germinating Seed Leaves	All monocots germinate with just one cotyledon (seed leaf); hence, the name 'monocotyledon'	All seeds germinate with two cotyledons ; hence , the name 'dicotyledon'
Vein system in leaves	Parallel- veined	Leaves with net-like venation
Arrangement of vascular tissue in stems	Scattered	Arranged in a ring
Flowers	Flowers in parts in 3s or multiples of three (3)	Flower parts that are not in multiples of three (3)
Roots	Fibrous roots	Tap roots

Vascular Bundles

Vascular bundles are strands that carry water and nutrients within the plant, consisting of xylem on the inside and the phloem on the outside separated by a layer cambium.

The xylem, sometimes called wood, has two main functions:

- To conduct water and dissolved minerals salts from the roots to the stem and eventually to the leaves.
- To provide mechanical support for the plant.

The xylem consist mainly of hollow vessels stretching from the roots to the leaves. Each xylem vessels is formed by a series of cells aligned in a single file with no cross-walls separating them. This results in hallow lumen that is continuous. At maturity, the xylem vessel is a dead structure. The cells that make up the xylem have lost their nucleus and cytoplasm and become 'wood'.

Xylem vessels are reinforced by a hard substance called lignin that is deposited on the vessels. It is this material that prevents the collapse of the xylem vessels and allows the xylem to provide mechanical support for the whole plant. Lignin may be deposited in different ways. In some plants it may be deposited in the form of rings (annular) or spirals. The whole wall of the xylem may also be deposited by lignin with the exception of some parts called pits.

The xylem vessel is well adapted to transport water and dissolved mineral salts because:

- It has a continuous lumen without any cell end-walls or protoplasm to prevent the flow of water.
- It is lignified to prevent the collapse of the vessels.

Phloem

The other vessel in the vascular bundle is the phloem. The phloem transports manufactured food (sugar and amino acids) from leaves to the other parts of the plant.

The phloem vessels usually consist of sieve tubes and companions cells. A sieve tube consists of single column elongated, thin-walled living cells called sieve tube cells. The end-walls or cross walls separating the cells are perforated by minute pores like a sieve. For this reason, they are called sieve plates. At maturity, a sieve tube cell would have lost its central vacuole and most of its other organelles including the nucleus, but it retains a thin layer of cytoplasm. The transport of manufactured food occurs through the cytoplasm of the sieve tube cells and across the perforated sieve plates by diffusion and active transport.

Because the sieve tube cells have lost almost all of their organelles, they are kept alive by companion cells. Each sieve tube cell is accompanied by a companion cell. The companion cell is a narrow, thin-walled cell with a rich cytoplasm and a nucleus. Besides nourishing the sieve tube cells, the companion cell also helps in the transport of food across the phloem.

The structure of the phloem allows it to be adapted for its role in the transport of food in the following ways:

- The sieve tube cells are perforated to enable food substances to pass through them to be transported to various parts of the plants.
- The sieve tube cells are accompanied by companion cells that keep them alive for the transport of food substances, in addition to directly aiding the transport of food substances.

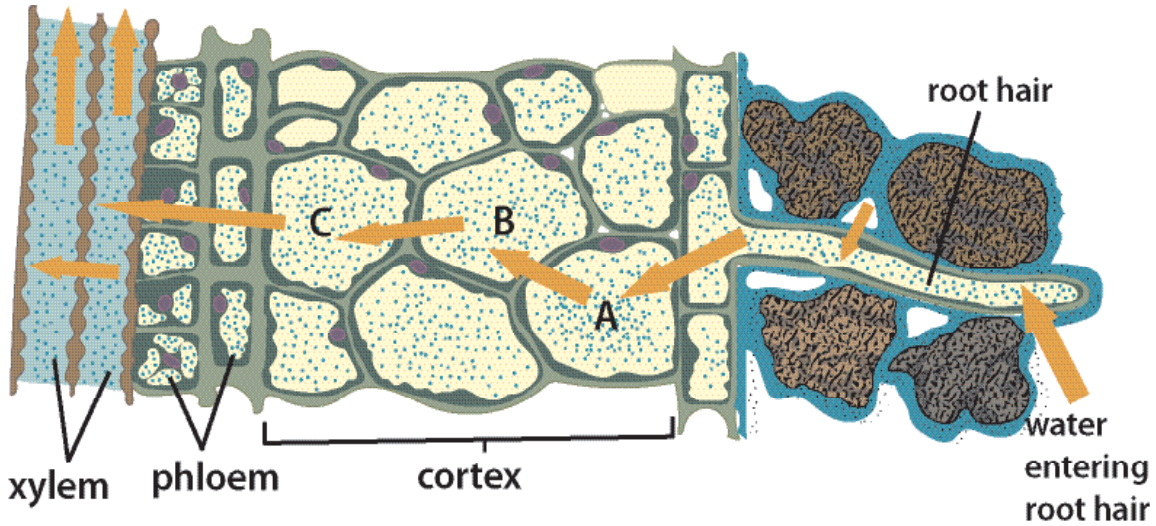
The cambium consists of a group of cells which can divide and differentiate to form new xylem and phloem when the plants grow.

Entry of Water through the roots

In plants, water is transported by differences in water potential. Absorption of water takes place mainly in the zone of maturation where there are numerous root hairs. Each root hair is actually a projection of the epidermal cell, which grows between soil particles and comes into contact or close contact with water surrounding them. Mineral salts are also found in the water that surrounds the root hairs. Hence, the water that surrounds the root hair is actually a dilute solution of mineral salts. This means that it has a high water potential.

The sap in the root hair cell, on the other hand, is relatively concentrated in sugars, amino acids and various mineral salts. This means that the root hair cell contains sap that has low water potential. So the sap is actually a concentrated solution relative to the solution in the soil surrounding the root hair. These two solutions are separated by the plasma membrane of the root hair cells, which functions as a partially permeable membrane. As a result of the difference in water potential, water from the soil will move into the root hair sap by osmosis.

Figure showing a section of the root showing the path of water through it.



With entry of water, the sap of cell A is more dilute than the next cell. That is, the sap in cell A will have a higher water potential compared to cell B. Hence, water moves by osmosis from cell A to cell B. Under the same process, water will move from cell B to cell C of the root cortex. This process continues until water enters the xylem vessels.

Entry of Mineral Salts through the Roots.

Owing to the partially permeability of the root hair plasma membrane, sugar and starch will not be able to move out of the sap and into the solution in the soil. However, it does allow dissolved minerals in salt in the soil to pass into the sap root hair by diffusion. As such, in conditions where there is a higher concentration of dissolved minerals salts in the soil solution compared to the solution in the root hair sap, the mineral salts will move into the sap by diffusion.

The root hair cell is most suitable for the transport of water and mineral salts into the roots because of the following structural adaptations:

- The root hair cell is elongated and narrow. This increases the surface area of the volume ratio for the absorption of water and mineral salts.
- The root hair cell sap is rich in sugar, amino acids and mineral salts. This makes it more concentrated than the soil solution, allowing water to move in by osmosis. In addition, the partially permeable plasma membrane of the root hair cell prevents the leaking out of sugar, amino acids and mineral salts.
- The root hair cell is the living cell. This allows it to generate energy from cellular respiration to be used for active transport of mineral salts.

Moving Water up the Stem

How does water move up the stem? Recall the one problem plants face in transporting water is that they have to transport water upwards, and in some cases at great heights and against gravity. How do they achieve this?

Studies have shown that living cells around the xylem vessels in the roots bring ions into the vessels using active transport. This lowers the water potential in the xylem vessels and results in water moving into the xylem vessels by osmosis and water flows upwards. This process is called root pressure. However, this pressure will not be sufficient to send water up the leaves of tall trees.

Another process that has been observed is the capillary action of the xylem vessels. Water tends to move up inside fine capillary tubes by capillary action. Since the xylem vessels in plants are narrow, capillary action helps to move the water up the xylem vessels. However, capillary action plays a very small part in sending water up the stems of tall plants or trunks of all trees.

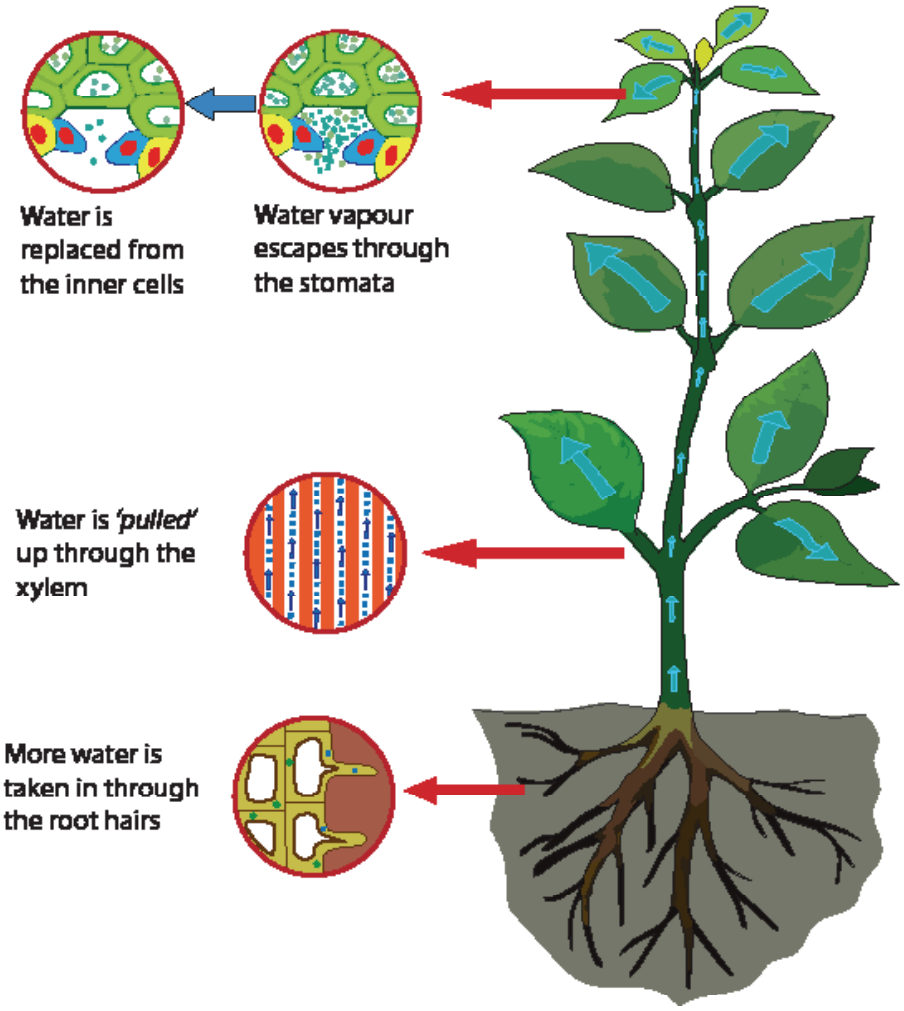
Studies have indicated that the transpiration pull is the strongest force that pulls water up the stem from roots.

Transpiration

Transpiration is the loss of water in the form of water vapour from the leaves, especially through the stomata, as a consequence of gaseous exchange.

When the stomata pores are open for gaseous exchange, especially during the day, water vapour inside the air spaces of the leaf behind the stomata also evaporates. As a result of this, water from the mesophyll cells move out to the air spaces by osmosis due to the water potential difference. The mesophyll cells around the air space will have a lower water potential. Water from the next cell will then move into those mesophyll cells. This results in a chain of events that create the transpiration pull.

When water moves out of the mesophyll cells, they will then draw water from the next cell and the process continues until it reaches the mesophyll cell nearest to the xylem. These cells then draw water from the xylem vessels in the leaf like a suction force. This suction force will pull water up the xylem vessel. This is known as transpiration pull. It is the main force in the transport of water and dissolved water and dissolved minerals salts up the stem. The stream of water up the plant is called transpiration stream.



Transpiration is important to plants because:

- The pulling of water due to transpiration is the main factor in lifting water and mineral salts through the stem, from roots to the leaves. This ensures that leaves have enough water for photosynthesis and mineral salts for cellular metabolism, and the production of other organic compounds such as amino acids
- The evaporation of water also helps the plant to stay cool as it removes latent heat and prevents the plant from being scorched by the sun.

However, excessive transpiration is harmful to the plant. In strong sunlight, excessive transpiration will cause the mesophyll cells to lose turgor pressure as water is drawn out of their sap. The turgor pressure in the mesophyll cells help to support the leaves firm, and also helps the leaves to spread out to absorb sunlight. If they were to lose turgor pressure, the leaves will become flaccid and the entire plant will wilt.

Wilting is the loss of turgidity in plant tissue when the intake of water in insufficient to replace that lost by transpiration or other means, causing a deflation of the plant cells.
The advantage of wilting is that the rate of transpiration will decrease. This means that the plant will reduce their loss of water because the leaves will fold up to reduce the surface that is exposed to the sun. This causes the guard cells to become flaccid and the stomata will close.
The disadvantage is that water is now a limiting factor for photosynthesis. Also, as the stomata are closed, the amount of carbon dioxide entering the leaves for photosynthesis is also reduced.

Factors affecting Transpiration

a) Light – stimulates the stomata to open, allowing gas exchange for photosynthesis and as a side effect , also increases transpiration since the stomatal pores are open. However, in the absence of light and closure of stomata, transpiration will decrease. The above will take place if all the external factors remain constant.
b) Humidity- the inter-cellular spaces in the leaf are normally saturated with water vapour. If the humidity of the air outside the stomata is low (the air is dry) then transpiration will increase due to the large difference in water potential. However if the humidity of the air outside the stomata is high (the air is damp) then transpiration will decrease due to the small difference in water potential.
c) Temperature –high temperature increases the rate of evaporation of water from the mesophyll cells, hence also increasing the rate of transpiration. However at low temperature , the rate of evaporation will be reduced and so will transpiration assuming that all other factors are kept constant
d) Air Movement/ Wind- wind blows away saturated air from around the stomata, replacing it with drier air, therefore increasing the water potential gradient and increasing transpiration. In the absence of the wind, the air around the stomata will get increasingly saturated with water vapour, reducing the water potential gradient with the inter-cellular air in the stomata. If the air does not move away then the transpiration rate will decrease.

Transport of Food Substances in Plants

The transport of manufactured foods like sugar and amino acids in plants is known as translocation.

Translocation of food occurs in the phloem. Unlike the water in xylem, the contents of the phloem can either move up or down a plant stem, often simultaneously. These manufactured foods are often sent to various parts of the plant from the leaves, to be used in cellular respiration, growth or storage (in stems or underground roots).

Surprisingly, the exact mechanism of sugar transport in the phloem is not known, but it is certainly far too fast to be simple diffusion. The main mechanism is thought to be the mass flow of fluid up the xylem and down the phloem, carrying dissolved solutes with it. Plants do not have hearts like animals, so the mass flow is driven by a combination of active transport (energy from ATP) and evaporation (energy from the sun). this is called the **mass flow theory.**

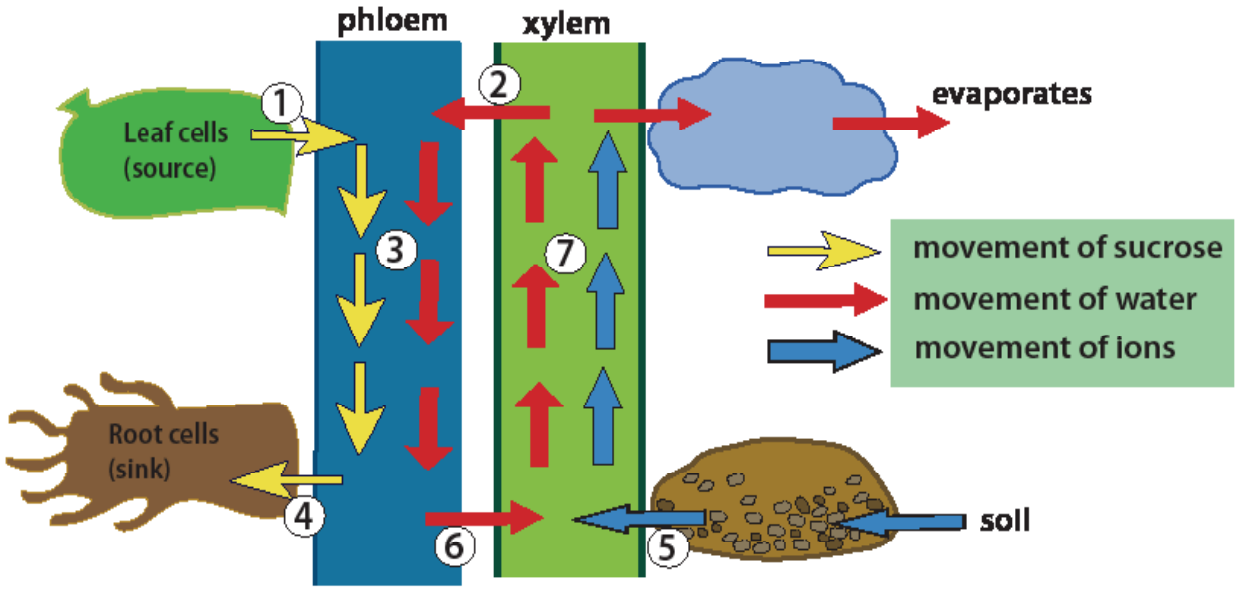


Diagram of mass flow theory

1) Sucrose produced by photosynthesis is actively pumped into the phloem vessels by companion cells.
2) This decreases the water potential in the leaf phloem , so water diffuses from the neighbouring xylem vessels by osmosis.
3) This increases the hydrostatic pressure in the phloem , so water and dissolved solutes are forced downwards to relieve the pressure. This mass flow: the flow of water together with its dissolved solutes due to a force.
4) In the roots, the solutes are removed from the phloem by active transport into the cells of the roots
5) At the same time, ions are being pumped into the xylem from the soil by active transport, reducing the water potential in the xylem.
6) The xylem now has a lower water potential than the phloem , so water moves in by osmosis from the phloem to the xylem.
7) The tension from the leaves pulls water and its dissolved ions up the xylem.

The mass-flow theory does indeed occur, and it explains the fast speed of solute translocation. However, there must be additional processes, since mass flow does not explain how different solutes can move at different speeds or even in different direction in the phloem. As a result of this, numerous translocation studies have been conducted.

Classification of Animals

Content Standard:	**11.2.1** Investigate and analyse the principles of scientific classification, diversity of living organisms and the cell
Benchmarks	**11.2.1.2** Compare and contrast the structure and function of different types of prokaryotes, eukaryotes and viruses **11.2.1.3** Describe unifying and distinguishing anatomical and physiological characteristics of representative organisms from each of the kingdoms
Essential Question	1. What characteristics do all animals have? 2. What are the different groups of invertebrates? 3. What are the different types of vertebrates?
Learning Objective	• Identify the different types of invertebrates as well as state the characteristics. • Classify invertebrates into different groups. • Identify the different types of vertebrates as well as state the characteristics and classification of their different groups
Knowledge	• There are two types of animals; Vertebrates and Invetebrates • Vertebrates are animals with backbones • Vertebrates are further broken down into five classes • Invertebrates are animal without backbones.
Skills	• Identify one invertebrate from another • Identify one vertebrate from another
Atitudes & Values	• Appreciate the knowledge of invertebrates • Appreciate the knowledge of vertebrates

Content Background

Animals are eukaryotes and they are divided into two main phylums called the Invertebrata and the Vertebrata.

Invertebrates

These are all the animals without backbone. Over 90% of all species on Earth are inthis category. in addition to not having a backbone, invertebrates have soft bodies because they do not have an internal skeleton (endoskeleton) for support. instead, many have structures on the outside (exoskeleton) that provide the support and protection. They are cold-blooded, meaning they can't regulate their body temperature, so it changes depending on the environment.

Invertebrates are diverse. They live in fresh water, salt water, on land and as parasites in other animals. There are carnivorous (meat eaters) invertebrates, herbivores (plant eaters) and omnivores (meat and plant eaters.) Some invertebrates grow bacteria and cells inside their bodies that make their food. Some invetebrates stay in one spot, while others fly, swim, float crawl and burrow.

1. Arthropods

These are organisms with external skeleton (exoskeleton) and jointed appendages. The exoskeleton protects them from predators and support for locomotion while the jointed appendages serve the purpose of locomotion. Animals in this group include insects, arachnids, crustaceans and myriapods.

2. Molluscs

They are a diverse group of marine, freshwater and terrestrial invertebrates that have one thing in common: they have soft body with the presence of a shell at some stages in their life cycle. Animals in this group include snails, chitons, limpets, clams, mussels, oysters, octopuses, etc.

3. Annelids

Group of organisms that are characterised by elongated and cylindrical bodies segmented by rings. Examples include ragworms, earthworms and leeches.

4. Cnidarians

These are aquatic animals with enhances shell for capturing food and have symmetrical bodies. Examples include hydras, jelly fishes, sea anemones and corals.

Vertebrates

This group contains all the animals with backbones.

Vertebrates can be divided into five groups:

1. The Fishes

These are aquatic vertebrates with scales covering their bodies. Their limbs are modified into fins for swimming. They breathe with gills and lay their eggs in water. Examples include tuna, tilapia and shark.

2. The Birds

Their bodies are covered with feathers, their limbs are modified as wings and they lay egg with shells. They share the same characteristics with mammals in that they are warm-blooded and have four-chambered heart. Examples include chickens, Bird of Paradise and Cassowary.

3. The Reptiles

Their skin has scales but no hair or feathers. They have claws on their toes and lay eggs on the land. Examples include snakes, lizards, alligators and turtles.

4. The Amphibians

Their skin lacks hair, scales and feathers and can be smooth or rough. They lay their eggs in water but their adult life can be lived on land. Examples include frogs, yellow-stripped caecilian and salamander.

5. The Mammals

These are warm blooded animals including humans, that have hair and they suckle their young. Mammals are divided further into three groups called the Monotremes, Marsupials and Placental Mammals.

i. Monotremes

These are the egg-laying mammals. After the eggs hatch, the young ones are taken care of by their mother. Examples include platypus and echidna.

ii. Marsupials

These are mammals that carry their young ones in their pouch until they are strong enough to live on their own. Examples include bandicoots and wallabies.

iii. Placental Mammals

These are mammals that have placenta, give birth to their young ones and provide parental care.

Microbes

Content Standard:	**11.2.2** Investigate the diversity of microorganisms, the relationships that exist between them and their effect on personal and community health.
Benchmarks	**11.2.2.1** Explain microorganisms and the essential place they occupy in the world of living things **11.2.2.2** Examine the basic characteristics of microbes and explain the roles of microorganisms in ecosystems and biotechnology

Essential Question	1. In what ways are microorganisms useful? 2. What are some beneficial roles of some bacteria in the field of science? 3. What are the negative sides of pathogens? 4. What would happen to the earth if there were no microbes? 5. Explain the significance of Protista and give some examples. 6. Explain that some viruses are beneficial and give examples
Learning Objective	• Explain the beneficial roles of some bacteria in the field of science. • Explain the negative side of pathogens with some examples. • State and explain the significance of some fungi with examples. • Explain the significance of protista and give some examples. • Explain that some viruses are beneficial and give example • Identify the different types of bacteria using their structures, as well as state the characteristics and classification of the different groups of bacteria. • Identify the different types of protista and fungi using their structures, as well as state the characteristics and classification of their different groups.
Knowledge	• Some microorganisms decompose dead organisms and food wastes to return nutrients to the soil. • Some microorganisms are useful in fermentation of food products. • Some microorganisms may cause spoilage during food preparation, storage, distribution and handling. • Food spoilage may be prevented by salting, freezing, and drying. • The different types of bacteria. • Groups of Protista and Fungi and their characteristics
Skills	• Describe ways of preventing food from spoiling. • Cite advantages and disadvantages of specific food preservation techniques • Identify bacteria based on shape and structure • Differentiate a Protista from a Fungi
Atitudes & Values	• Appreciate that not all bacteria are harmful • Appreciate the knowledge of fungi • Value the importance of having microbes

Content Background

Microbiology is the study of microorganisms that are too small to be seen with the naked eyes, their role and distribution in the environment and how they relate with other organisms. Before microbes became well-known, most scientists thought all living things (organisms) could be classified as either plants or animals. But when microbes were discovered it became clear that some of them did not really fit into either of these groups. Some had features of both and others had features of neither.

Five different types of microbes have been identified.

- Fungi
- Bacteria
- Protozoa
- Algae
- Viruses

Fungi and algae are plants. Protozoa are animals.

Bacteria and viruses are neither.

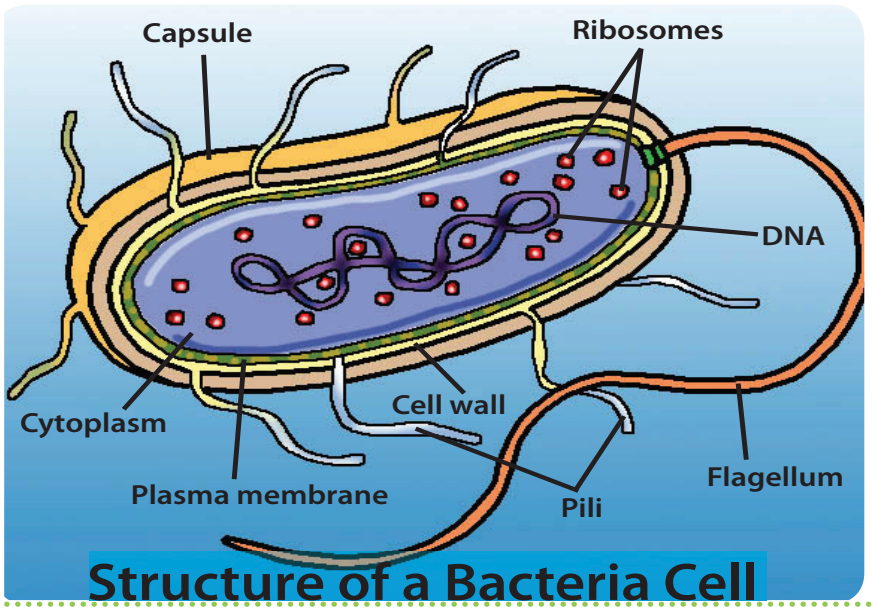
- Bacteria are similar to plants in some ways and similar to animals in others.
- Viruses are unlike all other organisms.

Prokaryotes: Bacteria

Prokaryotes and Eukaryotes are the two main domains from which all organisms are grouped under.

What are Prokaryotes?

Prokaryotes are one cell or single-celled organisms and they lack true nucleus. The Prokaryotic domain has only one Kingdom called Monera, which is further divided into Archaea and Eubacteria. Archae includes Archebacteria while Eubacteria includes Bacteria and Cyanobacteria.



Functions of the Bacterial Organelle

Capsule	Protection against phagocytic engulfment. The cell wall gives rigidity and protects the cell from swelling and bursting in dilute solutions. It also serves for attachment to surfaces.
Plasma membrane	Partially permeable and regulates the movement of substances into and out of the cell Plasma membrane
Ribosomes	Sites of translation (protein synthesis)
Flagellum	Swimming movement
Cell wall	depends on the type of bacteria, as shown below:
	* Gram-positive bacteria – gives rigidity and shape on cells. Prevents osmotic lysis.
	* Gram-negative bacteria – peptidoglycan preventsosmoticlysis and gives rigidity and shape.
DNA	Genetic material of cell

Classification of Bacteria

Bacteria can be classified according to several characteristics, some of which are listed below:

A. Classification of Bacteria based on Their Shape

Bacillus: - These are rod-shaped or filament-shaped bacteria.
Coccus: - These are spherical-shaped or oval-shaped bacteria.
Spirillum: - These are spiral-shaped bacteria. They are also called spirochetes.
Vibrio: - They are comma-shaped bacteria.

B. Classification of Bacteria based on Their Ability to Stain

Gram positive - has penetrable cell wall
Gram negative - has impenetrable cell wall

C. Classification of Bacteria based on Temperature Dependent Ability

Thermophilic - thrives in high temperature, between 41 and 122 degrees
Mesothermic - thrives best in moderate temperature, not too cold or not too hot but just in between, usually between 20 and 45 degrees
Hypothermic - thrives in low temperature, less than 20 degrees

D. Classification of Bacteria based on Oxygen Requirement

Aerobe - thrives well in the presence of oxygen
Anaerobe - thrives well in the absence of oxygen

i. **Autotrophs**

These bacteria have chloroplasts and therefore make their own food through the process of photosynthesis.

ii. **Chemoautotrophs**

These groups of bacteria make their own food using energy from chemical sources instead of sunlight.

iii. **Heterotrophs**

These bacteria do not synthesise their own food but obtain it from others. They feed on food materials like animals do.

iv. **Symbiotic**

These bacteria obtain food by living together with other organisms. They live in mutual beneficial support with them.

v. **Saprophytic**

These bacteria feed on dead and decaying material. In this way, they help in cleaning the environment from accumulation of waste.

vi.**Pathogenic**

These bacteria live in the body of other plants and animals and feed from the vital living elements in them. In this way, they create disease for them.

Eukaryotes: Protista & Fungi

Eukaryotes are organisms that contain true nucleus and they range from simple microscopic organisms to large multicellular organisms like a tree. The Eukaryotic domain has four Kingdoms called Protista (or Protoctista), Fungi, Plants and Animals.

Protista

Protista are single-celled organisms with true nucleus. Most of them are aquatic in nature but also live in damp or moist places. Their characteristic feature is the presence of cilia or flagella in their structure which help them in their movement.

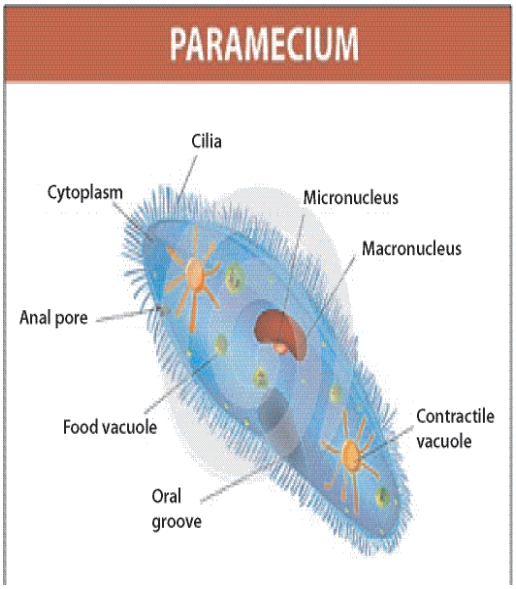
Some of them have repeating cells, like the spirogyra while others are multi-celled but with no system, like the seaweeds.

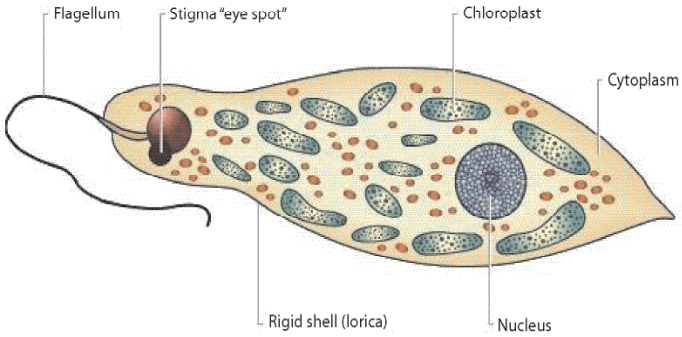
Classification and Structure of Protists

Protista is divided into three phyla according to their type of nutrition.

1. **Protozoa** – These are animal –like protists that ingest their food through heterotrophic nutrition. There are many examples of protozoans but the four main ones are amoeba, paramecium, euglena and plasmodium. Some species of euglena like the one shown below have chloroplasts and can photosynthesize

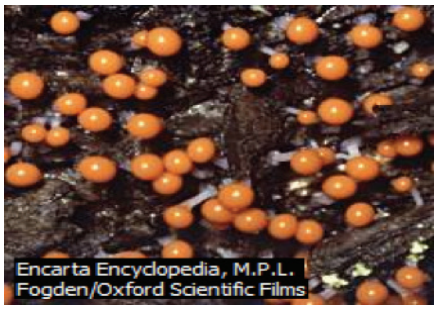
Structures of paramecium and euglena:

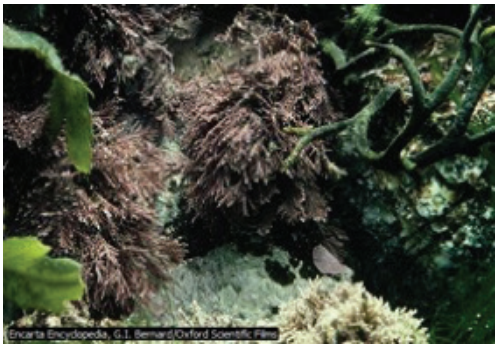




2. **Algae** – These are plant –like protists that make their own food by photosynthesis. Mode of nutrition is autotrophic. Examples include green, brown and red algae. The latter two have green pigments masked by the brown and red colour and they do photosynthesise.

