Biology

Teacher Guide

Senior High

Grade 12

Standards Based

Papua New Guinea

Department of Education

'FREE ISSUE
NOT FOR SALE'

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Teacher Guide

Senior High

Grade 12

Standards-Based

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Issued free to schools by the Department of Education

Published in 2020 by the Department of Education

ISBN: 978-9980-906-17-5

Graphic Designed and Layout by Michael John, CDD - Graphics Section

Contents

Acknowledgements

The Grade 12 Biology Teacher Guide was developed by the Curriculum Development Division of the Department of Education. The development of this Teacher Guide was coordinated by Moses Hatagen Koran 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.

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
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
STEM	Science, Technology, Engineering and Mathematics

Secretary's Message

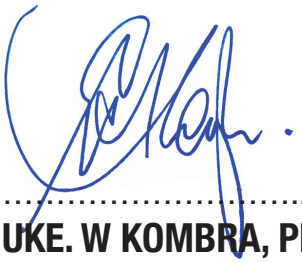
The aims and goals of the SBC identify the important knowledge, skills, values, and attitudes that all students are expected to acquire and master in order to effectively function in the society and actively contribute to its development, students' welfare and enable them to acquire and apply 21st Century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

The realignment of science curriculum is aimed at improving the organisation of content and context of what the students will be studying at the Senior High School level. It is envisaged that by the end of grade 12, the students will acquire the necessary Biology knowledge, skills and attitude or values to help them appreciate the contributions of Biology to the understanding of the world, living things and the influence of society at the same time aiming to strive and compete against 21st Century competencies and demands.

It is therefore, important for biology teachers to be creative, innovative and motivated when teaching biology. The realigned Science curriculum is focused on scientific skills and process, utilizing the analytical and inquiry based approaches where students will be encouraged to predict, explore, question, test ideas, formulate questions and challenge their own ideas and overtime become scientifically literate. Scientific literacy is critically important for Papua New Guinea to participate productively in an increasingly competitive knowledge and technologically based society.

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 Gr. 12 Biology Teachers Guide to be used 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 Century 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 further deepens 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 12 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.

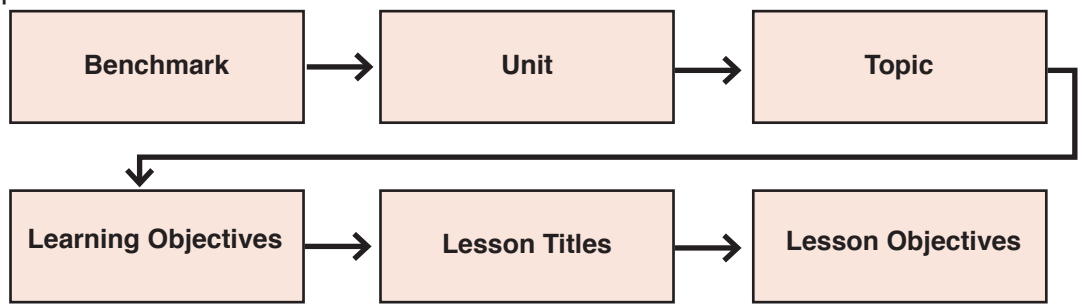
How to the use the Teacher Guide

TheTeacher 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

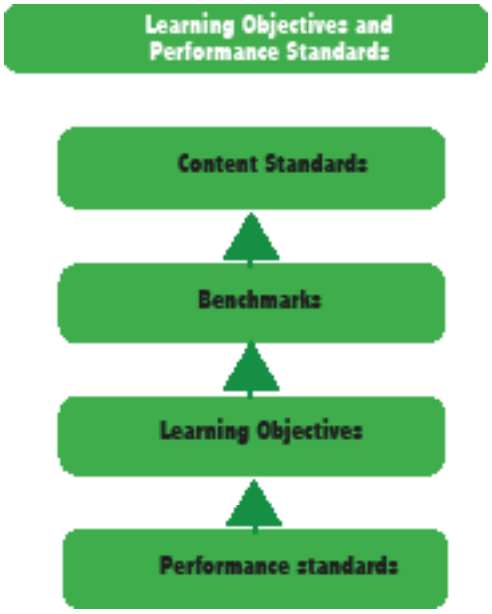
The syllabus outlines the ultimate aim and goals of SBE and SBC, what is to be taught and why it should be learned by students, the underlying principles and articulates the learning and proficiency standards that all students are expected to attain. On the other hand, the teacher guide expands on what 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 12 content.

Teachers will extract information from the syllabus (e.g., content standards and grade-level benchmarks) for lesson planning, instruction and is for measuring students' attainment 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).

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;

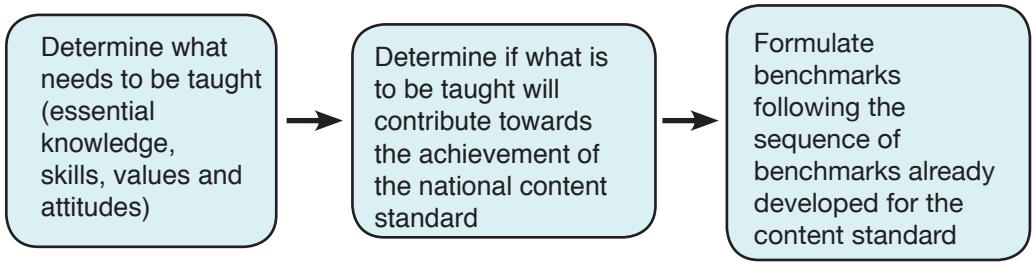
- are evidenced-based,
- are rigorous and comparable to regional and global standards,
- are set at the grade level,
- are linked to the national content standards,
- are clear, measurable, observable and attainable,
- articulate grade level expectations of what students are able to demonstrate to indicate 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 identify the differnt types of biotic and abiotic factors.

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.

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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.

Physics 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.

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

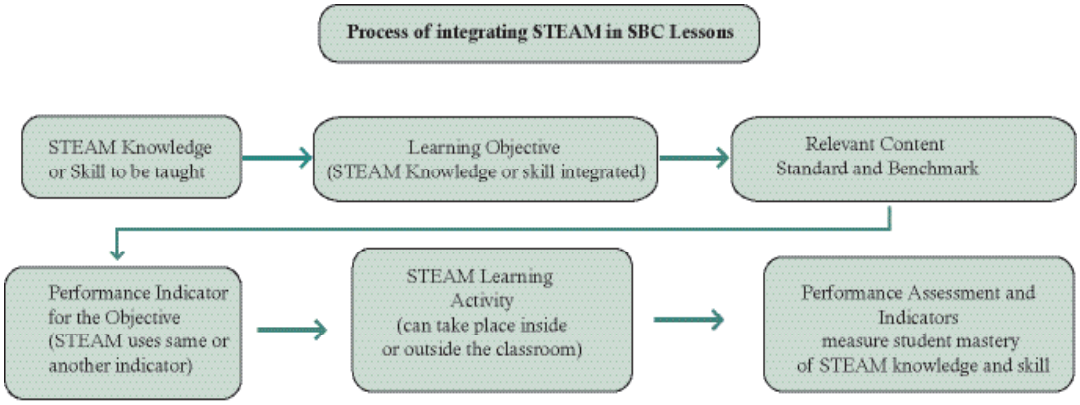
Effective STEAM lesson planning is key to the achievement of expected STEAM outcomes. STEAM skills can be planed and taught using separate STEAM-based lesson plans or integrated into the standards-based lesson plans. To effectively do this, teachers should know how to write effective standards and STEAM-based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

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.

Teachers are expected to integrate the essential STEAM principles, processes, skills, values and attitudes described in the grade 12 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.

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.

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)

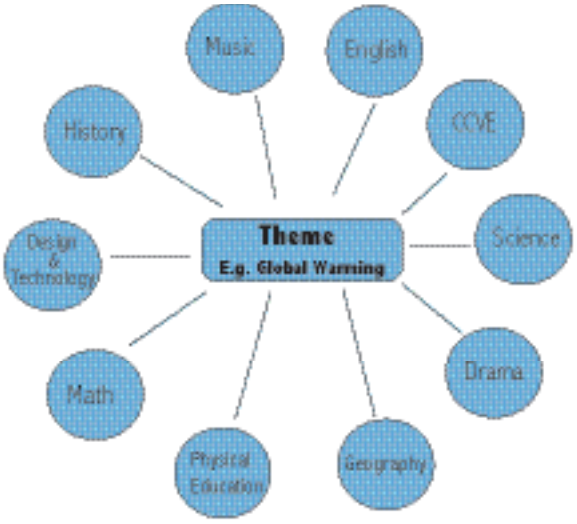
Teachers must develop intriguing curriculum by going beyond the traditional teaching of content based or fragmented teaching to one who is knowledge based and who should be perceived as a 21st Century innovative educator. Curriculum integration is a holistic approach to learning thus curriculum integration 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

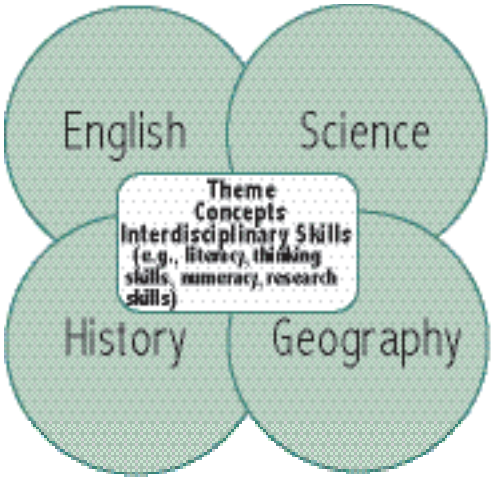
In this approach learning involves a theme or concept that will be taught right across all subject area of study by students. That is, content of a particular theme will be taught right across all subjects as shown in the diagram below. For instance, if the theme is global warming, subject areas create 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 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 Thinking Process

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;

- familiarize themselves with different methods of teaching in the classroom,
- develop an understanding of the role of a teacher for application of various, and
- 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	Units
Scientific Inquiry	
Life Science	Population Ecology
	Genetics
	Evolution

Content Overview

Table of strand, units and topics

The table below outlines the contents of Grade 12 Biology in strands, units, topics and with the **suggested lesson tittles** to be taught in an academic year. Teachers are provided with what will be taught under each of the strands in a year. This overview will guide the teachers on how to plan their teaching programs for a school year in each term.

Strand	Unit	Topic	Lesson Titles
1. Scientific Inquiry			
2.Life	Population Ecology	Biomes & Habitats	Introduction to Ecology
			Niche, Relationships in Communities
			Abiotic & Biotic Factors
			Pyramid of numbers & Biomass and Energy Flow
			Ecosystems and Biomes
			Terrestrial Environment
			Aquatic Environments
			Factors influencing Plant and Animal Life
		Interactions	Eutrophication and Biomagnification
			Carbon and nitrogen cycle
			Oxygen and Water Cycle
			Natural & Artificial Succession
		Population	Environmental Issues (Mining & Logging)
			Environmental Issues (Monocultural Farming and Overfishing)
			Environmental Issues: Plastics and Chemical Wastes
			Sustainable Management: Carbon Trade (Traditional Methods)
			Introduction to the Study of Population
			Sampling Methods
			Calculating and interpreting population graphs
			Factors affecting Population
		Humans and the Environment	Introduction to Human Population
			Factors affecting population Growth
			World Population Data Interpretation

Strand	Unit	Topic	Lesson Titles
2.Life	Genetics	Genes & Chromosomes	Components, structure and role of DNA, genes and Chromosomes in cells
			Structure and Function of Nucleic Acids and role in protein synthesis
			Cell Division: Mitosis & DNA Replication
			DNA Transcription & Translation & Protein Expression
			Role of Chromosomes in Genetic Makeup of Organisms
			Mitosis vs Meiosis in Eukaryotic Organisms
		Inheritance	Inheritance & Types of Inheritance Patterns
			Mendel's Experiments and Mendels Laws of Inheritance
		Variations	Discreet Variations
			Continuous Variations
		Mutations	Types of Mutations in Organisms
			Human Genetic Disorders due to Mutations
		Biotechnology Techniques	Gene Technology: Definition and Historical Developments.
			Processes Involved In Gene Technology
			Applications and Impacts on Human Society
			Applications of Gene Technology in other Branches of Science
	Evolution	Theories Mechanisms of Evolution	Theories in the Origin of Earth and Life
			Principles of Evolution: Darwin and Lamarck's Theories of Evolution
			Mechanisms of Evolution
		Evidence of Evolution	Types of Evidence of Evolution
			Patterns of Evolution

Biology Grade 12

Teaching Content

Biomes & Habitats

Content Standard	**12.2.1** Investigate the characteristics of population growth and explain the factors that affect the growth of various populations of species**.**
Benchmarks	**12.2.1.1** Identify and explain types of habitats, ecosystems, biomes and the interrelationship that exist between them **12.2.1.2** Describe the biotic and abiotic factors of the major biomes **12.2.1.3** Identify and explain types of behavioural, morphological and physiological adaptations of organisms in terrestrial and aquatic environments. **12.2.1.4** Examine the types of interactions that exist between organisms of different species. **12.2.1.5** Explain the flow of energy from one organism to another in order to survive.

Essential Question	1. What are the processes in an ecosystem? 2. How is energy transferred in an ecosystem? 3. What is the difference between a food chain and a food chain? 4. What is an organism, population, habitat, niche, community, ecosystem and biome? 5. What are interspecific and intraspecific relationships? 6. How do you describe species richness and diversity? 7. How do you relate community stability or succession to these populations?
Learning Objective	• Describe the non-cyclical nature of energy flow • Use in the correct context the terms: population, habitat, ecosystem, biomes, • community, species richness, species diversity, succession, community stability, intra and inter specific relationship. • Describe the ecological interactions –: mutualism, commensalism, competition, parasitism,
Knowledge	• Members of the same species make up a population; a collection with similar traits and ability to interact make up a community. • Different ecosystems have differing communities based on geographical location. • There are seven different biomes in the world. • Relationships in ecosystems and biomes are based on inter and intra specific relationships, ecological interactions and the climate and the environment.
Skills	• Construct a table with differing features of the seven biomes. • Calculate species richness and diversity. • Construct food webs and food chains and pyramids for biomass and others
Atitudes & Values	• Recognise and appreciate the value of the environment you live in. • Appreciate the richness of biodiversity in your local communities and pledge your to support their existence.

Content Background

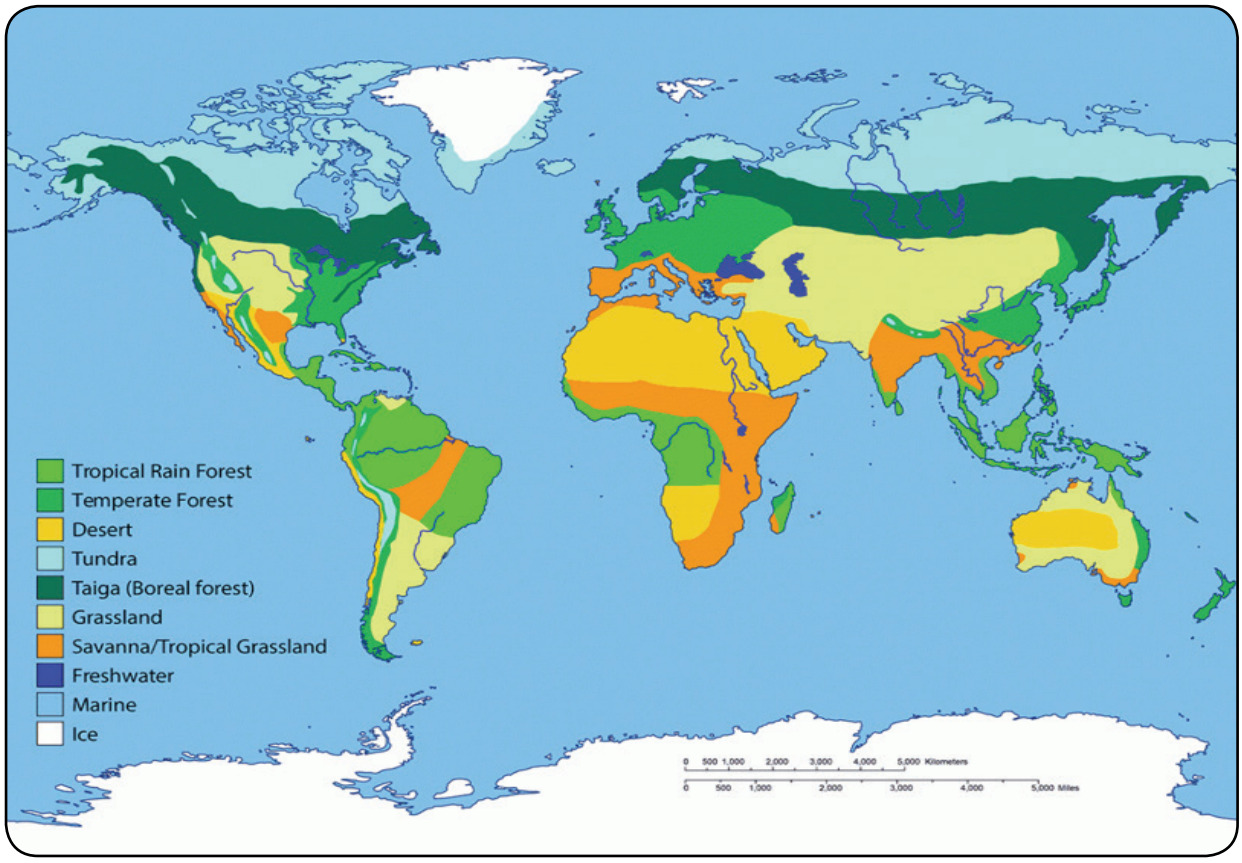
ECOLOGY

Ecology comes from the Greek word oikos meaning home, so it literally means studying the 'homes' of organisms. In its broadest sense an organism's 'home' is the part of the earth and its atmosphere inhabitable by living things. This is called the biosphere. The biosphere can be divided into a series of biogeographical regions, each inhabited by distinctive species of plants and animals. These organisms are able to move freely from place to place within each region, but not from one region to another, this being prevented by various natural barriers.