Green algae exposed at low tide.

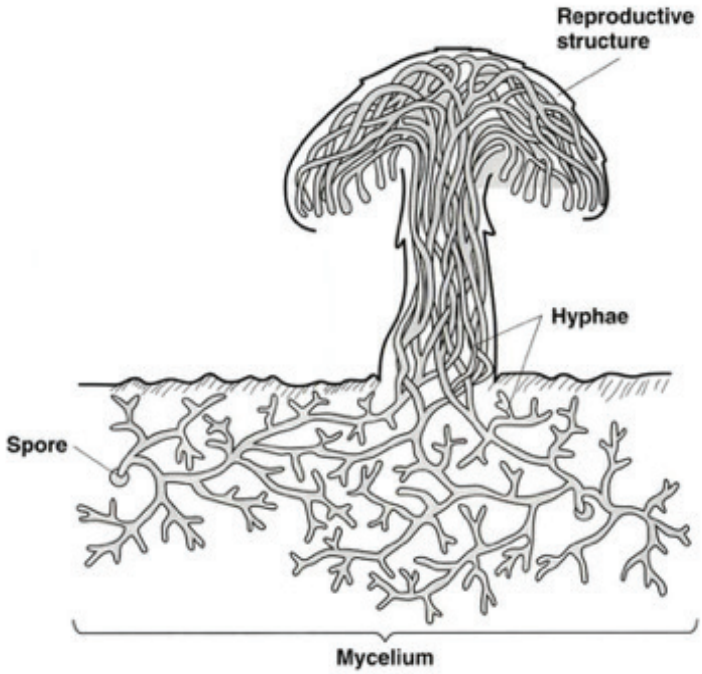




3. Slime Moulds & Water Moulds - These are fungus – like protists that ingests their food through heterotrophic nutrition, just like the protozoans. Slime mould inhabits dead leaves or trees

Fungi

These are single-celled or multicellular organisms that obtain their food by direct absorption of nutrients. The food is dissolved by the enzymes that the fungi secrete, is then absorbed through thin cell walls and is distributed by simple circulation or streaming of the protoplasm. Together with bacteria, fungi are responsible for the decay and decomposition of all organic matter, and are found everywhere.



Structure for sexually reproducing fungi

Functions of the Fungi organelles

The following are the organelles and their functions:

1. Hyphae - tubular shaped structure made up of filaments called hypa.
2. Mycellium – which is a network of hyphae
3. Reproductive Structure – which carries out reproduction, especially in those that reproduces sexually. This part is sometimes called the fruiting bodies.

Classification of Fungi

Like bacteria, fungi can be classified in several ways. Some of them are listed below.

A. Classification of Fungi based on Nutrition

1. Saprophytes - feed mainly on dead material, just like saprophytic bacteria, and break them down to release nutrients
2. Parasitic Fungi- two types:
   (i) Obligate parasite
   (ii) Facultative parasite

3. Predators - two examples:
   (i) Oyster Mushroom
   (ii) Arthrobotrys

4. *Symbionts* - two examples:
   (i) Lichens
   (ii) Mycorhizae

B. Classification of Fungi based on Method of Reproduction

1. Zygomycota – mainly terrestrial and feed on dead organic matter. Reproduction is asexual through spores. They also cause problems by growing on human food source, eg bread mould.
2. Basidiomycota - club-shaped and are known as club fungi. Reproduces sexually by spores. Eg. Mushroom
3. Ascomycota - pathogens of plants and animals, including humans. Reproduction can be both asexual and sexual.
4. Chytridiomycota – organisms in here are aquatic and microscopic. Reproduces asexually by produces spores that move around using flagella.
5. Glomeroycota – make up half of all the fungi found in soil and develop mycorrhizae with plants. This mutual symbiotic relationship results in the fungi obtaining sugars from the plant while the fungi dissolves minerals into the soil for the plant to take in. Reproduction is asexual.

It is important to note that all fungi reproduce by spores.

C. Classification of Fungi based on Morphology

1. Yeasts - unicellular, rounded fungi, reproduces by budding

2. Yeast like Fungi - grow partly as yeasts and partly as elongated cells resembling hyphae
3. Molds - multicellular, filamentous and have hypae. Produces spores

4. Dimorphic Fungi - can be in two forms, molds and yeasts, and they are the ones that cause infections.

D. Classification of Fungi based on Clinical Recognition

1. Superficial mycosis
2. Subcutaneous mycosis
3. Systemic mycosis
    i. Primary Pathogens
    ii. Opportunistic pathogens

How are Microbes Useful?

All living things need food to stay alive. They need food to supply them with energy and the raw materials needed for growth and reproduction.

In the process of using the food, some substances are formed which are useless to the organism. These substances are called waste products.

Microbes are able to use many substances for food that cannot be used by other living things. This is why they are found everywhere in such large numbers. As well, their waste products, whilst useless to the microbes themselves, are often useful to other organisms including man.

1. Decay

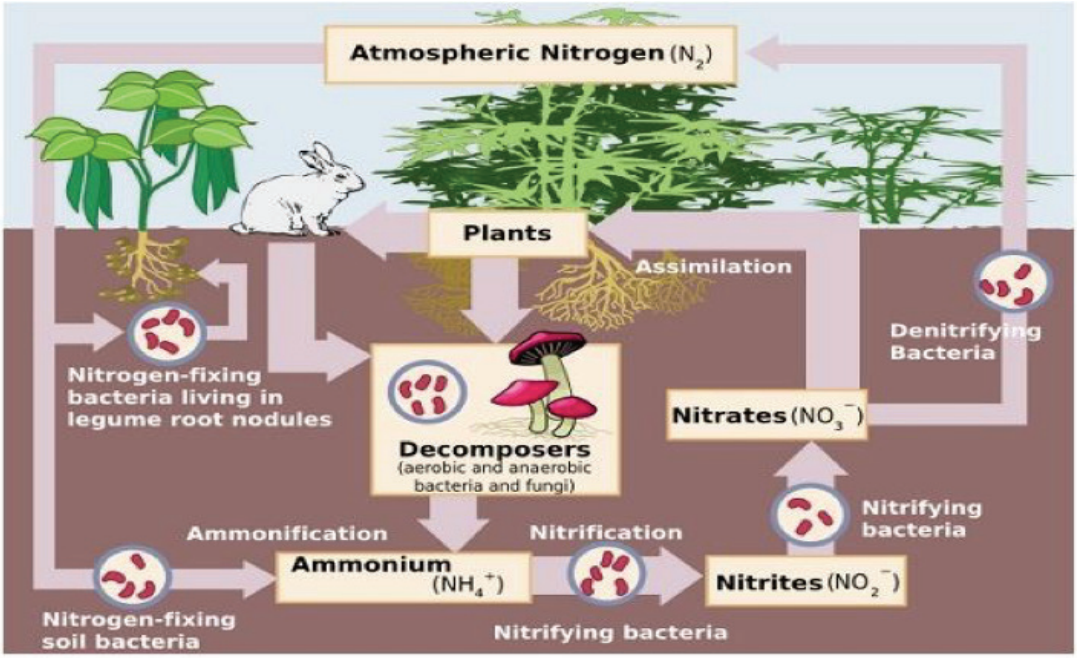
Imagine a world where wood did not rot, dead bodies did not decay and excreta and vegetation lay where they fell. Microbes living in the soil, in water, in faeces and sewage systems and rubbish dumps all use these dead organic matters for their food. By doing this they perform very useful function for the rest of the living world. They return to the soil many essential substances which can be used again for further plant and animal growth. Without the action of these bacteria and fungi which cause decay, the essential raw materials of life would be forever locked within the bodies of dead plants and animals, and their supply would eventually be exhausted. Soon, life as we know it would cease to exist

The Nitrogen and Carbon Cycles show how microbes play an important role in recycling these two important elements.

Benefits of Some Bacteria in Agriculture

1. Bacteria of the Nitrogen Cycle

The nitrogen cycle shows several beneficial bacteria that traps nitrogen from the air, decomposes dead plants and animals thereby releasing nitrogen, converts nitrogen into ammonium and nitrates for plants absorbtion, and release nitrogen back into the air.



2. Digestion of Cellulose

Living things need energy to stay alive. Animals get it from the energy-rich foods such as fats and carbohydrates which they eat. Plants contain three types of carbohydrates: sugar, starch and cellulose. Their cell walls are made of cellulose and so are the tough fibres and strings which strengthen their leaves and stems. Most animals including humans are unable to digest cellulose and so are unable to use the energy it contains. Some microbes can however digest it.

These cellulose-digesting bacteria and protozoa live in the stomachs of grass-eating animals like cows and sheep and wood-eating insects like ants or termites. They digest the cellulose that their host eats and so provide energy for both themselves and their host.

3. Nitrogen fixation

The element nitrogen is essential for the manufacture of proteins. Proteins are needed by all living things to build their bodies and grow. Nitrogen is present in the air but most living things cannot use it. Animals get their proteins by eating plants. Plants make their own proteins from carbon dioxide in the air and water and mineral salts in the soil. Some these salt contain nitrogen in the form of substances called nitrates. These nitrates, which are compounds of nitrogen and oxygen are soluble in water and therefore easily absorbed and used by plants.

Certain bacteria , (and a few fungi and algae) are able to combine nitrogen gas and oxygen gas directly into nitrates. These bacteria are found in the soil and also in special lumps or nodules on the roots of plants called legumes. In this way, these microbes increases the fertility of the soil.

4. Fermentation

The fermentation of carbohydrates (e.g sugar) into alcohol and carbon dioxide by yeasts is the basis of several important industrial processes:

a) Beer making: the action of yeasts on barley and hops
b) Wine making : the action of yeasts (occurring naturally on the skin of the fruit) on grapes
c) Bread making: the action of yeasts on sugar in the dough forms bubbles of carbon dioxide which lighten (leaven) the bread as it is baked.

5. Cheese and yogurt manufacture

The action of microbes on milk is used to make cheese and yoghurt.

a) Yoghurt is made by the action of bacteria on milk sugar
b) Cheese is made by the action of bacteria on milk solids

6. Vinegar is made by the action of bacteria on wine

7. Sauerkraut is made by the action of bacteria and cabbages.

8. In agriculture the preservation of grass (for animal food) as silage is achieved by the action of bacteria

9. The treatment of animal skin to make leather is done partly by the action of bacteria which digest the soft parts of the skin leaving behind the tough leather fibres untouched.

10. Antibiotic production: An antibiotic is a substance produced by one kind of microbe (usually a fungus) which either kills other microbes (especially bacteria), or prevents them from growing. The antibiotic penicillin is made by the fungus Penicillium.

11. Laundry detergents contain chemicals which break down starch. These chemicals are made by fungi

12. Vitamin production

a) Bacteria living naturally in our intestines and mouth provide us with several essential B-group vitamins.
b) Vitamins are made commercially by the action of microbes
Vitamin C- by bacteria, Vitamin B2 – by yeast, Vitamin B12 – by bacteria
Vitamin A – by fungi

13. Citric Acid for use in soft drinks (lolly water) manufacture is made by the action of a fungus on sugar

14. Biological Control. Microbes are sometimes used to control pests of plants crops and food animals. Example fungi on worms which destroy potato crops.

PROTISTA: The Benefits of Some Protista Due to their Structures

Benefits of Protista in Agriculture

Brown algae are used as fertilizer and as an ingredient for livestock meal.

Benefits of Protista in Food Industry

Sea weed or *nori* is harvested from red algae and consumed by the Japanese. Also from the same algae is agar, which is consumed in Asia as a delicacy and is used in laboratories as a medium for culturing microorganisms. Organic derivatives of alginates, from Kelps, are used as food gums in making icecream, puddings and processed cheese.

VIRUS: The Benefits of Some Virus

Benefits of Virus in Agriculture

Used in genetic engineering in producing disease resistant plants.

Benefits of Virus in Medicine

Used in genetic engineering in vaccine production.

Occurrence and Behaviour

Content Standard:	**11.2.2** Investigate the diversity of microorganisms, the relationships that exist between them and their effect on personal and community health.
Benchmarks	**11.2.2.1** Explain microorganisms and the essential place they occupy in the world of living things **11.2.2.2** Describe the reproduction and growth of microorganisms
Essential Question	1. What are microorganisms? 2. How do microorganism reproduce? 3. Are microorganisms helpful?
Learning Objective	• Describe the habitats of the microorganisms and explain how their structures help them to survive in that type of environment. • Describe the mode of nutrition for the microorganisms in relation to their structures. • Explain how the microorganisms reproduce and the conditions that encourage their reproduction. • State and explain the type of ecological interactions they share with other organisms.
Knowledge	• Habitats of microorganisms and how their structures help them to survive in that type of environment. • Mode of nutrition for microorganisms in relation to their structures. • How microorganisms reproduce and conditions that encourage their reproduction. • Ecological interactions that microorganisms share with other organisms.
Skills	• Evaluate the structures of the organisms and describe how that helps enable them to survive in their environments. • Evaluate the structures of the organisms and describe how that helps enable them to feed. • Investigate how the microorganisms reproduce and the conditions that encourage their reproduction. • Explain interactions that microorganisms share with other organisms
Atitudes & Values	• Appreciate the presence of microorganisms in our everyday life • Value the contributions of microorganism to the living community • Respect class mates opinions

Content Background

Microbes range in size from the largest of the protozoa which are about 0.1millimetres (or 100 micrometres) in diameter and can just be seen with the naked eye as a spot the size of a pin point, to the smallest virus which is about 0.00001 millimetres (or 0.01 micrometres) in diameter and can only be seen with an electron microscope. Note 1000 micrometres (µm)= 1 millimetre (mm)

Some microbes consist of one cell only; others have bodies made of many cells. Protozoa, bacteria and viruses are all single celled organisms. Some fungi and algae are single celled (e.g. the fungus, yeast and alga, chlamydomonas and others are many celled (the mould fungi and the green alga called spirogyra which forms the slime in the ponds.

Like all organisms, microbes need food (and energy) to stay alive; and like their larger relatives they get it in several different ways.

Many protozoa, like most animals, eat other organisms. Their food is then digested within their bodies and the soluble products are then incorporated into their body structure, or oxidized (during respiration) to obtain energy. These microbes are CONSUMERS.

Content Background

Most algae, like all green plants are able to trap the energy of sunlight and use this to make their own food by photosynthesis. Some bacteria are also able to do this. These microbes are PRODUCERS.

Most fungi and most bacteria are saprophytes. They live on the dead bodies of dead organisms and their wastes. Digestion takes place outside the bodies of the microbes. Digestive chemicals are secreted on to the food and the soluble products thus formed are then absorbed into the bodies of the microbes. These microbes are responsible for decay. They are DECOMPOSERS.

All viruses; some bacteria; some fungi and a few protozoa are parasites. These microbes live on or within some other organism. By absorbing blood, sap, digested food or the tissues of the living plant or animal the parasite obtains its food at the expense of its host. As a result of this method of feeding man parasites are pathogenic, causing diseases in their host organism. However, some are well adapted to their hosts that they produce no ill effects and in a few cases actually benefit their host.

FUNGI (singular: fungus)

Fungi are plants. Some are quite large (e.g. mushrooms and toadstools) but others (e.g. moulds, rusts, yeasts and mildews) are extremely small and are consequently classified as microbes. Fungi may be single-celled (e.g. yeast) or many celled (e.g moulds and the large fungi).

Although fungi are plants they do not contain chlorophyll. Therefore unlike the green plants, they are not able to trap the energy in sunlight and use it to make their own food by photosynthesis.

Since fungi cannot make their own food they must obtain if from other sources. They do this by means of special root-like feeding threads (called hyphae). These threads penetrate and digest the substance that is being used as food. The feeding method is similar to that of many bacteria. Digestion takes place outside the fungus. Digestive chemicals are produced which are secreted

(flow out) from the hyphae on to the food. These chemicals then breakdown the food so that the soluble substances are formed, together with the energy released, can be then absorbed by the fungus.

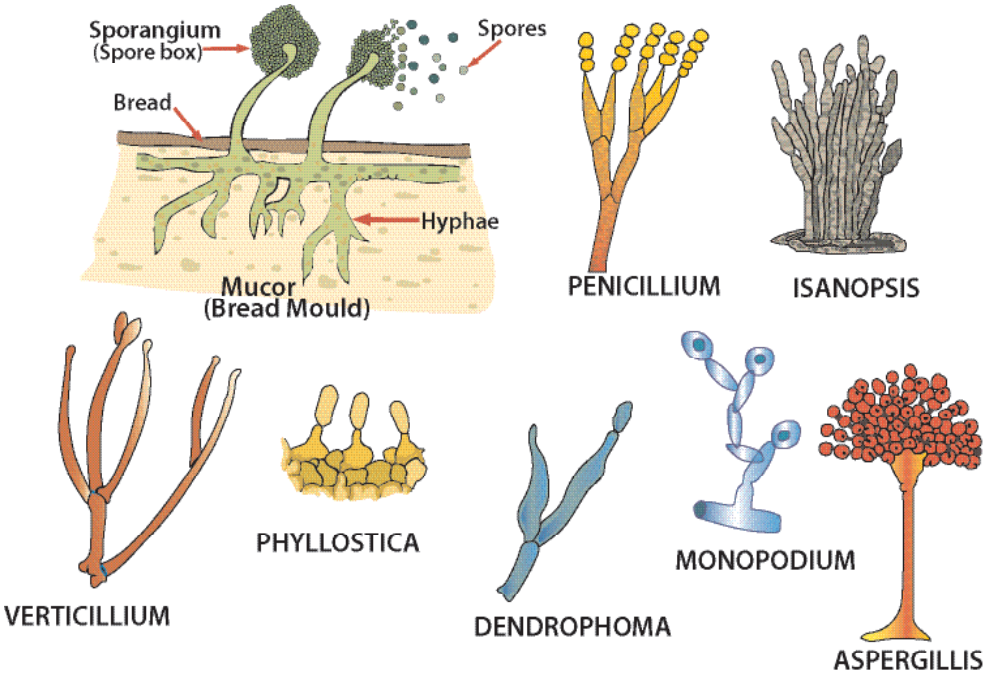
Fungi use other organisms, plant or animal; alive or dead, as their food.

-Those that live on living organism are called parasites.
-Those that live on dead organisms are called saprophytes.

Many of the parasitic fungi cause disease in animals (e.g. grille, ringworm) and especially in plants (e.g. taro plight, coffee rust, dieback and black pod in cocoa and white thread blight in coconut.)

The saprophytic fungi (together with certain bacteria) cause food to spoil and the bodies of dead organisms and their wastes to rot and decay. These DECOMPOSERS play a vital role in the recycling of essential nutrients in the living world.

Fungi reproduce by the production of spores from special parts known as SPORANGIA. These spores are produced asexually, but in many ways are similar to very tiny seeds. They are so small that they are easily carried from place to place by gentle air currents. Consequently they can be found in almost every environment and are often extremely hard to kill. Many of them can be boiled for an hour and still remain alive



Yeasts are fungi, most of which reproduce sexually by the process of 'BUDDING'. Yeasts get energy for their living processes by digesting plant sugars in the process known as "FERMENTATION". Yeasts are usually found on plant fruits, in sweet flower nectars.

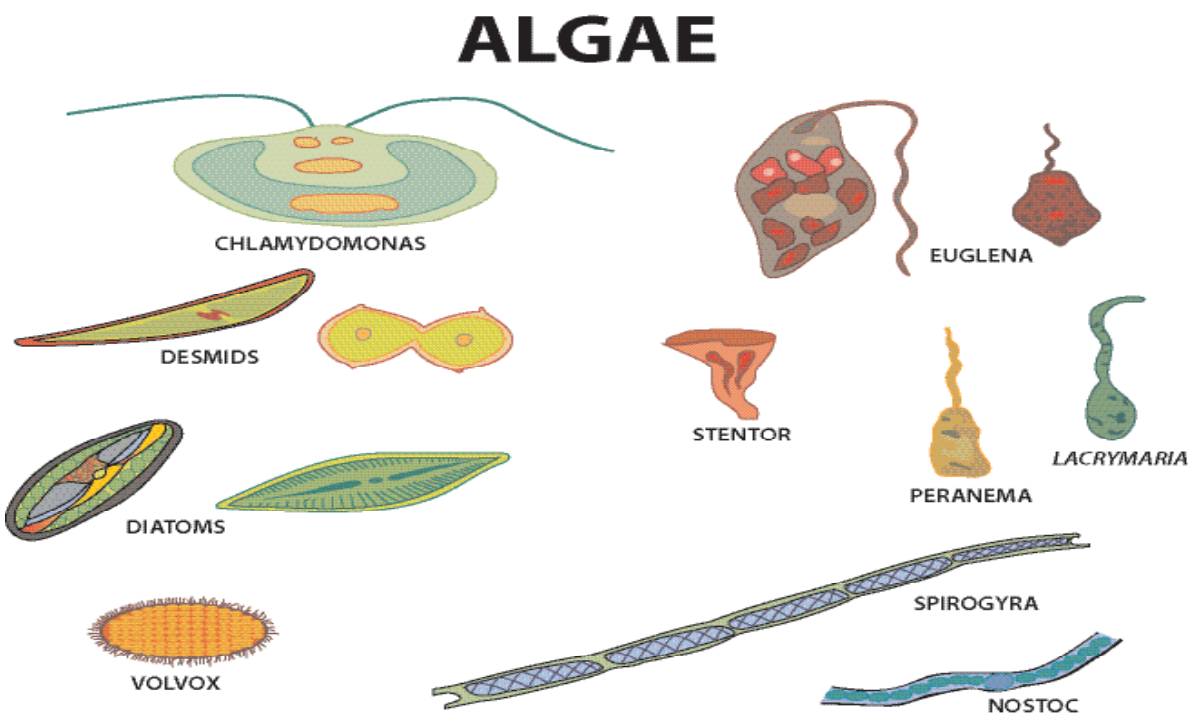
Yeasts are commercially important to man because they cause the fermentation of sugars. Without them, wine production, beer production , baking bread, vinegar production, coffee and cocoa fermentation and pure alcohol production would be almost impossible.

ALGAE (singular: alga)
Algae are simple plants which contain chlorophyll and are therefore able to carry out photosynthesis. They are PRIMARY PRODUCERS and play a very important role in many food webs especially in ponds, rivers and oceans.

Some algae are very large (e.g. seaweeds), but many are microscopic and are therefore classified as microbes. Some of these microscopic algae are single-celled (e.g. chlamydomonas) and others are many celled (e.g. spirogyra).

Algae live almost everywhere that water is found- ponds, puddles, rivers, lakes, seas, wet soils etc. They are not always obvious as many of them are so small. In the sea , marine algae are the primary source of food for the animals life of the sea. The marine algae are usually referred to a PHYTOPLANKTON. This mass of plant materials floats close to the surface of the water where there is sunlight available for photosynthesis.

Many algae are motile (can move by themselves) as they have hair-like structures called flagellae which they use to whip their way through the water.

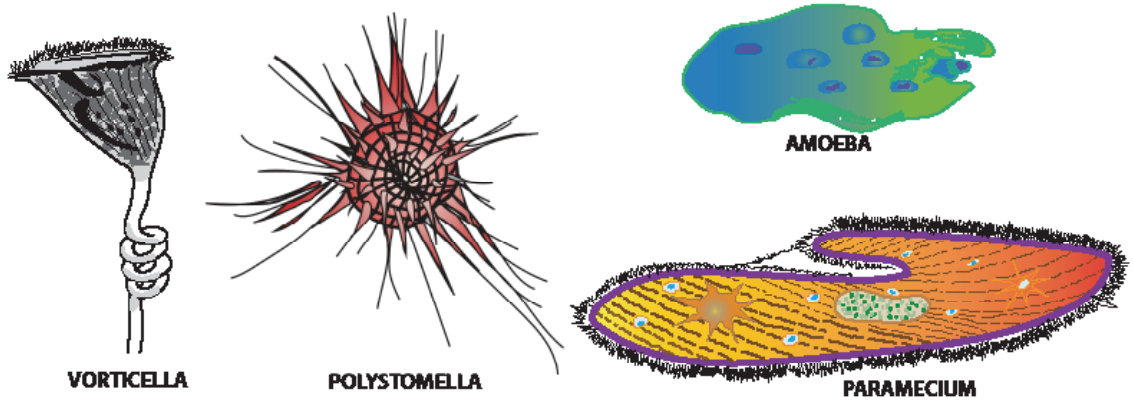


PROTOZOA (singular: protozoan)

Protozoa are animals. They are the most simple of all animals and consist of only one cell. They are all microscopic and are the largest of the microorganisms-some can be seen by the naked eye.

Most protozoa live in water: in the sea, in the freshwater of ponds and streams or in the soil. Some, however, are parasites and live in the bodies of other animals often causing diseases. (E.g. the parasite that causes malaria).

Most protozoa are able to move by themselves. Some have flagellae (e.g. monads, others have many small hair-like structures called cilia (e.g. Paramecium) to help them move and others move by changing the shape of their bodies (e.g. Amoeba).



Protozoa reproduce asexually by dividing into two. Many can survive hard times (e.g. if the pond dries up) by forming protective cysts around themselves. Inside the cyst the protozoan reproduces by dividing in two many times. When good conditions return the cyst breaks open and many new protozoa are released.

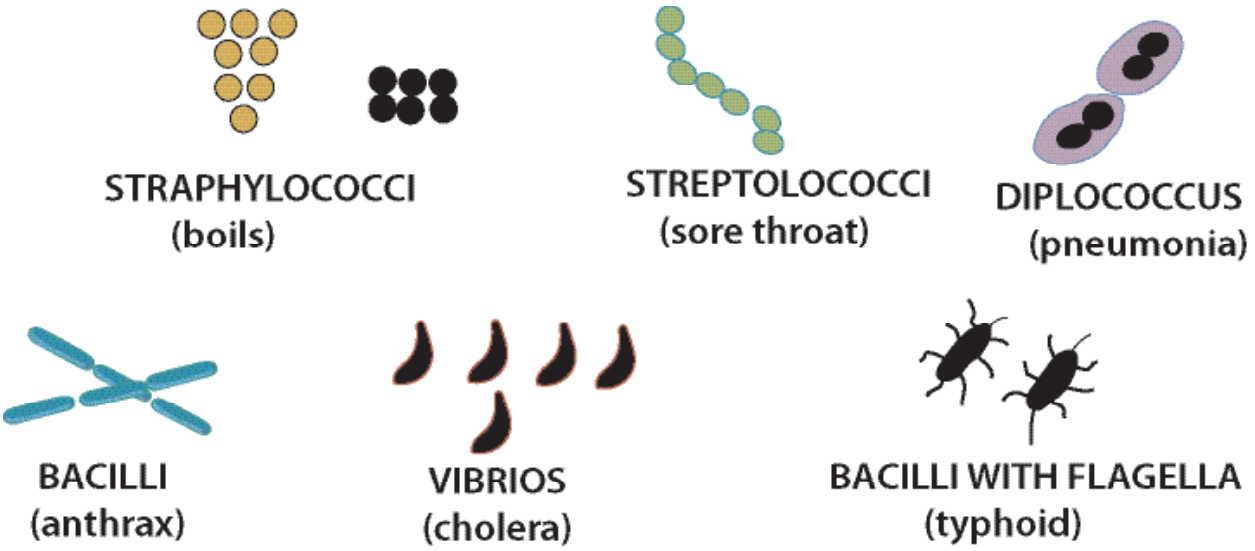
Bacteria (singular: bacterium)

Bacteria are very important microorganisms. They have been found living everywhere that life can exist. They occur in the depths of the ocean, in the upper layers of the atmosphere and in the ice sheets at the poles. Probably the only place where bacteria cannot live is in the hot lava of volcanoes.

Bacteria exist in huge numbers. A normal person's skin may have more bacteria on its surface than there are human beings living on Earth. A single grain of soil may contain from 200 000 to 100 000 000 bacteria, depending on the type of soil. The air in a town may have about 4 000 bacteria per cubic metre, mostly on dust particles.

Bacteria are extremely small. They range from 2µm to 0.5µm (where 1 000µm =1mm). To see most bacteria, a microscope with a magnification of at least 600 times is required. For this reason it is not usually possible for students to see individual bacteria under the microscope in the school science lab.

All bacteria are made of only one cell; this cell often lives by itself. In some cases, the cells form long strands like a string of beads (e.g. Streptococcus which causes sore throats) or clumps (e.g. Staphylococcus which causes boils.) (see diagram below). Most bacteria form masses of cells, called colonies, when grown on an adequate supply of food. These colonies are easily visible to the naked eye.



Bacteria exist in several different forms. Many look like short rods, many are spherical and a few have a twisted or corkscrew shape. They are classified according to their shape as follows:

Type	Appearance	Examples
Cocci (spheres)	 Single cocci  Diplococci  Streptococci (chains)	Bacterial pneumonia Scarlet fever Tonsillitis Gonorrhoea (VD) Boils
Bacilli (rods)	 Single bacilli  Diplobacilli  Chains of bacilli  Bacilli with flagella	Anthrax Bubonic plague Diphtheria Salmonella Tetanus Typhoid Tuberculosis (TB) Leprosy
Spirilla (spirals)	 Simple Spirilla (vibrios)  Spirilla with flagella  Cockscrew type of Spirilla (Spirochaetes)	Cholera Meningitis Jaundice Syphilis (VD)

Some bacteria possess whip-like 'tails" called flagellae which they use for movement. Others move by process that are not fully understood.

Bacteria usually produce asexually by dividing into two (binary fusion). This reproductive process is very rapid; many bacteria can reproduce every 20 minutes. They thus have the potential to produce huge populations in a very short time when the conditions for their growth are good (e.g. warm, moist conditions and an adequate food supply).

Bacteria may form spores with a protective protein coating called the capsule when conditions are bad (e.g. no food; too hot; no water etc.) this is highly resistant to mechanical and chemical attack. Inside the spore a bacterium may remain alive for many years until favourable conditions return- then they will "germinate" and immediately commence reproducing and growing. For this reason bacteria are very difficult to kill.

Most bacteria obtain energy for living by breaking down the organic material they use for food, externally, in much the same way as fungi do. They then absorb the liberated energy directly or absorb the soluble products of the digestion for further breakdown inside the bacterium itself.

Like fungi, many bacteria, especially those found in the soil, are saprophytes feeding on dead organism and their wastes causing them to decay. These decomposers are extremely important as the products of decay are then made available for other living things. Others play a vital part in maintain a constant supply of the element nitrogen which is an essential part of the organic material (amino acids, proteins) which al living things are made.

Many bacteria are parasites living on or within the bodies of other organisms. Many of these are pathogens. This means that they may cause disease in their host organisms. Many serious diseases in humans, other animals and plants are cause d by bacteria. Although these bacteria are obviously harmful it is important to realise that they form a very small part of the total bacterial population. **Most** bacteria are **harmless**. Indeed many are very helpful.

VIRUSES (singular: virus)

Viruses are the smallest of all the microbes. The largest virus is smaller than the smallest bacterium. They can pass through filters that will catch bacteria- a fact which led to their initial discovery. They are so small that they can only be seen with an electron microscope. Their average length is about 0.03μm or 0.0003 mm.

Viruses exist as single particles. They are not cells-their structure is very different. Viruses can only grow and reproduce inside other living things. Outside of a living cell a virus shows no normal signs of life. As such they are complete parasites. When a virus invades a living cell, it takes over the workings of the cells. It makes the cell produce many more viruses. Eventually, the cell dies and breaks open. Then, all the viruses inside fall out ready to attack new cells.

Because of the way they reproduce all known viruses are pathogenic; causing disease in their host organism. Many human diseases, including poliomyelitis, warts, influenza, measles, mumps and the common cold are caused by viruses. Viruses are also the cause of rabies in cats and dogs, foot and mouth disease in cattle and myxomatosis in rabbits. Plants are also attacked by viruses, usually causing discolouration of the leaves and flowers. Even bacteria are attacked by some viruses.