Although they possess a different fauna and flora, two such geographical region may be virtually identical in their climatic conditions, and this is reflected in similar adaptations shown by their respective inhabitants. These geographical regions, cutting right across different continents are lumped together as biomes. Each has its unique set of conditions, and each supports a particular type of flora and fauna

Biomes

Biomes are main ecological regions into which the land surface can be divided. Each has its own characteristic seasons, day length, rainfall pattern and maximum and minimum temperatures. The major biomes are **tundra, taiga** or boreal forest, also known as coniferous forest, temperate forest or deciduous forest, **tropical forest, temperate grassland, savannah or tropical grassland and desert.**



Most are named after the dominant vegetation, since it determines al other living things found there. Each biome is a giant habitat.

Each biome area and it and the fauna and flora it supports has changed in recent times and continues to change due to human activities and climate change as. It provides excellent opportunities for students to research and define the geographical and ecological characteristics of each biome and the impact of human activities and climate change in each biome.

Biomes are divided into smaller unit called zones, each with its own particular set of physical conditions. Individual organism may be specially adapted to live in one of these different zones, in some cases providing them withna means of avoiding the extremes of climatic conditions met with the biome as a whole.

Within its biome are numerous habitats, specific localities each with a particular set of condition and an appropriately adapted community of organisms. Typical habitats include fresh-water ponds, slow-flowing streams, rock pools etc.

Species

A group of organisms which are actively or potentially capable of interbreeding to produce fertile offspring. A group of organisms which show a close similarity in physical (morphological), biochemical and ecological characteristics and life history.

Population

Population refers to the number of individuals of a species in a specified region or ecosystem. For example, a small pond can be found to contain a population of 160 fish and support a population of 12 kingfishers.

Community

A community is a collection of populations of plants and animals which occur together in both space and time. The community of a small pond could be made of the following: spirogyra, salvinia, leeches, mayflies, dragonflies, mosquitoes, water boatmen, water beetles, mosquito fish, frogs and kingfishers. Even birds like the kingfisher that do not actually live in the pond are classed as part of the community because they feed there. Communities are greatly influenced by the climate. The community of a tropical rainforest is far more prolific and diverse when compared with the community of a desert ecosystem simply because the climate is more suitable.

Niche

An ecological niche is a precise description of all the physical, chemical and biological factors that a species needs to survive and reproduce.As such it may include more than one habitat as illustrated by amphibians such as frogs and toads. It can also may even span several biomes, as in the case with migratory birds and butterflies. For example , in the course of seasonal migration the golden plover may cover thousands of miles, taking through as many as six different biomes.

A species' ecological niche is usually less extensive when competitors and predators are present than when these are absent. Its niche in the absence of these other organisms is known as its fundamental niche; its niche in the presence is known as its realized niche.

The Physical Environment

Ecology is the study of the way in which living things interact with their environment. The environment is all the factors in the surroundings of organisms that directly or indirectly have an effect on them. These factors are either *biotic or abiotic*. **Biotic factors** are all living organisms in the environment. **Abiotic factors** are the non-living factors such as rocks, rain and temperature. Both affect the distribution of organisms in different habitats.

The physical environment includes factors such as temperature and humidity, which are not associated directly with the presence of other organisms. Some physical factors are directly climatic. Others are not necessarily associated with climate as such, though they may be th indirect result of it. The main physical factors are as follows:

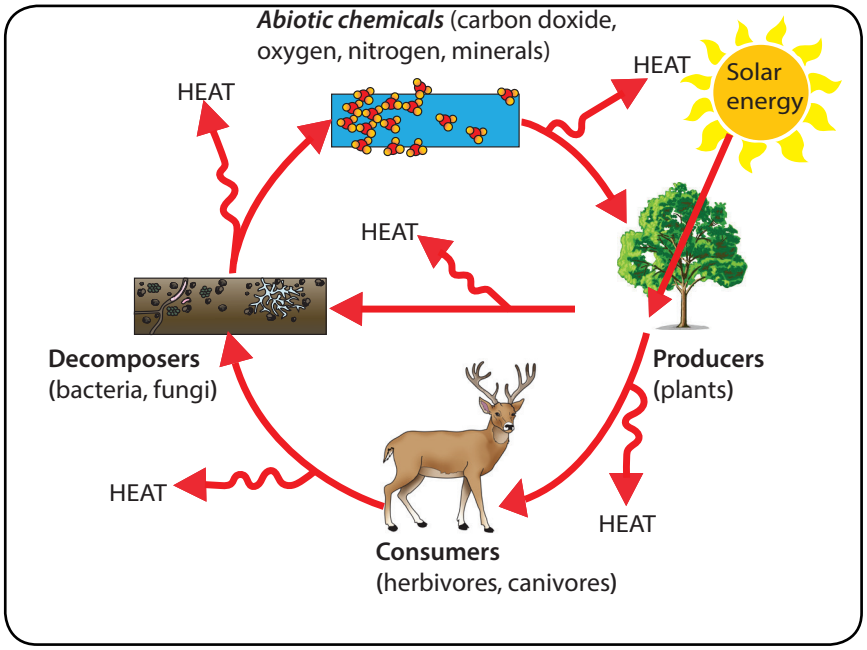
1. **Temperature**- organisms, wherever they live, must have the necessary physiological or behavioral adaptations to combat or avoid extremes of environmental temperature.
2. **Water** – dependent on the requirements and ability of the organism to conserve it under adverse conditions.
3. **Light** – essential for all green plants and photosynthetic adaptations for obtaining optimum illumination.
4. **Humidity-** This is important because it can affect the rate at which water evaporates from the surface of an organism, which in turn influences its ability to withstand drought
5. **Wind and air current** –Particularly applies to plants. Plants with strong root systems and tough stems can live in exposed places where winds are fierce. Wind also affects the evaporation rate and is instrumental in the dispersal of spores and seeds.
6. **pH –** This influences the distribution of plants in soil and freshwater. Some plants thrive in acidic conditions, others in neutral or alkaline conditions. Most are highly sensitive to changes in pH.
7. **Mineral salts and trace elements**- Plants living in soil deficient in a particular element must have special methods of obtaining it.
8. **Water currents** – Organisms capable of stemming or avoiding strong currents can survive in the open water.
9. **Salinity –** The importance is seen in the sharp distinction between marine and fresh-water species. It also influences the distribution of estuarine animals: they have special physiological or behavioural adaptations for withstanding the daily fluctuation in salinity that accompany the tidal rhythm.
10. **Wave action-** affects organisms living in the intertidal zone. To survive periodic buffeting by waves and exposure to air, special adaptations are required.
11. **Topography** –minor topography differences are important in the influencing the d distribution of organism as wide as geographical separation
12. **Background** –the distribution of organism whose shape or coloration are such that they are camouflaged when viewed against a particular background is related to the general texture and pattern of the environment. Sometimes the background consists of another organism; this is part of the biotic environment which will be discussed next. There are many cases of protective camouflage, particularly amongst insects, amphibians and reptiles

The Biotic Environment

The organism's biotic environment is made up of all the other organisms with which it comes into regular contact. With certain of these organisms it has a special relationship which may profoundly influence its distribution and abundance.

1. Predation. An organism may feed on, or be fed on by, other organisms. In such cases the distribution of feeder and fed are related. Herbivores are only found where there is suitable plant food, predators where there is suitable prey.
2. Competition. Organisms frequently compete with one another for such commodities as food, light, water, shelter, mate or nesting site. Competition exists both between individuals of the same species (intra-specific) and between individuals of the different species (inter-specific), and the closer the ecological niches of the competing organisms the fiercer is the competition. Coexistence is impossible between two species which compete with each other in every way. Sooner or later one will oust the other. In other words two different species can never occupy exactly the same ecological niche. This is known as the competitive exclusion principle and is an important ecological concept.
3. An organism may use another as a habitat. This specialized aspect of the biotic environment is seen in parasitism and other related related associations.
4. Certain plants rely on insects and other small animals for pollination and/or dispersal. Pollution sometimes involves a highly elaborate reciprocal relationship between a certain plant and a specific insect.
5. Some animals closely resemble another species that happens to be unpalatable to a predator , known as mimicry. The unpalatable species generally possesses distinctive colours or makings (warning coloration). Predators learn to recognize these signs and avoid attacking the particular species
6. One of the most biotic factor is the human species.

There are two main ideas about how ecosystems function: ecosystems have energy flows and ecosystems cycle chemical materials. These two processes are linked but they are not quite the same.



Energy enters the biological system as light energy or photons and is then transformed into chemical energy in organic molecules by cellular processes including photosynthesis and respiration and ultimately converted to heat energy. Without the continued input of solar energy, biological systems would quickly shut down.

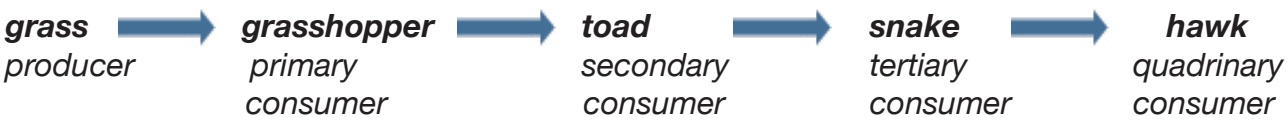
Elements such as carbon, nitrogen, water, oxygen or phosphorous enter the living organisms in a variety of ways. Plants obtain elements from the surrounding atmosphere, water or soils. Animals may also obtain elements directly from the physical environment but usually they obtain these mainly as a consequence of consuming other organisms. These materials are transformed biochemically within the bodies of organisms, but sooner or later due to excretion or decomposition, they are returned to an inorganic state. Bacteria often complete this process through decomposition or mineralization. During decomposition, these materials are neither destroyed nor lost, but cycled endlessly between their biotic and abiotic states within the ecosystems.

How does energy flow in the Ecosystem?

Energy enters the ecosystem from the Sun and flows through the ecosystem in a non-cyclic manner. Energy has to be supplied constantly to the ecosystem. Energy from the sun is captured by the process of photosynthesis in plants. Carbon dioxide is combined with hydrogen (from water molecules) to produce carbohydrates. Because this is the first step in the production of energy for living things, it is called primary production. Plants are hence called the primary producers. Herbivores obtain their energy by consuming plants and plant products, carnivores eat herbivores and scavengers feed on the carcasses of us all. In the ecosystem, the role of herbivores and carnivores are consumers and scavengers function as decomposers.

Food chains

The most obvious interaction between different organisms in an ecosystem is feeding. During feeding, one organism is obtaining food- energy and raw materials from another one. Usually one organism eats another, but then may itself be a food for the third species. The flow of energy between the different organism s in the ecosystem can be shown in a food chain. A food chain is the simplest representation of energy flow in a community. At the base is energy stored in plants, which are eaten by smaller organisms, which in turn are eaten by progressively larger organisms. Each stage in a food chain is known as a trophic level. The amount of energy that is passed on in a food chain is reduced at every step since energy can be created nor destroyed, it is not lost but is converted into some other form. During respiration, some energy is transferred to the environment as heat.



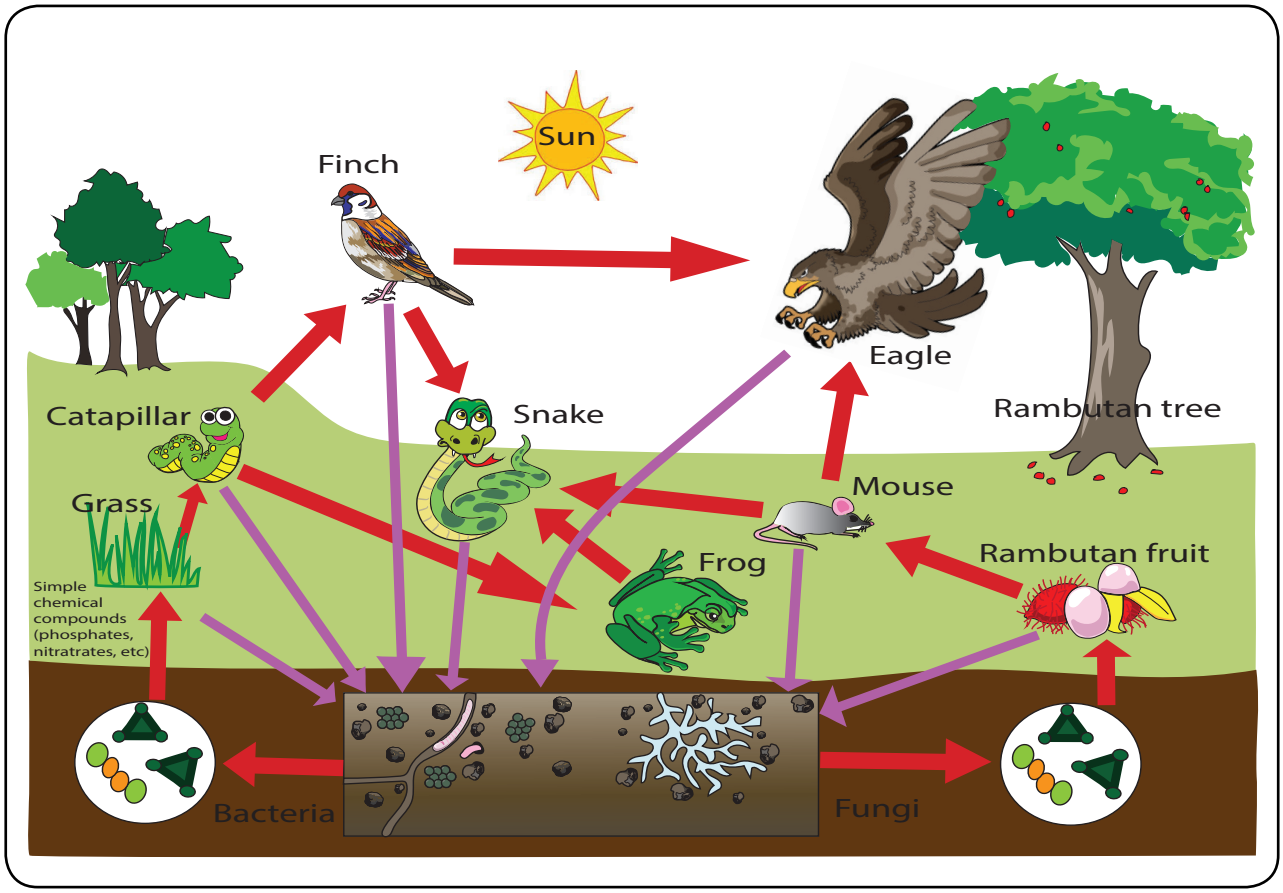
In a food chain, two things should be clear:

- The organisms tend to get bigger moving along the food chain. Predators such as cats, need to be large enough to overcome their prey, such as mouse.
- Energy is 'lost' as heat on moving from one trophic level to the next, so an animal to the right of a food chain needs to be eat several organisms 'below' it in order to obtain enough energy. For example a rabbit eats a lot of grass

Food chains and food webs provide qualitative information about an ecosystem- they show which organism feeds on which other organism. How do we show quantitative information, for example, how many predators can be supported by a certain number of plants at the start of the chain? We can use a pyramid of numbers or a pyramid of biomass.

Food webs

Since so little energy is transferred from the base to the top of a food chain , a top carnivore must eat many herbivores. These herbivores are probably not all of the same species. In turn each herbivore is likely to feed on many species. All these interconnected food chains in one part of an ecosystem can be shown in a food web. The more complicated a food web, the more stable the community is.



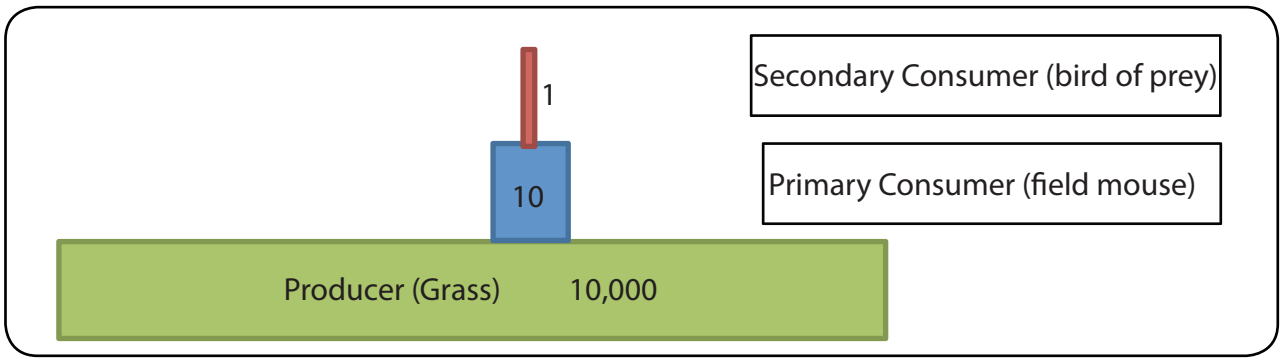
While a food chain and food web show the flow of energy from the food producers to consumers, it does not display the progressive loss of energy that occurs along a food chain. To display this information, ecologists construct ecological pyramids.

An ecological pyramid is a conceptual scheme that shows how the amount of biomes, number or energy at each level of the food chain decreases as one moves from the primary producers, through the different levels of the consumers. As such there are three types of pyramids:

- pyramid of numbers display the total number of organism in each trophic level.
- pyramid of biomass displays the total mass of the organisms in each trophic level .
- pyramid of energy displays the total amount of energy present in each trophic level.

Pyramids of numbers

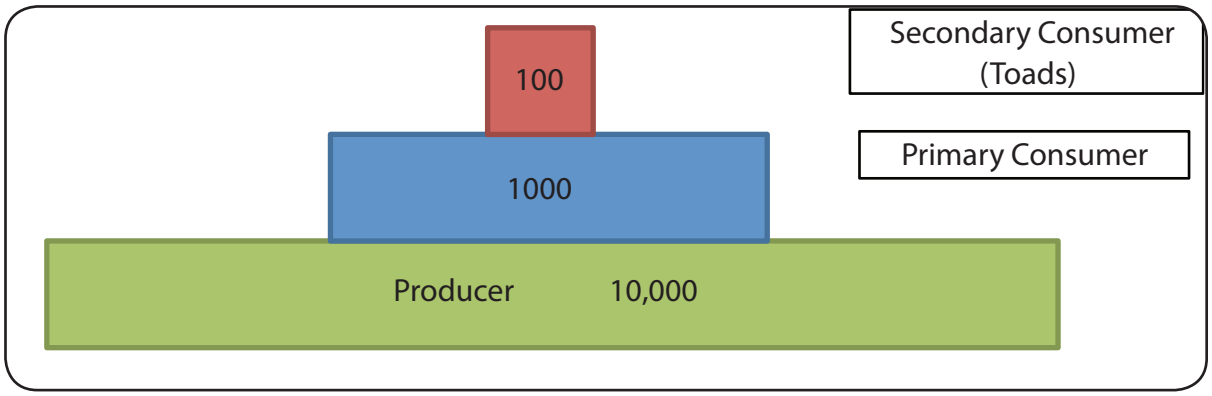
A pyramid of numbers displays the number of organism in each tropic level. It is easily understood that many grass plants are needed to feed fewer field mice, which in turn means fewer bird of preys would be able to feed. In a pyramid of numbers, the higher you move up each consecutive layer or level, the fewer the organisms there are than the level below it.



Pyramid of Biomass

How do we measure the amount of energy in a population?

Since all organisms are made of roughly the same organic molecules in similar proportions, a measure of their weight is a rough measure of the energy they contain. Biomass is the total weight of organisms. Unlike the pyramid of numbers, the pyramid of biomass will always display a pyramid shape for a food chain. This is because the mass of all food producers must be larger than the primary consumers to support them. Similarly, the mass of primary consumers must be larger than the secondary consumers the trophic level supports and so on.



Pyramids of energy

A pyramid of biomass describes how much biomass is present in a habitat *at the time the sample is take*. This can be misleading, because the different feeding levels may contain organisms that reproduce, and so replace themselves at different rates. For example, a grass in a field would replace itself more quickly than cattle feeding on the grass, so when the pyramid of biomass is constructed there would be more 'cattle biomass' than grass biomass' and the pyramid would be inverted. To overcome this difficulty a pyramid of energy can be constructed. This measures the amount energy flowing through an ecosystem over a period of time. The time period is usually a year, since this takes into account the changing rates of growth and reproduction in different seasons. It is even possible to add an extra base layer to the pyramid of energy representing the solar energy entering that particular ecosystem.

Looking at the food chain, food webs as well as the ecological pyramids, you should be able to understand the following points with regards to how energy flows in an ecosystem:

- the ultimate source of energy in an ecosystem is the Sun.
- the flow of energy is non-cyclic; it is not recycled
- energy is lost as you go up each trophic level.
- Eventually all energy that enters the biotic environment is lost as heat, egested materials and excreted materials. As such there must be continued input of energy from the Sun.

Biomes & Habitats

Content Standard	**12.2.1** Investigate the characteristics of population growth and explain the factors that affect the growth of various populations of species**.**
Benchmarks	**12.2.1.4** Examine the types of interactions that exist between organisms of different species **12.2.1.5** Explain the flow of energy from one organism to another in order to survive **12.2.1.6** Examine and evaluate the process in which biological communities have changed over time. **12.2.1.7** Explain how matter and energy flow through living systems and the physical environment.

Essential Question	1. What are the types of ecological interactions that occur between animals, plants, microbes and the environment? 2. Why is the flow of energy in food webs and chains and the biomass production in ecosystems important? 3. What is biodiversity? And why is it important to maintain biodiversity? 4. What are the conservations measures in place to prevent loss or extinction of biodiversity? 5. What is the difference between renewable and non-renewable resources and why is it important?
Learning Objective	• Describe the ecological interactions • Distinguish between species richness and diversity and explain community succession and stability in an ecosystem. • Describe in detail biomass production in the community and the energy flow through food webs and food chains. • Detail the different biogeochemical cycles and their importance.
Knowledge	• The relationships and interactions and species richness and diversity, community stability and succession are all important factors attributing to biodiversity that exists. • Biodiversity is at risk of loss and extinction. • Globally there are measures to combat this.
Skills	• Construct a table with differing features of the six biomes. • Calculate species richness and diversity. • Construct food webs and food chains and pyramids for biomass and others. • Calculate population growth rates, death rates, birth rates, and immigration and emigration rates. • Interpret demographic graphs.
Atitudes & Values	• Teach to others the importance of relationships between all living things in the any environment and that we should only take what we need and not over exploit our resources.

Content Background

Interaction

Organisms influence one another by being part of each other's environment. They can be harmful or beneficial to each other. For example, red ants (kurakum) living on a mango tree will build their nests using the leaves. The red ant benefits because it has a home, but the mango tree is harmed because its photosynthetic leaf area is reduced. Similarly a bird living in the mango tree has got food and a home in the mango tree and the mango tree benefits because its seeds are dispersed.

Many organisms living in the same habitat with lots of other organisms will develop many different types of interactions in order to survive.

Competition

Competition is a struggle between organisms for the same supply of food, water, space, mates, nest sites and any other environmental resources that are in limited supply. Competition may occur between members of the same species (intra specific competition) or between members of different species (inter specific competition).

An example of the intra specific competitions can be seen in the courtship behaviour of Birds of Paradise. The male Birds of Paradise put on spectacular displays of song and dance for the female Bird of Paradise. If the female Bird of Paradise likes the display, she will mate with the particular male. This example shows competition for mates. Intra specific competition is beneficial for the survival of a species because it ensures that the fittest or the most desirable characteristics are passed on to the next generation.

An example of inter specific competition would be tilapia and many of the native fishes in the inland river systems. The tilapia competes with other fish species for food and space. The tilapia reproduces more quickly than most native fishes so it takes up more space. It also will eat anything and therefore it is competing for all types of food, where most native fishes are eating only certain types of food.

Predation and grazing

As you have seen in the food webs, the most interaction between the organisms is within the food web. One organism becomes food for another organism, which in turn becomes food for another organism. Herbivores and carnivores affect the distribution of other species on which they graze or prey. For example, a hawk will prey on the bandicoot which grazes on grass, or a shark, preying on small reef fishes which graze on sea weeds.

Symbiosis

Sometimes two quite different organisms will live and function together in close association, to the benefit of at least one of them. Living together in a close partnership is called symbiosis. The different types of symbiosis are mutualism, commensalism and parasitism.

Mutualism

Mutualism is a partnership between two organisms where both organisms benefit (like you 'scratch my back and I'll scratch yours'). An example of mutualism can be seen in algae living in the mantle giant clams. The algae photosynthesise to produce sugar and oxygen which the giant clam uses. In return the giant clam produces carbon dioxide during respiration which the alga uses for photosynthesis. Another example can be seen in protozoans living inside the guts of termites and cockroaches. By living in the digestive track of their hosts, the protozoans have a ready supply of food for themselves. The protozoans in turn produce enzymes necessary to breakdown cellulose. In mutual interaction, one organism cannot survive in the absence of the other.

Commensalism

In a true commensal interaction one of the organisms is neither harmed nor benefits. An established case commensalism exists between a hermit crab and a sea anemone. The sea anemone obtains food particles from the crab and gets carried to place where it would not normally be found. The crab gains nothing from the association.

Epiphytism is a special type of commensalism. It is an association between two plants. One of them, usually a non-woody plant such as a fern, bromeliaed or orchid grows on the branches of trees so it can get enough sunlight to photosynthesise. In this case the plant growing on the outside of the tree is known as an epiphyte. In this interaction the tree is not harmed and does not benefit from the interaction. The epiphyte on the other hand has a host to grow on which holds it high off the ground where it can photosynthesise.

Parasitism

In parasitism one organism (the parasite) benefits and the other (the host) is harmed. Parasites live on their hosts using the host as a source of food. Parasites will kill their hosts very slowly; however a good parasite never kills its host. Parasites that eventually kill their hosts must reproduce and disperse before the host dies. Parasitism, like predation, is an important factor in controlling the population of the organism. The abundance of the host and its ability to reproduce is significantly reduced by the effect of the parasite.

Almost all organisms have parasites. Hookworms which are very common in the tropics, a parasites of humans. The larvae of hook worms occur in the soil and burrow into the skin that comes into contact with it. Inside the host they attach to the walls of the small intestine and feed on blood. If abundant, hookworms can cause anaemia.

Many fungi and bacteria are also parasites. For example, a parasitic fungi phytophthora infestans causes potato blight. In 1845 when the potato crop failed, half a million died of starvation or malnutrition in Ireland. In PNG in the late 1980s a fungi which causes rusts destroyed most of the coffee crop in the Highlands.

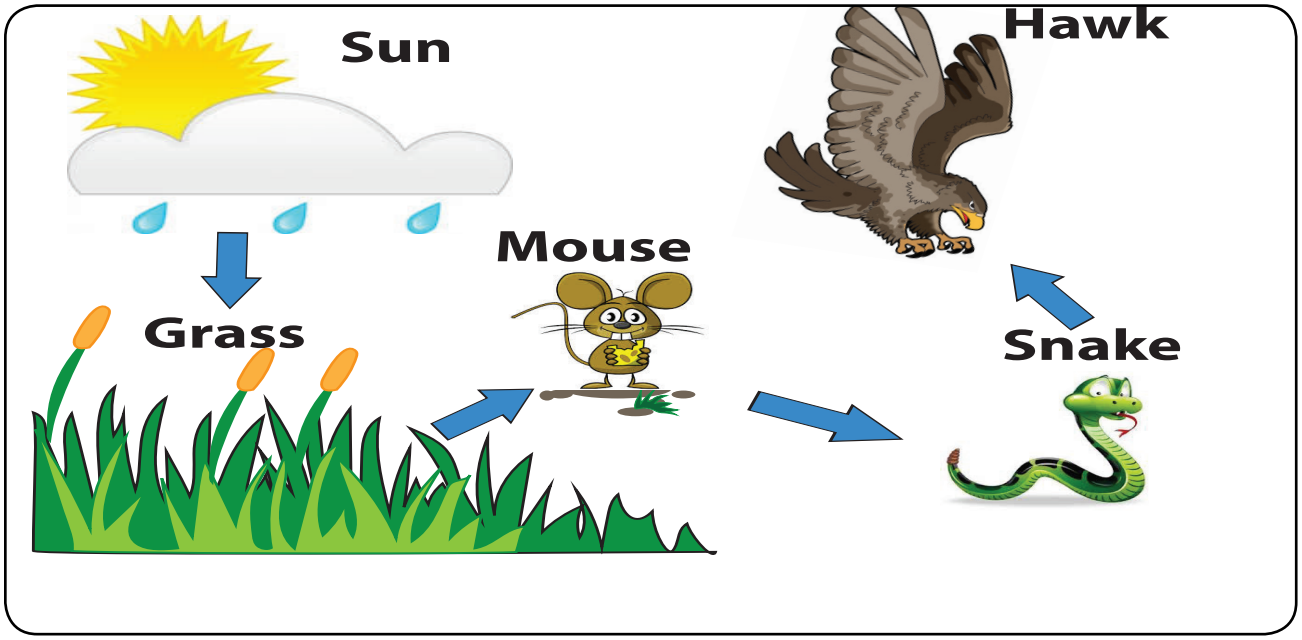
Energy in the ecosystem

The main use of food chains and food webs is to study path energy takes through the community. So where is this energy?

Green plants convert simple molecules to more complex molecules during the process of photosynthesis. This building of molecules requires energy which the plants get from the Sun. The energy is used to form chemical bonds which hold complex molecules together.

When these molecules are eaten as food by animals they are broken down into simple compounds again and the energy is released from the chemical bonds which have been broken.

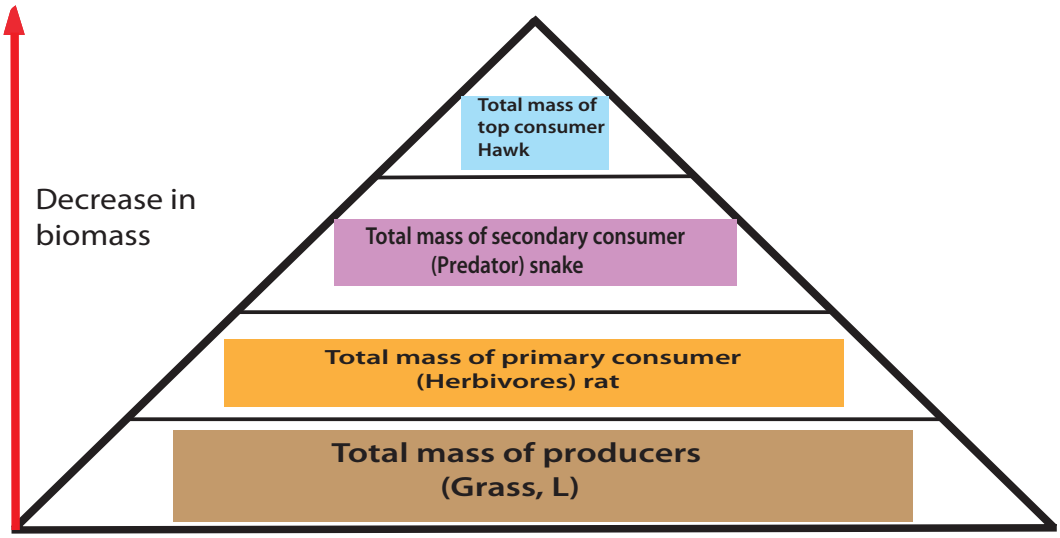
Once food is eaten and digested b animals, the energy it contains is available for the organism to use in the growth, work and reproduction. However, a lot of energy is lost in the form of heat, or is used to do work. This is not able to be passed on in the food chain.



In the above diagram the flow of energy from the sun to the grass, grass is eaten by a mouse, snake eats the mouse and the hawk eats the snake.

1. Sun is the source of energy which allows all living things to exist,
2. Energy from the sun is trapped by the green plants. It is changed into a form which animals can use. Some of the energy from the sun is trapped in green plants; some is lost.
3. When a mouse eats the grass, it get the energy stored in the grass. Some of the energy stays in the body of the mouse for the animal to use, some is lost.
4. When the snake eats the mouse, it gets energy from the mouse's body. Some of the energy from the mouse remains in the snake, some is lost.
5. When the hawk eats the snake, it gets the energy stored in the snake's body. Some of the energy from the snake remains in the hawk's body while some is lost.

The amount of food that is passed on in the food chain steadily decreases with each step so we find that there is a large amount of food material at the start of a food chain or food web to support a relatively few animals at the top.