Viruses are unique. They are not like anything else. It is not known for sure whether they are true living things or just complicated chemicals that have the ability to reproduce themselves. Some scientists say that they are very simple living things; a link between the living and the non-living world; whilst others place them at the opposite end of the scale believing that they are very complicated, highly developed and specialised organisms. Scientific research continues at present in an endeavour to reveal their true nature.

Modes of Nutrition

Bacteria

Different groups of bacteria feed differently. Autotrophic bacteria make their own food using energy from the sun in the process of photosynthesis. Chemoautotrophic bacteria also make their own food but they use chemicals instead of sunlight. Heterotrophic bacteria feed on food material like all animals do while saprophytic bacteria feed on dead matter and break them down to release nutrients into the soil. Others like symbiotic bacteria feed by living in mutualistic relationship with their host and provide for them their benefit in return. Parasitic bacteria obtain their nutrients by feeding on their hosts, which in return create diseases.

Fungi

Fungi do not contain chlorophyll hence they are heterotrophic in nature. Saprotrophs feed by secreting digestive enzymes onto the dead materials to digest them. These digested materials are then absorbed by their rhizoids into their body. Parasitic fungi on the other hand, live on their hosts and obtain nutrients from them using the tips of hyphae. Obligate parasites cause rust in some plants. Predator fungi like oyster mushrooms penetrate into round worms and obtain nutrients from them. In the process, they get paralyzed. Symbiotic fungi share a mutualistic relationship other organisms where both benefit from each other. For example, the symbiotic relationship between a fungi and an algae is called a lichen.

Protista

Protozoans and slime moulds are heterotrophic in nature. They ingest nutrients into their bodies while plant like protists are autotrophic in nature. They make their own food using chloroplast in their bodies.

Virus

Viruses are parasitic. They are found within their hosts bodies and suck up nutrients from them thereby inflicting sickness upon them.

Modes of Reproduction

Bacteria

Bacteria reproduce by binary fusion. A bacterium cell, which is a single cell, divides into two and they divide into four then eight, sixteen, thirty-two and so on.

Fungi

Fungi reproduce either sexually by forming zygospore or asexually by budding or fission.

Protista

Protists reproduce asexually by binary fission, multiple fission and budding. They can also reproduce sexually.

Virus

Viruses reproduce through a process called Lytic Infection, where a virus upon entering the cell makes a copy of itself, and causes the cell to burst or lyse.

Ecological Interactions with Other Organisms

Types of relationships

1. Parasitism

This type of relationship occurs when organisms either live in the body of their host, endoparasitic, or on their host, ectoparasitic, and feed from them. In the process, the host becomes affected with diseases while the parasite benefits. For example, mosquito parasite in a human body.

2. Commensalism

This is a type of food eating relationship that occurs when two organisms live with each other and one benefits but the other remains unaffected. For example, bacteria that live on the human skin and alimentary canal.

3. Mutualism

This is a type of relationship shared by two organisms where both benefit. For example, the association of fungi with algae to form lichen.

Impact on Species

Content Standard:	**11.2.2** Investigate the diversity of microorganisms, the relationships that exist between them and their effect on personal and community health.
Benchmarks	**11.2.2.2** Examine the basic characteristics of microbes and explain the roles of microorganisms in ecosystems and biotechnology. **11.2.2.5** Describe the reproduction and growth of microorganisms. **11.2.2.6** Investigate the transmission, symptoms, consequences and treatment of common sexually transmitted infections and diseases in humans.
Essential Question	1. How are microbes helpful in our lives? 2. What diseases do microbes cause? 3. How long does it take microbes to reproduce? 4. How do microbes enter our body? 5. How can we remove harmful microbes inside our body? 6. What are the common STIs do we have in PNG?
Learning Objective	• Explain the advantages and/or the disadvantages of the relationships between microbes and their hosts. • Describe the different processes used by pathogen to damage the host and ensure infections • Discuss the diseases and disorders that are caused by the effect of microbes on other living things. • Describe the major toxin types and their mechanisms of action. • Recognise various methods and types of microorganism transmission.
Knowledge	• The host can refer to an animal, a palnt or even other microorganism • Pathogenic viruses are manily thos of the families of Adenoviridae, bacteria, Picornaviridae, Herpesviridae, Hepadnaviridae, Flaviviridae, Polymavirus • Advantages and disadvantages of the relationships between microbes and their hosts. • Diseases and disorders that are caused by the effect of microbes on other living things
Skills	• State the advantages and disadvantages of the relationships between microbes and their hosts. • State the diseases and disorders that are caused by the effect of microbes on other living things
Atitudes & Values	• Appreciate the presence of microorganisms in our everyday life • Respect class mates opinions

Content Background

Entry into the Host

Microbes gain access to human tissues via mucosal surfaces within the body or epithelial surfaces on the outside of the body. Microbes gain access to human tissues via two main types of routes: mucosal surfaces within the body (linings of the respiratory, digestive, reproductive, or urinary tracts) or epithelial surfaces on the outside of the body (areas of skin that are either undamaged or compromised due to insect bites, cuts/scrapes, or other wounds).

Transmission of Microorganisms

Transmission of microorganisms occurs directly from one person to another by one or more of the following means:

- droplet contact by coughing or sneezing on another person.
- direct physical contact by touching an infected person.
- direct physical contact (usually by touching soil contamination or a contaminated surface.
- airborne transmission (if the microorganism can remain in the air for long periods).
- fecal-oral transmission (usually from contaminated food or water sources).
- contamination via intravenous drug us.
- contamination from blood given via transfusion or organ transplants.

Horizontal or Vertical Transmission

Disease can also be directly transmitted in two ways: horizontally or vertically. Horizontal disease transmission occurs from one individual to another in the same generation (peers in the same age group), and can occur by either direct contact (licking, touching, biting), or indirect contact. Vertical disease transmission involves passing a disease causing agent vertically from parent to offspring.

Pathogens must have a way to be transmitted from one host to another to ensure their species ' survival. Infectious agents are generally specialized for a particular method of transmission. Taking an example from the respiratory route, from an evolutionary perspective a virus or bacteria that causes its host to develop coughing and sneezing symptoms has a great survival advantage: it is much more likely to be ejected from one host and carried to another.

A locus is the point on the body where a pathogen enters. In droplet contact and other airborne transmission it is generally the respiratory system through the nose, mouth, or eye surfaces. In direct physical and indirect contact it is generally through a wound in the skin or through a mucous membrane. In fecal-oral transmission, it is through the mouth. In vector-borne transmission, it is at the bite or sting of the vector. Other common indirect routes include contaminated food or water.

Sexual Transmission

In sexual transmission, infection originates directly between surfaces in contact during intercourse (the usual route for bacterial infections and those infections causing sores) or from secretions (semen or the fluid secreted by the excited female). Sexually transmitted diseases such as HIV and Hepatitis B are thought to be transmitted through unprotected sexual intercourse (including anal and oral routes), contaminated blood transfusions, sharing hypodermic needles, and from mother to child during pregnancy, delivery, or breastfeeding. Bodily fluids such as saliva and tears do not transmit HIV. Oral sexual practices have increased the incidence of herpes simplex virus 1 (which is usually responsible for oral infections) in genital infections and the increased incidence of the type 2 virus (more common genitally) in oral infections. Herpes diseases that are transmitted primarily by oral means may be caught through direct contact with an infectious area of the skin.

Colonization and Growth

Infection begins when an organism successfully colonizes by entering the body, growing and multiplying from there. Most humans are not easily infected. Those who are weak, sick, malnourished, have cancer or are diabetic possess an increased susceptibility to chronic or persistent infections. Individuals who have a suppressed immune system are particularly susceptible to opportunistic infections.

Entrance to the host generally occurs through the mucosa in orifices like the oral cavity, nose, eyes, genitalia, anus, or open wounds. While a few organisms can grow at the initial site of entry, many migrate and cause systemic infection in different organs. Some pathogens grow within the host cells (intracellular) whereas others grow freely in bodily fluids. Some virulent bacteria produce special proteins that allow them to colonize parts of the host body. Helicobacter pylori is able to survive in the acidic environment of the human stomach by producing the enzyme urease. Colonization of the stomach lining by this bacterium can lead to gastric ulcer and cancer. The virulence of various strains of Helicobacter pylori tends to correlate with the level of production of urease.

Wound colonization refers to nonreplicating microorganisms within the wound, while in infected wounds replicating organisms exist and tissue is injured. All multicellular organisms are colonized to some degree by extrinsic organisms and the vast majority of these exist in either a mutualistic or commensal relationship with the host. An example of the former is the anaerobic bacteria species, which colonizes the mammalian colon, and an example of the latter is various species of staphylococcus that exist on human skin. Neither of these colonisations are considered infections.

The difference between an infection and a colonisation is often only a matter of circumstance. Non-pathogenic organisms can become pathogenic given specific conditions and even the most virulent organism requires certain circumstances to cause a compromising infection. Some colonizing bacteria, such as Corynebacteria sp. and viridans streptococci, prevent the adhesion and colonization of pathogenic bacteria. They thus have a symbiotic relationship with the host, preventing infection and speeding wound healing.

The variables involved in the outcome of a host becoming inoculated by a pathogen and the ultimate outcome include: the route of entry of the pathogen and the access to host regions that it gains, the intrinsic virulence of the particular organism, the quantity or load of the initial inoculant, and the immune status of the host being colonized. As an example, the Staphylococcus species remains harmless on the skin. But when present in a normally sterile space, such as in the capsule of a joint or the peritoneum the Staphylococcus species multiplies without resistance and creates a burden on the host.

Toxins are poisonous substances produced within living cells or organisms and can include various classes of small molecules or proteins that cause disease on contact. The severity and type of diseases caused by toxins can range from minor effects to deadly effects. The organisms which are capable of producing toxins include bacteria, fungi, algae, and plants. Some of the major types of toxins include, but are not limited to, environmental, marine, and microbial toxins. Microbial toxins may include those produced by the microorganisms bacteria (i.e. bacterial toxins) and fungi (i.e. mycotoxins).

Bacterial Toxins

Bacterial toxins are typically classified under two major categories: **exotoxins** or **endotoxins**.

Exotoxins are immediately released into the surrounding environment whereas endotoxins are not released until the bacteria is killed by the immune system. The release of toxins into the surrounding environment, regardless of when released, results in the disruption of metabolic pathways in the host eukaryote. These metabolic pathways include damaging cell membranes, disrupting protein synthesis, inhibiting neurotransmitter release, or activating the host immune system. The mechanisms of action by which toxins disrupt eukaryotic cell processes are dependent on the target. For example, the bacteria Listeria monocytogenes, associated with food-borne illnesses, specifically targets cholesterol by producing a pore-forming toxin protein, listeriolysin O. This exotoxin affects intracellular processes and creates unregulated pores within the cell membranes of the host. Another example of an exotoxin includes an enterotoxin produced by the bacteria *Staphlycoccal aureus. S. aureus* can produce staphylococcal enterotoxin B (SEB), associated with intestinal illness, which promotes activation of the immune system. Upon activation of the immune system, the release of large amounts of cytokines, inflammatory related molecules, causes significant inflammation. Lastly, an example of an endotoxin, includes the protein lipopolysaccharide (LPS) produced by gram-negative bacteria. The LPS is a component of the bacteria's outer membrane and promotes structural integrity. Upon destruction of the membrane by an immune response, the LPS is released and functions as a toxin.

However, bacterial toxins are also currently serving as new sources for potential drug development. Toxins have been shown to exhibit anticancer characteristics and fight again microbial virulence. The investigation of toxins as potential medicinal compounds is currently underway.

Mycotoxins

Mycotoxins are the classes of toxins produced by fungi. Mycotoxins are numerous and production of a specific mycotoxin is not restricted to one specific species. Mycotoxins are secondary metabolites that are toxic to humans and produced by fungi. There are various types of mycotoxins including, but not limited to, aflatoxins, ochratoxins, citrinin, and ergot alkaloids.

Aflatoxins

Aflatoxins are a type of mycotoxin that are produced by certain strains of *Aspergillus* fungi. The aflatoxins are further broken down into types: AFB1, AFB2, AFG1, and AFG2. These strains are present in a wide range of agricultural commodities associated with tropic and subtropic zones. These commodities include species of peanuts and corn. The most potent toxin is AFB1 and it is associated with carcinogenic effects.

Ochratoxin

Ochratoxin is a type of toxin produced by both *Penicillium a*nd *Aspergillus* species. Ochratoxins are further classified in types A, B and C and differ in structure. Ochratoxins have demonstrated carcinogenic properties and are often found in beverages such as beer and wine, as the fungal species which produce ochratoxins are often found on the plants used to produce these products.

Citrinin

Citrinin is a mycotoxin that has been isolated in numerous species of both *Penicillium* and *Aspergillus.* Many of these fungal species are utilized in food processing and are often found in foods including cheese, wheat, rice, corn, and soy sauce. Citrinin is known to function as a nephrotoxin, indicating it has toxic effects on kidney function.

Ergot Alkaloids

Ergot Alkaloids are specific compounds that are produced as toxic alkaloids in *Claviceps,* a group of fungi associated with grasses, rye, and related plants. The disease caused by ingestion of this fungi is called ergotism. Ergotism is characterized by detrimental effects on the vascular system in particular, including vasoconstriction of blood vessels resulting in gangrene, and eventually, limb loss if left untreated. Additionally, ergotism can present as hallucinations and convulsions as ergot alkaloids target the central nervous system. Due to the vascular system effects of ergot alkaloids, they have been used for medicinal purposes. they have been used for medicinal purposes.

Direct Damage

Direct damage to the host is a general mechanism utilized by pathogenic organisms to ensure infection and destruction of the host cell. The pathogenic organism typically causes damage due to its own growth process. The promotion of disease is characterized by the ability of a pathogenic organism to enter a host and inflict damage and destruction onto the host cell. The pathogenic organism must exhibit specific characteristics that promote its growth into a host cell including, but not limited to, the ability to invade, colonize, and attach to host cells.

The ability of a pathogen to gain entrance to a host cell is fundamental in the ability of the pathogen to promote and cause disease. The ability to manipulate the process of phagocytosis is a mechanism often utilized by bacteria to ensure they effectively invade a host. Phagocytosis is a process utilized by phagocytes (white blood cells) as a defense mechanism to protect from foreign bodies. The phagocytes engulf invaders and present them to additional factors within the immune system that result in their destruction. However, a successful and destructive pathogen often exhibits the ability to evade phagocytosis.

The mechanism(s) utilized by pathogens to avoid phagocytosis include avoiding both contact and engulfment. Pathogens that exhibit the ability to avoid contact utilize various processes to accomplish this, including: the ability to grow in regions of the body where phagocytes are incapable of reaching; the ability to inhibit the activation of an immune response; inhibiting and interfering with chemotaxis which drives the phagocytes to site of infection; and ‘tricking’ the immune system to identify the bacteria as ‘self. ‘ Additional mechanism(s) by which bacteria can avoid destruction is by avoiding engulfment. This is accomplished by the ability of the bacteria to exhibit produce molecules that interfere with the phagocytes ability to internalize the bacteria. Molecules that interfere with this process include certain types of proteins and sugars that block engulfment.

Once the pathogen has successfully evaded engulfment and destruction by the immune system, it is detrimental because the bacteria then multiply. Often times, bacteria will directly

attach themselves to host cells and utilize nutrients from the host cell for their own cellular processes. Upon the use of host nutrients for its own cellular processes, the bacteria may also produce toxins or enzymes that will infiltrate and destroy the host cell. The production of these destructive products results in the direct damage of the host cell. The waste products of the microbes will also damage to the cell. Examples of bacteria that will damage tissue by producing toxins, include, *Corynebacterium diphtheriae* and *Streptococcus pyogenes.* Specifically, *Corynebacterium diphtheriae* causes diphtheria, which isa disease of the upper respiratory tract. It produces a toxin, diphtheria toxin, which alters host protein function.

Type III and Type IV Secretion

Type III and IV secretion systems are utilized by pathogenic bacteria to transfer molecules from the bacterial cell to the host cell.

In regards to pathogenecity, secretion in microorganisms such as bacterial species involves the movement of effector molecules from the interior of a pathogenic organism to the exterior. The secretion of specific molecules allows for adaptation to occur, thereby promoting survival. Effector molecules secreted include proteins, enzymes or toxins. The mechanisms by which pathogenic bacteria secrete proteins involve complex and specialized secretion systems. Specifically, Type III and Type IV secretion systems are utilized by gram-negative pathogenic bacteria to transport proteins that function as pathogenic components.

Type III Secretion Systems

Type III secretion systems are characterized by the ability to inject a protein directly from the bacterial cell to the eukaryotic cell. It is often compared to the bacterial flagellar basal body which functions as a motor unit and extracellular appendage that is comprised of numerous proteins. The pathogenic bacteria which exhibit this capability contain a critical structural component, considered a protein appendage, that allows the injection of the protein into the host cell. The type III secretion system involves the formation of a complex, roughly ~20 proteins, that reside within the cytoplasmic membrane of the bacterial cell. The process of injecting or transferring the secretory protein from the bacterial cell to the host eukaryotic cell requires a membrane-associated ATPase. Certain species of pathogenic bacteria, including: *Salmonella, Shigella, Yersinia* and *Vibrio* exhibit type III secretion systems. The system is regulated by Ca2+ concentrations which regulate the opening and closing of gates present in the membrane by which the type III secretion system complexes can utilize for translocation. For example, in Salmonella, most commonly associated with *Enteritissalmonellosis,* or food poisoning, the bacteria injects a toxin, AvrA, that inhibits activation of the innate immune system of the host. The mechanism by which AvrA is injected involves exact and proper assembly of proteins which promote invasion of the host cell. Misalignment or improper organization of proteins involved in the type III secretion system prevent injection of secretory substances from the pathogen into the host cell. Another pathogen, *Shigella,* which utilizes type III secretion systems is able to successfully carry out its infection by evading the immune system. The movement between neighboring cells and evading the immune system, enhances its ability to inject its secretory protein into the host cell.

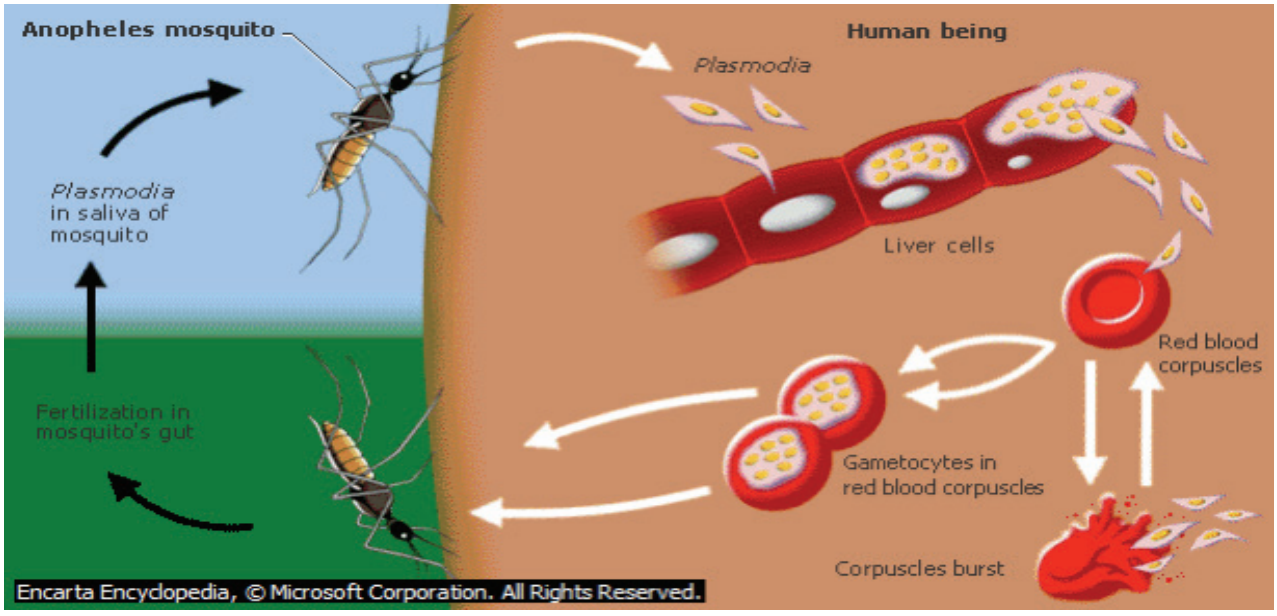
Type IV Secretion Systems

Type IV secretion systems are characterized by the ability to transfer secretory molecules via a mechanism similar to the bacterial conjugation machinery. The type IV secretion systems can either secrete or receive molecules. The bacterial conjugation machinery allows transfer of genetic material to occur via direct cell-to-cell contact or by a bridge-like apparatus between the two cells. The type IV secretion system utilizes a process similar to this. However, the exact mechanism(s) this process utilizes is unknown but there is a general understanding.

This specific secretion system can transport both DNA and proteins. An example of a pathogenic bacteria that utilizes the type IV secretion system is ***Helicobacter pylori. H. pylori,*** most commonly associated with stomach ulcers, attaches itself to epithelial cells within the stomach, then via a type IV secretion system, injects a secretory molecule. The secretory molecule injected into the epithelial cells is an inflammation-inducing agent derived from their own cellular wall. The secretory molecule, peptidoglycan, is recognized by the host system as a foreign substance and activates expression of cytokines which promotes an inflammatory response. This inflammatory response of the stomach is a key characteristic of individuals with ulcers. Peptidoglycan is not the only secretory molecule transferred to the stomach epithelial cells but additional proteins, such as CagA, which function in disruption of host cell cellular activities can be transferred as well.

Negative Impacts of Parasitic Relationships

- *Malaria Parasite in a human body (Endoparasite)*. Malaria parasite is carried by the female anopheles mosquitoes, which act as a vector. The mosquito transmits the parasite, which is a protozoan from the genus plasmodium, into a human when it sucks blood. The parasite then enters the liver and multiplies by asexual reproduction. These mass production of parasites then invade red blood cells and destroy them causing anaemia and malaria in humans.



Human Head Lice (Ectoparasite). The lice lives on human hair, have piercing and sucking mouth parts and lays eggs. They feed on blood by piercing the head and sucking blood with their mouth parts. The beaten parts turn into sores and can cause fever when not treated quickly.

Disease and Disorders from Microbes on other Living Things

The table below shows some of the many diseases caused by microbes on humans. Can you think of other diseases caused by microbes on man, plants and animals?

Bacterial Diseases	Viral Diseases	Fungal Diseases	Protista Diseases
Tuberculosis	HIV	Athlete's Foot	Malaria
Cholera	Chicken pox	Ringworm	
Tooth Decay	Measles	Dandruff	
	Influenza	Fungal Pulmonary disease	
	Ebola	Candidiasis	

Prions and Viroids

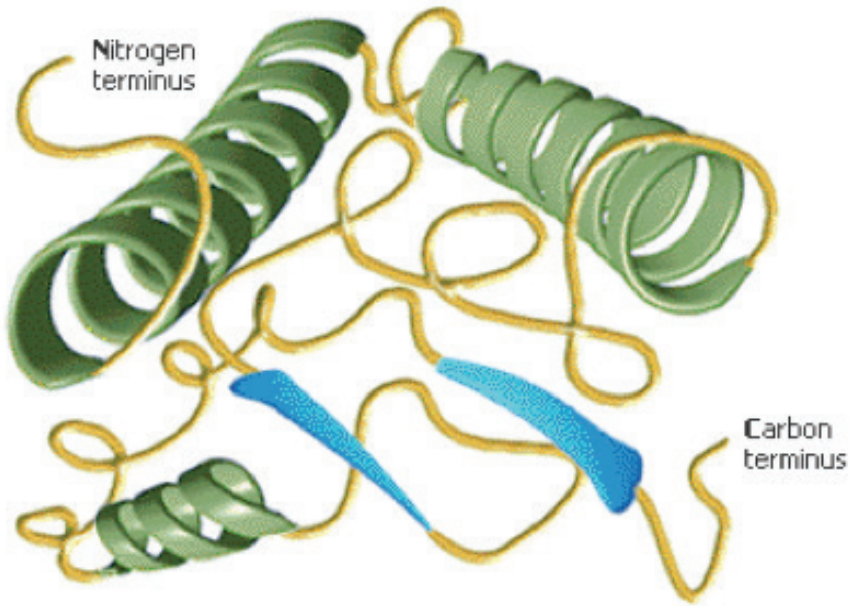
Content Standard:	**11.2.2** Investigate the diversity of microorganisms, the relationships that exist between them and their effect on personal and community health.
Benchmarks	**11.2.2.7** Investigate the characteristics and behaviours of prions and viroids

Essential Question	1. What are the differences between the structure of a virus, a viroid and a prion? 2. What effects do prions and viroids have on humans and animals.
Learning Objective	• Explain what prions are, describe their structures and explain their effects on humans and animals • Explain what viroids are, describe their structures and explain their effects on plants.
Knowledge	• What prions are, their structure and their effects on humans and animals. • What viroids are, their structure and their effects on plants.
Skills	• Describe the structure of prions and their effects on humans and animals. • Describe the structure of viroids and their effects on humans and animals
Atitudes & Values	• Appreciate the work of viroids and prions.

Content Background

Prions – Their Effects on Humans and Animals

Prions are infective agents that contain abnormal protein and they forms part of the human brain and tissue. It is believed to be found in sheep, which eventually makes its way into humans through food products. Below is structure of a prion found in a sheep. Prion is the cause of scrapie, which is the degeneration of brain tissue, in sheep and Creutzfeldt-Jakob Disease (CJD), one of a range of degenerative diseases of the nervous system in humans.



The table below summarises some of the diseases caused by prions and their distribution.

Kuru	Human beings	Papua New Guinea
Creutzfeldt-Jakob disease		
(iatrogenic, sporadic, or familial)	Human beings	Worldwide
Gerstmann-Sträussler-Scheinker syndrome	Human beings	Worldwide (rare)
Scrapie	Sheep, goats	Widely distributed in sheep. Not found in Argentina, Australia, New Zealand, Uruguay
Chronic wasting disease	Mule, deer, elk	North America
Transmissible mink encephalopathy (TME)	Farmed mink	
Bovine spongiform encephalopathy (BSE)	Cattle	North America, Europe

Viroids – Their Effects on Plants

Viroids are tiny infectious particle that measure about 1/10 the size of the smallest viruses. They contain only RNA and lack a protein coat. They can be transmitted from one plant to another and they are the main cause of diseases in higher plants, causing some to have stunted growth, discolouration and eventually death. Viroids have no genes that enable them to make protein and so are completely dependent on the host cell for replication.

Treatment & Prevention of Diseases Caused by Microbes

Content Standard:	**11.2.2** Investigate the diversity of microorganisms, the relationships that exist between them and their effect on personal and community health.
Benchmarks	**11.2.2.6** Investigate the transmission, symptoms, consequences and treatment of common sexually transmitted infections and diseases in humans

Essential Question	1. What causes infectious diseases? 2. How does the body respond during an infection? 3. How can infectious diseases be prevented or diagnosed and treated?
Learning Objective	• Explain the cause of an infection. • Discuss the effect of the types of medicines used in managing some common diseases caused by bacteria, fungi, protista and virus.
Knowledge	• Microorganisms and viruses cause various diseases. • Some diseases caused by microorganisms may be waterborne, such as typhoid; or airborne, such as influenza • Effect of the types of medicines used in managing some common diseases caused by, bacteria, fungi, protista and virus
Skills	• Give evidence that microorganisms exist. • Identify diseases caused by microorganisms and viruses and enumerate ways to prevent them • Describe healthy habits to prevent the spread of viruses that cause diseases. • Explain why clean water and air are important. • Report gathered information on the effects of cigarette smoking, alcohol intake and use of prohibited drugs. • Produce creative work to inform others about the dangers of the above mentioned un-healthy habits and encourage others to stay away from them • Evaluate the types of medicines used to treat and prevent diseases caused by bacteria, fungi, protista and virus.
Atitudes & Values	• Appreciate the importance of medicines to treat and prevent disease • Appreciate the importance of maintain a healthy community

Content Background

A disease is any change that impairs the function of an individual in some way; that is, it harms the individual. A disease can be due to any one of many different factors. Inherited diseases are passed on from parents to children via the genetic material in sperm and eggs.

Micro-organisms, e.g. viruses and bacteria, cause diseases which disrupt the equilibrium of physiological systems in humans. This topic explores how some infectious diseases are diagnosed and treated.

An *infectious disease* is one caused by *pathogens.* A pathogen may be:

- Non-cellular agents, such as prions or viruses
- Cellular agents, or microorganism, such as bacteria or fungi
- A multicellular organism, such as worm.

Infections refer to a pathogen being present in a host but infectious does not necessarily equate with disease. A particular micro-organism may be present in a host but if it is not causing damage to host cells then the micro-organism is not being pathogenic. Some micro-organism may be part of the natural flora of the body.

How pathogens enter the body?

1. Through Natural Openings in the body

Many microbes can enter the body through its natural openings. The nose, mouth, urinary passage , anus and vagina are all possible entrances for pathogens.

Each of these openings leads to a tube lined with a soft , moist mucous membrane. This mucus often contains enough food for microbes to live on. Fortunately, if a person is healthy, these membranes are able to resist the penetration of most microbes. But if a person is tired, weak, run-down or not well-fed then this resistance will be low.

The way in which pathogens is spread or transmitted determines which of these openings it enters.

a) The *nose* is the entrance through which airborne pathogens enter the body. When we breathe, tiny droplets of water or dust containing pathogens are taken into our respiratory system (lungs and bronchial tubes). In this way the pathogens causing respiratory diseases such as pneumonia, influenza, tuberculosis and the common cold enter the body

b) The *mouth* provides entrance for microbes present in drinking water and food, and also for microbes transferred to the lips by contaminated fingers or cups and spoons and forks. Pathogens causing gastro-intestinal diseases (e.g. cholera, typhoid, dysentery, food poisoning) enter in this way.

c) The *sexual organs.* The bacteria causing the venereal diseases, syphilis and gonorrhea, enter the body through the penis or vagina during sexual intercourse. Other infections not associated with sexual activity can also enter through these openings.

2. Through the Skin

a) Unbroken skin forms a natural barrier to most microbes. Fortunately very few can penetrate the skin directly. The bacteria that cause boils and pimples invade hair follicles and cause infections there. Spores of the fungi causing grille and athlete's foot (tinea) and the bacteria causing leprosy can pass directly through the skin.

b) Broken skin provides entrance for many pathogens. Skin can be broken in several ways:

- Cuts and wounds allow bacteria such as those causing blood poisoning and tetanus to enter the body.
- Bites, mostly by insects, inject the pathogens causing diseases such as malaria and dengue (mosquito) and rabies (dog).

Defending the body against pathogens

Our bodies are surrounded by microbes all the time. Yet with the exception of the alimentary canal and the skin, our bodies are free from these organisms, except when we surfer from disease. A dead body soon decays and decomposes due to the action of microbes, but a living body is able to resist this action.

The human body has several methods of defence to prevent infection by:

- Making it difficult for microbes to enter.
- Using methods of destroying those microbes that do get in.

1. External defences - these make it difficult for microbes to enter the body.

Protectors	Methods of Protection
Unbroken skin	The thickness of the surface layer of cells prevents the entrance of bacteria and most pathogens
Mucous membranes lining the mouth, nose, eyes and intestinal tract.	Mucus is a slimy substance containing the enzyme lysozyme which destroys some bacteria by breaking down their cell walls. It also acts as a barrier and it is continually flowing it prevents bacteria from doing much damage in any one place.
Eyelids, eyelashes, tears	Eyelids and eyelashes prevent the entrance of bacteria. Tears wash away and also hairs in the nose destroy those that do get in as they also contain lysozyme.
Hairs in the nose	The hairs point outwards and filter dust particles and bacteria attached to them from the air we breathe.
Cilia in the bronchial	These small hair-like structures are constantly moving and forcing foreign substance e.g. bacteria towards the mouth so that they may be expelled.
Various reflex actions such as sneezing and coughing	Those reflexes remove irritating agents from the throat.
Secretions of the digestive system	Saliva in the mouth; gastric juice in the stomach; bile from the liver can all destroy bacteria
Secretions of the sexual organs	Secretions of the vagina and the penis kill most bacteria (except those causing VD)
Formation of clots	Contact with air (e.g. wounds) causes the blood to clot and seal off the wound so that more microbes cannot enter.