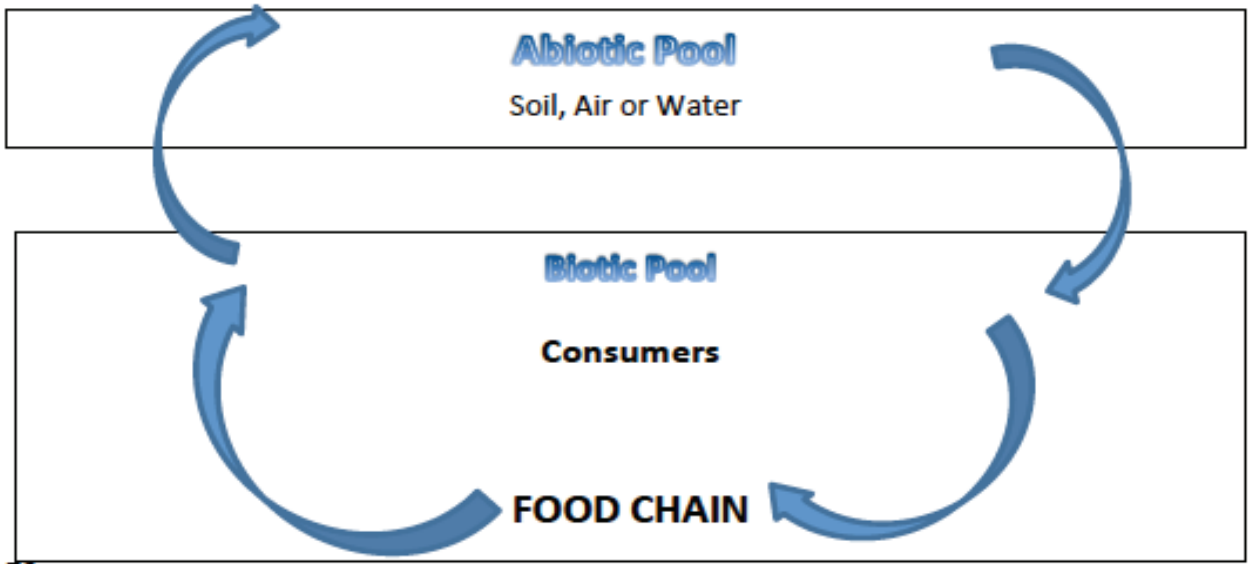


Nutrient Cycle

Energy flow through food chains in one direction, starting from the Sun to the producer and different levels of carnivores. Energy is eventually lost from the ecosystem but is continuously replaced by the Sun.

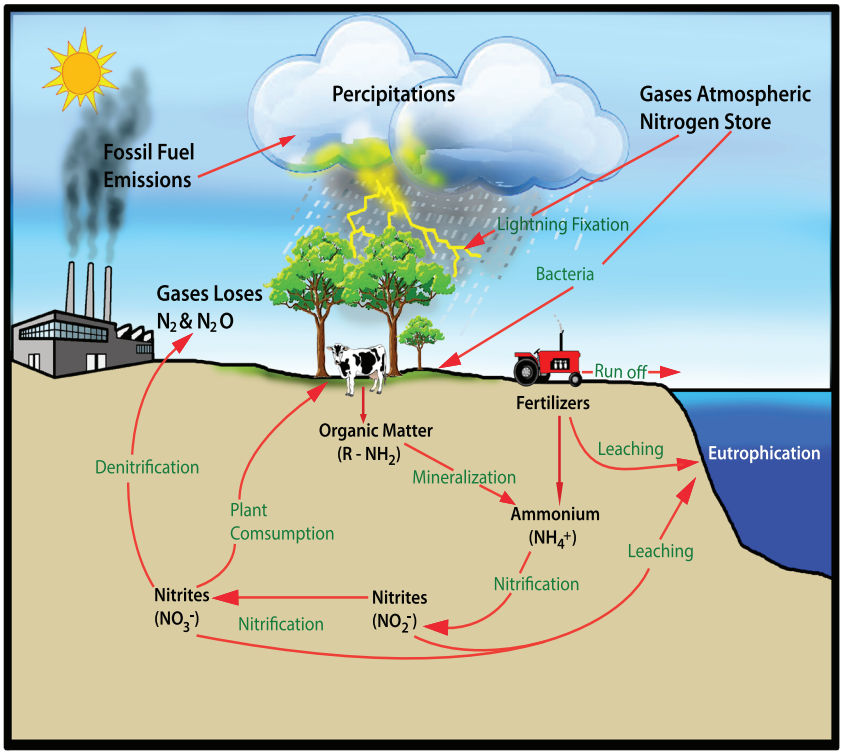
Everything else, on the other hand, has been and is being recycled, that is, used before other organisms. The atoms making up these chemicals once made up the tissue of animals and plants long since dead. In fact atoms that made up the tissues of dinosaurs 100 million years ago are still here today in the tissues of living organisms- maybe even in your own body.

The orgainsms are made up of numerous different chemical compounds. These compounds are made up of different elements. These elements are cycled through the living (biotic) and the non-living (abiotic) part of the ecosystem. The compounds (from the soil, air or water) are incorporated into the plant tissues which get passed along the food chain. When the organism produces waste products or dies the compounds are or elements are released back into the soil, water or air (the abiotic pool).



The Nitrogen Cycle

Plants need nitrogen for the synthesis of proteins and other compounds, including DNA and vitamins. Nitrogen gas makes up about 80% of the Earth's atmosphere, but plants do not have the enzymes necessary to use the nitrogen directly- instead they must absorb it as nitrate. Nitrate is formed by two sets of process carried out by microorganisms- nitrogen fixation and nitrification.



In **nitrogen fixation**, nitrogen and hydrogen are combined to form the ammonium ions and then nitrate. The process depends upon enzymes that are only possessed by certain bacteria called nitrogen-fixing bacteria in legumes, lightning and volcanoes. Nitrates are readily available in artificial fertilizers in farms also.

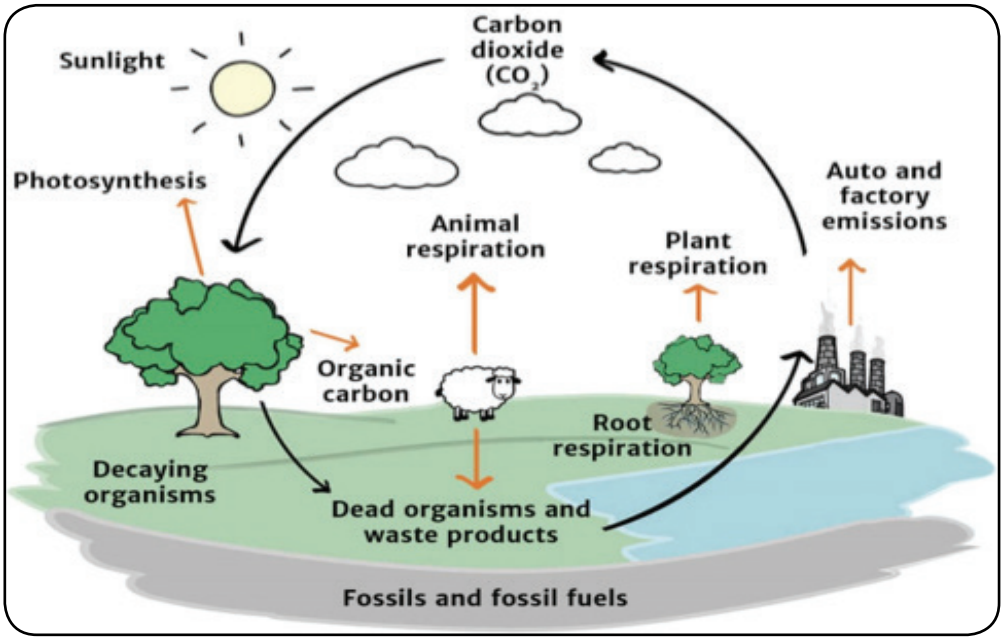
In **nitrification**, ammonium ions produced by decomposition of amino acids and proteins in dead plants and animals and animal wastes are oxidised (this is also called **mineralization**), first to nitrite and then to nitrate. The process is carried out by nitrifying bacteria which live in the soil. Nitrification only happens if oxygen is present. In the absence of oxygen the process is reversed and denitrifying bacteria obtain their energy by converting nitrate to nitrogen gas. This is why waterlogged soils for example tend to lose nitrate as nitrogen gas.

Once nitrate has been formed by either nitrogen fixation or nitrification, it can be absorbed by plants through their roots. Eventually the plant dies and its body is added to the animal wastes and remains in the soil. Decomposers break down the nitrogen compounds in these wastes and remains and the formation of nitrate can begin again.

In a typical ecosystem, the process recycles nitrogen between living organism and the environment. However, some processes cause the loss of nitrate from the environment. This happens naturally as a result of **denitrification** and less naturally when crops are harvested and removed from the site where they have grown. These losses of nitrate can be made up either by nitrogen fixation or by adding nitrate in the form of fertilisers.

The Carbon cycle

The carbon cycle is a complex series of processes through which all of the carbon atoms inexistence rotate. Most life forms on the Earth are carbon-based. The same carbon atoms in your body today have been used in countless other molecules since time began.

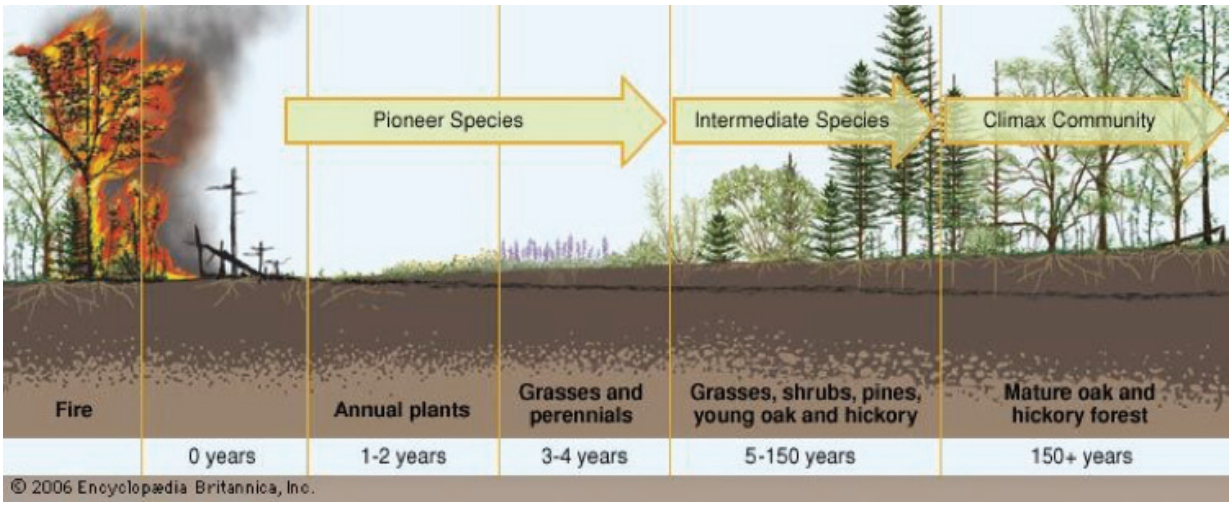


Succession

Succession is a process in which communities of plant and animal species are replaced in a particular area over time by a series of different and usually more complex communities as the available soil becomes more plentiful.

Each species modifies the habitat in which it lives. It may provide food for other species, it may provide a living space for others, or it may make the environment unsuitable for previously successful species.

Here is an example where a forest area was destroyed by bush fire and the regeneration of the forest over the years through a succession process.



Population

Content Standard	**12.2.1** Investigate the characteristics of population growth and explain the factors that affect the growth of various populations of species**.**
Benchmarks	**12.2.1.8** Identify and analyse methods of sampling population and factors that limit population growth. **12.2.1.9** Use models to represent population dynamics and discuss factors affecting population growth.
Essential Question	1. What is population growth? 2. Why is it important to discuss population growth? 3. How can a population be estimated? 4. What factors affect population growth? 5. How is growth measured?
Learning Objective	• Define and explain what population growth is and the factors that affect the growth rate. • Calculate growth rate. • Explain how population is regulated by means of density-dependent and density-independent factors. • Explain population dynamics. • State and explain the methods of transacts and quadrats used in population sampling. • Calculate population size and percentage cover. • Calculate the abundance and distribution of plant species within a given area using quadrat sampling. • Explain the human population growth patterns from graphs. • Contrast the key characteristics of population growth, factors affecting growth, the difference in growth patterns locally and internationally as well as in developed and developing countries.
Knowledge	• Population growth and factors that affect the growth rate. • How to calculate growth rate. • How population is regulated by density-dependent and density-independent factors. • Population dynamics. • Sampling populations using Transact and Quadrat Methods. • How to calculate population size, percentage cover and density. • How to calculate the abundance and distribution of plant species within a given area using quadrat sampling. • The human population growth patterns in PNG and other parts of the world. • Human population growth is growing at an alarming rate. There are differing factors that contribute to this growth rate. It differs between developed and developing nations.
Skills	• Describe the factors that affect growth rate. • Measure the growth rate of a place through calculation. • Distinguish between density-dependent and density-independent factors. • Examine the two different methods used in sampling populations. • Calculate population size, percentage cover and density distribution of a species of organism in a given area. • Demonstrate the quadrat sampling technique. • Measure the sample size, percentage cover and density distribution of species of organisms in a given area. • Judge the human population growth patterns of places by studying population pyramids and graphs. • Intepret demographic graphs. • Interpret growth of population on graphs and tables.
Atitudes & Values	• Realize the importance of the factors (good and bad) affecting human population growth in your community and as a means of outreach, teach these to your local community.

Content Background

A population is the total number of individuals of any one species in a particular habitat. The population will not spread out evenly throughout the habitat, nor will its numbers remain steady. The population is made of a variety of individuals which include (both male and female), juveniles, larvae, eggs or seeds.

One way to study population is to select a common animal or plant population. It is easier to study plant populations because plants do not move from place to place. Some slow moving animals such as earthworms and sea cucumbers can be also sampled easily.

Population Size

Ecologists need to know the estimated size of populations and how the size changes over time. Populations often remain stable but some change for many reasons; for example, migration, change in climate, pollution, habitat destruction and introduced species. When ecologist know that a population is being affected by human activities then it is possible to introduce some management scheme to prevent the extinction of the species. For example, if a turtle population is found to be declining then it is possible to control the hunting of turtles, the harvesting of turtle eggs and to make the beaches where they lay their eggs a nature reserve.

Using Quadrants

It is not possible to identify and count every individual plant or animal in a large area. For example, we cannot count every single grass plant. However, it is possible to study a small area using a quadrat. A quadrat is a square frame usually made of wood or metal that is used to mark out an area in which the plants and animals are to be studied. A square with 50 cm sides would be suitable for sampling grassland whilst a string with 10m sides could be used for sampling the trees in a forest.

Quadrats can be used to estimate the total population of a species in a given area and to estimate percentage cover. The percentage cover of plants is the area of ground occupied by all the parts of the plants that are above the ground, such as shoots, flowers and leaves.

Animal Population

Because animals have the ability to move about it may be easier to find out about animal populations by using the technique which is known as the capture-recapture method. The capture-recapture method is widely used in the ringing of birds and tagging of fish and mammals.

In this method a fixed amount of time is used to catch individuals of the same species of animal. Each individual is marked in a suitable way so that it can be identified later. For example, the shell of a snail, beetle or grasshopper can be marked with a spot of paint. The marked animals are released back into the habitat. After a certain period of time, a sample of the same species of animals are captured at random in the same place for the same period of time. Some of these animals will be unmarked but some will be marked animals that have been caught before. The size of the population can then be calculated using the following formula:

$$\textbf{Total population} = \frac{\text{Number first sample x Number captured in second sample}}{\text{Number of individuals recaptured}}$$

$$\textbf{Tp} = \frac{\text{T1 x T2}}{\text{T2m}}$$

Example

Sixty cane toads were caught at night. Each was tagged and released. The following night 41 were captured; of which 26 had tags and 15 did not have any tag.

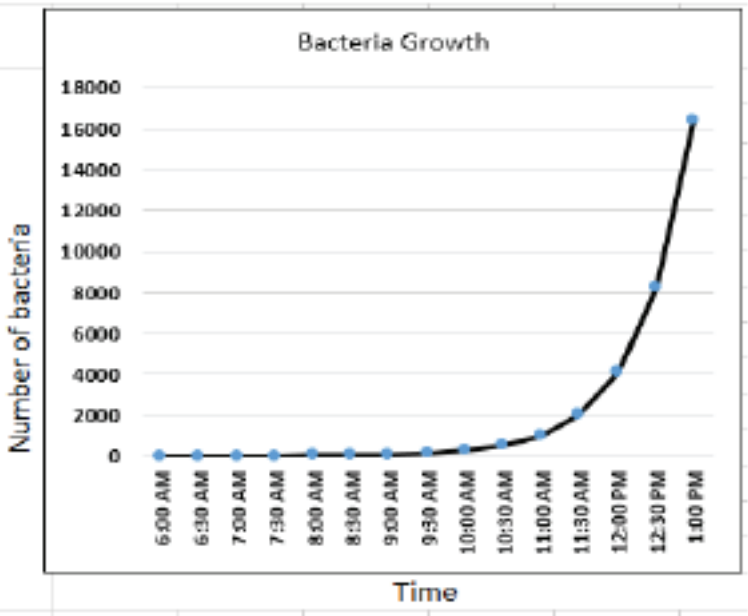
$$\textbf{Total Population of cane toads in the area} = \frac{60 \times 41}{26} = 95$$

Population Growth

Taking quadrats and the capture-recapture method are two simple ways of estimating the number of individuals that make up the population of a particular plant or animal species living in an area. In a natural environment the size of a population remains the same over a period of time although there may be changes over short periods of time. When a population increases in size this is known as *population growth.*

If population are able to grow without being controlled by death, food supply, competition and diseases, then they would soon reach very large sizes. For example, scientists have calculated that if the human population continues to grow at the present rate, there will be at least 100 people for every square metre of the Earth's surface in 100 years time. Similarly, uncontrolled bacterial growth could occupy the whole world in just a few weeks. The table below shows how a population of bacteria which reproduce very rapidly can double the size of its population every half an hour and reach an enormous size in just a short period of time.

Time	Number of bacteria	Generation number
6:00 AM	1	0
6:30 AM	2	1
7:00 AM	4	2
7:30 AM	8	3
8:00 AM	16	4
8:30 AM	32	5
9:00 AM	64	6
9:30 AM	128	7
10:00 AM	256	8
10:30 AM	512	9
11:00 AM	1024	10
11:30 AM	2048	11
12:00 PM	4096	12
12:30 PM	8192	13
1:00 PM	16384	14



Exponential population growth

From the graph, it shows a steeply rising curve. This type of curve is called *exponential curve* or *sigmoid curve*. It represents a population that is growing exponentially; this is called exponential growth. In exponential growth the number of individuals making up a particular increases by doubling.

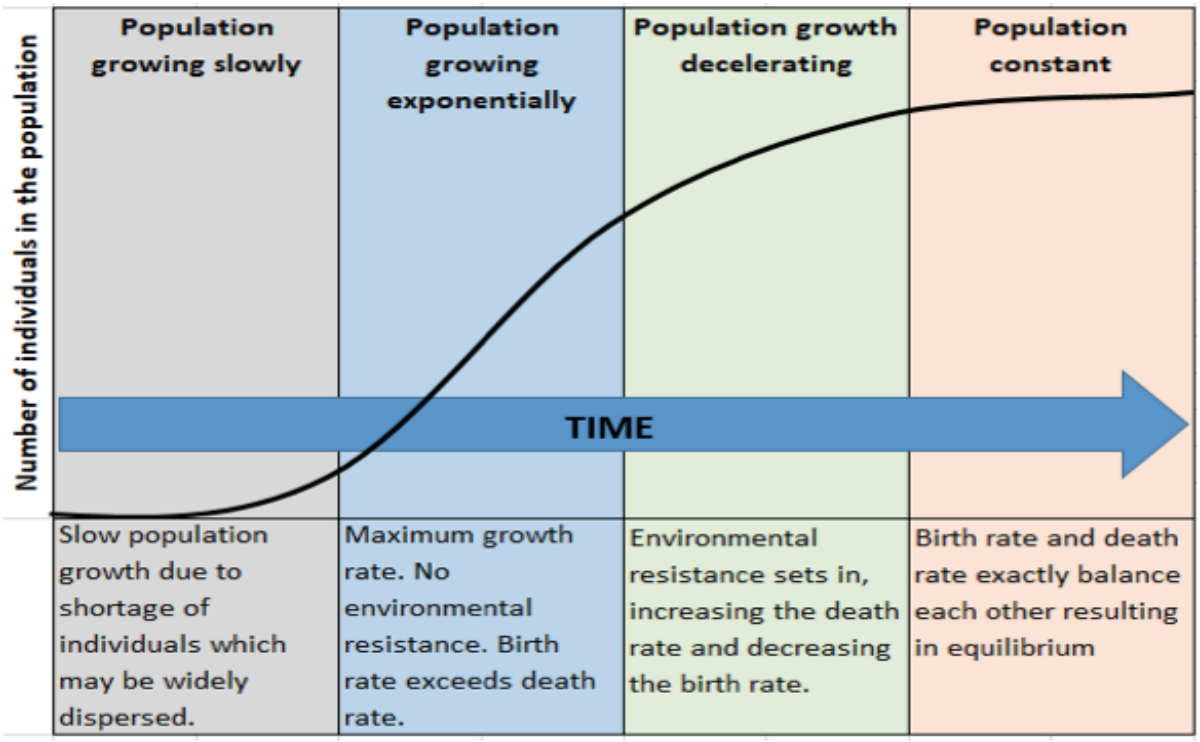
Studying how population grow

Most populations normally grow in size. That is, more new individuals are produced and added to the population than are lost through death or animals moving away.

Newly established communities often experience rapid increase in the size of their populations. This increase occurs in several stages.

Again, one of the most noticeable things about the graph is its exponential nature. This is shown by the fact that it rises very quickly in the early stages as a result of rapid reproduction which adds new individuals to the population at a very fast rate.

The population growth slows down and levels off in the later stages. In nature, populations of many living things show exponential population growth.



Birth rates, death rates, immigration and emigration

In any species of living things new individuals are born and older ones die. The rate at which individuals are born is called *birth rate*, and the rate at which they die is called the *death rate*. The birth rate is sometimes called *natality* while the death rate is sometimes referred to as *mortality*.

The birth rate and death rate are expressed as percentages. So, if for example, the birth rate is 10% per year, then it means that 10 more individuals would be born and added to the population for every 100 individuals in the original population. Therefore the population will increased to 110 from 100.

Now if the death rate of the same was 3%, then it means that three people in every 100 would die each year.

The birth rate is normally higher than the death rate in most populations. This results in more individuals being added to the population than are being lost through death. The overall number of individuals within the population therefore increases resulting in *population growth.*

The growth of population also depends on the number of animals that are entering or leaving a particular area where the population exits. The movement of animals from one habitat to another is called migration. There are two types of migration. *Immigration* occurs when animals move into the population and *emigration* occurs when animals move out of the population. Immigration and emigration can both be measured to work out the *net migration*. The net migration is the difference between immigration and emigration of individuals in a particular population.

Measuring the different features of populations

The birth rate, death rate and the growth rate of a population can all be measured . the net migration can also be worked out from the immigration and emigration.

The following formulae can be used to calculate the different characteristics of a population.

$$\textbf{Birth Rate} = \frac{\text{Number of births per year}}{\text{Total number of individuals in the population}} \times 100$$

$$\textbf{Death Rate} = \frac{\text{Number of deaths per year}}{\text{Total number of individuals in the population}} \times 100$$

$$\textbf{Net Migration} = \text{Immigration} - \text{Migration}$$

$$\textbf{Growth Rate} = \frac{\text{Birth} - \text{Death} + \text{Net migration}}{\text{Total population}} \times 100$$

Population Distribution

Populations of organisms are found in specific habitats. However, the distribution or spread of individuals throughout the area is not always even. It depends largely on the types of environmental conditions present in the area.

The spread of a plant population within an area will be dependent on abiotic or non-living environmental factors like sunlight, water, soil nutrients and temperature. Natural disasters like droughts affect population numbers and sizes in a n area. In a natural environment it is not usually possible to say whether changes in the numbers and sizes of populations are mainly due to one particular factor as there are many possible factors that may be responsible for the changes that are seen.

There are three types of distribution patterns of organisms

1. Uniform - known as uniform or even distribution, this distribution pattern is characterized by the maximization of distance between any two individuals. Typically this is found in plants; they compete for a resource such as soil nutrients or moisture, so they space themselves far apart in order to maximize the amount of resource consumption. It can also be a result of territorial behaviour as in penguin colonies.

2. Clumped - the most common distribution pattern in nature, clumped distribution is the opposite of uniform: individuals minimize the space between others; as a result, "clumps" of species form around each other. This can be a result of unreliable resources. If one area tends to accumulate one resource important to the population, the individuals of the population will clump around this resource. It is also found among many animals to either aid predation or fend off predators. Hyenas, lions, and cheetahs hunt in packs to ensure a kill while schools of fish aggregate to minimize the chance that any one fish will be eaten.

3. Random - in very homogenous environments, random or unpredictable spacing will occur, but this is not common in nature. For random distribution to occur, an individual of the population won't have any affinity or repulsion from another individual, nor will they have a preference for location due to biotic factors. Some examples of random dispersion include the random destinations of dandelion seeds dispersed by the wind and oyster larvae that are carried by water currents.

Population density

The factors affecting the sizes of populations have already been described. However, simply knowing the size of a population is not very useful. Some means of comparing the size of populations of various species in different areas from time to time is needed to see what's happening to the population.

This idea can be illustrated in the following way. Two farms in the same locality carry the same number of cattle. No real comparison between the two farms can be made unless the total area of each farm is known. If there are 200 cattle on each farm but one farm is half the size of the other then the 200 cattle on the small farm will be more crowded than those on the larger farm. Some idea of how many organisms are present in a given area or space can be very valuable information. This is often described as population density. Population density refers to the total number of individuals of a particular species per unit area.

Using 'population density' instead of total numbers' makes the comparison of population sizes in different places or from time to time in the same area much more useful. For example, it is possible to relate the number of grasshoppers to the number of frogs in a particular area or the number of grasshoppers to the percentage cover of cabbages at different times.

$$\textbf{Population Density} = \frac{\textbf{Total number of individuals}}{\textbf{Total area of the place in which the organisms are spread}}$$

Human and the Environment

Content Standard	**12.2.1** Investigate the characteristics of population growth and explain the factors that affect the growth of various populations of species**.**
Benchmarks	**12.2.1.10** Investigate and describe environmental factors affecting population growth and distribution.

Essential Question	1. What is biodiversity and how important is it to the ecosystem? 2. How do introduced species impact the diversity? 3. What is a sustainable management practice? 4. How has human population impacted the environment?
Learning Objective	• Explain what ecosystem diversity is. • Discuss introduced species and diversity. • Explain sustainable management and conservation of environment. • Explain how changes in human population have altered or impacted the environment • Human effects in terms of cause, effect and possible remedies
Knowledge	• Human activities have detrimental repercussions on the ecosystem • Human activities include water pollution by untreated sewage, inorganic wastes and the use of insecticides have largely impacted our environment • Human activities threaten to delicate balance of the ecosystem • Conservation is necessary to preserve biodiversity and to maintain balance
Skills	• Identify environmental factors that affect the distribution of population • Identify human activities that threaten the population growth • Construct a sustainable management plan to conserve the environment • List endangered plants and animals that are threatened by the human population
Atitudes & Values	• Appreciate what the environment provides to mankind • Develop a caring attitudes towards the environment • Value the importance of environment.

Content Background

Humans already are or could easily become the most significant biotic factor in every environment. Primitive humans had a temporary effect on the environment because they were nomadic and allowed the environment periods of time to recover. After humans became cultivators and settlers the following 'effects' on the environment gradually become noticeable:

- The use of tools and the domestication of animals meant more efficient agriculture.
- The greater need for shelter, agricultural land and fuel meant a greater rate of deforestation and desertification
- The careless of pesticides and fertilisers, together with increasing consumption of fossil fuels, produced problems of pollution. These have been added to by the development of nuclear energy sources.

Human success, measured as an increase in population size, is largely due to our ability to solve complex problems and modify the environment for our benefit. This places great demands on the environment causing changes in the atmosphere, the aquatic environment and the land. Humans have also intentionally or otherwise seriously upset the balance of populations of other living organisms.

Pollution is any effect of human activities upon the environment and a pollutant is an product of human activities that has a harmful effect on the environment. When looking at pollution, we shall consider three key points:

- What is the cause?
- What are the effects?
- What are the solutions?

Pollution of the atmosphere

The major problems with the Earth's atmosphere are the greenhouse effect and production of acid rain.

Burning of fuels has a more effect on the atmosphere. The combustion process oxidises elements and compounds in the fuel. These oxides affect the atmosphere- carbon dioxide is a greenhouse gas and sulphur dioxide and oxides of nitrogen contribute to acid rain. The major other pollutants of the atmosphere are the chlorofluorocarbons (CFC)

DNA, Genes & Chromosomes

Content Standard	**12.2.3** Investigate the process of meiosis, laws of heredity and evaluate social, ethical and environmental implications of genetic research and related technologies.
Benchmarks	**12.2.3.1** Describe the process of meiosis in terms of cell division and the movement of chromosomes. **12.2.3.2** Explain how the concepts of DNA, genes, chromosomes, alleles, mitosis, and meiosis account for the transmission of hereditary characteristics from generation to generation. **12.2.3.3** Describe the structure and function of DNA, genes and chromosomes and the processes of DNA replication, transcription, and translation in the cell.
Essential Question	1. What is the study of Molecular Genetics? 2. What are nucleic acids, genes and chromosomes? 3. How do cells divide? And how is DNA replicated? 4. How are proteins made? 5. What is mitosis and where does it occur? 6. What is meiosis and where does it occur? 7. In what ways did Griffiths, Hershey & Chase, Chargaff and Watson & Crick contribute to genetics as we know it today?
Learning Objective	• Define and describe the nature of DNA, genes and chromosomes. • Explain how DNA replication, transcription and translation occur. • Describe the process of mitosis and its role in somatic cells • Describe the process of meiosis and its importance to sexual reproduction. • Summarize the events leading up to the discovery and confirmation of genetic material by early scientists. • Explain the components, structure and role of DNA, genes and chromosomes in cells. • Explain the structure and function of nucleic acids and their role in protein synthesis. • Explain the process of Mitosis and DNA replication in cell division. • Explain DNA Transcription, Translation and Protein Expression. • Explain the role of chromosomes in Genetic makeup of organisms. • Describe the stages involved in mitosis and meiosis in eukaryotic organisms.
Knowledge	• Nucleic acid sequences create DNA sequences which create genes. All genes are located on chromosomes in the nucleus of a eukaryotic cell. • Eukaryotic cells have linear chromosomes and prokaryotic cells have circular ones. • DNA provides the blue-print of life. • Cell division occurs after DNA replication. • DNA replication and mitosis are part of the cell cycle of all somatic cells. • Mitosis occurs in somatic cells and results in the production of identical, diploid daughter cells. • Meiosis occurs in sex cells and results in haploid cells. • Meiosis and crossing over contributes to genetic diversity. • Components, structure and role of DNA, genes and chromosomes in cells. • Structure and function of nucleic acids and their role in protein synthesis. • Mitosis and DNA replication in cell division. • DNA Transcription, Translation and Protein Expression. • Role of chromosomes in genetic makeup of organisms. • Stages involved in mitosis and meiosis in eukaryotic organisms.
Skills	• Construct from coloured blocks or pegs nucleic acid sequences that make up a gene. • Draw the DNA double helix and relate it to how it fits into chromosomes. • Remove pegs or blocks from nucleic acid structure to represent mutation. • Construct simple monohybrid and dihybrid crosses; test cross and Punnet squares. • Learn about new gene methods in theory.
Atitudes & Values	• Recognise the value of knowing that the nucleus of the cell that gives rise to the blue-print of life. • Realise that your physical make-up is determined by these unseen things we call genes.

Content Background

Cell Division

In order to multiply cells undergo **cell division**: one divides into two, two into four, four into eight, and so on. The word division is misleading in some ways because it implies that the process always involves halving the cell and its contents. In fact we know that the cell division is accompanied or preceded by the formation of new cell components so that the products of cell division, the daughter cells, are essentially similar to the parent cell. Understanding cell division is largely a question of appreciating how this uniformity is preserved.

In any description of cell division the chromosomes occupy a central position. As the vehicles of heredity they determine the characteristics of the cell and its progeny, and is essential that they should be correctly distributed between the daughter cells. It is known that a cell normally has a fixed number of chromosomes and these occur in pairs: the so called **diploid condition**. Two types of cell division are recognised according to the behaviour of the chromosomes. In the first of these, the daughter cells finish up containing exactly the same number of chromosomes as the parent cell. This is called **mitotic cell division (or just mitosis)** and is the type of cell division which takes place during an organism's growth. In the other type of division, known as **meiotic cell division (or meiosis)** the daughter cells finish up with half the total number of chromosomes present in the parent cell. This kind of cell division generally takes place in the formation of gametes, though in some organisms it may occur in the formation of spores.

It is useful to make a distinction between the division of the nucleus (which involves mitosis o meiosis) and the division of the cell which generally follows immediately afterwards. The latter is sometimes refered to as cytokinesis. The entire sequence of events which takes place in a cell between one cell division and the next comprises the cell cycle.