2. Internal Defences- these are methods by which any microbes getting in to the body are destroyed or made harmless.

a) Phagocytes –these are white blood cells, either granulocytes or monocytes. These cells are able to move independently and are found in the blood and the surrounding tissues. They destroy microbes by 'eating' them. They surround and engulf the microbe , absorb it and then digest it.

If a microbe enters the body(e.g. through a wound or cut), phagocytes from all over the body move to the damaged area to fight the infection. Phagocytes are made in the bone marrow, the spleen and the lymph nodes and are stored in special parts of the liver.

b) Antibodies. These are large protein molecules which are made by other types of white blood cells called lymphocytes. They are found in the blood.
When 'foreign ' protein, such as protein found on the surface of bacteria or in the toxins (poisons) they release, gets into our bodies, the lymphocytes are stimulated to make antibodies. These antibodies combine with foreign protein (or antigens as they are called) and in doing so either destroy it, make it harmless, or make it more easily caught and eaten by the phagocytes.

Each type of anti-body can only react with the particular type of foreign protein (or antigen) which caused its production. If another type of antigen enters the blood, the existing antibodies have no effect upon it. New antibodies to match the new antigens must be produced. E.g. anti-bodieseffective against bacteria causing T.B. will have no effect on those causing pneumonia.

Name of the disease	Pathogen which causes the disease	Signs and symptoms of the disease	Method of transmission of the disease	Control of the disease	
				Prevention	Treatment
Pneumonia	Bacteria (pneumonococcus	Chills, fever, chest pains	• By air (droplet infection) • By direct mouth contact • Contact with fresh discharge from nose or throat of infected	Avoid overcrowding and poor ventilation	Penicillin or other antibiotics and sulphur drugs
Influenza	Virus	Fever, chills, headache, coughing, sore throat	• By air(droplet infection) • By direct contact • Contact with fresh discharge from nose or throat of infected persons.	-Avoid overcrowding and poor ventilation -vaccination	Warmth and rest, antibiotics to prevent secondary infection by bacteria.
Malaria	Protozoan (Plasmodium)	Alternate fever, chills, headache, nausea,anaemia, enlarged spleen.	• by female Anopheles mosquitoes	Elimination of the Anopheles mosquitoes	Anti-malaria drugs (e.g. chloroquine)
Diarrhoel diseases (Gastroenter-ritis)	Bacteria (eg. Salmonella also some viruses and protozoa)	Diarrhea, nausea, fever, vomiting stomach pains	• In food especially meat, eggs and milk products	Thorough cooking, proper storage and hygienic handling of food Good sanitation	-Take plenty of fluids -Chlorophenical antibiotics in severe cases

Name of the disease	Pathogen which causes the disease	Signs and symptoms of the disease	Method of transmission of the disease	Control of the disease	
				Prevention	Treatment
Tuberculosis (T.B	Bacteria (Tubercule bacillus)	Cough, spitting blood, lung scars, fever, swollen glands	• -by air (droplet infection) -in food e.g. milk	Chest X rays Vaccination Avoid over crowding	Antibiotics e.g. streptomycin -rest and fresh air
Measles	Virus	Red skin rash, itchy eyes, fever. Severe amongst malnourished children.	• -by air (droplet infection) • -by contact with nose and throat discharge and urine of infected persons.	Vaccination	Warmth and rest. (no specific treatment)
Whooping cough	Bacteria (bacillus)	Violent coughing, "whooping" as breath is drawn in. Mainly in children under	• -by air (droplet infection) • -by contact with nose and throat discharge of infected persons.	Vaccination	Antibiotics
Leprosy	Bacteria (bacillus)	Lumps and nodules on the skin, patches without feeling, disfiguration of the face.	• -through skin and membranes of the nose. • -by close contact with infected persons over a long period of time.	Isolation of serious cases.	Drugs e.g. sulphone and dapsone.
Hepatitis (infective)	Virus	Fever, weakness, nausea, jaundice (yellow colour), loss of appetite	• by direct contact • -possibly by air • -by contact with faeces or urine of an infected person.	Good sanitation and personal hygiene habits	-immunization (injection with immune serum globulin)

Name of the disease	Pathogen which causes the disease	Signs and symptoms of the disease	Method of transmission of the disease	Control of the disease	
				Prevention	Treatment
Poliomyelitis (infantile paralysis)	Virus	Paralysis of muscles: inability to move	• -by direct contact with throat discharge of an infected persons.	Vaccination (oral vaccine)	Iron lung for lung muscles to enable patient to breath.
Meningitis	Bacteria (coccus)	Fever, intense headache, nausea, vomiting, stiff neck. Possibly a rash, deuterium and coma.	• -by air (droplet infection) • -By contact with nose and throat discharge of infected persons.	Avoid overcrowding and poor ventilation.	Penicillin or other antibiotics
Impetigo	Bacteria	Sores with scabs, usually on head (face). Common on malnourished children.	• -by direct contact with persons. • -by flies	-Good diet -Good personal hygiene habits -Avoid contact with infected persons	-Gentian violet - penicillin
Ulcers	Bacteria (bacilli)	Large, pus-filled, usually open sores.	• -through cut or sores • -by flies	-Good diet -Good personal hygiene habits	-wash with Eusol and cover - penicillin
Grille	Fungus	Itchy, discolored skin, patches, rough flaky skin.	• By direct contact with an infected person or their clothes, bedding etc.	-Avoid contact with infected persons or their personal possessions -wash regularly	-Whitfield's ointment (Benzoic acid) -Grille lotion (salicylic acid) -Griseofulvin tablets
Scabies	A mite (not a microbe)	Itchy lumps, especially between fingers, wrist, elbows etc.	• Direct contact	Good personal hygiene habits	-wash thoroughly -paint with benzyl benzoate
Venereal diseases VD syphilis	Bacteria (spiroachaete)	Painless Sore at place of infection, rash and sore throat.	• Sexual intercourse with an infected person.	Avoid sexual intercourse outside marriage	Penicillin and other antibiotics e.g. tetracycline or chloramphenicol
Gonorrhea	Bacteria (coccus	Itching and burning sensation when passing urine, yellow discharge. Less obvious in women than men.	• As for syphilis	As for syphilis	As for syphilis

The Role of Medicine in the Management of Infectious Diseases.

Common STIs in Papua New Guinea

<table>
<tr><th>Infection (STDs)</th><th colspan="2">Symptoms</th><th>Treatment</th><th>Medical problems if STI not treated</th></tr>
<tr><td colspan="5">Bacterial STDs</td></tr>
<tr><td rowspan="3">Gonorrhoea (bacteria)</td><td>In Women</td><td>In Men</td><td rowspan="3">• Cured with antibiotics</td><td rowspan="3">• Infertility or sterility
• Blindness in babies if woman giving birth has gonorrhoea
• Painful swelling of joints
• Damage to heart and liver</td></tr>
<tr><td>Pain when urinating</td><td>Heaviness, pain and inflammation of the testicles. Heavy pus-like discharge and pain urinating.</td></tr>
<tr><td colspan="2">Many people have gonorrhoea but have no symptoms at all. A person without any symptoms can still pass the infection on and may develop complications from the infections.</td></tr>
<tr><td rowspan="2">Chlamydia (bacteria)</td><td>In Women</td><td>In Men</td><td rowspan="2">• Cured with antibiotics</td><td rowspan="2">• Infertility or sterility
• Eye damage to babies if woman giving birth has Chlamydia</td></tr>
<tr><td>Usually no symptoms increased vaginal discharge or irritation, irregular bleeding.</td><td>Usually no symptoms sometimes pain during urination and discharge from penis. Can cause heaviness and inflammation of the testicles and a small, hard area of painful swelling at the base of the testicles.</td></tr>
<tr><td>Donovanosis (bacteria)</td><td colspan="2">Small red bumps on the penis or vagina and around the anus which bleed easily. The sores might be painful swelling at the base of the testicles.</td><td>• Cured with antibiotics</td><td>• Ulcers will become larger and parts of the genitals will be destroyed
• Infection may spread to other parts of the body</td></tr>
</table>

Infection (STDs)	Symptoms	Treatment	Medical problems if STI not treated
Bacterial STDs			
Syphilis (bacteria)	*3 Stages* 1. Primary syphilis: A small pimple appears where the bacteria entered the body, usually on the penis or inside o f the vagina. A colourless, infectious liquid oozes from the pimple. The sore disappears by itself without medication, but the bacteria will spread to other parts of the body. 2. Secondary syphilis: A few weeks or months after the sore disappears the following symptoms may appear: • Fever • Swelling in the groin, armpits and neck • Sores appear in the most parts of the body (mouth, genitals and armpits) • Skin develops a dry scaly rash These symptoms disappear within a couple of weeks if left untreated, but the bacteria are still in the body. 3. Tertiary syphilis: The infection continues to attack the body and may affect organs such as the heart, brain and bones.	• Cured with antibiotics	• If left untreated, syphilis may result in blindness, birth defects or stillbirth, heart trouble, poor mental health and death
Viral STDs			
HIV (human immunodeficiency virus)	Infected people show no symptoms for many years (may have flu-like symptoms shortly after infection). Lifelong damage to immune system and AIDS conditions begin between 1 and 20 years after infection.	• No vaccine or cure • Antirettroviral therapy keeps people healthier for longer	• AIDS – related illnesses such as TB, pheumonia and diarrhea
Genital herpes (virus)	Discomfort or itching with small blisters appearing in infected areas of the skin, usually the genital area. Fever can occur. After a few days, blisters form a thin yellowish crust which disappears in 10-12 days. Blisters can recur.	• Symptoms can be treated with drugs, but the virus remains in the body and the infection cannot be cured.	• Urinary problems, possible meningitis in the most severe cases • Increased risk of cancer

Infection (STDs)	Symptoms		Treatment	Medical problems if STI not treated
Viral STDs				
Genital warts (human papilloma virus, or HPV)	Tiny painless lumps (cauliflower-like) around vagina, penis or anus. Sometimes no symptom.		• Treated with freezing or special paint • Virus remains in the body and can reappear later	• Linked to cervical cancer
Fungal STDs				
Thrush (Candidia – yeast)	In Women	In Men	• Antifungal creams and other natural options	
	Creamy thick discharge, smelly, itchy and inflamed vagina. Can also be caused by stress or use of antibiotics.	Itchy rash on penis or anus. Can be found in mouth and throat.		

Source: *Common STIs in Papua New Guinea, Gr. 11 Biology Save Book, pages 298-300*

Autotrophic Nutrition

Content Standard:	**11.2.3** Investigate the process of making food in plants and how animals get their energy.
Benchmarks	**11.2.3.1** Explain the different types of autotrophic nutrition. **11.2.3.2** Investigate and analyse the importance, the raw materials and the products of photosynthesis. **11.2.3.3** Identify and explain the site, chemistry and the conditions required for photosynthesis
Essential Question	1. How do plants feed? 2. How do plants make their food? 3. What factors affect the rate of photosynthesis?
Learning Objective	• State and define the two main types of nutrition as well as describe the main classes of nutrients. • Explain what autotrophic nutrition is and discuss the process of photosynthesis, both dark and light stages. • State the types of organisms that carry out photosynthesis and describe the functions of their structures that enable them to do so. • State and explain factors that affect the rate of photosynthesis.
Knowledge	• The two main types of nutrition and the main classes of nutrients. • Autotrophic nutrition and the process of photosynthesis, both dark and light stages. • Types of organisms that carry out photosynthesis and the functions of their structures that enables them to do so. • Factors that affect the rate of photosynthesis.
Skills	• Evaluate the two main types of nutrition and describe the classes of nutrients. • Evaluate both the dark and light stages of photosynthesis in autotrophic nutrition. • Distinguish organisms that carry out photosynthesis by the presence of chloroplasts in their structures. • Evaluate the factors that affect the rate of photosynthesis.
Atitudes & Values	• Appreciate the role of plants as the main source of food and oxygen production. • Be responsible and take care of plants • Promote a healthy lifestyle through proper diet

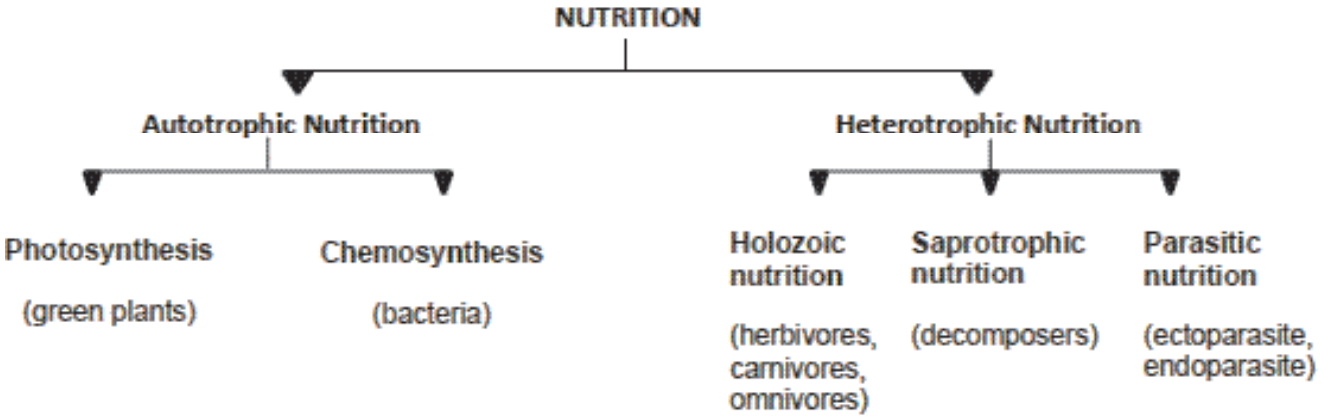
Content Background

What is Nutrition?

Nutrition is the study of the different types of feeding modes that organisms use to survive. There are two main types of nutrition.

1. Autotrophic Nutrition	process in which plants combine inorganic substances, especially carbon dioxide and water, to make an organic compound called glucose as its food. This is done using energy from the sun in the process called photosynthesis.
2. Heterotrophic Nutrition	process in which animals obtain ready-made food from the plants and other animals.

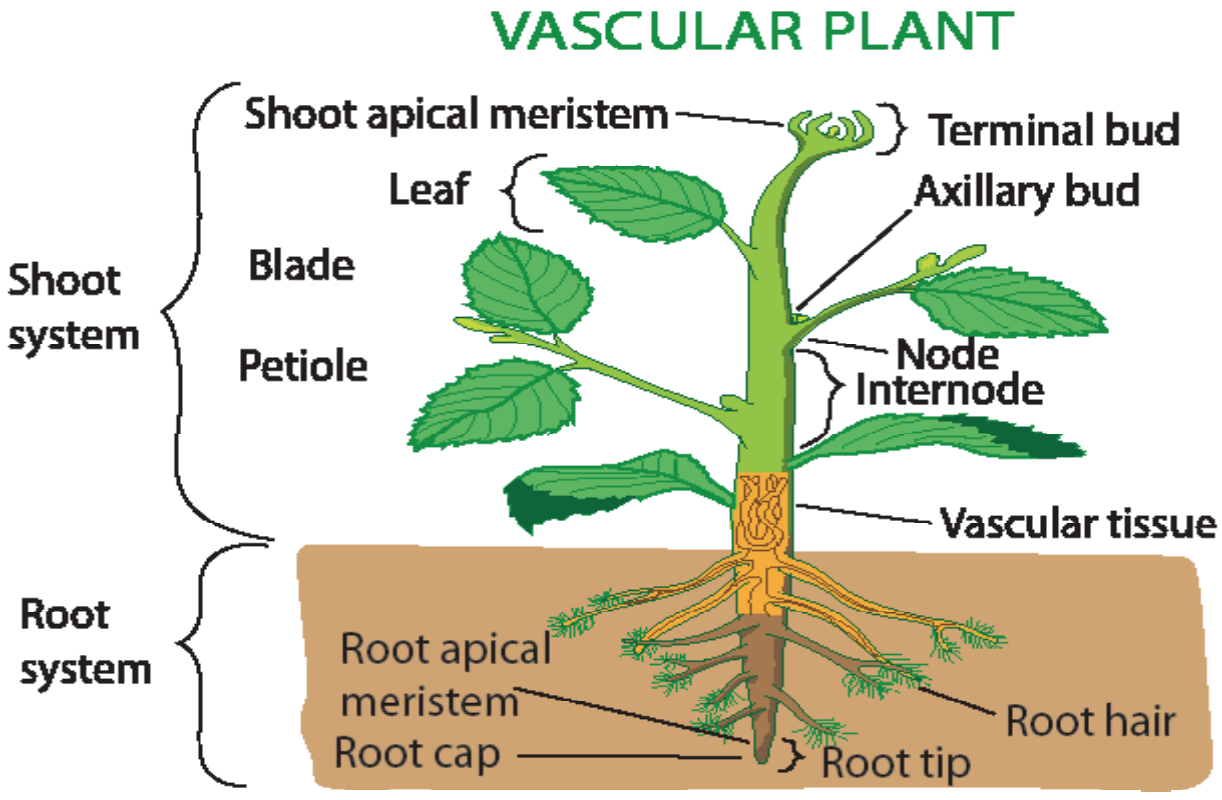
They can be further classified as shown below.



Autotrophic Nutrition & Photosynthesis

Plants have a different mode of nutrition compared to animals. Plants are called food producers or autotrophs which means 'self-feeding'. They can produce their own food from the organic substances available in their surroundings using light. *Photosynthetic autotrophs* include green plants, algae and some bacteria. These autotrophs are able to harness solar energy from the sun and combine this energy with other materials from the environment to form organic substances, such as glucose in a process called *photosynthesis*.

Autotrophic nutrition is carried out by plants where they combine inorganic substances such as water from the soil and carbon dioxide from the air in the presence of light to produce sugar, which is an organic substance and oxygen gas as a by-product. These events take place in a process called photosynthesis.



Before we look at the process of photosynthesis, let us consider the structure of a plant. A plant is made up of two parts: the Shoot System and the Root System. Shoot system remains above the ground and is exposed to sunlight and carbon dioxide while the root system is hidden beneath the ground and is exposed to water and minerals. The root system anchors the plant to the ground while the shoot system carries out photosynthesis and moves its products to all parts of the plant.

Photosynthesis

During photosynthesis, plants absorb water through their roots while carbon dioxide enters the leaf through openings called stoma (singular: stomata). The green pigment of the leaf called chlorophyll traps the sunlight which is used in splitting the water molecule into hydrogen ions and oxygen molecules. The hydrogen ion then reduces carbon dioxide gas to produce carbohydrate while oxygen molecule is released as a by-product. All these take place in series of steps in two main stages called the *light* and the *dark* stages. However, for now, they can all be summarized in the simple balanced equation below:

$$\text{Carbon Dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{Glucose} + \text{Oxygen}$$

$$6CO_2\,(g) + 6H_2O\,(l) \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6\,(aq) + 6O_2\,(g)$$

The Two Stages of Photosynthesis

i. Light Stage

This stage occurs in the thylakoid membranes of the chloroplast and it has a two-fold function:

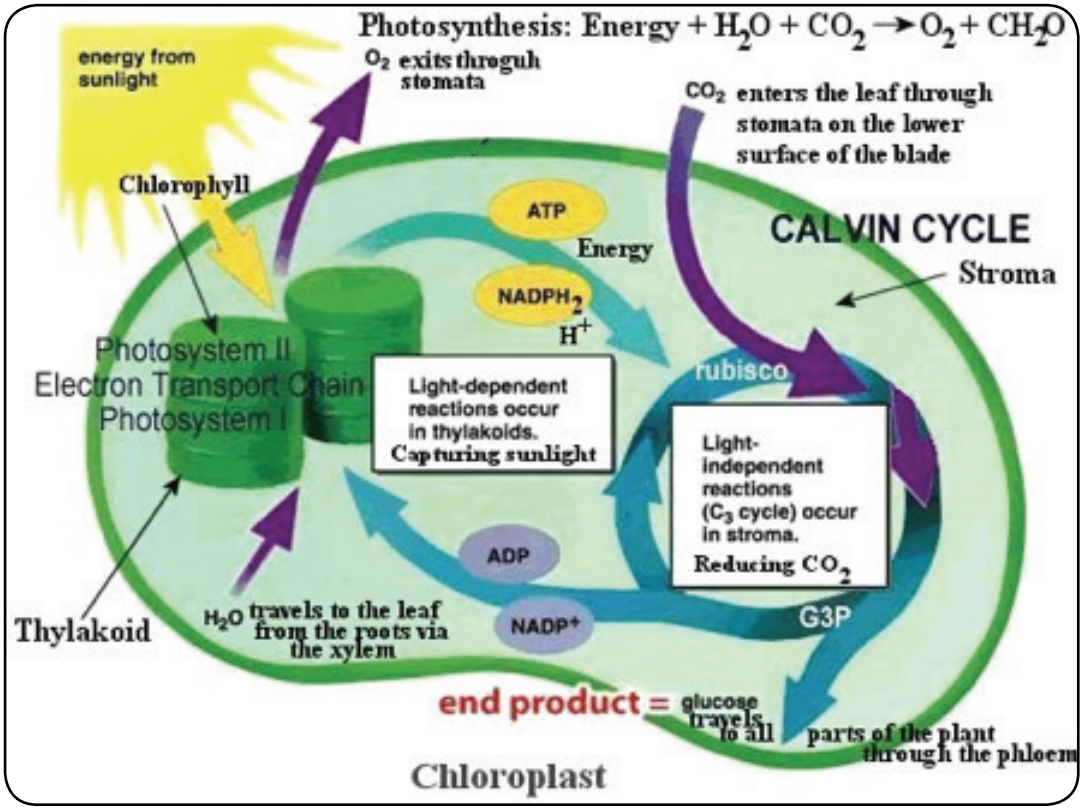
a. Splitting of water molecule, in the process called photolysis, to provide protons (H+) for the reduction of carbon dioxide to carbohydrate (which is stored as starch in the tubers of the plants). Oxygen is also given off as a by-product.

b. Formation of NADPH and ATP which are needed for the production of glucose in the dark stage.

ii. Dark Stage

This stage occurs in the stroma of the chloroplast. In here, chains of reactions occur in what is known as the Calvin Cycle. The reactions of the Calvin cycle add carbon (from carbon dioxide in the atmosphere) to a simple five-carbon molecule called RuBP. These reactions use chemical energy from the NADPH and ATP that were produced in the light reactions. The final product of the Calvin Cycle is glucose.

These stages are summarised in the next page:



Features of a Leaf

In order to photosynthesise efficiently a leaf needs:

- A method for exchange of gases between the leaf and its surroundings
- A way of delivering water to the leaf
- A system for the removal of the glucose so that it can be transported to other parts of the plant
- An efficient means of absorbing light energy

Part	Function
Waxy cuticle	Reduce water loss. It is thicker on the upper surface since this surface is usually more exposed to the warming rays of sunlight.
Upper epidermis	A complete covering usually one cell thick. It is transparent to allow the free passage of light and has the major function of preventing the entry of disease-causing organisms such as bacteria and fungi.
Palisade mesophyll	Tall thin cells arranged in columns and separated by very narrow air spaces. Cells contain many chloroplasts and the dense packing of these cells allows the absorption of the maximum amount of light energy.
Vein	The transport system in and out of the leaf. The xylem vessels deliver water and mineral salts and the phloem sieve tubes carry away the organic products of photosynthesis such as glucose.
Spongy mesophyll	These cells are rather loosely packed and covered with a thin layer of water. The air spaces between them aid the diffusion of gases through the leaf. The air spaces are saturated with water vapour so water diffuses out of the leaf.
Stomata	These minute pores allow the entry of carbon dioxide and the exit of oxygen. They are mainly present in the lower epidermis. This surface is less exposed to the Sun's radiation so that evaporation of water is kept to minimum. The stomata can be closed when no carbon dioxide intake is needed (e.g. in the dark)

Energy Production

Autotrophs produce their own energy by one of the following two methods:

- Photosynthesis - Photoautotrophs use energy from sun to convert water from the soil and carbon dioxide from the air into glucose. Glucose provides energy to plants and is used to make cellulose which is used to build cell walls. E.g. Plants, algae, phytoplankton and some bacteria. Carnivorous plants like pitcher plant use photosynthesis for energy production but depend on other organisms for other nutrients like nitrogen, potassium and phosphorous. Hence, these plants are basically autotrophs.

- Chemosynthesis - Chemoautotrophs use energy from chemical reactions to make food. The chemical reactions are usually between hydrogen sulfide/ methane with oxygen. Carbon dioxide is the main source of carbon for Chemoautotrophs. E.g. Bacteria found inside active volcano, hydrothermal vents in sea floor, hot water springs.

	Autotroph	Heterotroph
Food Chain Level	Primary	Secondary or Tertiary
Types	Photoautotroph, Chemoautotroph	Photoheterotrophic, Chemoheterotrophic
Examples	Plants, algae, and some bacteria	Herbivores, omnivores, and carnivores
Definition	An organism that is able to form nutritional organic substances from simple inorganic substances such as carbon dioxide.	Heterotrophs cannot produce organic compounds from inorganic sources and therefore rely on consuming other organisms in the food chain.
What or How they eat?	Produce their own food for energy	They eat other organisms to get proteins and energy.

Factors that affect rate of Photosynthesis

The rate of photosynthesis is affected by the following environmental limiting factors: carbon dioxide concentration, light intensity and temperature.

Availability of light- light provides the energy that drives photosynthesis (by splitting water molecules). Without enough light, plants cannot photosynthesis quickly, even if there is plenty of water and carbon dioxide. The light energy absorbed by a plant depends on:

- The intensity of light-Increasing the light intensity will increase the rate of photosynthesis.
- The wavelength of the light
- The length of time (duration) that the light is available

Carbon dioxide concentration has a major influence on the rate of photosynthesis since it is the substrate that is in shortest supply (there is almost always enough water for photosynthesis). Photosynthesis is also limited by the amount of carbon dioxide. Even if there is plenty of light, a plant cannot photosynthesise if it has run out of carbon dioxide.

Temperature affects the rates of enzyme activity. Temperature can also be a limiting factor.

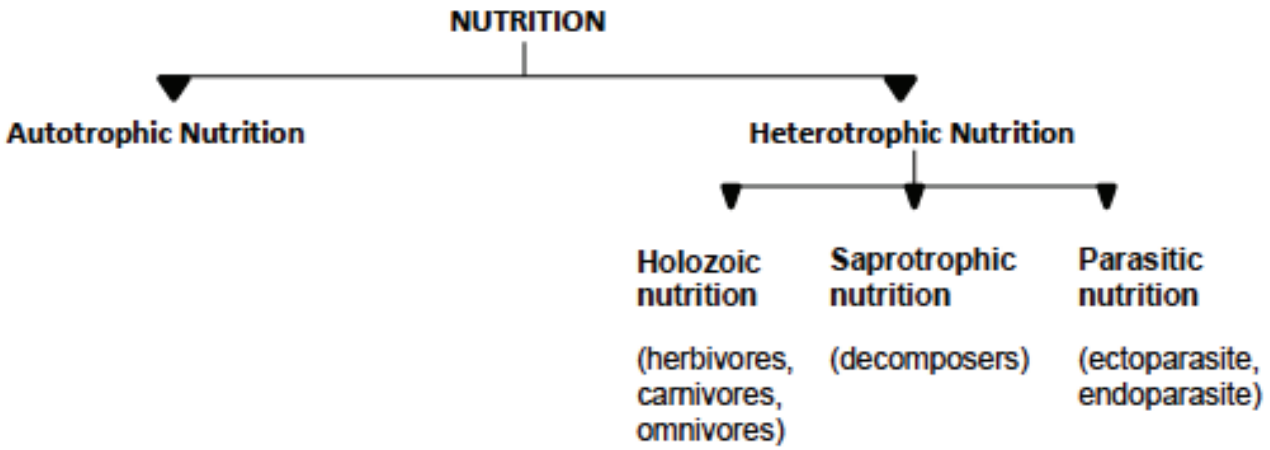
Heterotrophic Nutrition

Content Standard:	**11.2.3** Investigate the process of making food in plants and how animals get their energy.
Benchmarks	**11.2.3.4** Explain the different types of heterotrophic nutrition.

Essential Question	1. What are the main types of heterotrophic nutrition? 2. How does the food travel from the mouth to the 3. What food do you eat?
Learning Objective	• State and explain the four types of heterotrophic nutrition with some examples. • Describe the structures of the human digestive system and state their functions as well as those of other organisms • Describe the tooth structure of animals that allow them to feed.
Knowledge	• Four types of heterotrophic nutrition with some examples. • Structures of the human digestive system (as well as those of other organisms) and their functions. • Tooth structure of animals that enables them to feed.
Skills	• Explain the four types of heterotrophic nutrition • Identify the structures of the human digestive system and state their functions as well as those of other organisms • Analyse the structures of teeth in animals and relate that to how they feed.
Atitudes & Values	• Appreciate the importance of the digestive system. • Taking good care of their teeth

Content Background

Organisms that are unable to synthesize their own food substances from simple inorganic raw materials must obtain their food in organic form. Such organisms include all animals and fungi, most bacteria and protists and a few flowering plants. They are known as heterotrophs'to feed on others', and their mode of nutrition is heterotrophic. They obtain organic substances from various sources, which can ultimately be traced back to green plants and certain micro-organisms that have manufactured them from inorganic materials.



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Three types of heterotrophic nutrition are recognised:

1. *Holozoic nutrition*. This involves feeding on solid organic material obtained from the bodies of other organisms. Although this is an almost exclusively animal method of nutrition, some protists and specialised plants can do it too.

2. *Saprotrophic nutrition*. This involves feeding on soluble organic compounds obtained from dead animals and plants. Saprotrophs readily take up materials which are already in solution, but they can also put solid matter into solution so that it can be absorbed. The activities of these Saprotrophs are extremely important in bringing about decay of dead bodies and releasing from them elements that can subsequently be used by plants and various micro-organisms to build up new organic substances. Organisms which promote decay are collectively known as *decomposers*.

3. *Parasitic nutrition.* This is indulged in by a variety of animals, flowering plants, protists, fungi and bacteria. It involves feeding on the organic compounds present in the body of another living organism, the host. These organic compounds are often in solution, as in the case of a gut parasite such as the tapeworm, but sometimes the parasite feeds on the solid tissue like a holozoic organism. Moreover, a parasite can kill its host and then continue to feed on saprotrophically on its dead remains. This shows that, as with so many other man-made categories, there are no hard and fast dividing lines between these three methods of nutrition.

The problem facing any heterotrophic organism is how to acquire and take in the organic substances it needs. This must occur before the organic materials can be assimilated into tissues. For a heterotroph feeding on organic substances in solution (such as a gut parasite) there is no problem.

All it has to do is to absorb the substance straight across its integument, or the lining of its gut. But an animal that feeds on solid organic material has to have means of obtaining food and rendering it into a suitable form for absorption into the body. For obtaining food a variety of structures are employed; teeth, tentacles, claws, pincers and so on. With the aid of these devices food is taken into a *gut* or *alimentary canal* or *gastro-intestinal tract* in the act of *ingestion*. It is then subjected to a combination of physical and chemical digestion which converts the solid food into soluble compounds capable of being absorbed. Finally the fluid products of digestion are absorbed across the walls of the gut, generally into some kind of *circulatory system* which distributes them to the various tissues where they are incorporated into the cells and either built up into complex materials (assimilation) or broken down for energy release (respiration).

Physical and Chemical Digestion

The physical part of digestion is achieved by cutting and /or crushing action of teeth or their equivalent, followed by rhythmical contractions of the gut which pound up and mix the semi-solid food. To fulfill this function the gut wall, particularly the mammalian stomach, is well endowed with muscles. These are also responsible for pushing the food along the gut in the process known as peristalsis. Physical action is accompanied by the secretion of digestive enzymes. Some of these are secreted by glands situated outside the gut: salivary glands and pancreas for example.

Others come from glands located in the gut wall itself. Abundant quantities of mucus, secreted along with the digestive enzymes, protect the mucosa and facilitate the passage of food along the gut. Variable quantities of acid or alkali are also secreted to provide the correct pH for optimum functioning of the enzymes. The details of the digestive system vary in different animals but in general they fall into three groups:

1. Carbohydrases which break down carbohydrates
2. Lipases which break down fats; and
3. Proteases which break down proteins.