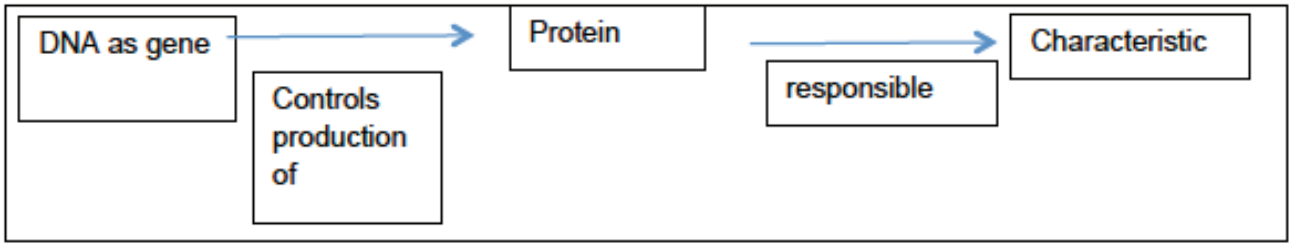
Mitosis

For purposes of description mitosis is divided into four stages: **prophase, metaphase, anaphase and telophase**. At each of these stages certain crucial events take place, particularly in regard to the chromosomes. However, it is important to realize that mitosis is a continuous process and there are no sharp breaks between stage one and the next. Typically the entire process takes about an hour and is followed by a **resting stage (called interphase)** during the daughter cells grow and prepare for the next division. This involves synthesis of new materials and replication of organelles. In actively dividing cells interphase lasts between 12 and 24 hours.

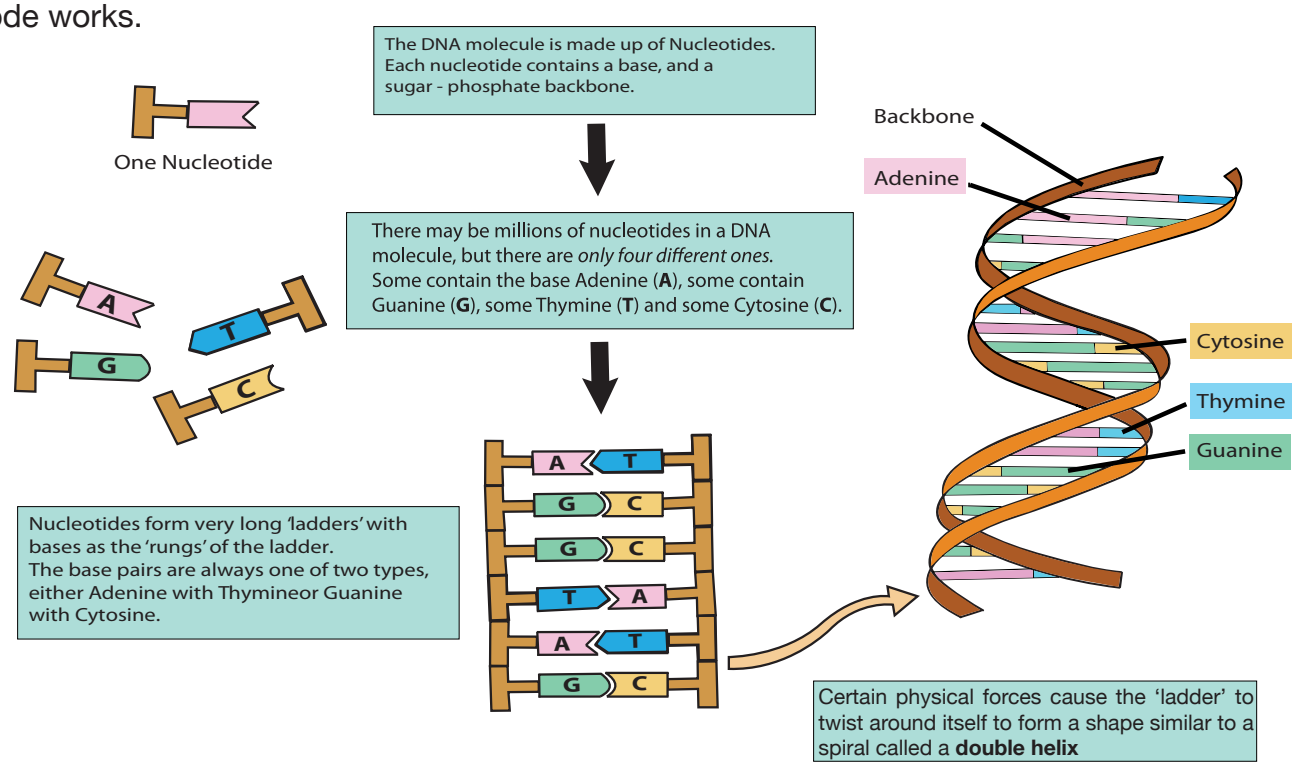
Characteristics depend on proteins

It has been discovered that the characteristics that a cell or organism possess depend on the **proteins** that the cell can manufacture.

For cells to specialise in the many different ways that they do, they must make different proteins. The instructions as to which proteins should be manufactured at any one time in a cell are carried as **genes** on the **chromosomes**. Chemical tests have shown that chromosomes are largely composed of the enormous molecule called **deoxyribonucleic acid** or **DNA** for short in other word:



DNA carries its instructions as coded messages using just four different chemical compounds called **nucleotide** bases or organic bases. The names of the bases are shown in the diagram below, but you only need to remember their initial letters (A,T,G and C) to understand how the code works.



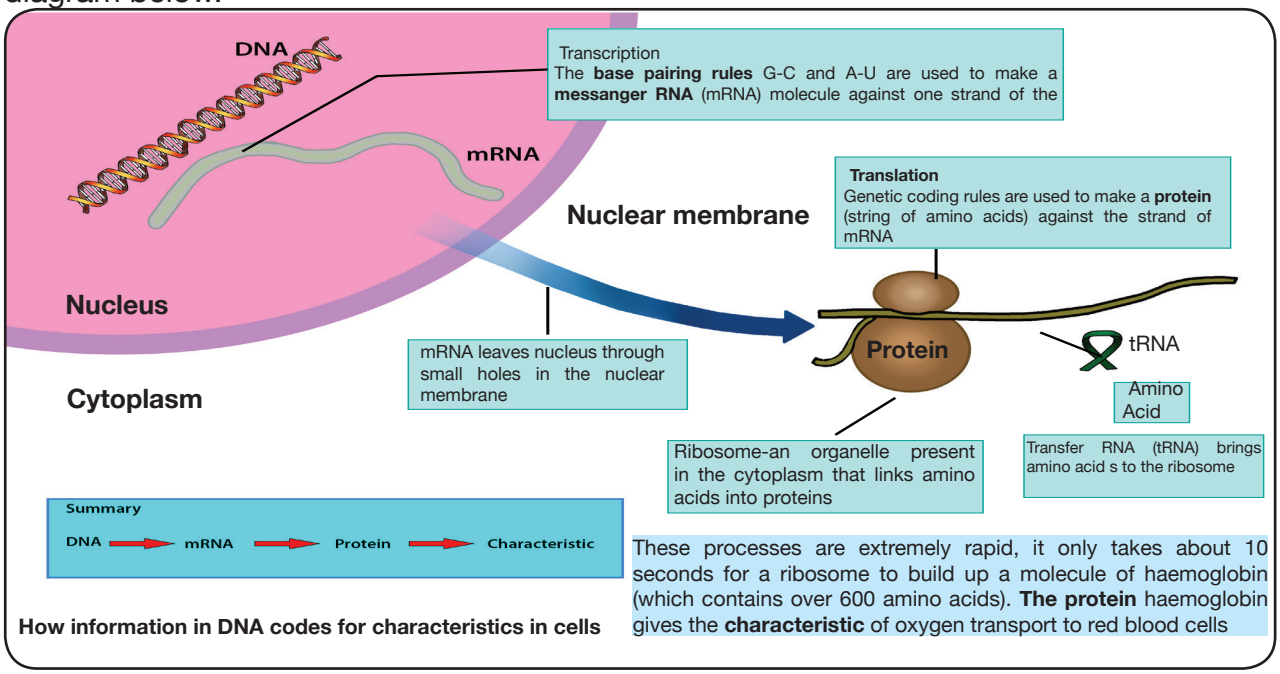
Passing the messages to the ribosomes

This coded information in the genes is located on the chromosomes, which are in the nucleus. You may remember that the protein-manufacturing stations, called **ribosomes**, are found outside the nucleus in the cytoplasm. How does the code pass from the nucleus to the ribosomes in the cytoplasm? It is carried by another type of nucleic acid called messenger RNA (mRNA)

Transcription and translation

The mRNA is made by the process called **transcription**, which literally means' cross writing'. The base sequence in the DNA is transcribed into another base sequence in the mRNA, using very similar base pairing rules to those used in the replication of DNA. There is one important difference- RNA never contains the base thymine (T). Thymine is replaced by a fifth base called uracil (U) so instead of the base pair A-T used in DNA replication, in transcription we have the base pair A-U.

Once it has been made, the mRNA leaves the nucleus and travels to the ribosomes. The sequence of bases in the mRNA is used to build up a sequence of amino acids into a protein in the ribosome. This process is called **translation**. It involves rewriting the language of bases into a language of amino acids. The process transcription and translation are outlined in the diagram below.



How information in DNA codes for characteristics in cells

What is a Chromosome?

To understand why humans are the way they are, we have to look at cells. We must look at a material found in the centre of our cells. This material is called **chromosomes**. Chromosomes are found in the nucleus of our body cells. They are long, coiled thread-like structures made of DNA and protein. We have 23 pairs of chromosomes. That means each cell has 46 in all. Chromosomes are made up of **alleles**. Each one has more than 2000 alleles along its length. Alleles are instructions for cells. Because chromosomes come in pairs, alleles come in pairs too. Each cell has two sets of instructions for everything. Two paired alleles work together to make a gene. Bird genes give it wings. Our genes give us fingers and everything else that makes us human. Wings from birds and fingers from humans are all **traits**. These traits start in the cells. Each cell follows its gene's instructions on how to develop and work. All the cells work together to make wings or fingers. Some cells die or are destroyed. New ones are always being formed. This process of cell growth and cell division is called the cell cycle.

What is Genetics?

Genetics (from the Greek word 'genno' which means '**give birth**' is the science of genes, heredity and the variations of organisms. The word genetics was first applied to describe the study of inheritance and the science of variation by English scientist William Bateson in a letter to Adam Sedgewick, dated April 18, 1905.

Genes are short pieces of the DNA molecules of a chromosome (in humans, each DNA is thought to contain about 1000 genes). Each gene is connected series of about 250 'rungs' on the DNA 'ladder'. Since the order of the rungs varies, each gene has a different 'code' relating to one specific characteristic (trait) of the organism, eg. Its blood group or the composition of a hormone. With the exception of the sex chromosomes, the genes carried on are paired homologous chromosome are also paired and run down the chromosomes in the same order (one member of each pair on each chromosome). These paired genes control the same characteristics and may give identical instructions. However, their instruction may also be different, in which case the instructions from one gene (**the dominant gene**) will 'mask out' those from the other (the recessive gene), unless incomplete dominance or codominance is shown. Two such non-identical genes are called alleles or allelomorphs.

Incomplete Dominance or Blending.

Incomplete dominance is a situation where pair of genes which control the same characteristic give different instructions but neither is dominant or obvious in the result. For example a lack of dominance between a gene of red colour and one for white results in the intermediate roan colour of some cows.

Incomplete dominance can be used by gardeners to produce flowers of the same species but with a variety of colours. They do this by cross-pollinating flowers of different colours.

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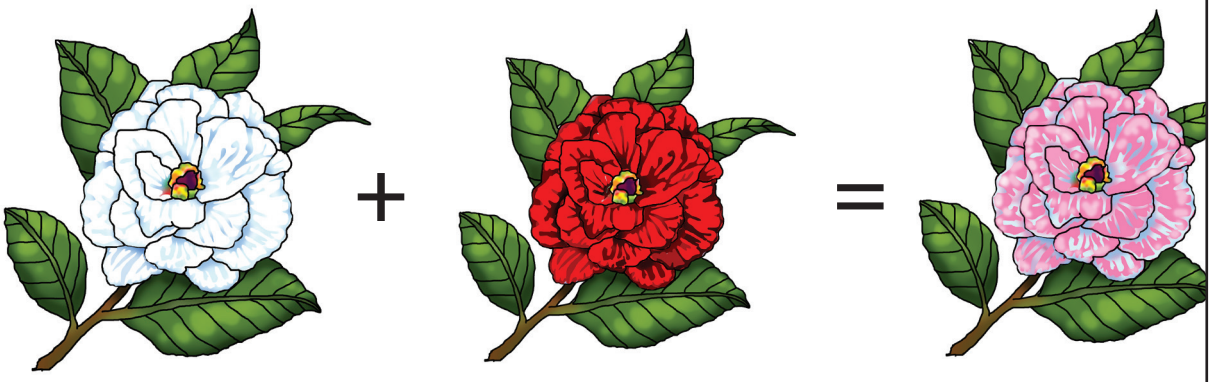


/hite Camellia **Red Camellia** **Pink Camellia**

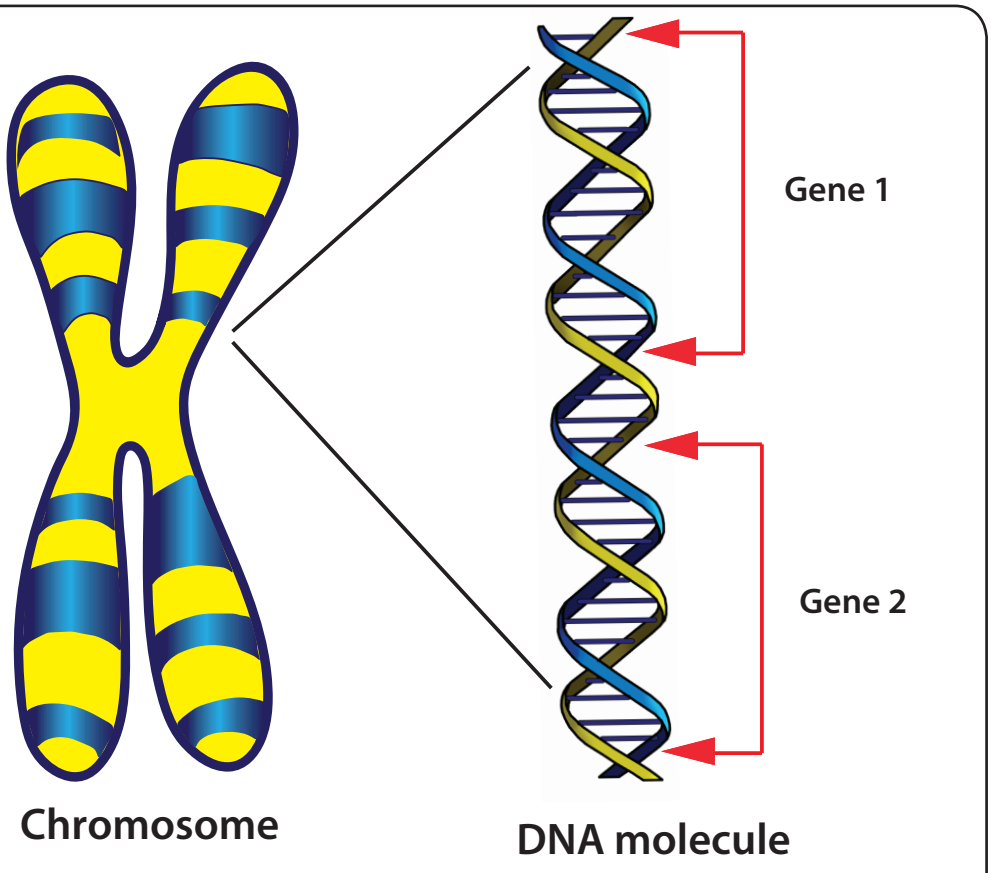
Codominace

Codominace is a situation where a pair of genes controlling the same characteristic give different instruction s, neither is dominant but both are represented in the result. The human blood group AB, for example, results from equal dominance between a gene for group A and one for group B.

What is the relationship between chromosomes, Genes and DNA?

To figure out the difference between these terms, you will have to recall what we have learnt about the life of a cell and its nucleus. When a cell is not actively dividing, its nucleus contains chromatin- a tangle of fibres composed of protein and a chemical molecule known as deoxyribonucleic acid (DNA). When the time comes for a somatic cell to divide into two new cells, the DNA is duplicated via mitosis so that each new cell can receive a complete copy of all the genetic material in the 'parent cell'.

During cell division, chromatin organises itself into chromosomes. Each chromosome is made up of the chemical molecule known as DNA. The chromosome comprises genes- individual segments of DNA that contain the instruction needed to direct the synthesis of a protein with a specific function. Each chromosome actually contains a single immense molecule of DNA that, in humans, has a length of up to 12 centimetres when stretched out.



Diagrammatic representation of a chromosome containing genes. The entire structure is made up of DNA.

What is DNA?

Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions specifying the biological development of all cellular forms of life (and many viruses). It is often referred to as the molecule of heredity as it is responsible for the genetic propagation of most inherited traits. During reproduction, DNA is replicated and transferred to the offspring as you have learnt.

In bacteria, (prokaryotes), DNA is not separated from the cytoplasm by a nuclear envelope. By contrast, in the complex cells that make up other organisms (plants, animals, fungi and protists), most of the DNA is located in the cell nucleus. The energy generating organelles such as chloroplast s and mitochondria also carry DNA for their own functions, as do many viruses.

Basically, DNA is a basic building block of life and it contains all the information that living things need to function correctly. For example, in humans, tis can cause variations I hair colour, affect one ability to roll one's tongue and cause heredity diseases.

Your DNA is composed of genes inherited from both your mother and father. DNA from both

The Cell Cycle

Our bodies need to grow. Our genes give instructions for this growth. Cell growth and divisions comes in three phases. The first is **interphase**. It is the period when a cell grows. During this phase, it duplicates the material in the chromosomes. The material is a dense mass inside the cell's nucleus.

The second phase is **mitosis**. It is a multistage process. The material in the cell's nucleus divides. It forms two nuclei. The first stage is **prophase**. The dense nuclei material condenses into fibres called chromosomes. Each chromosome has two identical strands. These are called **chromatids**. These two strands are pitched together by a **centromere**. This gives the X-like appearance. The second stage of mitosis is **metaphase**. The chromosomes line up in the centre of the cell. The centromere divides. The parts move to opposite ends of the cell. Next is **anaphase**. The two chromatids separate. They move to opposite ends too. The final stage of mitosis is **telophase**. Nuclei form around each chromatid.

The third phase of cell growth is **cytokinesis**. It is the final stage of the cell cycle. The remaining material is distributed between the two cell parts. They finish dividing. The cell division is then complete. Each cell has become two cells. At the end of this phase, each of the two new cells enters the interphase. The cell cycle begins again.

Meiosis: Sex Cell growth and development

Sex cells are different than body cells. Sex cells are formed during a process called **meiosis**. It is different than mitosis. During mitosis, our 46 chromosomes are duplicated. Two cells each with 46 chromosomes are created. In meiosis, a cell duplicates once. Then it divides again. It produces cells with only 23 chromosomes. That is half the usual number. Males use meiosis to create sperm cells. Females use it to create egg cells. When fertilisation occurs, the sperm from the father and the egg from the mother combine. They make one full set of chromosomes. There are 46 chromosomes for the offspring.

Inheritance Patterns

Content Standard	**12.2.4** Investigate the molecular basis of inheritance and gene expression and explain the basic patterns and mechanisms of inheritance.
Benchmarks	**12.2.4.1** Explain the concepts of genotype, phenotype, dominance, recessiveness, and sex linkage

Essential Question	1. How can simple and complex inheritance patterns be differentiated? 2. What other types of inheritance patterns exist: - Incomplete - Codominance - Epistasis, pleiotropy & metabolic mutations - Sex-linked genes
Learning Objective	• Describe how Mendel devised classical mono and di-hybrid inheritance patterns • Outline the construction of monohybrid inheritance patterns. • Draw Punnet to solve and express monohybrid inheritance problems. • Outline dihybrid inheritance patterns. Construct punnet squares to solve dihybrid problems. • Describe Mendel's two laws. Law of Independent Assortment and Law of Segregation. • Describe the other types of Non-Mendelian Inheritance Patterns and how they contribute to variation.
Knowledge	• Inheritance and types of inheritance patterns. • Mendel's experiment and his laws of inheritance. • Inheritance patterns can be simple or complex and involve continuous and discontinuous variations.
Skills	• Work together with peers in the student activity. • Problem solve inheritance patterns • Compare and contrast: - Complete inheritance - Incomplete inheritance - Codominance - Epistasis - Pleiotrophy - Sex-linked and sex influenced inheritance - Multiple alleles
Atitudes & Values	• Be aware that inheritance is carried down from generation to generation. • Appreciate how inheritance can be predicted in different organisms

Content Background

Two influences make you what you are at this moment: heredity and environment. Heredity is the set of characteristics that you inherited from your parents. Environment is the set of factors that have acted on you throughout your life.

The study of inheritance or heredity is the study of the mechanisms behind the transfer of genetic materials from parents to offspring. Our characteristics such as hair, eye colour, height and many other traits are passed down from one generation to another, but why is that we don t look exactly like our parents or siblings. Did we inherit only some of the characteristics? Or did our paternal characteristics mix with our maternal ones? Scientists were not able to answer these questions until the mid-19th Century when an Austrian monk, Gregor Mendel carried out breeding experiments with garden pea plants and gave a series of accurate explanations for the mechanism of inheritance. These explanations which are called **Mendelian inheritance** or **Mendelian genetics** involve the **Laws of Inheritance**, and form the basis of genetic experiments today.

Monohybrid Inheritance

For Mendel's inheritance experiments, Mendel carefully selected plants that exhibited the seven characteristics he had chosen. The seven traits are:

- Seed shape
- Seed Colour
- Flower Colour
- Pod shape
- Pod colour
- Flower position
- Stem height

Inheritance that involves only one pair of contrasting trait is called monohybrid inheritance.

In one of his experiments, Mendel crossed purebred tall plants (long stem) with purebred dwarf plants (short stem) and vice versa (crossed the pollen from the dwarf to the stigma of the tall plants). He the planted the seeds and observed the results. The hybrids of the cross were called the **first filial generation of the F1 generation**. In the f1 generation, all the plants were tall. He then allowed the F1 generation to self-pollinate and give rise to the **second filial generation or the F2 generation**. Out of the 1064 plants in the F2 generation, 787 were tall plants and 277 were dwarf plants giving a ratio of about 3 tall: 1 dwarf.

He also crossed the other six pairs of contrasting characteristics. All the results indicate a **ratio of 3:1.**

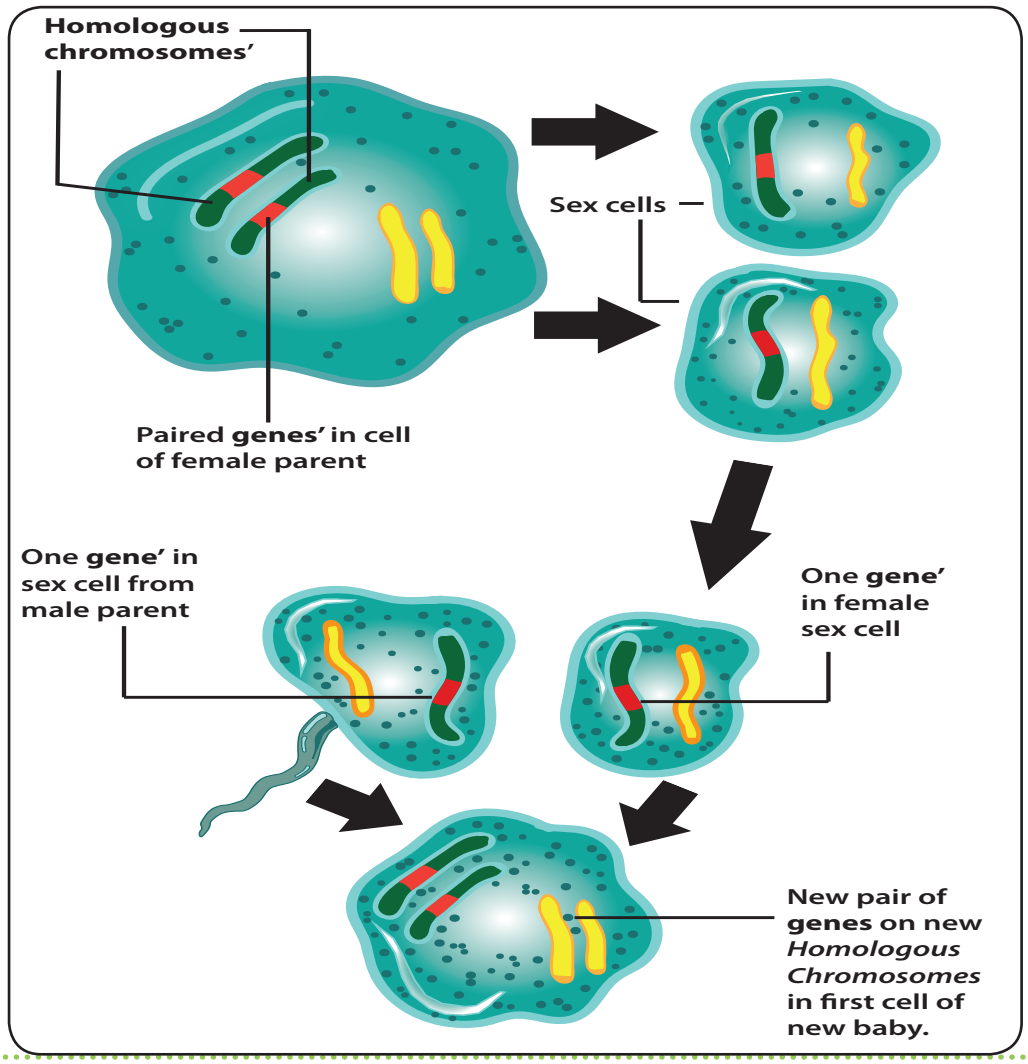
In all his experiment, Mendel observe that one trait remained unchanged in the F1 generation while the other contrasting trait disappeared only to reappear again in one quarter of the F2 generation. Mendel called the trait the remained unchanged in F1 hybrid a **dominant trait** and the other a **recessive trait**.

From these series of experiments, as well as other pea plant experiments, Mendel was able to offer an acceptable explanation of inheritance, now known as **Mendel's Laws of Inheritance**. He concluded that:

- Heredity factors are responsible for the transmission of characteristics
- Each characteristic is controlled by a pair of factors in the cell of the organism. For example in the length of the pea plant, there is a pair of factors that dictate whether the plant will be tall or dwarf but one will be dominant to the other. This is known as Mendel's Law of Dominance.
- The factors in each pair will separate or segregate during gamete formation and each gamete will contain only one factor. This is known as Mendel's Law of Segregation
- In other experiments in which he crossed two pairs of contrasting characteristics forming resulting in dihybrid inheritance, he observed that the characteristics are distributed to the gametes independently of one another and they unite at random. This is known as Mendel's Law of Independent Assortment.

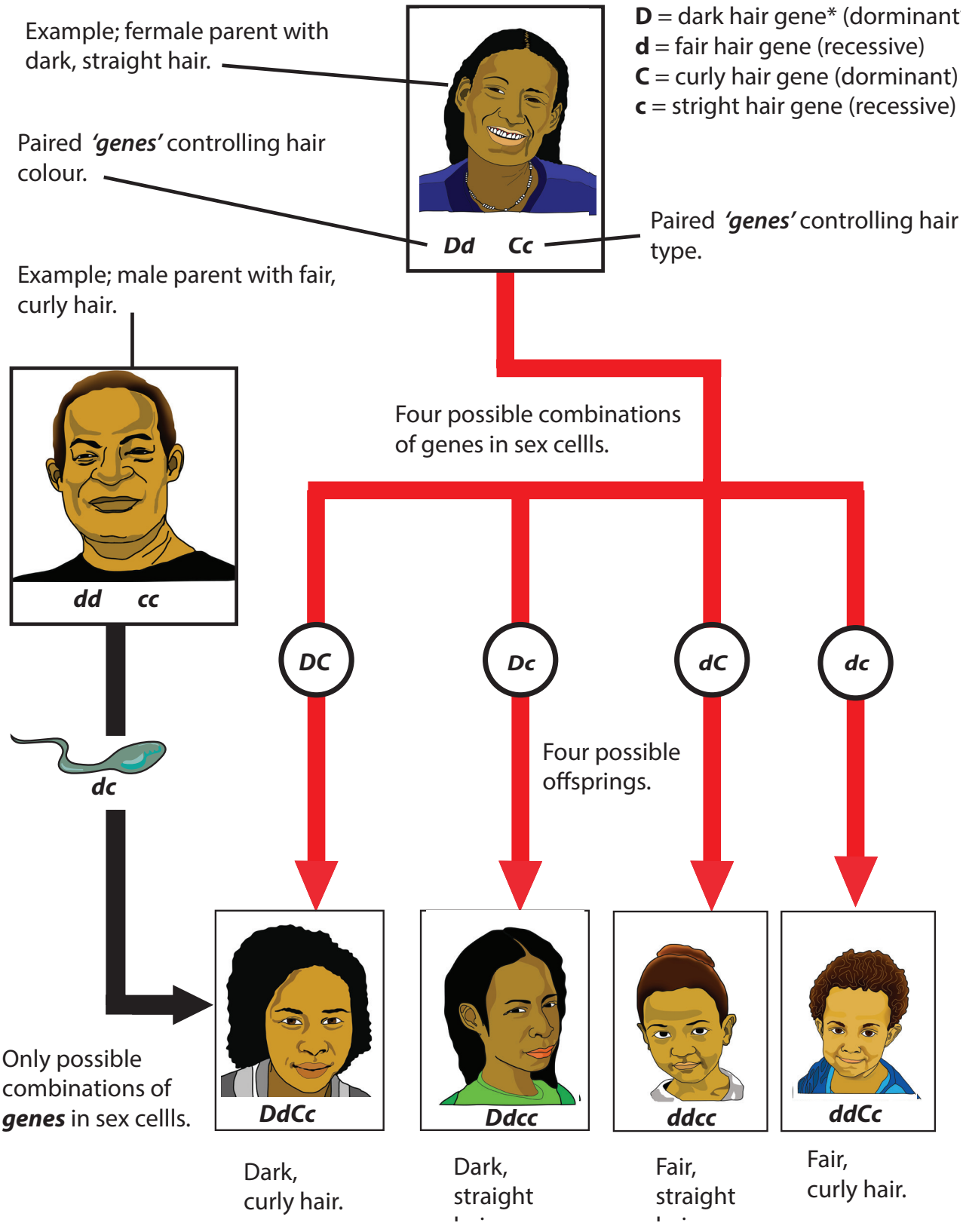
Law of segregation (Mendel's first Law)

Homologous chromosomes always separate when the nucleus of a cell divide to produce gametes, hence so too do the paired genes which control the same characteristics. The offspring thus always have paired genes (one member of each pair coming from each parent.



Law of independent assortment (Mendel's Second Law)

Each member of a pair of genes can join with either of the two members of another pair when a cell divides to form gametes (sex cells). Hence all the different mixes are possible in a new individual.



Mutations

Content Standard	**12.2.5** Investigate the process of meiosis, laws of heredity and evaluate social, ethical and environmental implications of genetic research and related technologies.
Benchmarks	**12.2.5.1** Explain how the concepts of DNA, genes, chromosomes, alleles, mitosis, and meiosis account for the transmission of hereditary characteristics from generation to generation. **12.2.5.2** Describe the structure and function of DNA, genes and chromosomes and the processes of DNA replication, transcription, and translation in the cell.

Essential Question	1. How can simple and complex inheritance patterns be differentiated? 2. What other types of inheritance patterns exist: - Incomplete - Codominance - Epistasis, pleiotropy & metabolic mutations - Sex-linked genes
Learning Objective	• Describe how Mendel devised classical mono and di-hybrid inheritance patterns • Outline the construction of monohybrid inheritance patterns. • Draw Punnet to solve and express monohybrid inheritance problems. • Outline dihybrid inheritance patterns. Construct punnet squares to solve dihybrid problems. • Describe Mendel's two laws. Law of Independent Assortment and Law of Segregation. • Describe the other types of Non-Mendelian Inheritance Patterns and how they contribute to variation.
Knowledge	• Inheritance and types of inheritance patterns. • Mendel's experiment and his laws of inheritance. • Inheritance patterns can be simple or complex and involve continuous and discontinuous variations.
Skills	• Work together with peers in the student activity. • Problem solve inheritance patterns • Compare and contrast: - Complete inheritance - Incomplete inheritance - Codominance - Epistasis - Pleiotrophy - Sex-linked and sex influenced inheritance - Multiple alleles
Atitudes & Values	• Be aware that inheritance is carried down from generation to generation. • Appreciate how inheritance can be predicted in different organisms

What is Mutation?

Every now and again a natural population of animals or plants throw up an individual with some characteristics strikingly different from the rest of the population, for example haemophilia and cystic fibrosis in humans, white eyes and vestigial wings in *Drosophilia*, resistance of bacteria to penicillin or flies to DDT- the list is unending. It can be shown from studies of inheritance that these conditions are generally recessive and are transmitted in a Mendelian fashion. The genetic mechanism producing the change is known as **mutation**. Any descendants of an individual with mutation, showing the new characteristics, are called **mutants**. Mutations are the basis of discontinuous variation in populations.

It is a characteristic of mutations that they are comparatively rare, at least in terms of the rate at which gametes are produced. In most organisms the mutation rate varies between one and 30 mutations per million gametes. The rarity of mutations can also be seen in their occurrence in a population, a **mutation frequency**. At any one gene locus in each generation a mutation occurs in only one individual out of approximately 500 000. The exact number is variable since the genes at different loci have different mutation rates. Expressed in this way the mutation rate certainly seems to be low. However, it must be remembered that each individual has a large number of loci at which it can happen. The overall mutation rate is therefore much greater than is realised by considering a single locus.