The physical and chemical processes of digestion go hand in hand. The chopping of a solid lump of food before it is subjected to the action of digestive enzymes increases the surface area over which chemical digestion can subsequently take place.

It is unusual for any one enzyme to break a large complex organic molecule right down into its constituent sub-units, but between them this is what they do. Thus the various carbohydrates together break polysaccharides like starch into monosaccharides like glucose; lipases break down fats into fatty acids and glycerol; and proteases break down proteins into amino acids. In all these cases the action is one of hydrolysis in which the larger molecule is split by the addition of water.

How Digestive Enzyme Work

The mode of the digestive enzymes can be illustrated by proteins. A protein is generally attacked first by enzymes that break the peptide links in the interior of the molecule. Such enzymes, called *endopeptidases*, have the effect of splitting proteins and large olypeptides into smaller polypeptides. In the human gut pepsin and trypsin are examples. The smaller polypeptides are then attacked by enzymes which break off their terminal amino acids. These enzymes are called *exopeptidases*. Some exopeptidases, known as aminopeptidases, will only attack that end of a polypeptide chain which has a free amino (NH2) group. Others known as *carboxypeptidases*, only attack the end of a polypeptide chain with a free carboxyl (COOH) group. Either way, the result is the liberation of free amino acids.

The same principles apply to the digestion of carbohydrates. Certain enzymes break the glycosidic bonds in the interior of polysaccharide chains, forming shorter polysaccharides; other enzymes then attack the ends of these polysaccharide chains, liberating free monosaccharides. Saliva and pancreatic juice both contain enzymes which break down starch first to dextrin, consisting of shorter polysaccharide chains, and then to disaccharide maltose.

Absorption and Assimilation

The products of digestion (glucose, fatty acids, glycerol and amino acids) are all molecules small enough to be absorbed through the wall of the gut. The inner lining of the absorptive part of the intestine is generally greatly folded or bears numerous finger-like villi to increase its surface area. The absorptive surface may be made even greater by the individual epithelial cells bearing numerous *microvilli*. Aided by this large surface area, the products of digestion are absorbed through the wall of the gut for transport to the tissues. To this end the gut wall may be permeated by numerous capillaries. Through the bloodstream the soluble food substances are taken to the tissue cells where they are either assimilated or respired. In the meantime any indigestible material incapable of being broken down by the digestive enzymes continues into the posterior reaches of the gut, to be egested through the anus as *faeces.*

The Site of Digestion

In the system just described, food is digested completely before being taken into the cells lining gut. This is spoken of as *extracellular digestion* because chemical breakdown is completed outside the cells. In contrast to this is intracellular digestion where solid food particles are taken up into the cells by phagocytosis and then digested in food vacuoles within the cells. The most obvious example of this is Amoeba, a single –celled protist which has a very thin and flexible plasma membrane enabling it to change its shape as a result of cytoplasmic streaming within the cell. When the cytoplasm streams towards one particular point a projection called a *pseudopodium* is formed. When it comes into contact with a small particle of nutritional value, a diatom or green flagellate for example, it responds by forming a cup-shaped invagination which engulfs the food particle. Eventually the 'lips' of the cup seal, and the food becomes enclosed in a *food vacuole*. Digestive enzymes are now secreted into the vacuole and the soluble products of digestion are absorbed into the surrounding cytoplasm. The entire process of digestion is therefore carried out inside the cell.

Feeding and Digestion in Humans

In the Buccal Cavity

In the buccal cavity the food is subjected to the chewing action of the *teeth (mastication)*. The teeth are ideally suited to this function, being exceedingly hard and differentiated. The *incisors* are for cutting the food and the *premolars* and *molars* for crushing it. The *canines* are poorly developed in man, but are well developed in other mammals such as the great cats where they are using for tearing flesh. While being chewed, the food is mixed with *saliva* secreted by the *salivary glands*. The flow of saliva is initiated by the sight, smell, taste or thought of food. It is a watery mixture of mucus and an enzyme, *salivary amylase* or *ptyalin*, which hydrolyses the polysaccharide starch to the disaccharide maltose.

Saliva is generally neutral or very faintly alkaline, this being the optimum pH for the action of the enzyme. The functions of saliva are twofold: it lubricates the food in preparation for its passage down the oesophagus, and it starts the digestion of starch. Towards the back of the buccal cavity the food is shaped by the action of the tongue into a bolus which is forced through the *pharynx* into the *oesophagus* in the act of *swallowing*. Triggered by the tactile stimulation of the soft palate and wall of the pharynx, swallowing is a reflex in which contraction of the tongue forces the bolus against the soft palate thereby closing the nasal cavity.

The opening into the larynx, the glottis is closed by the valve-like *epiglottis*, so the bolus enters the oesophagus. While all that is happening respiration is momentarily inhibited. The nerve centre responsible for controlling this swallowing reflex is located in the hindbrain.

Down to the Stomach

The bolus is propelled down the oesophagus by the peristalsis. Once in the stomach the food is acted on by the *gastric juice* secreted by *gastric glands* situated in the thick stomach wall. Gastric juice contains *hydrochloric acid* and two main enzymes: *pepsin* which breaks down into short polypeptide chains; and rennin which coagulates casein, the soluble protein of milk, forming an insoluble curd which is then attacked by pepsin. These enzymes are secreted by the so –called *chief* (or *peptic*) *cells* in the wall of gastric glands.

Into the duodenum

Peristaltic contractions of the stomach keep the chime moving towards the *duodenum*, the first loop of the small intestine. The passage of food into the duodenum is controlled by a ring of muscle, the *pyloric sphincter,* situated immediately between the far end of the stomach and the duodenum. By alternately contracting and relaxing, the pyloric sphincter can hold food back or let it through.
The duodenum is the main seat of digestion in the gut. The agents of digestion come from three sources: the *liver, pancreas* and *wall of the small intestine* (duodenum and ileum).

Main Classes of Nutrients

There are five (5) main classes of nutrients that animals take in to make their food.

1. Proteins

Proteins are needed for growth and repair of body tissues, for example, healing of wounds, replacement of skin and mucous membrane and production of antibodies. Proteins are used to build cell membranes, enzymes and other structural features such as bones, tendons, hair and fingernails.

Proteins are made up of simple units called amino acids. When proteins are consumed in the diet, the digestive system breaks them down into amino acids for the body to absorb them easily and build the types of proteins that our body needs.

Proteins can be obtained from eating eggs, milk and other dairy products, nuts, and meat such as chicken and fish.

The table below shows some functions of several proteins.

Aspect	Functions	Examples
Storage	Legume Storage, albumin, and proteins.	Supplies food during the early stage of the seedling or embryo.
Hormone Signalling	Counterpart activities of different body parts.	Glucagon and Insulin.
Transport	It transports substances throughout the body through lump or blood cells.	Haemoglobin.
Contraction	To carry out muscle contraction.	Myosin.
Digestive Enzyme	Breaks down nutrients present in the food into smaller portions so that it can be easily absorbed	Pepsin, Amylase, and Lipase

2. Carbohydrates

Carbohydrates are needed for cellular respiration and energy production and can be obtained by eating starchy foods such as sweet potato, coconut, rice, and taro. These plants make sugar and store them in the food of carbohydrates, which get broken down to simple sugars such as glucose and fructose in the digestive system. Other sources of carbohydrates include foods from grains, vegetables, fruits and milk products. There are three types of carbohydrates:

i. Monossacharides

They contain only one sugar molecule. Examples include glucose, fructose and galactose.

ii. Disaccharides

They contain two sugar molecules or monossacharides. Examples include sucrose, lactose and maltose.

iii. Polysaccharides

They contain more than two sugar molecules or dissacharides. Examples include starch, glycogen and cellulose.

3. Fats (or Lipids)

Fats or lipids are made up of fatty acids and glycerol. They are needed for energy and warmth and also form the cell membranes. They can either be in liquid form called oil or in solid form called fat. Fatty acids are further classified into saturated and unsaturated fatty acids.

Too much fat in the body is unhealthy as it can block the flow of blood causing high blood pressure and other heart diseases.

4. Vitamins

Vitamins are organic substances that the body need in order to function. There are two types: Water-Soluble Vitamins and Fat-Soluble Vitamins. A lack in any of those can lead to certain diseases, for example, lack of Vitamin C results in scurvy.

The table below shows some of the vitamins that are necessary for the body.

Water-Soluble Vitamins	Importance	Good Food Sources
Vitamin B1 (thiamine)	Maintains healthy nerves, muscles, and blood vessels, prevents beriberi	Meat, whole grains, legumes
Vitamin B2 (riboflavin)	Important in wound healing and in metabolism of carbohydrates, prevents dryness of skins, nose, mouth, and tongue	Yeast, liver, kidney
Vitamin B3 (niacin)	Maintains healthy nerves and skin, prevents pellagra	Legumes, fish, whole grains
Vitamin B6 (pyridoxime)	Coenzyme used in amino acid metabolism, prevents microcytic anaemia	Whole grains (except rice), yeast, liver, mackerel, avocado, banana, meat, vegetables, eggs
Vitamin B12 (cyanocobalamin)	Required for DNA synthesis and cell division; prevents premicious anaemia (incomplete red blood cell development)	Meat, liver, eggs, dairy products, whole grains
Folic acid	Used in synthesis of haemoglobin, DNA and RNA; prevents megaloblastic anaemia and spina bifida.	Asparagus, liver, kidney, fresh greens, vegetables, yeast
Pantothenic acid	Needed to make coenzyme A for carbohydrate and lipid metabolism	Liver, eggs, legumes, dairy products, whole grains
Biotin	Used in fatty acid synthesis and other reactions using CO2	Eggs, liver, tomatoes, yeast
Vitamin C (ascorbic acid)	Antioxidant, used in synthesis of collagen (in connective tissues) and epinephrine (in nerve cells); promotes wound healing, protects mucous membranes, prevents scurvy.	Fresh fruit (especially citrus), fresh vegetables, liver, raw meat

Fat-Soluble Vitamins	Importance	Good Food Sources
Vitamin A (retinol)	Antioxidant; precursor of visual pigments, prevents night blindness and zerophthalmia	Yellow and dark green vegetables, some fruits, fish oils, dairy products
Vitamin D (calciferol)	Promotes calcium absorption and bone formation; prevents rickets and osteomalacia	Eggs, liver, fish, cheese, butter
Vitamin E (tocopherol)	Antioxidant, protects cell membranes against organic peroxides, maintains health of reproductive system	Whole grains, nuts, vegetable oils, legumes
Vitamin K	Essential for blood clotting, prevents haemorrhage	Green leafy vegetables

S***ource:*** *UPNG, 2009: ORGANISM DIVERSITY STRUCTURE & FUNCTION, pages 27-28*

5. Minerals

These are inorganic substances that are required by the body to carry out certain functions as tabulated below. There are two types of minerals: Major Elements and Trace Elements.

Major Element	Importance	Good Food Sources
Electrolytes (Na+, K+, Cl-)	Maintain balance of fluids in body, maintain cell membrane potentials	Raisins, prunes, K+ also in dates and bananas
Calcium	Part of crystal structure of bones and teeth, maintains muscle and nerve membranes	Dairy products, peas, canned fish with bones (sardines, salmon), vegetables
Phosphorus	Part of crystal structure of bones and teeth	Dairy products, corn, broccoli, peas, potatoes, prunes
Magnesium	Maintains muscle and nerve membranes	Meat, milk, fish, green vegetables
Iron	Part of haemoglobin used in energy-producing	Meat, egg yolks, whole grains, beans, vegetables
Iodine	Maintains thyroid gland, prevents goitre	Fish and other seafood products

Trace Element	Importance	Good Food Sources
Fluorine	Strengthens crystal structure of tooth enamel	Fluorinated drinking water, tea
Zinc	Promotes bone growth and wound healing	Seafood, meat, dairy products, whole grains, eggs
Copper	Cofactor for enzymes used to build proteins, including collagen, elastin, and hair	Nuts, grains, shellfish, liver
Selenium	Statistically associated with lower death rates from heart disease, stroke and cancer	Vegetables, meat, grains and sea-food

Source: *UPNG, 2009: ORGANISM DIVERSITY STRUCTURE & FUNCTION, page 28*

Gas Exchange in Plants

Content Standard:	**11.2.4** Investigate the conversion process of the food substance to energy forms that allow organisms to live.
Benchmarks	**11.2.4.1** Identify and describe the specialised gas exchange surfaces in various organisms. **11.2.4.3** Compare the different types of respiration and their characteristics. **11.2.4.5** Examine structures involved in gas exchange in plants.
Essential Question	1. What are gas exchange surfaces? 2. What is diffusion? 3. How do the organs used for gas exchange differ?
Learning Objective	• Explain diffusion and osmosis in leaves during gas exchange. • State and explain the properties or characteristics of gas exchange surfaces in plants. • Name and explain the types of specialised gas exchange surfaces in plants. • Explain the process of gas exchange during photosynthesis and respiration in plants with examples from experiments to confirm the presence of oxygen and carbon dioxide in test tubes, i.e. Burning splint test, limewater test and glucose test. • Explain the factors that affect the rate of gas exchange in plants.
Knowledge	• Diffusion and osmosis in leaves during gas exchange. • Properties or characteristics of gas exchange surfaces in plants. • Types of specialized gas exchange surfaces in plants. • The process of gas exchange during photosynthesis and respiration in plants with examples from experiments to confirm the presence of oxygen and carbon dioxide in test tubes, i.e. Burning splint test, limewater test and glucose test. • Factors that affect the rate of gas exchange in plants.
Skills	• Explain diffusion and osmosis in leaves during gas exchange. • Describe the properties of gas exchange surfaces in plants. • Describe the types of specialized gas exchange surfaces in plants. • Evaluate the factors that affect the rate of gas exchange in plants.
Atitudes & Values	• Appreciate and value the importance of gas exchange.

Content Background

To live, organisms need to take in nutrients and gases, transport these to where they are needed in the body and get rid of the wastes. Although the structures of the respiratory, circulatory and excretory systems vary throughout animals and plants, the feature these systems have in common is their function- the transportation of gases and nutrients for cells and the excretion of wastes that would build up, poison and eventually cause the death of the organism.

In order to carry on photosynthesis, green plants need a supply of carbon dioxide and a means of disposing of oxygen. In order to carry on cellular respiration, plant cells need oxygen and a means of disposing of carbon dioxide (just as animal cells do). Unlike animals, plants have no specialized organs for gas exchange (with the few inevitable exceptions!). The are several reasons they can get along without them:

- Each part of the plant takes care of its own gas exchange needs. Although plants have an elaborate liquid transport system, it does not participate in gas transport.
- Roots, stems, and leaves respire at rates much lower than are characteristic of animals. Only during photosynthesis are large volumes of gases exchanged, and each leaf is well adapted to take care of its own needs

- The distance that gases must diffuse in even a large plant is not great. Each living cell in the plant is located close to the surface. While obvious for leaves, it is also true for stems. The only living cells in the stem are organized in thin layers just beneath the bark. The cells in the interior are dead and serve only to provide mechanical support.
- Most of the living cells in a plant have at least part of their surface exposed to air. The loose packing of parenchyma cells in leaves, stems, and roots provides an interconnecting system of air spaces. Gases diffuse through air several thousand times faster than through water. Once oxygen and carbon dioxide reach the network of intercellular air spaces (arrows), they diffuse rapidly through them.
- Oxygen and carbon dioxide also pass through the cell wall and plasma membrane of the cell by diffusion. The diffusion of carbon dioxide may be aided by aquaporin channels inserted in the plasma membrane.

Diffusion

Nutrients, water and oxygen move into all living cells by diffusion. Oxygen for example is continually used up by cells during respiration. As a result, the concentration of oxygen in the cells falls and the concentration of the carbon dioxide rise. Oxygen molecules then diffuse into the cells until the concentration is raised again, and carbon dioxide diffuses out of the cells until the concentration is low again. With diffusion, gases such as oxygen and carbon dioxide are able to travel within the bodies of plants and animals to where they are needed or expelled when necessary.

How do materials get transferred in and out of cells? Take for example, amoeba, which requires oxygen, mineral salt and other organic molecules. These substances are present in higher concentrations in the external environment than in the cytoplasm. Hence, these substances move into the amoeba by diffusion.

Similarly, waste products and carbon dioxide produced by the Amoeba are found in higher concentrations within the amoeba relative to its external environment. Hence these substances move out by diffusion as well. This is because the cell membrane is partially permeable and this means that the cell membrane allows small particles to pass though it.

The Stomata

Stomata pores perforating the epidermis of the leaves and stem. They usually most numerous in the lower epidermis of the leaf where there may be as many as 400 per mm^2 (apple). There are generally fewer in the upper epidermis and fewer still in the stem.

The functions of the stomata are:

1. To allow exchange of carbon dioxide and oxygen between the inside of the leaf and the surrounding atmosphere
2. To permit the escape of water vapour from the leaf

Circulation and Gas Exchange in Animals

Content Standard:	**11.2.4** Investigate the conversion process of the food substance to energy forms that allow organisms to live.
Benchmarks	**11.2.4.1** Describe the specialised gas exchange surfaces in various organisms **11.2.4.5** Explain the anatomy of the respiratory system in animals and the process of ventilation and gas exchange from the environment to the cells.
Essential Question	1. How do the organs used for gas exchange differ? 2. How does the circulatory system work?
Learning Objective	• Name and explain the types of specialized gas exchange surfaces and systems in animals. • Name and describe the types of circulatory / respiratory systems in animals. • Explain the process of respiration, inhalation and exhalation, in vertebrates. • Explain the effect of exercise on breathing rate. • Explain the process of respiration in invertebrates. • State and discuss the components of the circulatory system. • Explain the process of circulation in a human circulatory system. • Explain the process of circulation in the circulatory system of a grasshopper.
Knowledge	• State and explain the properties or characteristics of gas exchange surfaces in animals. • Types of specialized gas exchange surfaces and systems in animals. • Types of circulatory / respiratory systems in animals. • Respiration, (inhalation and exhalation) in vertebrates. • The effect of exercise on breathing rate • Respiration in invertebrates. • Components of the circulatory system. • The process of circulation in a human circulatory system. • The process of circulation in the circulatory system of a grasshopper.
Skills	• Explain the properties or characteristics of gas exchange surfaces in animals. • Describe the types of specialized gas exchange surfaces and systems in animals. • Evaluate the circulatory / respiratory systems in animals. • Distinguish between inhalation and exhalation. • Measure their breathing rates during exercise and analyse the results. • Describe the process of respiration in invertebrates. • Describe the components of the circulatory system. • Describe the process of circulation in a human circulatory system. • Describe the process of circulation in the circulatory system of a grasshopper..
Atitudes & Values	• Value the importance of gas exchange. • Appreciate the function of the circulatory and respiratory system

Content Background

Gas Exchange in Animals

In small animals, the surface volume ratio is large enough for diffusion across the general body surface to satisfy their respiratory needs. But in larger animals, particularly active ones, the surface- volume ratio is too small for this to be so, and a special respiratory surface has to be developed. Animals that use the general body surface for gas exchange include coelenterates, flatworms and many annelids including the earthworm.The same applies to protists. For the most part these organisms are small enough not to require a special respiratory surface. Many are comparatively inactive, and their sluggishness considerably reduces their need for oxygen. In some the surface volume ratio is increased by the whole body being flattened (e.g. flatworms), or by the development of flat surfaces inside the body (e.g. sea anemones). Both these adaptations can be looked upon as evolutionary strategies designed to solve the problem of gas exchange.

Specialised Respiratory Surfaces

Most other animals have developed special respiratory surfaces. In all cases they consist of numerous flat surfaces, sacs or tubes with a large surface area for gas exchange. The simplest are external gills, epidermal outgrowths from the body surface found in the lugworm and young tadpoles. In contrast, internal gills are enclosed in cavities within the body where they are protected from damage: in fish they consist of folded epithelial sheets on either side of a series of pouches connecting the pharynx with the exterior. Air- breathing vertebrates have developed lungs which develop as sac-like outgrowths of the pharynx. A quite different arrangement is found in insects: air pores at the surface open into a system of branching tracheal tubes which ramify through the body, coming into close association with all the tissues. Although these various respiratory devices may seem rather different, they all have one essential feature in common: the exposure of a large surface area to whatever medium the animal happens to live in. we might note in passing that the leaves of a plant achieve the same effect.

To illustrate the basic principles involved in the structure and function of a respiratory surface, we will consider gas exchange in two quite different animals: humans and fishes. Both have highly specialized internal surfaces connected to the outside world by a respiratory tract. In both cases a ventilation mechanism brings the external medium into contact with the respiratory epithelium.

Gas Exchange in Humans

In the human respiratory system, the lungs are located in the thorax, whose walls are formed by the ribs and intercostal muscles, and floor, by the muscular diaphragm. The lungs are surrounded by a pleural cavity lined by pleural membranes. The pleural cavity contains a thin layer of lubricating fluid.

Air is drawn into the lungs via the trachea and bronchi. The expansion of the thoracic cavity is brought about by the upward and outward movement of the ribs, accompanied by the flattening of the diaphragm by contraction of its muscles which are disposed in a mainly radial direction. All this constitutes inspiration. The process then goes into reverse, air being expelled from the lungs in the act of expiration. Expiration is a mainly passive process resulting from elastic recoil of the tissues that have been stretched during inspiration. However, in forced breathing, or when the respiratory tract is blocked, expiration is aided by contraction of the abdominal muscles which raises the pressure in the abdominal cavity, forcing the diaphragm upwards.

At rest, the pressure in the lungs is atmospheric, but because the lungs are elastic and tend to pull away from the walls of the thorax, the pressure in the pleural cavity is slightly less than atmospheric. During inspiration, when the walls and floor of the thorax are moving outwards and downwards respectively, the pleural pressure falls. This has the immediate effect of lowering the lung pressure to below atmospheric, so that air rushes into the lungs. This increases their volume and returns the lung pressure to atmospheric. On expiration, the pressure of the thoracic wall and the diaphragm against the pleural cavity raises the pleural pressure. This is transmitted to the lungs whose pressure therefore increases and volume decreases as air is expelled.

Structure of the Lungs

The lungs are sponge-like in texture, and consist of a tree-like system of tubes which ramify from the two bronchi. The tubes terminate as sac-like atria from which arise numerous alveoli. Although a certain amount of gas exchange can take place across the walls of the smaller tubes, it is the alveoli which play the leading role in this respect. The efficiency of the mammalian lung as the respiratory surface depends on the fact that a vast number of alveoli come into very close association with an extensive capillary system. In humans the two lungs contain approximately 700 million alveoli, giving a total surface area of over 70 square metres; if the lungs were opened out into a continuous sheet they would just about cover the surface of a tennis court! The capillary network in the lungs has a total area of about 40 square metres. In the lungs therefore an enormous surface area for gas exchange is packed into a comparatively small space. This general principle also applies to other terrestrial vertebrates like amphibians and reptiles, except that in these more primitive vertebrates the total surface area relative to the size of the lungs is nothing like so great.

The relationship between the alveoli and the capillaries is an extremely intimate one. The walls of the capillaries and alveoli both consist of a single layer of flattened epithelial cells firmly applied to each other. The resulting barrier between the alveolar cavity and the blood is a mere 0.3μm thick in its thinnest part. As such, it offers minimum resistance to the diffusion of gases from one side to the other.

The Breathing Cycle

A person breathing normally at rest takes in, and expels, approximately half a litre of air during each respiratory cycle. This is known as the tidal volume, and it can be measured by means of a recording spirometer.
The rate of respiration can be expressed in terms of ventilation rate, the volume of air breathed per minute.

Clearly: VENTILATION RATE = TIDAL VOLUME X FREQUENCY OF INSPIRATIONS.

The ventilation rate changes according to circumstances: in muscular exercise, for example both the frequency and depth increase, resulting in a greater ventilation rate. The important point is that the lungs have a much greater potential than is ever realized in resting conditions, and this permits the respiratory apparatus to adapt to changing needs. If you take a deep breath, you can take into your lungs about 3 litres of air over and above the tidal volume. This is known as the inspiratory reserve volume, and is brought into use when required. If at the end of a normal expiration you expel as much air as possible, the extra air expired amounts to about one litre, and is called the expiratory reserve volume. The total amount of air that can be expired after a maximum inspiration (i.e. the tidal volume plus inspiratory and expiratory reserve volumes) is known as the vital capacity. The vital capacity of an average person lies between 4 and 5 litres but in a fit athlete it may exceed 6 litres. Even after a maximum expiration, about 1.5 litres of air remains in the lungs. This is known as the residual volume.

How much of the air taken in is actually used in gas exchange? Of the half litre or so inspired in quiet breathing only about 350 cm^3 gets into the parts of the lungs where gas exchange is possible. The rest remains in the trachea and bronchial tubes, collectively known as dead space, no gas exchange takes place. If the capacity of the lungs is about six litres, it is clear that in resting conditions only a small fraction of the total volume of air present in the respiratory apparatus is used in gas exchange.

At each inspiration during normal quiet breathing, about 350 cm^3 of inspired air mixes with some 2.5 litres of air already present in the alveoli. With so little new air mixing with so much air already present, it is probable that the composition of the air in the depth of the lungs remains relatively constant in resting conditions. Through this air, situated between the inspired air and the blood, gases diffuse to and from the surface. Comparison of the composition of inspired and expired air gives some indication of the exchanges that take place in the lungs. Note that with continual gas exchange going on between the alveolar air and blood, it is the ventilation of the lungs which keeps the composition of the alveolar air more or less constant.

Tropism in Plants

Content Standard:	**11.2.5** Investigate plant tropism, reproduction, endocrine, nervous and defence system.
Benchmarks	**11.2.5.1** Investigate plant hormones and how they influence plant tropism.

Essential Question	1. What are the main types of tropism in plants? 2. What functions do hormones perform in plants?
Learning Objective	• State the names of plant hormones and explain their function and importance. • State and explain the different types of tropisms in plants. • Describe the effect of a plant coleoptile in response to the stimuli of light when covered and exposed.
Knowledge	• Names of plant hormones and their function and importance. • The different types of tropisms in plants. • The effect of a plant coleoptile in response to the stimuli of light when covered and exposed.
Skills	• Describe plant hormones and their function. • Analyse the different types of tropisms in plants. • Set up an experiment to demonstrate the effect of light on the direction of a plant.
Atitudes & Values	• Take care when handling Science equipment • Appreciate the work of light

Content Background

Fruit growth and maturation is just one of many changes that occur during the life cycle of a flowering plant. Changes during the life-cycle-from the time of its formation from germinating seed to the time that the plant matures and itself produces seeds-involve both growth and development. Growth (increase in size) and development (change in form) are seen in many events, such as the formation of buds, lengthening of stems, downward growth of roots, expansion of leaves, appearance of flowers, development and ripening of fruits. For each plant species in a particular environment, the events of growth and development occur in a predictable sequence.

Plant growth and development are influenced by both internal and external factors and by the interactions between these factors. Internal factors include chemical substances (such as auxins) that are produced by plants cells. These chemical substances are known as hormones. Indoleacetic acid (IAA), an important auxin, is just one of many plant hormones that influence growth and development in plants. Some of these hormones stimulate responses in plants; others act as inhibitors. External factors include environmental factors such as light intensity, temperature, day length and gravity.

Because environmental factors sometimes influence or control the production and amount of a particular plant hormone, there can be difficulty in distinguishing between hormonal and environment effects. Plant hormones are transported via the xylem or phloem and sometimes both but particularly in phloem. It is believed that hormone signaling in plants is similar, in principle to that occurring in animals.

Plant hormones have many of the same characteristics as animal hormones. Plant hormones are produced by cell plants in relatively small amounts, usually act on other cell of the plants and are able to produce specific effects even when present in very low concentrations. Plant hormones are produced mainly I the cells of growing regions of shoots and roots (meristems), in young leaves, in growing seeds and in developing fruits.

Plant hormones are involved in the regulation of any processes. The same hormone may produce different effects in various tissues of a plant. The action of the plant hormones in some case depends on the concentration of the hormone in question. Plant hormones do not act in isolation, and the presence of one hormone may influence the actions of the other.

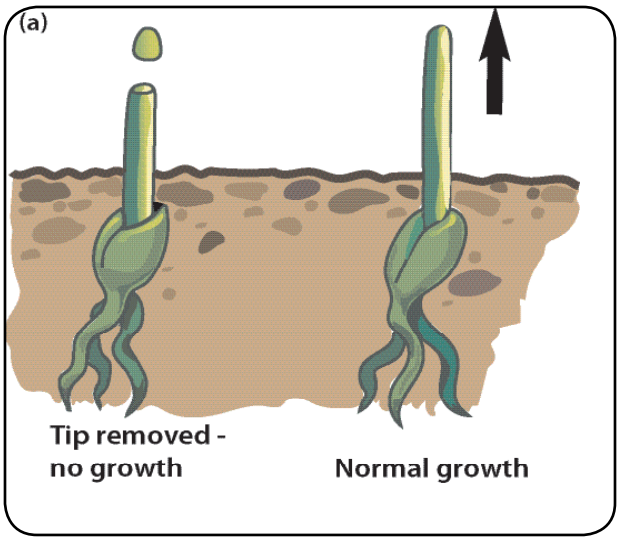
Plant hormones are generally classified as follows:

Hormone	Where produced or found in Plant	Major Functions
Auxin (IAA)	Embryo of seed, meristems of apical buds, young leaves	Stimulates stem elongation (low concentration only), root growth, cell differentiation, and branching; regulates development of fruit; enhances apical dominance; functions in phtotropism and gravitropism; promotes xylem differentiation; retards leaf abscission
Cytokinins	Synthesized in roots and transported to other organs	Affect root growth and differentiation; stimulate cell division and growth; stimulate germination; delay senescence
Gibberellins	Meristem of apical buds and roots, young leaves, embryo	Promote seed and bud germination, stem elongation and leaf growth; stimulate flowering and development of fruit; affect root growth and differentiation
Brassinosteroids	Seeds, fruit, shoots, leaves and floral buds	Inhibit root growth; retard leaf abscission; promote xylem differentiation
Abscisic acid	Leaves, stems, roots green fruit	Inhibits growth; closes stomata during water stress; promotes seed dormancy
Ethylene	Tissues of ripening fruit, nodes of stems, aging leaves and flowers	Promotes ripening, opposes some auxin effects; promotes or inhibits growth and development of roots, leaves and flowers, depending on species

Auxins

The label 'auxins' refers to many hormones, including IAA. A major action of auxins is to control enlargement and elongation of plant cells. Auxins stimulate elongation of cells in stems, but a high concentration in inhabit the growth of the roots. Auxins also stimulate growth of lateral and adventitious roots. Promote growth of flowers and fruits and influence the differentiation of unspecialized cells into vascular tissue.

Auxins are produced by the growing tips of plants. Their site of production was first identified in germinating grass seeds. It was fund that the first leaves (coleoptiles) of these germinating seeds did not grow if their tips were removed.



IAA is responsible for apical dominance. Apical dominance exists when lateral buds on the stem close to the apex of a plant do not develop while the growing tip at the apex of a plant grows and develops. Development of the lateral buds is inhibited as a result of the action IAA that is produced by the terminal bud at the apex of the plant. The IAA moves down the stem through the phloem and exerts an inhibitory effect.

When the bud at the apex is nipped off, the source of IAA is removed and lateral buds lower down on the stem begin to develop. By selectively pruning or removing growing tips with their terminal buds, gardeners can produce more bushy plants because more lateral buds will develop into leafy shoots.
Auxins are involved in the bending of plant shoots and roots in response to light and gravity.

Tropism and Auxins

External factors such as light, gravity and touch exert an influence on plant growth and development. The growth of a plant in response to a stimulus such as light or water is called a tropism. When a plant grows towards

Defence System

Content Standard:	**11.2.5** Investigate plant tropism, reproduction, endocrine, nervous and defence system.
Benchmarks	**11.2.5.2** Examine the defence system in living things
Essential Question	1. How do plants defend themselves from predators? 2. How do animals defend themselves from other animals? 3. How does the body protect itself from harmful microorganisms and other substances? 4. How does the body's immune system become weak? 5. What can be done to boost the body's natural immune system?
Learning Objective	• Describe the different approaches that plants take to defend themselves against predators, weather, salinity and other things. • Describe the different approaches that animals take to defend themselves against predators, weather, salinity, and other things. • Describe the lymphatic system and explain its role in defence mechanism of the human body. • State and explain what happens during the First, Second and Third lines of defence in humans. • Explain what non-specific and specific immune mechanisms are. • Explain and differentiate between natural and acquired immunity in humans.
Knowledge	• Different approaches that plants take to defend themselves against predators, weather, salinity and other things. • Different approaches that animals take to defend themselves against predators, weather, salinity, and other things. • The lymphatic system its role in the defence mechanism of the human body. • First, Second and Third lines of defence in humans. • Non-specific and specific immune mechanisms and their roles. • The difference between natural and acquired immunity in humans.
Skills	• Analyse the defence mechanisms of plants. • Analyse the defence mechanisms of animals. • Describe the role of the lymphatic system in the body's defence mechanism. • Compare the activities that occur in the first, second and third lines of defence mechanisms. • Distinguish between the roles of non-specific and specific immune mechanisms. • Differentiate between natural and acquired immunity in humans.
Atitudes & Values	• Appreciate science for its usefulness in improving quality of life

Content Background

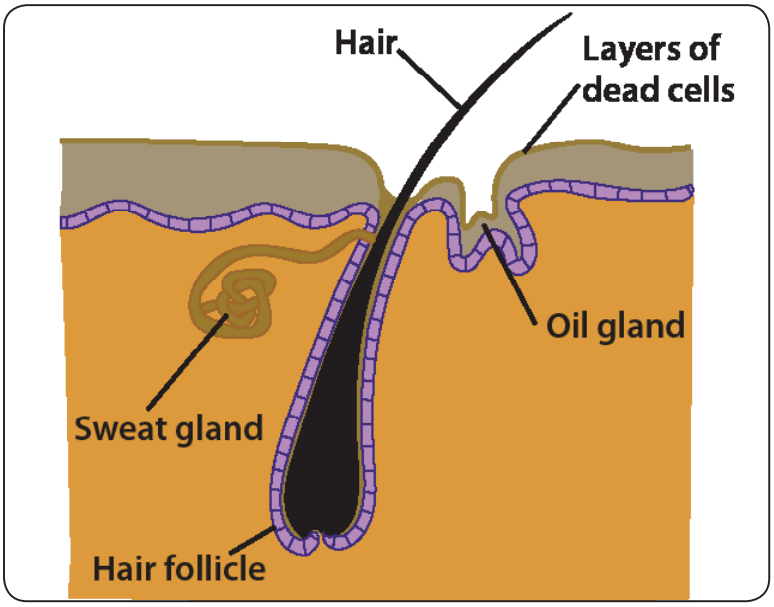
The *immune system* is able to distinguish foreign material from material that is made by the body. Material made by the body's cells is called 'self'.

Non-specific: First Line of Defence

The first line of defence is designed to prevent the entry of any disease-causing pathogens. The protective mechanisms include the skin, mucous membranes, cilia and natural body secretions (such as lysozymes in tears, saliva, sweat and mucus).

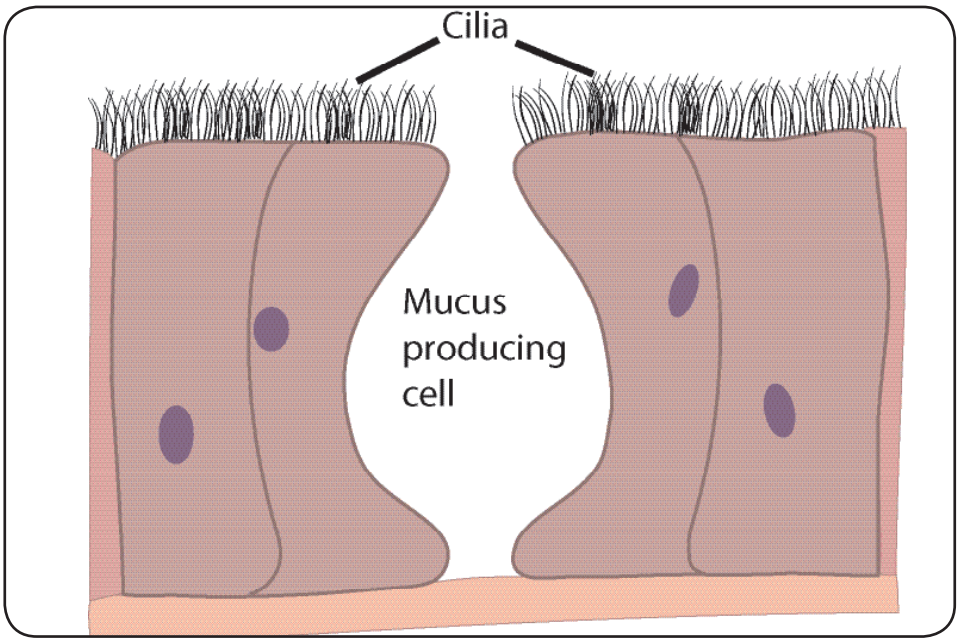
Skin

The skin is much tougher than you think, yet it can easily be peel off the rest of the body. It fences the body off from harmful microorganisms and acts as a waterproof coating. The oil in the skin decomposes so that the skin has an acidic pH, inhibiting the growth of fungi and harmful bacteria. In fact the skin is covered in bacteria, most of which prevent pathogens from gaining a foothold.



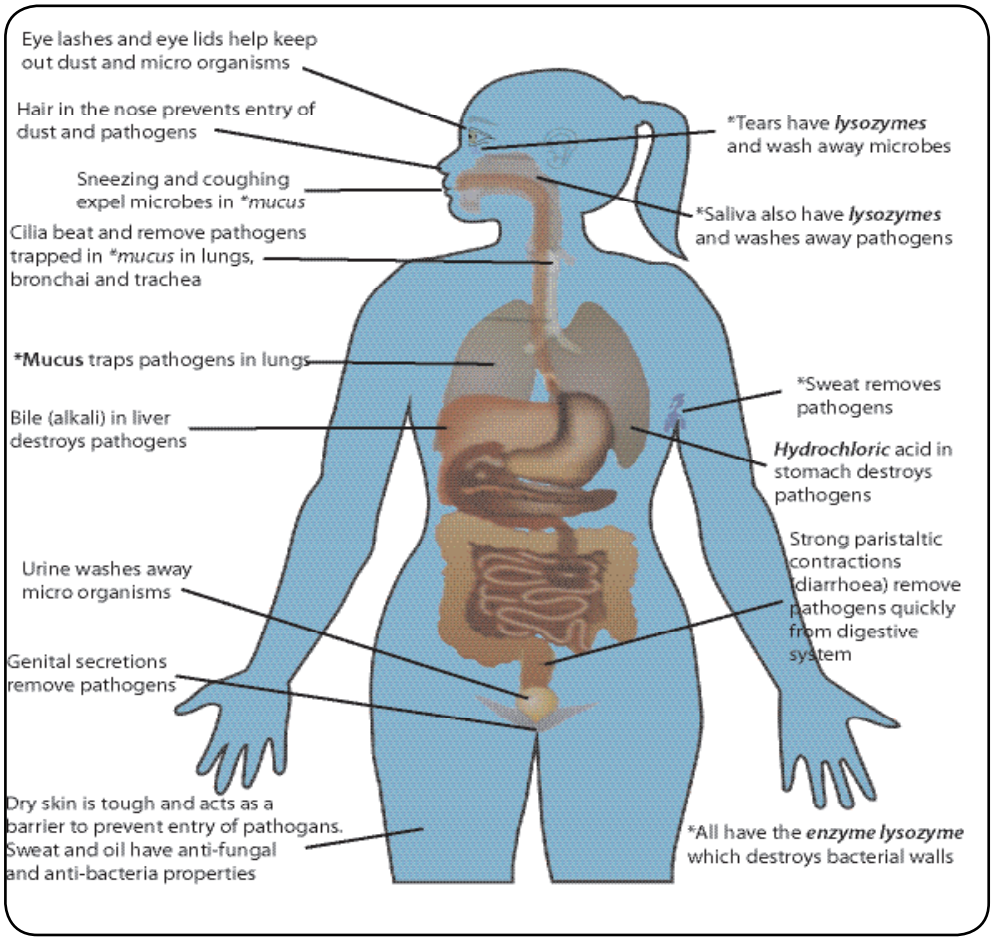
Mucous membranes and cilia

It is always uncomfortable when you first get a cold. Often the nose is streaming and constant sneezing. While the virus can be spread in mucus droplets, the mucus mainly acts as a trap to trap pathogens and prevent them from entering the cells. Mucous membranes line your excretory, digestive, respiratory and reproductive systems and the mucus produced is effective in trapping bacteria. Fluids that wash over the mucus membranes such as in tears and saliva often contain lysozymes that cause the bacterial cell walls to disintegrate. Cilia are microscopic hair-like structures attached to epithelial cells. They beat to move the mucus along towards the outside, causing entrapped dead and alive microorganisms to be expelled from the body.



Natural body secretions

Chemicals inside and outside your body will act as barriers to disease. Externally, sweat , tears, mucus and oil on your skin will make the environment inhospitable to invading microorganisms. While these secretions wash pathogens away or alter the pH of your skin, they (apart from oil) also contain lysozymes, chemicals that cause bacterial cell walls to break down. Internally there are chemicals, such as hydrochloric acid in your stomach or bile (alkaline) in your small intestine, that produce a pH that destroys or inhibits growth of pathogens. Other internal secretions flush out pathogens. They include acidic sterile urine which cleanses the urinary tract and secretions from symbiotic bacteria. For example, bacteria (microflora) in the genital tract produce an acidic pH that prevents growth of fungi and bacteria. Similarly, microflora in your gut will control disease. However, any imbalance in numbers due to the excess use of antibiotics will cause symptoms such as diarrhea due top microbes in food and water.



Non-specific: Second line of defence

Once pathogens have successfully entered the body, the second line of defence will spring into action to prevent further trauma and to protect you from disease, using inflammation, phagocytosis, involvement of your lymph system and cell death to contain the pathogens. This defence is a non-specific response because any pathogen will elicit a chain of responses regardless of its type of antigen or whether it has had a prior history of infecting your body.

Inflammation

Inflammation occurs because damaged tissue releases histamines, chemicals that increase dilation of blood vessels leading to increased blood circulation to an area. Histamines also cause leakage of blood vessel walls so that the white blood cells, such as phagocytes, can penetrate the affected area to kill the pathogen or contain the foreign object.

Phagocytosis

White blood cells called phagocytes move through blood capillary walls to the affected site and release more histamines, which encourage other phagocytes to travel this area. Phagocytes (phago=eating, cyte=cell) will actively engulf or surround the invader. There are many types of phagocytes but the most obvious within the first few hours or days of infection are the neutrophils. For a few hours, monocytes will also circulate and phagocytose foreign material. If infection is chronic, however, monocytes will migrate into tissues and change into other larger white blood cells: the macrophages that play a more prominent role in engulfing invaders. Many white blood cells that actively seek and destroy foreign agents will accumulate later as dead phagocytic cells and bacteria and fluid at the site, which becomes obvious as pus. Other white blood cells such as eosinophils and basophils are relatively uncommon. If you have worms, however, eosinophils will be present in greater numbers than normal, or if you have hay fever or asthma, more basophils will be active.

Lymph system

The lymph system is a fluid transport system parallel to the blood vascular system. It returns fluid to the blood near shoulders. Along the lymph vessels are lymph nodes (also known as lymph glands) or lymph organs- these are storage or maturation sites for other white blood cells (B and T lymphocytes) that are used in the specific immune response or third line of defence. When the lymph fluid flows through lymphatic tissue, B and T lymphocytes zero in on pathogens that they recognize from a previous infection-they have a specific response to the foreign antigens (living or non-living material). Doctors therefore check the glands (lymph nodes) in your neck to see if they are swollen as evidence of infection. Also when somebody has tonsillitis the doctor will check your tonsils (lymph organs) to see if they are swollen and full of pus.

Cell death to contain the pathogen

The body always tries to contain or seal off foreign antigen from the rest of the body so that the invader does not harm its host. This process is a chronic inflammatory response characterized by the presence of macrophages and lymphocytes and the formation of a tough wall of tissue that encloses the pathogen to form a granuloma. The macrophages and lymphocytes completely surround the invader and eventually die but the pathogen also dies because it is fenced off from its supply. For example when infected by TB, patients often exhibit these granulomas in their lungs-the bacilli are fenced off to prevent further infection and to stop them harming their host.

Triggering the immune response

Any foreign object that gets into your body is considered by your immune system to be an invader. Your body will activate an appropriate immune response in an attempt to destroy and remove it to maintain your health. All invaders are collectively called antigens (living or non-living proteins) and include bacteria, viruses and any other foreign proteins such as prions, fungi, macro-parasites or even transplanted organs from another human (if you are not being given your identical twin's organ). The use of transplanted organs (especially kidneys, hearts, livers and lungs) is now increasing and is much more successful than in pioneering attempts. In those days organs were constantly rejected because the recipient's immune system recognised foreign proteins (antigens) and produced antibodies to attack the transplanted tissue. New drugs are now used to counteract the body's automatic immune response.

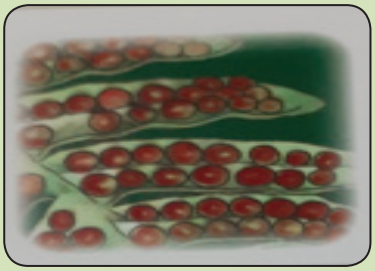
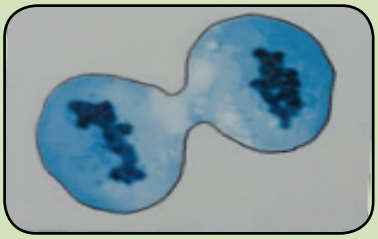
Reproduction System

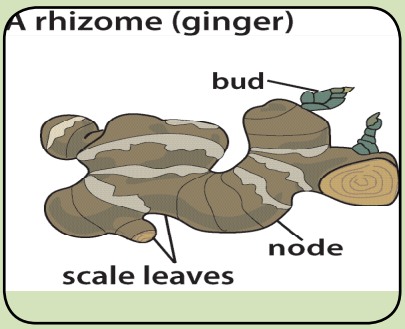
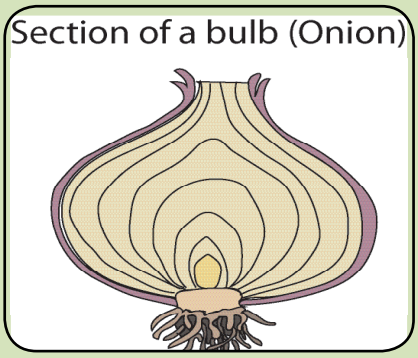
Content Standard:	**11.2.5** Investigate plant tropism, reproduction, endocrine, nervous and defence system.
Benchmarks	**11.2.5.3** Investigate the reproduction types and patterns of living things including their reproductive structures. **11.2.5.4** Research reproductive hormones and their functions in animals.
Essential Question	1. What are the main types of reproduction? 2. How does the reproduction in plants occur? 3. How does reproduction in animals occur? 4. What are the roles of hormones in the reproduction system?
Learning Objective	• State and explain the two main modes of reproduction. • State and explain the different types of asexual reproduction and their occurrence in other organisms. • State and explain the different types of sexual reproduction and their occurrence in other organisms. • Describe the reproductive system of plants and discuss the process of reproduction, from pollination to seed dispersal and types of seed dispersal. • Discuss the different types of asexual reproduction in plants as well. • Describe the reproductive system of animals and discuss the process of reproduction, from mating to birth. • Discuss the different types of asexual reproduction in animals. • Describe the human reproductive system and explain the process of reproduction from conception to birth. • explain the role certain hormones play in the reproduction of humans. • explain the secondary sexual characteristics associated with puberty in males and females. State and explain the different types of family planning methods. • State and explain the different types of diseases that are transmitted sexually.
Knowledge	• The two main modes of reproduction. • Different types of asexual reproduction and their occurrence in other organisms. • Different types of sexual reproduction and their occurrence in other organisms. • The reproductive system of plants and the process of reproduction, from pollination to seed dispersal and types of seed dispersal. • The different types of asexual reproduction in plants. • The reproductive system of animals and the process of reproduction, from mating to birth. • The different types of asexual reproduction in animals. • The human reproductive system and the process of reproduction from conception to birth. • The role of certain hormones in the reproduction of humans. • Secondary sexual characteristics associated with puberty in males and females. • Different types of family planning methods. • Different types of diseases that are transmitted sexually.
Skills	• Explain the two modes of reproduction. • Differentiate between the types of asexual reproduction. • Differentiate between how organisms achieve their sexual reproduction process. • Describe the reproductive system of plants and differentiate the types of seed dispersal process. • Differentiate between the types of asexual reproduction in plants. • Describe the reproductive system of animals. • Differentiate between the types of asexual reproduction in animals. • Describe the process of reproduction from conception to birth. • Explain the role of hormones in reproduction. • Explain the sexual characteristics associated with puberty. • Evaluate the types of family method. • Analyse the types of sexually transmitted diseases.
Atitudes & Values	• Appreciate science for its usefulness in improving quality of life

Content Background

No known living organism can live forever. Hence if a species is to survive, it must continually produce offspring. Reproduction is the process of generating new offspring. It can be achieved in two ways; **asexual reproduction** and **sexual reproduction.**

Asexual reproduction is the process by which genetically identical offspring are produced from one parent.

Types of Asexual Reproduction	Description	
Binary fission (splitting)	Unicellular organisms such as bacteria and the Amoeba divide into two or more parts each and lead a separate existence.	
Budding	Hydra and yeast develop outgrowths and these buds later detach from the parent and develop into independent organisms.	
Fragmentation	Filamentous algae such as the Spirogyra breaks off into fragments, with each portion regenerating the missing parts to form new individuals.	
Sporulation	Bacteria, algae, fungi, ferns and mosses develop unicellular bodies called spores which detach from the parent and develop into new individuals	
Cloning	Mitotic division that results in a development of a clone with the exact genetic make-up.	
Parthenogenesis	The development of a female gamete to produce identical offspring without fertilization. This is common in aphids and bees.	

Vegetative Propagation	Vegetative propagation is the separation of a part of the parent plant which then develops into a new plant. Almost any part of the plant may be modified to become the organ for vegetative propagation. The buds on the rhizome of a ginger produce vertical growths which develop into new plants. The onion bulb is bud/modified shoot whose leaves are swollen with food. It survives the winter when all the other parts of the plant die. The bulbs reproduce by sprouting an additional bulb at the side and a new plant develops from it.	 

Artificial Vegetative Reproduction

Gardeners have taken advantage of plants' abilities for vegetative reproduction for centuries. Some of the common methods include cuttings, layering, marcotting, budding and grafting. These are methods of artificial vegetative reproduction. Gardeners employ these methods to grow plants that produce healthy, sweet and large fruit. With artificial vegetative propagation, gardeners are able to cultivate large numbers of the same healthy and high yielding plants.

Cutting

Cuttings are leafy shoot or root fragments that can develop adventitious roots and shoots. Propagation by cuttings is a relatively easy method and can provide a large number of plantlets in a very short time. Stem cutting involves cutting a stem just below a node. The cutting is then placed viable soil, so that the node can develop roots to form a new plant. Plants like sugar cane and tapioca can be propagated by this method.

Layering

In layering, a low branch with a node is selected and a ring of bark is removed from the node, which is then covered in the soil. After roots have developed from the ringed section, an independent new plant is produced. This method is widely practiced to grow lime trees.

Marcotting

Marcotting or air-layering is similar to layering. However, instead of placing the ringed section in the soil on the ground, a layer of soil is just wrapped around the ringed section without pulling it to the ground. Fruit plants such as rambutans are propagated this way.

Budding and Grafting

Grafting is the union of a part of a plant with that of other plants(s) of the same species that are specifically selected for different purposes (e.g. disease resistance, adaptability to environmental constraints, productivity). A healthy plant with established roots is selected to become the stock. A section of another plant to be propagated called the scion is cut off and attached to the stock. The stock absorbs water and minerals through its roots and transports them to the scion. Plants cultivated in this manner include roses, cherry and almond.

As mentioned, all the above methods have been in use for centuries. Nowadays, scientists have even gone further. They can grow plants by putting the cuttings in test tubes on specially prepared mixtures of chemicals called culture media. This is called in vitro culture. In vitro means “in glass”. The piece of plant can be very small, so one plant can produce thousands of offsprings in this way. The mixture of chemical is prepared in a jelly called agar. This agar jelly helps to support the plant whilst its roots grow and absorb the nourishment in the agar. In this way, the conditions for the growth of the plant can be very carefully controlled. When these offsprings have grown roots and leaves they can be transferred to soil where they will grow into adult plants.

Sexual Reproduction

Sexual reproduction is the process involving fusion of two nuclei to forma zygote and the production of genetically dissimilar offspring.

Sexual reproduction increases the variation within a species resulting in an increased likelihood of producing some offspring that will be able to adapt to environmental changes, as each offspring will receive a different mixture of genes.

Sexual Reproduction in plants

Flowering plants or angiosperms are the most abundant and diverse plants on Earth. Most a terrestrial and lack locomotion. This poses several problems for sexual reproduction. Gametes are delicate single cells. For two plants to cross-fertilse, there must be a mechanism for the two gametes to reach each other safely. There must also be a mechanism to disperse their offspring far away from the parents so that they not have to compete with the parent for light, water and soil minerals.

Pollination

Pollination is the transfer of pollen from a male reproductive structure to a female reproductive structure by a vector such as wind or insects. Cross-pollination is pollination that occurs between different plants. If pollen grains are transferred to the stigma of the same flower or a different flower on the same plant, the process is called self-pollination.

There is usually a vector for pollination. A vector is an external agent that ‘assists’ in bringing the pollen from the male organ/flower to the female organ/flower. This can be either insects or wind. Flowers are that are pollinated by insects are usually modified for this function and they are characteristically different from wind-pollinated flowers.

Cross-pollination

The seeds produced by cross-pollination give rise to healthier plants as they possess a superior mix of genes from two parents. Continued in-breeding in self-pollination will lead to production of offspring that are weaker and less adaptable to changes in the environment. Cross pollination has the following advantages:

1. Offspring produced may inherit strong/ superior genes from parents.
2. More viable seeds may be produced.
3. More varieties of offspring can be produced as there is an increase in the gene pool contributed by both parents. This increases the chances of survival as some seedlings may inherit superior genes that can adapt to changes in the environment.

Since cross-pollination is advantageous, plants have evolved to increase the chances of cross-pollination in the following ways:

- Dioecious plants bear either male or female flowers so that self-pollination is impossible.
- In plants with bisexual flowers, the anthers and the stigma may mature at different times.
- Alternative plants with bisexual flowers have their stigmas situated some distance away from the anthers. This is seen in the hibiscus plant.

Insect Pollination

When an insect comes to a flower, it lands on the petal. The insect will force its way in between the two wing petals and move in to collect its nectar. Its back will force the keel petal upwards and this will expose the stigma and anthers which brush against the insects. When this happens, some pollen will be attached to the insect's back. At the same time, pollen from another flower which has attached to the insect's back previously will then stick to the stigma. The insect then moves on to another flower and the whole process is repeated.

Insect-pollinated flowers are different wind-pollinated flowers. Because they have need to attract insects, wind-pollinated flowers often , scent and nectar. They are usually lack colour, scent or nectar. They are usually inconspicuous and unattractive. The table be low summarises the differences between insect-pollinated flowers and wind-pollinated flowers.

Wind-pollinated flowers	Insect-pollinated flowers
• Petals are dull in colour; usually yellow or pale green. They are also small and inconspicuous • Flowers occur in inflorescence above the vegetative leaves • They are unisexually with excess male flowers • No scent is produced • No nectar is produced • Stigmas are feathery and protrude outside the flower • Anthers dangle outside the flower so that the pollen is released easily • Filament is long and slender so that the anther anthers may swing in the breeze outside the flower • Pollen is light and minute with smooth surfaces. Some even have wing-like extensions to aid wind transport • Very large quantities of pollen are produced	• Petals are brightly coloured large and conspicuous petals • Flowers occur singly • They are mostly bisexual • Scent is produced to attract insects • Nectar is produced by nectary glands along with nectar guides to lead the insect to the nectar • Stigma lies within the corolla • Anther lies inside the flower to allow insects to brush against itr when collecting nectar • Filament is strong to support the insects when they visit the flower • Pollen grains are larger and have projections or sticky surfaces to help them stick to insects • Smaller quantities of pollen are produced

Seed Dispersal

Plants must have a mechanism to disperse their offspring far enough away from the parent so that they do not have to compete with their parent for light, water and soil minerals. This mechanism is known as fruits and seed dispersal. Not only is dispersal important to prevent overcrowding and over sharing of resources, it also allows plants to colonise new habitats and reduce the spread of diseases.

There are a variety of dispersal mechanisms and these could be affected by internal mechanism or external agents, such as wind, water or animal.

Internal Mechanism: Explosive Action

Fruits such as balsam, rubber, caesalpinia and other leguminous fruits literally explode, flinging seeds in different directions. These fruits have evolved various adaptations to enhance their explosive effect when they are ripe.

External Mechanism: Wind

Some seeds that are light are dispersed by wind. These include cotton and floss. Others that are dispersed by wind but are quite large and heavy develop wing-like structures so that they can be carried by the wind. These include the angsana and shorea. Other plants such the poppy bear their fruit as a capsule at the top of a long stalk which is easily shaken by the wind. When this happens, the small seeds are shaken out and carried by the wind. The lalalng has a unique adaptation for dispersal by a parachute mechanism. Each fruit has tufts of hair arising from its coat. This increases the air resistance through its movements.

External Mechanism: Water

Coastal plants such as coconut and lotus have fruits with spongy or fibrous layers, which enclose large chambers of air. The trapped air allows them to float for long period of time away from the parent plant.

External Mechanism: Animals

This category of plants relies on a range of animals both large and small to disperse their seeds. Essentially, there are two methods. In the first method, are succulent and juicy fruits attract animals to eat them. The seeds, however, have been adopted to be indigestible. As such, after the animals have wandered away, the seeds will be passed out of the animals' digestive system together with their stool. These seeds germinate away from the parent and also have added benefit of fertilizer from the animals' stool.

The second method involves evolving special adaptations such as hooks, spines or sticky surface that cling on a temporarily to the animals that pass by. This allows the seeds to be dispersed to distant habitats.

Nervous System

Content Standard:	**11.2.5** Investigate plant tropism, reproduction, endocrine, nervous and defence system.
Benchmarks	**11.2.5.5** Describe the anatomy and physiology of the endocrine, excretory and nervous systems and explain how these systems interact to maintain homeostasis.
Essential Question	1. How does the nerve system function? 2. What is the difference between involuntary and voluntary reflexes? 3. What is the difference between central and peripheral nervous systems? 4. Where is the nervous system?
Learning Objective	• Describe the structure and role of the nervous system in animals. • Describe and explain the structure and types of nerve cells and how they work in the nervous system. • Differentiate between involuntary and voluntary reflexes. • Explain what Central and peripheral nervous systems are and be able to differentiate one from the other.
Knowledge	• The structure and role of the nervous system in animals. • The structure and types of nerve cells and how they work in the nervous system. • Difference between involuntary and voluntary reflexes. • Central and peripheral nervous systems and how they differentiate from each other.
Skills	• Analyse the structure and role of the nervous system in animals. • Identify and analyse the structure of the different types of nerve cells and how they work. • Differentiate between involuntary and voluntary reflexes. • Differentiate between central and peripheral nervous systems
Atitudes & Values	• Appreciate science for its usefulness in improving quality of life

Content Background

There are millions of cells and scores of different tissues and organs in the body of an animal such as a mammal. The cells and organs do not all work independently- their activities are coordinated, which means that they work together, carrying their various functions at certain times and at certain rates according to the needs of the body.

Coordination in mammals is achieved through two systems, each with its own particular role. The nervous system deals with the rapid but short-lasting responses, whereas the endocrine system brings about slower, longer lasting responses.

Nervous System

The nervous system is the network of body tissues that detect process and distribute information in the body using electrical and chemical transmissions. It is in two parts:

1. The central nervous system (CNS) which comprises the brain and spinal cord.
2. The peripheral nervous system (PNS), which consists of the cranial nerves from the brain (including the optic nerve), spinal nerves from the spinal cord and the sense organ that transmits sensation and motor information back and forth from the body to the central nervous system.

The sense organs receive stimuli and so they are appropriately called receptors. There are a wide range of receptors found in the sense organs of animals. There are receptors for light (photoreceptors) found in the retina in the eye. Olfactory receptors for smell in the nose, gustatory (taste) receptors in the tongue and pain receptors on the skin. There are also receptors that pick up stimuli from the internal environment, such as chemoreceptors that detect the concentration of carbon dioxide in the blood or hormones in the hypothalamus in the brain. They are responsible for informing the central nervous system of any changes in the surroundings, by transmitting sensory signals in the form of impulses. These nerve impulses are electrical in nature. The nerve impulse is transmitted by the nerves in a fraction of a section. For example, if someone touches your shoulder from behind, you will feel the touch almost instantaneously.

Receptor	Stimulus detected	Location
Mechanoreceptors	Pain, pressure, gravity, touch	Skin, ear
Photoreceptors	Light	Rods and cones on the retina in the eye
Chemoreceptors	Chemicals	Taste buds, blood vessels, hypothalamus
Thermoreceptors	Temperature	Skin, hypothalamus
Electroreceptors	Electricity	Skin

When the central nervous system receives the impulses, it processes the information and then sends the impulses to the muscles. The muscles will then carry out the necessary effects. For example if you see a poisonous snake in your path, you will flinch, jump back, scream or even look around for assistance. Again all these occur in a fraction of a second. Since the muscles act upon the instruction from the central nervous system and carry out their effects, they are called effectors. In short, nerve impulses are transmitted from the receptors to the central nervous system and then from there to the effectors. Hence, the brain, spinal cord and nerve tissues are the coordinators of both **involuntary** and **voluntary** actions in the body.

Involuntary actions

Reflexes concerned with the 'housekeeping' tasks of the body, such as breathing, do not reach the conscious level of the brain. They are dealt with by the autonomic branch of the nervous system. Responses may be more complex than simple reflex arc. For example, the CNS may store information and then compare an incoming stimulus with a previous one. It chooses the correct response for this particular situation, and sends information out to the effectors to bring about the appropriate action. Each time a particular impulse passes along the same route, so that reflex actions become learned reflexes. Talking and cycling are examples of learned reflexes. Whether or not a reflex has been learned, it is an involuntary action- a particular stimulus always leads to the same response.

Voluntary Actions

During evolution, the front of the spinal cord became highly developed to form the brain. The advanced development of the brain, particularly those parts that deal with learning, sets mammals (and especially humans) apart from 'lower animals. The brain is involved in the voluntary actions, in which a conscious choice is made about the response to a particular stimulus.

Nerve Tissue

The nervous tissue is made up of specialized cells called nerve cells. Although the size and shape of neurons differ in different parts of the body, their general structure is similar. Each neurone consists of a cell body with a nucleus and cytoplasmic process called nerve fibres that transmit impulses. There are three types of neurones:

- Sensory neurones or receptor neurones which transmit impulses from the sense organs or receptors to the central nervous system. For example, the photoreceptors in the eye might receive the stimulus from the environment that the light has increased. They then send this information to the brain.
- Motor neurones, which transmit impulses from the central nervous system to the effector cells. The effector cells then carry out the response to the stimulus detected by the original sensory neuron. So if the message sent by the photoreceptors informs the brain that there is too much light hitting the retina, the motor neuron then sends the message to the muscles around the iris to constrict the pupil, so that less light enters the eye.
- Relay neurones (also known as association, connector, multipolar or interneurons) are found in the nervous system and communicating with the rest of the body. For example, they communicate between sensory neurones and motor neurones as well as between themselves.

Nerve impulses

Messages pass along neurons in the form of electrical impulses called action potentials which travel very quickly from one end of a nerve cell to the other. In a living mammal the impulses always travel along a neurone in a certain direction. They are then passes on to another neurone, to a muscle cell or to a gland cell. The end of the neurone is separated from the next cell by a tiny gap, visible under a microscope, and the impulse can only cross this gap in one direction. This gap , called a synapse, acts like a valve.

Endocrines System

Content Standard:	**11.2.5** Investigate plant tropism, reproduction, endocrine, nervous and defence system.
Benchmarks	**11.2.5.5** Describe the anatomy and physiology of the endocrine, excretory and nervous systems and explain how these systems interact to maintain homeostasis.
Essential Question	1. How does the endocrine system function? 2. How does the exocrine system work? 3. What are the major organs of the endocrine system? 4. What are some common endocrine disorders?
Learning Objective	• Describe and explain the role of endocrine and exocrine systems in animals. • Describe the structure and function of the endocrine system. • State and define the types of hormones found within the endocrine system and the glands that produce them. • Discuss the elements of the human endocrine and exocrine systems. • Discuss the process of homeostasis, especially on how the endocrine system interacts with other systems in the human body to bring balance.
Knowledge	• The structure and function of the endocrine system. • Types of hormones found within the endocrine system and the glands that produce them. • Elements of the human endocrine and exocrine systems. • How the endocrine system interacts with other systems in the human body to bring homeostasis.
Skills	• Describe the structure and function of the endocrine system. • Analyse the hormones and the glands that produce them. • Analyse the elements of the human endocrine and exocrine systems. • Explain the process of homeostasis
Atitudes & Values	• Appreciate science for its usefulness in improving quality of life

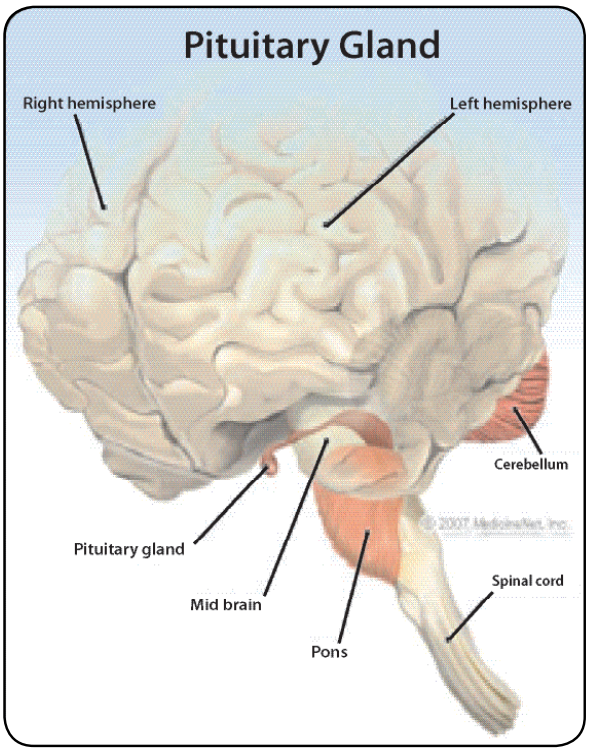
Content Background

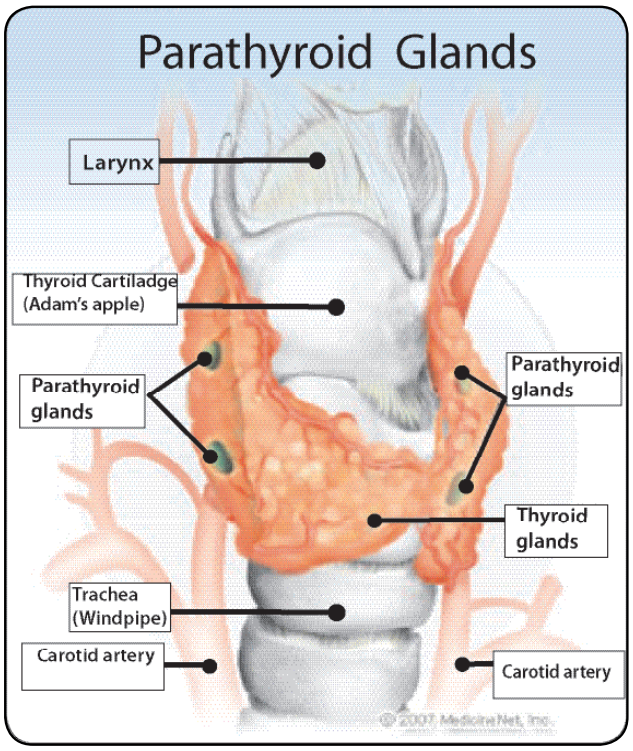
Endocrine System

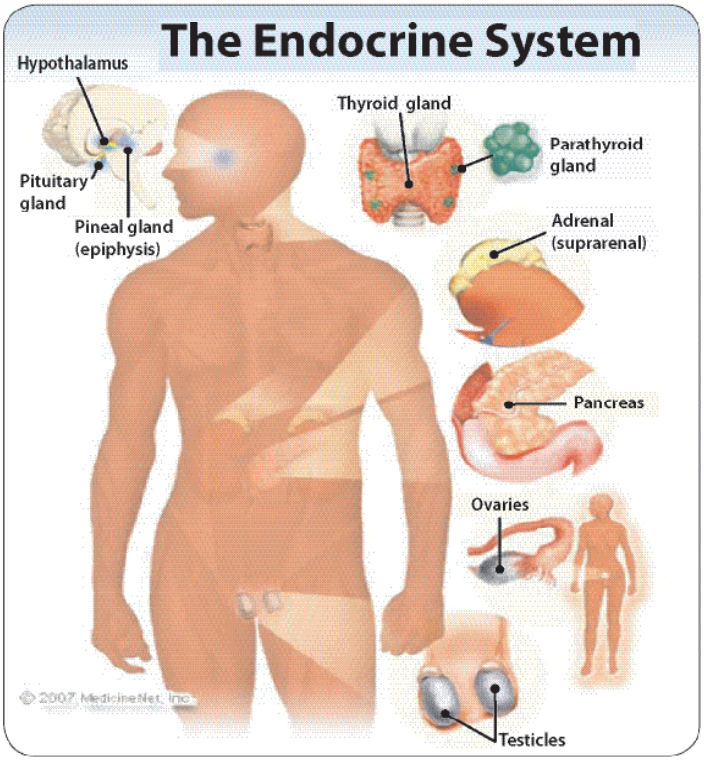
The endocrine system is the collection of glands that produce hormones that produce and secrete hormones, chemical substances produced in the body that regulate the activity of cells or organs. These hormones regulate metabolism, growth and development, tissue function, sexual function, reproduction, appetite, body temperautre, sleep and mood, among others.

The word endocrine is derived from the Greek words “endo,” meaning within, and “crinis,” meaning to secrete. In general, a gland selects and removes materials from the blood, processes them and secretes the finished chemical product for use somewhere in the body. The endocrine system affects almost every organ and cell in the body.

Hormones are chemical messengers created by the body. They transfer information from one set of cells to another to coordinate the functions of different parts of the body. The major glands of the endocrine system are the hypothalamus, pituitary gland, thyroid gland, parathyroid glands, adrenal glands, pancreas, ovaries (in female) and testicles (in males).


Pituitary Gland
Right hemisphere
Left hemisphere
Cerebellum
Pituitary gland
Mid brain
Pons
Spinal cord


Parathyroid Glands
Larynx
Thyroid Cartilage (Adam's apple)
Parathyroid glands
Parathyroid glands
Thyroid glands
Trachea (Windpipe)
Carotid artery
Carotid artery


The Endocrine System
Hypothalamus
Pituitary gland
Pineal gland (epiphysis)
Thyroid gland
Parathyroid gland
Adrenal (suprarenal)
Pancreas
Ovaries
Testicles

Although the hormones circulate throughout the body, each type of hormone is targeted toward certain organs and tissues. The endocrine system gets some help from organs such as the kidney, liver, heart and gonads, which have secondary endocrine functions. The kidney, for example, secretes hormones such as erythropoietin and renin.

The thyroid also secretes a range of hormones that affect the whole body. “Thyroid hormones impact a host of vital body functions, including heart rate, skin maintenance, growth, temperature regulation, fertility and digestion

Endocrine System Organs

Part	Function
Hypothalamus	The hypothalamus is located in the lower central part of the brain. This part of the brain is important in regulation of satiety, metabolism, and body temperature. In addition, it secretes hormones that stimulate or suppress the release of hormones in the pituitary gland. Many of these hormones are releasing hormones, which are secreted into an artery (the hypophyseal portal system) that carries them directly to the pituitary gland. In the pituitary gland, these releasing hormones signal secretion of stimulating hormones. The hypothalamus also secretes a hormone called somatostatin, which causes the pituitary gland to stop the release of growth hormone.
Pituitary Gland	The pituitary gland is located at the base of the brain beneath the hypothalamus and is no larger than a pea. It is often considered the most important part of the endocrine system because it produces hormones that control many functions of other endocrine glands. When the pituitary gland does not produce one or more of its hormones or not enough of them, it is called hypopituitarism. The pituitary gland is divided into two parts: the anterior lobe and the posterior lobe. The anterior lobe produces the following hormones, which are regulated by the hypothalamus: • Growth hormone: Stimulates growth of bone and tissue (Growth hormone deficiency results in growth failure. Growth hormone deficiency in adults results in problems in maintaining proper amounts of body fat and muscle and bone mass. It is also involved in emotional well-being.) • Thyroid-stimulating hormone (TSH): Stimulates the thyroid gland to produce thyroid hormones (A lack of thyroid hormones either because of a defect in the pituitary or the thyroid itself is called hypothyroidism.) • Adrenocorticotropin hormone (ACTH): Stimulates the adrenal gland to produce several related steroid hormones • Luteinizing hormone (LH) and follicle-stimulating hormone (FSH): Hormones that control sexual function and production of the sex steroids, estrogen and progesterone in females or testosterone in males • Prolactin: Hormone that stimulates milk production in females The posterior lobe produces the following hormones, which are not regulated by the hypothalamus: • Antidiuretic hormone (vasopressin): Controls water loss by the kidneys • Oxytocin: Contracts the uterus during childbirth and stimulates milk production The hormones secreted by the posterior pituitary are actually produced in the brain and carried to the pituitary gland through nerves. They are stored in the pituitary gland.

Thyroid Gland	The thyroid gland is located in the lower front part of the neck. It produces thyroid hormones that regulate the body's metabolism. It also plays a role in bone growth and development of the brain and nervous system in children. The pituitary gland controls the release of thyroid hormones. Thyroid hormones also help maintain normal blood pressure, heart rate, digestion, muscle tone, and reproductive functions.
Parathyroid Glands	The parathyroid glands are two pairs of small glands embedded in the surface of the thyroid gland, one pair on each side. They release parathyroid hormone, which plays a role in regulating calcium levels in the blood and bone metabolism.
Adrenal Glands	The two adrenal glands are triangular-shaped glands located on top of each kidney. The adrenal glands are made up of two parts. The outer part is called the adrenal cortex, and the inner part is called the adrenal medulla. The outer part produces hormones called corticosteroids, which regulate the body's metabolism, the balance of salt and water in the body, the immune system, and sexual function. The inner part, or adrenal medulla, produces hormones called catecholamines (for example, adrenaline). These hormones help the body cope with physical and emotional stress by increasing the heart rate and blood pressure.
Reproductive Glands	The reproductive glands are the main source of sex hormones. In males, the testes, located in the scrotum, secrete hormones called androgens; the most important of which is testosterone. These hormones affect many male characteristics (for example, sexual development, growth of facial hair and pubic hair) as well as sperm production. In females, the ovaries, located on both sides of the uterus, produce estrogen and progesterone as well as eggs. These hormones control the development of female characteristics (for example, breast growth), and they are also involved in reproductive functions (for example, menstruation, pregnancy).
Pancreas	The pancreas is an elongated organ located toward the back of the abdomen behind the stomach. The pancreas has digestive and hormonal functions. One part of the pancreas, the exocrine pancreas, secretes digestive enzymes. The other part of the pancreas, the endocrine pancreas, secretes hormones called insulin and glucagon. These hormones regulate the level of glucose (sugar) in the blood.

Some endocrine glands also have non-endocrine functions. For example, the ovaries and testes produce hormones, but they also have the non-endocrine function of producing eggs and sperm respectively.

Endocrine System Hormones

Hormones are the chemicals the endocrine system uses to send messages to organs and tissue throughout the body. Once released into the bloodstream, they travel to their target organ or tissue, which has receptors that recognise and react to the hormone.

Below are some examples of hormones that are produced by the endocrine system.

Hormone	Secreting gland(s)	Function
adrenaline	adrenal	increases blood pressure, heart rate, and metabolism in reaction to stress
aldosterone	adrenal	controls the body’s salt and water balance
cortisol	adrenal	plays a role in stress response
dehydroepiandrosterone sulfate (DHEA)	adrenal	aids in production of body odor and growth of body hair during puberty
estrogen	ovary	works to regulate mentsrual cycle, maintain pregnancy and develop female sex characteristics; aids in sperm production

follicle stimulating hormone	pituitary	controls the production of eggs and sperm
glucagon	pancreas	helps to increase levels of blood glucose
insulin	pancrease	helps to reduce levels of blood glucose level
luteinising hormone (LH)	pituitary	controls estrogen and testosterone production as well as ovulation
melatonin	pituitary	controls sleep and wake cycles
oxytocin	pituitary	helps with lactation, childbirth and mother-child bonding
parathroid hormone	parathyroid	controls calcium levels in bones and blood
progesterone	ovary	helps to prepare the body for pregnancy when an egg is fertilised
prolactin	pituitary	promotes breast-milk production
testosterone	ovary, teste, adrenal	contributes to sex drive and body density in males and females as well as development of male sex characteritics
thyroid hormone	thyroid	help control several body functions, including the rate of metabolism and energy levels.

Diseases of the endocrine system

Hormone levels that are too high or too low indicate a problem with the endocrine system. Hormone diseases also occur if your body does not respond to hormones in the appropriate ways. Stress, infection and changes in the blood's fluid and electrolyte balance can also influence hormone levels, according to the National Institutes of Health.

A common endocrine disease is diabetes, a condition in which the body does not properly process glucose, a simple sugar. This is due to the lack of insulin or, if the body is producing insulin, because the body is not working effectively. Diabetes can be linked to obesity, diet and family history. To diagnose diabetes, do an oral glucose tolerance test with fasting. It is also important to understand the patient's health history as well as the family history. Infections and medications such as blood thinners can also cause adrenal deficiencies.

Diabetes is treated with pills or insulin injections. Managing other endocrine disorders typically involves stabilising hormone levels with medication or, if a tumor is causing an overproduction of a hormone, by removing the tumor. Treating endocrine disorders takes a very careful and personalised approach, as adjusting the levels of one hormone can impact the balance of other hormones.

Hormone imbalances can have a significant impact on the reproductive system, particularly in women.

Another disorder, hypothyroidism, a parathyroid disease, occurs when the thyroid gland does not produce enough thyroid hormone to meet the body's needs. Insufficient thyroid hormone can cause many of the body's functions to slow or shut down completely. It has an easy treatment, though. Thyroid cancer begins in the thyroid gland and starts when the cells in the thyroid begin to change, grow uncontrollably and eventually form a tumor. Tumors — both benign and cancerous — can also disrupt the functions of the endocrine system.

Hypoglycemia, also called low blood glucose or low blood sugar, occurs when blood glucose drops below normal levels. This typically happens as a result of treatment for diabetes when too much insulin is taken. The condition can occur in people not undergoing treatment for

Standards-Based Lesson Planning

What are Standards-Based Lessons?

In a Standards-Based Lesson, the most important or key distinction is that, a student is expected to meet a defined standard for proficiency. When planning a lesson, the teacher ensures that the content and the methods of teaching the content enable students to learn both the skills and the concepts defined in the standard for that grade level and to demonstrate evidence of their learning.
Planning lessons that are built on standards and creating aligned assessments that measure student progress towards standards is the first step teacher must take to help their students reach success. A lesson plan is a step-by-step guide that provides a structure for an essential learning.
When panning a standards-based lesson, teacher instructions are very crucial for your lessons. How teachers instruct the students is what really points out an innovative teacher to an ordinary teacher. Teacher must engage and prepare motivating instructional activities that will provide the students with opportunities to demonstrate the benchmarks. For instance, teacher should at least identify 3-5 teaching strategies in a lesson; teacher lectures, ask questions, put students into groups for discussion and role play what was discussed.

Why is Standards-Based Lesson Planning Important?

There are many important benefits of having a clear and organized set of lesson plans. Good planning allows for more effective teaching and learning. The lesson plan is a guide and map for organizing the materials and the teacher for the purpose of helping the students achieve the standards. Lesson plans also provide a record that allows good, reflective teachers to go back, analyze their own teaching (what went well, what didn't), and then improve on it in the future.
Standards-based lesson planning is vital because the content standards and benchmarks must be comparable, rigorous, measurable and of course evidence based and be applicable in real life that we expect students to achieve. Therefore, teachers must plan effective lessons to teach students to meet these standards. As schools implement new standards, there will be much more evidence that teachers will use to support student learning to help them reach the highest levels of cognitive complexity. That is, students will be developing high-level cognitive skills.

Components of a Standards-Based Lesson Plan

An effective lesson plan has three basic components;

- aims and objectives of the course;
- teaching and learning activities;
- assessments to check student understanding of the topic.

Effective teaching demonstrates deep subject knowledge, including key concepts, current and relevant research, methodologies, tools and techniques, and meaningful applications.

Planning for under-achievers NORMA

Who are underachieving students?
Under achievers are students who fail or do not perform as expected. Underachievement may be caused by emotions (low self-esteem) and the environment (cultural influences, unsupportive family)

How can we help underachievement?

Underachievement varies between students. Not all students are in the same category of underachievement.

Given below a suggested strategies teachers may adopt to assist underachievers in the classroom.

- Examine the Problem Individually
  It is important that underachieving students are addressed individually by focusing on the student's strengths.
- Create a Teacher-Parent Collaboration
  Teachers and parents need to work together and pool their information and experience regarding the child. Teachers and parents begin by asking questions such as;
  - In what areas has the child shown exceptional ability?
  - What are the child's preferred learning styles?
  - What insights do parents and teachers have about the child's strengths and problem areas?
- Help student to plan every activity in the classroom
- Help students set realistic expectations
- Encourage and promote the student's interests and passions.
- Help children set short and long-term academic goals
- Talk with them about possible goals.
- Ensure that all students are challenged (but not frustrated) by classroom activities
- Always reinforce students

Standards-Based Lesson Planning

The following sample lesson can help teachers to plan effective lessons. Teachers are encouraged to study the layout of the different components of these lessons and follow this design in their preparation and teaching of each lesson. Planning a good lesson helps the teacher in maintaining a standard teaching pattern which should not deviate students learning of the concept from the topic.

Topic: Cells
Grade: 11
Length of Lesson: 40 minutes

National Content Standard: 11.2.1 Investigate the origins, diversity, principles of scientific classification and cell structure of living things.
Grade Level Benchmark: 11.2.1.3 Investigate cells as the basic structural unit of all organisms including adaptations and their functions.

Essential Knowledge, Skills, Values, and Attitudes

Essential Knowledge	• The cell is the smallest structure that carries out all the activities necessary for life. • Plant cell contain cell membrane, nucleus, cytoplasm, cell wall and chloroplast • Animal cells contain cell membrane, nucleus and cytoplasm • Cells come in many size and shape. The size and shape of the cell relates to its job or function
Essential Skills	• Label on a drawing, the parts of a typical plant or animal cell. • Compare plant and animal cells
Essential Attitudes & Values	• Appreciate the wonders of our bodies where many different types of cells work together effectively

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Materials: Copies of plant and animal cell handout

Lesson Objective: Students will be able to;

- state that all living things are made of cells, which are the basic units of life
- identify similarities and differences between a plant and animal cell.

Essential Questions:

What is the difference between an animal cell and a plant cell?

Lesson Procedure

Teacher Activities	Student Activities
Introduction	
• Explain what students will learn and how it will be useful. • Connect what they will learn to prior learning or experience.	• Listen to the teacher.
Body	
Guided Practice	
• Give students a copy of the plant and animal cells. • Ask students to study the plant and animal cells and their properties. • Ask students to stop and give a difference between a plant or a an animal cell. • Ascertain if students understand what they are supposed to do.	• Read the properties of plant and animal cells. • Give one difference given in the plant or animal cell. • Let teacher know if they understand what to do.
Independent Practice	
• Ask students to read the plant and animal cell handout and figure the difference between the two types of cells • Ask students to state a difference between the two cells	• Read the plant and animal cell handout and try to explain the difference between the two types of cells. • State the similarities and differences between the two cells with justification
Conclusion	
• Revise the key concepts of the lesson • Ask students to provide explanantions for their answers	• Listen to the teacher. • Give reasons to justify their explanations.

Performance Assessment and Standards

National Content Standard: 11.2.1 Investigate the origins, diversity, principles of scientific classification and cell structure of living things

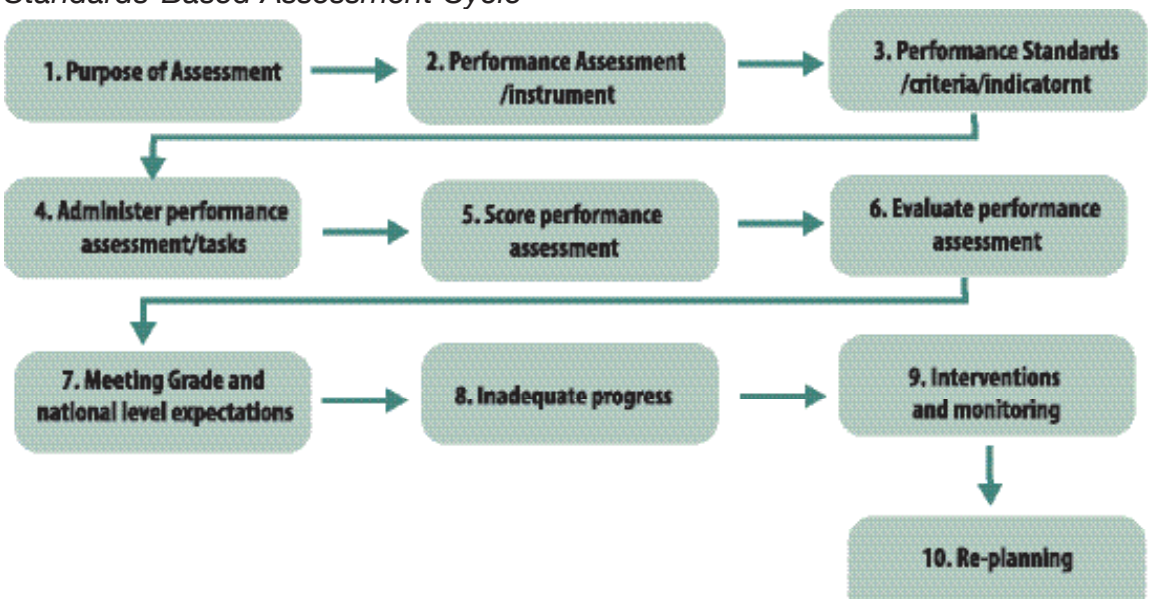
Lesson Topic	Topic	Benchmark	Performance Assessment	
Cells	**Cells**	**12.1.1.1.** Investigate cells as the basic structural unit of all organisms including adaptations and their functions		
	PROFICIENCY RUBRIC			
	Advanced	**Proficient**	**Partially Proficient**	**Novice**
	Identify all the properties and explain the difference between plant and animal cell.	Identify all the properties of a plant and animal cell.	Identify more than half of the properties of a plant and animal cell.	Identify less than half of the properties of a plant and animal cell.

Assessment, Monitoring and Reporting

What is Standards-Based Assessment (SBA)?

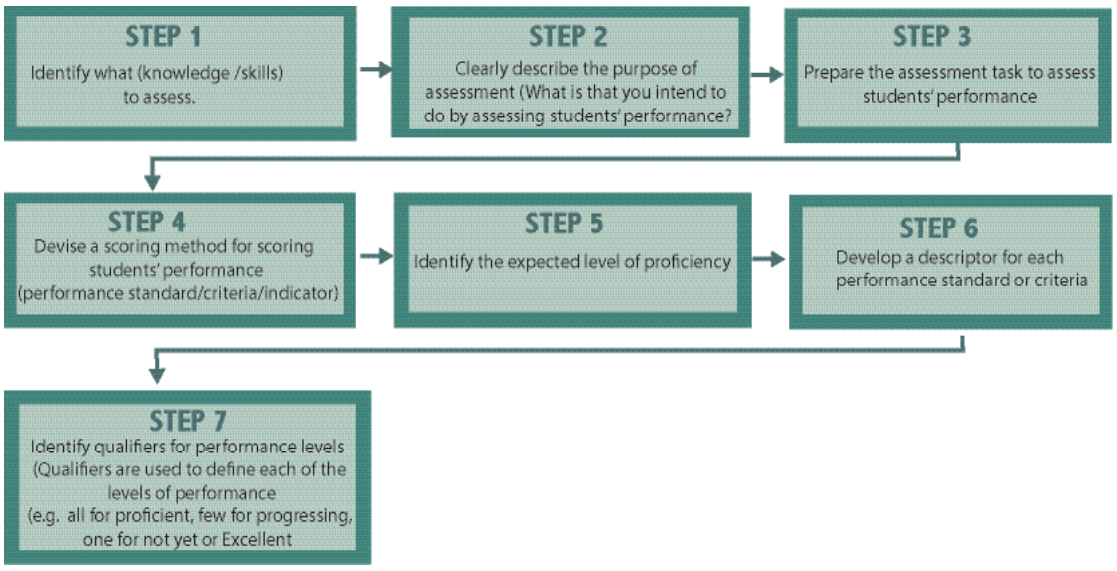
Assessment and reporting is an integral part of the delivery of any curriculum used in the schools. In Standard Based Curriculum (SBC) assessmentencourages the use of benchmarks and commended types of assessment that promote standards for a range of purposes.

Standards-Based Assessment Cycle



Standards-Based Assessment Process

Teachers are required to use the steps outlined below when planning assessment. These steps will guide you to develop effective assessments to improve student's learning as well as evaluating their progress towards meeting national and grade –level expectations.



Purpose of Standards-Based Assessment

Standards-Based Assessment (SBA) serves different purposes. These include instruction and learning purposes. The primary purpose of SBA is to improve student learning so that all students can attain the expected level of proficiency or quality of learning.

Enabling purposes of SBA is to:

- Measure students' proficiency on well-defined content standards, benchmarks and learning objectives
- Ascertain students' attainment or progress towards the attainment of specific component of a content standard
- Ascertain what each student knows and can do and what each student needs to learn to reach the expected level of proficiency
- Enable teachers to make informed decisions and plans about how and what they would do to assist weak students to make adequate progress towards meeting the expected level of proficiency
- Enable students to know what they can do and help them to develop and implement strategies to improve their learning and proficiency level
- Communicate to parents, guardians, and relevant stakeholders the performance and progress towards the attainment of content standards or its components
- Compare students' performances and the performances of other students

Principles of Standards-Based Assessment

The principle of SBA is for assessment to be;

- emphasise on tasks that should encourage deeper learning,
- be an integral component of a course, unit or topic and not something to add on afterward,
- a good assessment requires clarity of purpose, goals, standards and criteria of practices that should use a range of measures allowing students to demonstrate what they know and can do,
- based on an understanding of how students learn of practices that promote deeper understanding of learning processes by developing their capacity for self-assessment,
- for improving performance that involves feedback and reflection,
- on-going rather than episodic,
- given the required attention to outcomes and processes, and
- be closely aligned and linked to learning objectives, benchmarks and content standards.

Standards-Based Assessment Types

In standards-Based Assessment, there are three broad assessments types.

1. Formative Assessment

Formative assessment includes 'assessment *for* and *as Learning'* and is conducted during the teaching and learning of activities of a topic.

Purposes of assessment for Learning

- On-going assessment that allows teachers to monitor students on a day-to-day basis.
- Provide continuous feedback and evidence to the teachers that should enable them to identify gaps and issues with their teaching, and improve their classroom teaching practice.
- Helps students to continuously evaluate, reflect on, and improve their learning.

Purposes of assessment as Learning

- Occurs when students reflect on and monitor their progress to inform their future learning goals.
- Helps students to continuously evaluate, reflect, and improve their own learning.
- Helps students to understand the purpose of their learning and clarify learning goals.

2. Summative Assessment

Summative assessment focuses on 'assessment *of learning'* and is cconducted after or at the conclusion of teaching and learning of activities or a topic.

Purposes of assessment of Learning

- Help teachers to determine what each student has achieved and how much progress he/she has made towards meeting national and grade-level expectations.
- Help teachers to determine what each student has achieved at the end of a learning sequence or a unit.
- Enable teachers to ascertain each student's development against the unit or topic objectives and to set future directions for learning.
- Help students to evaluate, reflect on, and prepare for next stage of learning.

3. Authentic Assessment

- Is performed in a real life context that approximates as much as possible, the use of a skill or concept in the real world.
- Is based on the development of a meaningful product, performance or process
- Students develop and demonstrate the application of their knowledge, skills, values and attitudes in real life situations which promote and support the development of deeper levels of understanding.
- Uses either summative or formative assessment methods in real life context.

Authentic assessment refers to assessment that:

- Looks at students actively engaged in completing a task that represents the achievement of a learning objective or standard.
- Takes place in real life situations.
- Asks students to apply their knowledge, skills, values and attitudes in real life situations.
- Students are given the criteria against which they are being assessed.

Performance Assessment

Performance assessment is a form of testing that requires students to perform a task rather than select an answer from a ready-made list. For example, a student may be asked to explain historical events, generate scientific hypotheses, solve math problems, converse in a foreign language, or conduct research on an assigned topic. Teachers, then judge the quality of the student's work based on an agreed-upon set of criteria. It is an assessment which requires students to demonstrate that they have mastered specific skills and competencies by performing or producing something.

Types of performance assessment

i. Products

This refers to concrete tangible items that students create through either the visual, written or auditory media such as:

- Creating a health/physical activity poster.
- Video a class game or performance and write a broadcast commentary.
- Write a speech to be given at a school council meeting advocating for increased time for health and physical education in the curriculum.
- Write the skill cues for a series of skill photo's.
- Create a brochure to be handed out to parents during education week.
- Develop an interview for a favourite sportsperson.
- Write a review of a dance performance.
- Essays.
- Projects.

ii. Process Focused Tasks

It shows the thinking processes and learning strategies students use as they work such as:

- Survival scenarios.
- Problem solving initiative/adventure/ activities.
- Decision making such as scenario's related to health issues.
- Event tasks such as creating a game, choreographing a dance/gymnastics routine, creating an obstacle course.
- Game play analysis.
- Peer assessment of skills or performances.
- Self-assessment activities.
- Goal setting, deciding a strategy and monitoring progress towards achievement.

iii. Portfolio

This refers to a collection of student work and additional information gathered over a period of time that demonstrates learning progress.

iv. Performances

It deals with observable affective or psycho-motor behaviours put into action such as:

- Skills check during game play.
- Role plays.
- Officiating a game.
- Debates.
- Performing dance/gymnastics routines.
- Teaching a skill/game/dance to peers.

Assessment Strategies

It is important for teachers to know that, assessment is administered in different ways. Assessment does not mean a test only. There are many different ways to find out about student's strengths and weaknesses. Relying on only one method of assessing will not reflect student's achievement.

Provided in the table below is a list of suggested strategies you can use to assess student's performances. These strategies are applicable in all the standards-based assessment types.

Assessment Strategies

STRATEGY	DESCRIPTION
ANALOGIES	Students create an analogy between something they are familiar with and the new information they have learned. When asking students to explain the analogy, it will show the depth of their understanding of a topic.
CLASSROOM PRESENTATIONS	A classroom presentation is an assessment strategy that requires students to verbalize their knowledge, select and present samples of finished work, and organize their thoughts about a topic in order to present a summary of their learning. It may provide the basis for assessment upon completion of a student's project or essay.
CONFERENCES	A conference is a formal or informal meeting between the teacher and a student for the purpose of exchanging information or sharing ideas. A conference might be held to explore the student's thinking and suggest next steps; assess the student's level of understanding of a particular concept or procedure; and review, clarify, and extend what the student has already completed
DISCUSSIONS	Having a class discussion on a unit of study provides teachers with valuable information about what the students know about the subject. Focus the discussions on higher level thinking skills and allow students to reflect their learning before the discussion commences.
ESSAYS	An essay is a writing sample in which a student constructs a response to a question, topic, or brief statement, and supplies supporting details or arguments. The essay allows the teacher to assess the student's understanding and/or ability to analyse and synthesize information.
EXHIBITIONS/ DEMONSTRATIONS	An exhibition/demonstration is a performance in a public setting, during which a student explains and applies a process, procedure, etc., in concrete ways to show individual achievement of specific skills and knowledge.
INTERVIEWS	An interview is a face-to-face conversation in which teacher and student use inquiry to share their knowledge and understanding of a topic or problem, and can be used by the teacher to explore the student's thinking; assess the student's level of understanding of a concept or procedure and gather information, obtain clarification, determine positions, and probe for motivations.
LEARNING LOGS	A learning log is an ongoing, visible record kept by a student and recording what he or she is doing or thinking while working on a particular task or assignment. It can be used to assess student progress and growth over time.
OBSERVATION	Observation is a process of systematically viewing and recording students while they work, for the purpose of making programming and instruction decisions. Observation can take place at any time and in any setting. It provides information on students' strengths and weaknesses, learning styles, interests, and attitudes.
PEER ASSESSMENT	Assessment by peers is a powerful way to gather information about students and their understanding. Students can use set criteria to assess the work of their classmates.
PERFORMANCE TASKS	During a performance task, students create, produce, perform, or present works on "real world" issues. The performance task may be used to assess a skill or proficiency, and provides useful information on the process as well as the product.

PORTFOLIOS	A portfolio is a collection of samples of a student's work, and is focused, selective, reflective, and collaborative. It offers a visual demonstration of a student's achievement, capabilities, strengths, weaknesses, knowledge, and specific skills, over time and in a variety of contexts.
QUESTIONS AND ANSWERS (ORAL)	In the question–and-answer strategy, the teacher poses a question and the student answers verbally, rather than in writing. This strategy helps the teacher to determine whether students understand what is being, or has been, presented, and helps students to extend their thinking, generate ideas, or solve problems.
QUIZZES, TESTS, EXAMINATIONS	A quiz, test, or examination requires students to respond to prompts in order to demonstrate their knowledge (orally or in writing) or their skills (e.g., through performance). Quizzes are usually short; examinations are usually longer. Quizzes, tests, or examinations can be adapted for exceptional students and for re-teaching and retesting.
QUESTIONNAIRES	Questionnaires can be used for a variety of purposes. When used as a formative assessment strategy, they provide teachers with information on student learning that they can use to plan further instruction.
RESPONSE JOURNALS	A response journal is a student's personal record containing written, reflective responses to material he or she is reading, viewing, listening to, or discussing. The response journal can be used as an assessment tool in all subject areas.
SELECTED RESPONSES	Strictly speaking a part of quizzes, tests, and examinations, selected responses require students to identify the one correct answer. The strategy can take the form of multiple-choice or true/false formats. Selected response is a commonly used formal procedure for gathering objective evidence about student learning, specifically in memory, recall, and comprehension.
STUDENT SELF-ASSESSMENTS	Self-assessment is a process by which the student gathers information about, and reflects on, his or her own learning. It is the student's own assessment of personal progress in terms of knowledge, skills, processes, or attitudes. Self-assessment leads students to a greater awareness and understanding of themselves as learners.

Samples of Assessment Types

Strand 2: Life **Unit :** Cells

Content Standard 11.2.1 Investigate and analyse the principles of scientific classification, diversity of living organisms and the cell

Topic: Cells- Basic Unit of Life

Benchmark 11.2.1.7 Describe the structure, function and importance of specialised cells and tissues in multi-cellular organisms.

Lesson topic: Cells and Enzymes

Instructional Objective: By the end of the practical lesson, students should be able to create structural models of the cells and enzymes

Materials: Card board, scissors pencil, A4 paper

What is to be assessed? (KSAVs)

Knowledge	Skills	Values and Attitudes
• Enzymes are proteins produced by living cells • Enzymes control every chemical reaction that takes place in living cells	• Identify properties of enzymes • Identify factors affecting actions of enzymes. • Draw a sketch of the model before creating the model	• Value the work of individual students • Actively participate in the practical activity

What is to be assessed? - (KSAVs)
A 3-Dimensional Model of Cell and Enzymes

Purpose of the assessment
To measure students' proficiency on the achievement of the benchmarks and learning objectives in this unit. (This assessment is to be conducted after teaching the unit)

Expected level of proficiency
All students are expected to;
- create a 3D model of Cells and Enzymes
- structures and functions of cells and enzymes .

Assessment Strategy
- Group project. In groups of 3-4 students , complete the given task within the given time frame.

Performance Task

Students will do a practical project . You can use other assessment tools to assess students proficiency on these benchmarks.

Task

Students will be given two weeks to complete this assignment.
They are to;

1. Present a model to the class as an informal talk
2. Do a logbook to show the progress of the work. This may include photos, diagrams and journal entries.
3. A bibliography to accompany the model.

Assessment Scoring

Category	6	5	4	3	2	1	0
Logbook	An excellent logbook. It contains a detailed record of the	A good attempt at providing a record of	Some attempt at recording the	A limited attempt at documenting the construction process	A very brief document. No visuals and does not reflect the process of model making	Significant omissions made to the logbook.	Not present
	All structures are present and correctly modelled. It is labelled in a clear, concise and well –presented manner	All structures are present and correctly modelled, however, the labelling is not clear and well presented.	Most of the relevant structures of the cell are presented and labelled correctly	Most of the relevant structures of the cell are presented but not labelled or incorrectly	There are significant omissions of structures of the cell present in the model. Those present are labelled correctly	There are significant omissions of structures of the cell present in the model. Those present are not labelled or labelled incorrectly	The structure of the cell are incorrect and not labelled
				Appropriate materials were selected and there was an attempt at creative modification to make them even better. The structure shows some ingenuity.			Materials not present

Physical presentation of the model			Great care taken in presentation so that the structure is neat, attractive and follows plans accurately. The structure holds up well under typical stresses.	Presentation was careful; one or two details could have been refined for a more attractive product. The structure functions well under typical stresses.	Presentation accurate but three or four details could have been refined for a more attractive product. The structure falls apart in some areas.	Presentation appears careless. Many details need refinement for a strong attractive product	
Orall presentation of model to the class			Presentation is clear, informative, engaging and well prepared	Presentation is three of the following; clear, informative, engaging and well prepared	Presentation is two of the following; clear, informative, engaging and well prepared	Presentation is one of the following; clear, informative, engaging and well prepared	Not complete
Bibliography present					Bibliography present and sources are referenced correctly	Bibliography present but sources are not referenced correctly	Bibliography not present
Critique of model			All 4 questions answered appropriately	3 questions answered appropriately	2 questions answered appropriately	1 question answered appropriately	0 questions answered
Total							

Recommended Resources:

- 'NSW Biology Text book '
- Worksheet
-

Sample 2: Summative Assessment

Strand 2: Physical Science

Content Standard 11.2.1: Students will be able to examine and explain the structure, properties and changes of motion with motion equation.

Topics 1- 5: *(Refer to the topics in kinematics unit)*

Unit: Kinematics

Benchmark: 11.2.1.1 to 11.2.1.3 *(Refer to the benchmarks in kinematics unit)*

Lesson topics: *(Refer to the lesson topics in kinematics unit)*

Instructional Objective (s): *(Refer to kinematics unit)*

Knowledge	Skills	Values and Attitudes
• Motion, equations of motion, trigonometry and algebraic laws.	• Drawing up Motion graphsnand apply algebraic laws to solve related problems	• Appreciate the usefulness of Motion and problems display confidences in solving motion related problems.

Scientific Thinking: Think about how to solve motion related questions.

What is to be assessed? - (KSAVs)

The unit, Unit: "Kinematics" of Strand 2

Purpose of the assessment

To measure students' proficiency on the achievement of the benchmarks and learning objectives in this unit. (This assessment is to be conducted after teaching the unit)

Expected level of proficiency

All students are expected to;

- Describe the characteristics of motion by applying the equations of motion and graphs.
- Explain characteristics of motion by using graphs

Assessment Strategy

This assessment can be conducted in one lesson as a unit test, or as an assignment.

Performance Task

Students will do an assignment out of 20 marks. You can use other assessment tools (assignment, projects, etc.) assess students proficiency on these benchmarks.

Task: Students will be given two week to complete this assignment. They are to;

1. Investigate who is the fastest runner in class.
2. Draw a motion graph to determine the speed of students.

Assessment Tool

An assignment will be used to measure students' proficiency.

Assessment Scoring

Rubrics must be developed to articulate the real proficiency of the child. This is an analytical rubrics used to assess the child's learning through the assessment tool an assignment.

Performance standards/ Criteria	A	B	C	D	Score
	Advance 20	**Proficient 13-19**	**Progressing 6-12**	**Not Yet 2-5**	**__/20 Marks**
(10 marks) Criteria/ Constraints	Assignment was completed with all constraints and criteria met or exceeded. Reflects attention to detail and quality.	Assignment was completed with some of the constraints and criteria met. Reflects some attention to detail, but quality is minimal.	Assignment was completed with a few of the constraints and criteria met. Reflects minimal effort and lacks detail or quality.	Assignment was not completed and does not reflect the adherence to the constraints or criteria.	
(10 marks) Presentation of Motion Graph	Correct sketch of the Motion Graph and represented all information correctly and answered all the related questions with clear calculation steps	Correct sketch of the Motion Graph and represented all information correctly and answered all the related questions.	Satisfactory sketch of the Motion Graph and represented most information correctly and answered some of the related questions.	Shows poor knowledge of the person or persons involved in these major events	

Analysis. (3 marks)	Student carefully analyzed the information collected and drew appropriate and inventive conclusions supported by the evidence.	Student shows good effort in analyzing the evidence collected.	Student conclusions could have been supported by stronger evidence. Level of analysis could have been deeper	Student conclusions simply involved restating information. Conclusions were not supported by evidence.	
Time Management	Assignment completed and turned in on time. Student worked diligently when assignment time was available. Student was on task most of the time.	Assignment was completed, but had notable errors. Student utilized assignment time somewhat efficiently, but spent time socializing. Student was on task 70% - 80% of the time.	Assignment was not turned in on time and/or complete. The student was on task less than 60% of the time.	Assignment was not turned in on time and was not completed. Student wasted Assignment time and at times was disruptive to others.	

Recommended Resources:

- Essential of Physics
- Grade 11 Physics Save Book

Strand 2: Physical Science

Content Standard: 11.2.2 Students will be able to Investigate and derive Newton's Laws of motion and apply it to solve real life problems.

Unit : Force and Motion

Benchmark: 11.2.2.1 to 11.2.2.5 *(Refer to the benchmarks in unit: force and motion, strand 2)*

Topics: *(Refer to the topics in the unit force and motion)*

Instructional Objective: (Refer to the topics in unit: force and motion, strand 2)

What is to be assessed? - (KSAVs)
The essential knowledge, skills, attitudes and values in the unit "Force and Motion"

Purpose of the assessment

To measure students proficiency on the achievement of the benchmarks and learning objectives in this unit. This assessment is to be conducted after teaching this unit.

Expected level of proficiency

All students are expected to:

- Use vectors to explain force and motion
- Apply the laws of motion to determine the effects of forces on the linear motion of objects
- Explain the characteristics of motion by using graphs

Assessment Strategy

This assessment can be conducted as a project, practical test or assignment relating to a real life situation.

Performance Task

Students will do a Real World Application Project (Sinusoidal Modeling) out of 30 marks. You can use other assessment tools (assignment, projects, etc.) to assess student's proficiency on these benchmarks.

Task: Students will be given three weeks to complete this project. They are to:

- Investigate any real-world phenomenon that can be modelled by a sinusoid.
- Research and collect data, develop a predictive model, graph it, and present it to the class using a visual presentation platform like, iMovie, Powerpoint, etc.
- Choose any topic, and the freedom to be as creative and outside-the-box with this project as they wish.

Note: Students should now understand that any variable that is cyclical, harmonic, oscillating, or periodic in nature can be modeled graphically by a sine or cosine wave. There are countless applications of sinusoid modeling in real life.

Some of these applications include:

- Changes in Temperature over time.
- Hours of daylight over time.
- Population growth/decay over time.
- Ocean wave heights (high and low tides) over time .
- Sound waves.
- Electrical currents.
- Ferris wheels and roller coasters.
- Tsunamis and tidal waves.
- Earthquakes.
- Wheels and Swings.

Task Details: Students are to;

- Collect no less than 12 real-world data points that can be modeled sinusoidally. The more data, the better! Providing 24 or more data points will earn maximum points on the rubric.

- A predictive model of the format y = Asin (Bx + C)+ D or y = Acos (Bx + C) + D for the data must be developed using the techniques they learned in class. This model could be used to predict outcomes into the future.

- A neatly organized graph of the original data and a graph of their developed model must both be embedded in their presentation. To produce these graphs they may use their graphing calculators, the Desmos app, or they may draw the graphs themselves. Pictures or screenshots of their graphs may be used. The objective is to compare the two graphs side-by-side or on top of one another, so they could see how accurate and predictive their model is.

- A reflection must be submitted with your project (1-2 paragraphs). This reflection should be neatly and logically written/typed with no grammatical errors, and should summarize their experience in doing this project. What did they learn? What did they enjoy or dislike? What would they change? How well did they work with their partner? Etc.

Criteria	Model/Exemplar	Proficient	Developing	Beginning	Score
	(4 points	(3 points)	(2 points)	(1 point)	
Data Collection	Data is authentic, appropriately labeled and clearly presented in an X-Y table. Contains 24 or more measurements.	Data is authentic, appropriately labeled and clearly presented in an X-Y table. Contains 13-23 measurements.	Data is authentic, appropriately labeled and clearly presented in an X-Y table. Contains 12 measurements.	Data is incorrectly labeled, not presented in an X-Y table, and contains less than 12 measurements.	
Mathematical Calculations/ Model Development	All calculations are very clear, organized, and neatly completed with no inaccuracies.	All calculations are clear, organized, and neatly completed with 1-2 inaccuracies.	Most calculations are clear, organized, and neatly completed with 3-4 inaccuracies.	Calculations are unclear and disorganized and 5 or more inaccuracies may be present.	
Graphs	All graphs are neatly produced, axes are appropriately scaled and labeled, data points are accurately plotted, colorful, and smooth curves are drawn.	All graphs are neatly produced, axes are appropriately scaled and labeled, data points are accurately plotted, colorful, and smooth curves are drawn.	All graphs are not neatly produced, axes are not appropriately scaled and labeled, data points are not accurately plotted, and smooth curves are not drawn.	All graphs are not neatly produced, axes are not appropriately scaled and labeled, data points are not accurately plotted, and smooth curves are not drawn	

Visual Presentation	The presentation is clear, colorful, creative and entertaining, shows a great deal of editing and audio/visual effects, keeps the audience fully engaged, fully utilizes available technology, and lasts 5-10 minutes.	The presentation is clear and colorful, shows some editing and audio/visual effects, keeps the audience mostly engaged, and fully utilizes technology, and lasts 3-5 minutes	The presentation is bland and basic, does not show editing or effects, keeps the audience moderately engaged, and does not fully utilize technology, and lasts 1-2 minutes	The presentation is erratic and poorly produced, lacks effort, does not show any editing or effects, the audience is not engaged, and does not utilize technology, and lasts under 1 minute.	
Effort and Collaboration	An exceeding amount of time and effort are present and the task responsibilities were shared equitably among group partners.	A substantial amount of effort is present and the task responsibilities were shared equitably among group partners.	An average amount of effort is present, and the task responsibilities were not shared equitably among group partners.	A poor amount of effort is present, and the task responsibilities were not shared equitably among group partners.	
Reflection	Writing is clear, concise, and well organised. Thoughts are expressed in a coherent and logical manner. Contains 2 or more paragraphs with very few grammatical errors present.	Writing is mostly clear, concise, and well organized. Thoughts are expressed in a coherent and logical manner. Contains 1-2 paragraphs with several grammatical errors present.	Writing is unclear and disorganized. Thoughts are not expressed in a logical manner. Contains 1-2 paragraphs with several grammatical errors present.	Writing is unclear and disorganized. Thoughts ramble and make little sense. Contains 1 paragraph with many grammatical errors present.	

Sample 4: STEAM Assessment

(Integrated Strands in relation to the project from integrated subjects)

Unit: (Integrated Units from all Subjects in this project)

Content Standard: (Integrated Content Standard from all Subjects in project)

Benchmark: (Integrated Benchmarks from all Subjects in this project)

Topic: (Integrated Topics from all Subjects in this project)

Lesson topic: (Integrated Topics from all Subjects in concern)

Instructional Objective (s): Students will be able to;

- Create a STEAM project "building a prototype model of a catapult launching system" to enhance their understand of this concept

Values/Attitudes	Appreciate the beauty of the application of mathematics during the designing process of the project.
Skills	Calculating size and space Time management and efficiency, Linear measurement and scaling techniques, Calculating mechanical advantage
Knowledge	Size and space Time management and efficiency, Linear measurement and scaling techniques
Mathematical Thinking	Think about how to integrate and apply the mathematical knowledge in the project

What is to be assessed? - (KSAVs)

Integrated subjects concepts used designing the projects.

Purpose of the assessment

To measure students proficiency on the achievement of the benchmarks and learning objectives for integrated subjects in the project. (STEAM Project)

Expected level of proficiency

All students are expected to:

- Build a prototype model of a catapult launching system through integrating concepts learned in other subjects.

Performance Task

Student will carry out a project worth 30 marks that should contribute to the School Learning Improvement Program (SLIP). This project will assess students proficiency on the mentioned benchmarks. In order for this assessment type to attain its intended purpose the following must be done carefully;

Task: Students will be given a month to complete this project.

1. All grade 12 Science teachers discuss the STEAM project with their HOD
2. The Science HOD brings this project to the attention of the Head Teacher hence it will involve the learning of all grade 12 classes in the school.
3. Once approved by the Head Teacher, the Science HOD now convenes a meeting with all other subject HOD to integrate this project into their learning. HOD for Science will have developed criteria already and will discuss around that.
4. The HOD for other subjects meet with their respective subject teachers to gauge their views and write up criteria's with reference to the theme of the project, "STEM Design and Engineering Challenge" bringing out the essence of their subjects in this project.
5. The Head Teacher then convenes a meeting with all teachers as they are now aware of the project. HOD for respective subjects give feedback from their meetings. Issues concerning this project must be ironed out and all subjects now carry out this assessment, starting with Science.

The grade 12 Science teachers will now do the following;

(i) Group the students into groups of 6 to design (drawing and manual) a tangible technology that will enhance the notion of "building a prototype model of a catapult launching system"

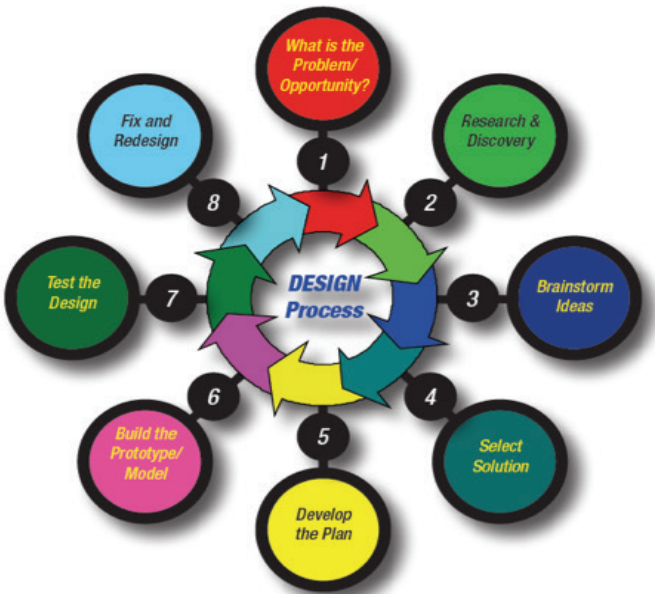
(ii) The teacher then assesses their designs and the best designs now compete with the other best designs from other grade 12 classes.

(iii) All the best designers now create models of their designs with assistance from their class members. At this stage the other subjects now carry forward this assessed projects theme, 'building a prototype model of a catapult launching system" however in the context of their subjects. STEAM is an integrated approach of teaching. All subjects must

incorporate the theme put forward by Science. They develop criteria that should address this theme. For instance; Technology and Industrial Arts (TIA) will develop criteria that will engage the students to construct the models. Mathematics teachers will develop criteria to test students' knowledge of the Mathematical thinking process of Engineering Design thinking when they create the models around the theme of "prototype model of a catapult launching system". The English subject teachers will set criteria and guidelines for students on how to write reports so they write to tell others what they have learned and experienced. They must also be given guidelines to writing report. Students get to write report of how they designed this technology. The Science teacher will provide criteria for the students in terms of the physical, chemical, biological and geological properties of the materials used to work out the size and shape of the technology.

Task: Students will be given 6 weeks to complete this project. They are to;

- Design and build a prototype model of a catapult launching system that is easy to use and easy to transport.
- Follow the Design Process to prepare their prototype model in time.
- Write and prepare a short presentation to explain the catapult that was built and the process of building it.



Design Specification:

The catapult should be designed to launch a golf ball at least fifteen feet, to a 18cm x 18cm target.

- The catapult should include a system for determining range, reliability, and accuracy.
- The catapult should be mobile, yet stable. Outriggers or other support systems need to be included to maintain stability when the launcher is used.
- The catapult should be no larger than 30cm long x 30 cm deep x 90cm tall.
- The catapult should feature a locking pin or trigger that activates the catapult to launch.
- Your team should prepare to deliver a presentation about the merits of your catapult model and design.

Assessment Strategy

Design Project will be used to measure student's proficiency.

The students will be reinforced in the following STEAM concepts.

Science

- Applications of simple machines, including wheels and axles, levers, and pulleys
- Balance and equilibrium
- Energy transformations, such as rotary motion to linear motion
- Mechanical advantage

Technology and Engineering

- Prototyping and modelling
- Invention and innovation
- Structural integrity/strength
- Brainstorming and problem solving
- Trial and error engineering concepts

Arts

- Sketching and painting

Mathematics

' Calculating size and space
- Time management and efficiency
- Linear measurement and scaling techniques
- Calculating mechanical advantage

Project Rubric

Category	Advanced	Satisfactory	Partial Credit	Unacceptable
	9 -10 points	7- 8 points	1 - 6 points	0 points
Quality/ Workmanship	Maximum effort was put forth to complete the project in a professional manner. Project demonstrates a high degree of quality and attention to detail. Workmanship is excellent.	Some effort was made to complete the project to a level that was sufficient for grading, but does not meet a professional level of quality or appearance. Workmanship is of acceptable quality.	Minimal effort was made to complete the project and the quality and workmanship is sub-par, but still meets the minimal standard.	Little or no effort was made to produce a quality project. Project obviously does not meet minimal standards.
Creativity/ Design	Project reflects many fundamental elements of design and creativity. Project demonstrates an advanced understanding of creative thinking and attention to aesthetics and presentation.	Project reflects some of the elements of design and creativity, but lacks attention to aesthetics and presentation.	Project was completed, but does not reflect the acceptable levels of design and creativity. Effort was minimal and project is mediocre at best.	Project was not completed on time or reflects little or no effort to complete assignment at an acceptable level.
Functionality	Project meets or exceeds the design requirements of purpose and functionality. All elements of the design have been met and the project does what it was designed to do.	Project meets some of the design requirements of purpose and functionality. Not all elements of the design have been met, but the project does what it was designed to do.	Project is somewhat functional, but reflects minimal effort. It is intermittent and doesn't always do what it was designed to do.	Project does not work and demonstrates a lack of effort or understanding of the basic elements of functionality and purpose.
Design Process	Project reflects a clear understanding and application of design process including evidence of research, brainstorming, design and problem solving, prototyping and testing.	Project reflects some understanding and application of accepted design loop principles and sequence including evidence of research, brainstorming, design and problem solving, prototyping and testing.	Project reflects minimal understanding and application of design process.	Project does not show evidence that design process was used. Project does not meet accepted levels of design criteria.
Criteria/ Constraints	Project was completed with all constraints and criteria met or exceeded. Reflects attention to detail and quality.	Project was completed with some of the constraints and criteria met. Reflects some attention to detail, but quality is minimal.	Project was completed with a few of the constraints and criteria met. Reflects minimal effort and lacks detail or quality.	Project was not completed and does not reflect the adherence to the constraints or criteria.

Time Management	Project completed and turned in on time. Student worked diligently when project time was available. Student was on task most of the time.	Project was completed, but had notable errors. Student utilized project time somewhat efficiently, but spent time socializing. Student was on task 70% - 80% of the time.	Project was not turned in on time and/or complete. The student was on task less than 60% of the time.	Project was not turned in on time and was not completed. Student wasted project time and at times was disruptive to others.
Resource Management	Always takes responsibility for use and care of all building components and resources. Always returns building components and materials to proper storage compartments.	Consistently takes responsibility for use and care of building components and resources. Somewhat consistent in returning building components to proper storage compartments.	Sometimes takes responsibility for use and care of building components and resources. Inconsistent in returning building components to proper storage compartments.	Does not take responsibility for the proper use and care of building components and resources. Is careless and does not practice proper storage and safety practices.
Teamwork	Notable teamwork shown with a determination to participate/contribute to team success. Completed required individual tasks that contributed to the success of the team.	Teamwork was noted, but was sometimes off task or working on non-related tasks. Contributed to the success of the team, but could have been more engaged to complete tasks sooner.	Notable time off-task with minimal effort given for team success, or did the project alone without relying on others to do their share of the project.	Was not a team player. Either took over project completely, or did not engage in team direction or plans.
Writing/ Reflection	Writing/reflection is very well organized and explained. Student includes all details in design process. Document has almost no grammatical errors.	Writing/reflection is somewhat organized and explained. Student includes most details in design process. Document has very few grammatical errors.	Writing/reflection is not organized and explained. Student includes only a few details in design process. Document has many grammatical errors.	Writing/reflection is incomplete or not turned in. Student includes no details in design process. Document has many grammatical errors.
Presentation	Presentation was well organized and presented in a logical sequence. Presentation reflects a full knowledge of the topic with clear answers and explanations to questions asked.	Presentation was fairly organized and most information presented in a logical sequence. Answers to questions were vague or lacked clarity or accuracy.	Presentation was unorganized and lacked a logical sequence. Presentation reflected little attention to detail. Answers to questions were inaccurate and confusing.	Presentation was not acceptable and reflects a lack of organization or knowledge of the topic. Presentation shows little effort to meet expectations.

Glossary

Words	Definition
Active Transport	Is the movement of molecules across a cell membrane from the region of lower concentration to a region of higher concentration-against the concentration gradient
Auxins	A group of plant hormones that control cell elongation.
Aerobic Respiration	The breakdown of glucose to simple inorganic compounds in the presence of oxygen and with release of energy that is transferred to ATP
Anaerobic Respiration	Form of respiration occurring in the absence of oxygen in which glucose is broken down to smaller compounds, such as lactate, with release of energy that is transferred to ATP
Asexual Reproduction	The production of genetically identical offspring from one parental organism only.
Autotroph	An organism that can make its own food (usually using sunlight)
Bacteria	(singular: bacterium) microscopic, usually unicellular, organism and member of Kingdom Monera.
Cell wall	A semi-rigid structure located outside the cell membrane of plants, algae, fungi and bacteria
Cellular respiration	Process of transferring energy present in organic compounds to a form useable by cells, typically ATP
Cytoplasm	The cellular substance outside the nucleus in which the cell's organelles are suspended
Diffusion	Is the net movement of ions or molecules from a region of higher concentration to a region of lower concentration, down the concentration gradient until equilibrium is reached
Ecosystem	A biological community of interacting organisms and their physical environment.
Enzyme	Biological catalysts made of proteins
Eukaryotes	Are organisms whose cells contain a nucleus within a membrane.
Golgi body	Organelle that packages material into vesicles for export from a cell
Invertebrates	Are animals without a backbone or bony skeleton.
Non-vascular plants	Are small, simple plants without a vascular system. They do not have a phloem or xylem
Nucleus	A membrane bound organelle that houses the DNA and directs all nuclear activities.
Osmosis	Is the movement of water molecules from a region of higher water potential to a region of lower water potential, across a partially permeable membrane
Passive transport	Is a process that will occur naturally, so long as there is a difference in concentration and the cell does not need to supply any form of energy to facilitate the transport
Photosynthesis	Process of using energy in sunlight to convert water and carbon dioxide into carbohydrates and oxygen in green plants

Phylum	Is a level of classification or taxonomic rank below kingdom and above class
Prokaryotes	A unicellular organism that lacks a membrane-bound nucleus, mitochondria, or any other membrane-bound organelle.
Vacuole	A space or vesicle within the cytoplasm of a cell, enclosed by a membrane and typically containing fluid.
Vascular Plant	A plant that is characterized by the presence of conducting tissue.
Vertebrates	General term for animals with a backbone, such as fish, amphibians, reptiles, birds and mammals.
Viroids	Small pieces of RNA that cause some diseases in plants

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Appendices

Appendix 1: Bloom's Taxonomy

LEVEL OF UNDERSTANDING	KEY VERBS
CREATING Can the student create a new product or point of view?	Construct, design, and develop, generate, hypothesize, invent, plan, produce, compose, create, make, perform, plan, produce, assemble, formulate,
EVALUATING Can the student justify a stand or decision?	Appraise, argue, assess, choose, conclude, critique, decide, defend, evaluate, judge, justify, predict, prioritize, provoke, rank, rate, select, support, monitor,
ANALYZING Can the student distinguish between the different parts?	Analyzing, characterize, classify, compare, contrast, debate, criticise, deconstruct, deduce, differentiate, discriminate, distinguish, examine, organize, outline, relate, research, separate, experiment, question, test,
APPLYING Can the student use the information in a new way	Apply, change, choose, compute, dramatize, implement, interview, prepare, produce, role play, select, show, transfer, use, demonstrate, illustrate, interpret, operate, sketch, solve, write,
UNDERSTANDING Can the student comprehend ideas or concepts?	Classify, compare, exemplify, conclude, demonstrate, discuss, explain, identify, illustrate, interpret, paraphrase, predict, report, translate, describe, classify,
REMEMBERING Can the student recall or remember the information?	Define, describe, draw, find, identify, label, list, match, name, quote, recall, recite, tell, write, duplicate, memorise, recall, repeat, reproduce, state,

Appendix 2: 21st Century Skills

WAYS OF THINKING	Creativity and innovation Think creatively Work creatively with others Implement innovations Critical thinking, problem solving and decision making Reason effectively and evaluate evidence Solve problems Articulate findings Learning to learn and meta-cognition Self-motivation Positive appreciation of learning Adaptability and flexibility
WAYS OF WORKING	Communication Competency in written and oral language Open minded and preparedness to listen Sensitivity to cultural differences Collaboration and teamwork Interact effectively with others Work effectively in diverse teams Prioritise, plan and manage projects
TOOLS FOR WORKING	Information literacy Access and evaluate information Use and manage information Apply technology effectively ICT literacy Open to new ideas, information, tools and ways of thinking Use ICT accurately, creatively, ethically and legally Be aware of cultural and social differences Apply technology appropriately and effectively
LIVING IN THE WORLD	Citizenship – global and local Awareness and understanding of rights and responsibilities as a global citizen Preparedness to participate in community activities Respect the values and privacy of others Personal and social responsibility Communicate constructively in different social situations Understand different viewpoints and perspectives Life and career Adapt to change Manage goals and time Be a self-directed learner Interact effectively with others

Appendix 3: Standards-Based Lesson Plan Template

Standards-Based Lesson Plan (Integrating STEAM)

Topic:

Lesson Topic:

Grade:

Length of Lesson:

National Content Standard

Grade Level Benchmark

Essential Knowledge, Skills, Values, and Attitudes

Knowledge:

Skills:

Values:

Attitudes:

Materials:

- **Lesson Objective:**

Essential Questions:

Lesson Procedure

Teacher Activities	Student Activities
Introduction	
Body	
Guided Practice	
Independent Practice	
Conclusion	

Appendix 4: Standards-Based Lesson Plan Template-Integrating STEAM

Standards-Based Lesson Plan (Integrating STEAM)

Topic:
Lesson Topic:
Grade:
Length of Lesson:

National Content Standard

Grade Level Benchmark

Essential Knowledge, Skills, Values, and Attitudes

Knowledge:

Skills:

Values:

Attitudes:

STEAM Knowledge and Skill

Knowledge:

Skill:

Performance Indicator:

STEAM Performance Indicator:

Materials:

- **Lesson Objective:**

Essential Questions:

Performance Assessment and Standards

<table>
<tr><td colspan="5">National Content Standard:</td></tr>
<tr><td>Lesson Topic</td><td>Topic</td><td>Benchmark</td><td colspan="2">Performance Assessment</td></tr>
<tr><td rowspan="4"></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Advanced</td><td>Proficient</td><td>Partially Proficient</td><td>Novice</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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