The low rate of mutation made it difficult to study them until the discovery in 1927 by the American geneticist H.J. Muller that the mutation rate of *Drosophilla* can be greatly accelerated by irradiation with X-rays. Since then it has been found that other factors also speed up the mutation rate. The **mutagenic agents** include gamma rays, ultraviolet light and a variety of chemical including mustard gas. This has made it possible to study the development and transmission of mutations in some detail.
Life style habits such as smoking and taking of drugs may also increase the likelihood of mutations in genes, which in turn may lead to cancer.

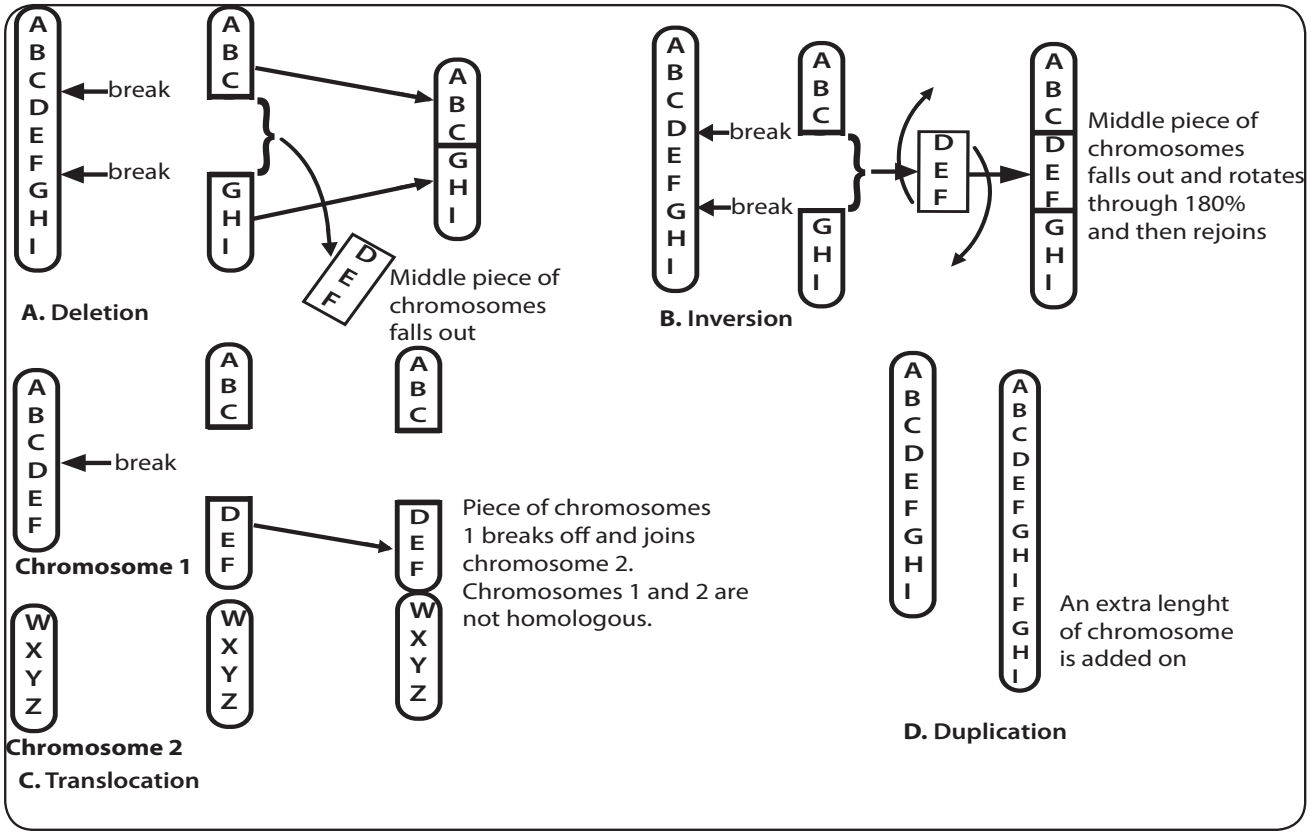
Mutagen	Effect
X-ray	Gene and chromosome aberrations
UV light	Structural distortion of DNA
Colchicine	Prevents spindle-formation in mitosis and so doubles chromo-some number
Cyclamate	Chromosome aberrations
Mustard Gas	Guanine in DNA replaced by other bases
Nitrous acid	Adenine in DNA deaminated so it behaves like guanine
Acridine orange	Addition and/or removal of bases in DNA

From these studies three salient facts emerge. First, mutations arise spontaneously and are undirected by the environment. Environmental influences can affect the mutation rate but they cannot induce a particular mutation to take place. From the evolutionary standpoint, the only direct part played by the environment is in selecting mutants that happen to possess advantageous characteristics. Second, mutations though not necessarily permanent , are relatively persistent. A mutant gene may be transmitted through many generations without further change, after which it may mutate agai, producing yet again another novel characteristics, or it may change back to its original condition. But the fact that it can persist unaltered for at least several generations make it possible for natural selection to get to work on it. Third, the vast majority of mutations confer disadvantages on the organism s that inherit them. The occurrence of a useful mutation is an extremely rare event indeed. In the course of evolutionary history infinitely more harmful mutations have been selected against than beneficial mutations selected for. This being so, evolution would seem to be a wasteful process and it certainly is in terms of the lives of individual organisms. In the long history of animals and plants there have been innumerable 'bosh shots' and relatively few successes. But by transmitting favourable mutations to their offspring it is the success that have been responsible for the wide variety of highly adapted forms which populate our planet today.

The genetic mechanism that brings about the deviation from the norm is called mutation. Because changes about mutations occur at the genetic level, offspring from the mutant usually would inherit the changes as well. There are two main types of mutation- **chromosome mutation** and **gene mutation** and both usually occur during gamete formation.

Chromosome Mutations

During meiosis when chromosomes become intertwined there is plenty of opportunity for various kinds of structural aberration to take place. For example a chromosome may break in two places and the section in between may drop out, taking all its genes with it. The two ends thenjoin up, giving a shorter chromosome with a chunk missing in the middle. This is called a deletion and insofar as it leads to the total loss of genes it can have a profound effect on the development of an organism: in fact all but the very shortest deletion is lethal. Another kind of chromosome abnormality occurs if a chromosome breaks in two places and the middle piece then turns round and joins again so that the normal sequence of genes is reversed. This is called inversion. Sometimes a section of one chromosome breaks off and becomes attached to another chromosome. This is rather like crossing-over except that it occurs between non- homologous chromosomes: it is known as translocation. Yet another abnormality occurs when a section of a chromosome replicates so that a set of genes is repeated: this is duplication.



In all these cases the sequence of genes is altered. This is important because it can bring into close proximity genes whose combined effect produces a beneficial characteristic. The closer together such genes are on the same chromosome, the less likely they are to be separated by crossing-over, and the more persistent will be the resultant characteristic. All the abnormalities described so far a visible when homologous chromosomes pair during meiosis. Since equivalent loci lie alongside each other, any change in the sequence of genes will prevent the chromosomes lying parallel with one another. Thus deletion will cause a loop, inversion a twist, and so on.

Another kind of chromosome abnormality is caused by the addition or loss of one or more whole chromosomes. To understand this, think of meiosis. Normally in meiosis homologous chromosomes come together and then segregate into separate cells, so that the gametes finish up with only one of each type of chromosome instead of the normal two. However, on some occasions the two homologous chromosomes, instead of separating, go off into the same gamete. This phenomenon is known as non-disjunction and it results in half the gametes having two of the chromosomes whilst the other half have none

Let's look at one of the example s of chromosome mutation in the case of **Down syndrome** or **trisomy 21**.

Many errors can occur during cell division. In meiosis, the pairs of chromosomes are supposed to separate and go to opposite ends in the dividing cell (anaphase). This event is called '**disjunction**'. However, occasionally one pair doesn't divide, and the whole pair goes to one end or to one daughter cell. This means that in the resulting daughter cells, one will have 24 chromosomes and the other will have 22 chromosomes. This accident is called 'non-disjunction'. If a sperm or egg with an abnormal number of chromosomes merges with a normal mate, the resulting fertilised egg will have an abnormal number of chromosomes (47 instead of 46). In Down syndrome, 95% of cases are caused by this event; one gamete has two 21st chromosomes instead of one, so the resulting fertilised egg has three 21st chromosomes instead of two. Hence the scientific name, trisomy 21. Recent research has shown that these cases, approximately 90% of the normal cells are the eggs. The cause of the nondisjunction error is not known; but there is a definite connection to maternal age.

Individuals with Down syndrome usually have the following symptoms:

- Mental retardation
- Reduced resistance to diseases
- Congenital heart abnormalities (like 'hole in the heart')
- Short stocky body
- Thick neck
- Characteristics folds of skin over the inner corner of the eye which produces a superficial similarity to Mongolians.

Also caused by non-disjunction are various sex chromosomes abnormalities. For example, some individuals have the genetic constitution **XXY**, which is caused by failure of the **X** chromosomes to separate during oogenesis in the mother. Normally such individuals are outwardly males, but they cannot manufacture sperm and may possess some female features, a condition known as Klinefelter's syndrome. Another abnormality, where an **X** or **Y** chromosome is missing, gives the genetic constitution **XO**. Such individuals are sterile females with immature genitalia, a condition called Turner's syndrome. Other sex chromosomes anomalies are now known, e.g. **XXX** and **XXY**, and all arise as a result of abnormal behaviour of the chromosomes during meiosis. Some of these conditions appear to be associated with slight mental retardation.

Polyploids

Sometimes cell division fails altogether, resulting in half the gametes having two of each type of chromosomes (i.e. diploid), the rest having none. If a diploid gamete fuses with a normal haploid gamete the resulting individual is **triploid**, i.e. it has three of each type of chromosome. If two diploid gametes fuse, a tetraploid individuals results. It is thus possible for an organism to acquire one or more complete extra sets of chromosomes, a phenomenon called **polyploidy**.

Ploypoidy also occurs if the whole set of chromosomes doubles after fertilization. In this case the chromosomes replicate as they would prior to mitosis. However, the spindle fails to be formed and the cell does not divide, so the cell finishes up with twice the normal number of chromosomes. If this happens to a diploid cell, a tetraploid will result, and so on. This can be particularly important in cases where two different varieties of a species, with different sets of chromosomes are crossed.

Gene Mutations

Gene mutation has played an important part in generating evolutionary changes. It arises as a result of chemical changes to individual genes. An alteration in the sequence of nucleotides, in that part of the DNA molecule corresponding to a single gene, will change the order of amino acids making up a protein, and this can have far-reaching consequences on the development of an organism. In some cases the proper functioning of some vital protein may be completely prevented. If this results in the early death of the organism, the gene is described as a **lethal gene**.

Examples of gene mutation which causes dire effect in humans are sickle cell anaemia and cystic fibrosis. People with sickle cell anaemia have **sickle haemoglobin (HbS)**, which is different from the **normal haemoglobin (HbA)**. It is a recessive genetic disease that occurs in individuals with both alleles of the gene codes for sickle haemoglobin. If the individual has a normal allele for haemoglobin and one allele for sickle haemoglobin, the individual will not suffer from the diseases. However, she or he will pass it on to the next generation since the allele is recessive.

When sick haemoglobin gives up oxygen to the tissues, it stick together to form long rods inside the red blood cells making these cells rigid and sickle-shape. Normal red blood cells can bend and flex easily. Because of their shape, 'sickled' red blood cells cannot squeeze through small blood vessels as easily as the normal red blood cells. This can cause the small blood vessels to get blocked and thus stop oxygen from getting through to where it is needed. Oxygen deficiency in turn can lead to severe pain and damage to the organs.

Different Kinds of Gene Mutations

The kind of gene mutation that causes sickle-cell anaemia is called **substitution**. In this process one or more incorrect nucleotides are substituted for the correct ones. In the simplest kind of substitution, such as occurs in sickle-cell anaemia, only one nucleotide is changed. This is called **point mutation**. If we look upon DNA as a conveyor of coded information, we can see at once that even this very slight change is enough to completely alter its information content. As an analogy consider the wrong information which might be conveyed by a misprint in a telegram in which a single incorrect letter is substituted for the correct one:

Intended message: FLOSSIE NOW ARRIVING BY AIR FROM PORT MORESBY.
Actual Message: FLOSSIE NOT ARRIVING BY AIR FROM PORT MORESBY.

Such a trivial error could alter a person's destiny, just as gene mutations have undoubtedly altered the course of evolution.

Other examples of other misprints in telegrams. Here is an example of an extra letter creeping into a message. A geneticist would call it an *insertion*:

- Intended message: PLEASE SAY WHERE YOU ARE.
- Actual Message: PLEASE STAY WHERE YOU ARE.

On the other hand, a letter might be left out (deletion) as in the following example:

- Intended message: WILL SEND FRIEND TO COLLECT JEWELLERY.
- Actual Message: WILL SEND FIEND TO COLLECT JEWELLERY.

Another possibility is that two letters might be printed the wrong way round, resulting in an inversion.

Intended message: GUERILLAS SENDING ARMS TO AID RIOTERS.
Actual Message GUERILLAS SENDING RAMS TO AID RIOTERS.

Sometimes an inversion may involve more than two letters as in the example.

- Intended message: BRING THERMOS ON OUTING.
- Actual Message: BRING MOTHERS ON OUTING.

Substitutions, insertions, deletions and inversions all occur in nature and can be induced in laboratory organisms by various mutagenic agents. The mistake in the genetic code may be very small and yet it can have consequences out of all proportion to the size of the mistake itself.

Somatic Mutations

Sometimes a mutation occurs in non-reproductive (i.e. somatic) cells of an organism. This is called **somatic mutations**. The resulting genetic change will be present in all the cells descended from the original mutant cell and, as such, may profoundly affect the individual. However, as the genetic change is not present in the gametes, it will be transmitted to future generations and will not contribute to evaluation- unless of course it affects the reproductive success of the individual.

Somatic mutations may cause such phenomena as birth marks and other skin blemishes in humans, and splashes of the 'wrong' colour in flowers: for example, blue irises sometimes have brown streaks. However, the effects of somatic mutations are not always visible; some may affect the physiology rather than the structure of the organism.

Whatever the manifestations, somatic mutations result in some of the cells of the organism having a different genetic constitution from the rest. Such an individual is described as a **genetic mosaic**. The proportions of cells affected will depend on how early in development the mutation occurs: obviously more cells will show the genetic change if the mutation occurs in the early embryo rather than in the adult. Somatic mutations can occur in any stage in life and an accumulation of them in older individuals is thought to contribute to senescence.

Variations

Content Standard	**12.2.5** Investigate the process of meiosis, laws of heredity and evaluate social, ethical and environmental implications of genetic research and related technologies.
Benchmarks	**12.2.5.1** Explain how the concepts of DNA, genes, chromosomes, alleles, mitosis, and meiosis account for the transmission of hereditary characteristics from generation to generation. **12.2.5.2** Describe the structure and function of DNA, genes and chromosomes and the processes of DNA replication, transcription, and translation in the cell.

Essential Question	1. How are traits passed from one generation to the next?
Learning Objective	• Describe the difference between continuous and discontinuous variation and give examples • Give examples of environmental factors that act as forces of natural selection • Assess the importance of natural selection as a possible mechanism for evolution • Give examples of artificial selection such as in the production of economically important plants and animals .
Knowledge	• Natural selection is a process by which biological populations are altered over time, as a result of the propagation of heritable traits that affect the capacity of individual organisms to survive and reproduce • Natural selection includes ecological selection and sex selection.
Skills	• Explain how meiosis contributes to the genetic variability of organisms • Draw chromosomes during meiosis to show Mendel's laws of segregation and independent assortment
Atitudes & Values	• Be aware that inheritance is carried down from generation to generation. • Appreciate how inheritance can be predicted in different organisms

Content Background

All humans are similar to each other. They have the same body form, structures and patterns of development and aging. These common characteristics identify them as a species. However no two people are alike, even identical twins. People differ from each other in height, weight, eye colour, hair colour, intelligence and many other characteristics. The different expressions of the same body characteristics in different individuals of the same species are known as **variations**. There are two types of variations-*discontinuous variation* and *continuous variation.*

In **discontinuous variation**, the characteristic is normally controlled by a single gene with two alleles and are usually not modified by environmental changes. As such, there are a limited number of distinct forms in the population. Characteristics that show discontinuous variations have several features:

- An organism either has the characteristics or it does not have it. There is no range of these characteristics between these extremes. An organism can easily be placed into definite categories and there is no disagreement about the categories
- These characteristics are usually qualitative- they cannot be measured
- They are the result of genes only- they are not affected by the environment.

Discontinuous variations are clear-cut in humans. They include the ABO blood groups, the ability to 'roll' the tongue, the ability to close one eye or raise one eyebrow.

Continuous variation is usually caused by the effect of many genes called polygenes (can be referred to as polygenic inheritance), as well as their interaction with environmental factors Characteristics that show continuous variations have several features:

- Every organism within one species shows the characteristics, but to a different extent. The characteristics can have a value within a range. Different scientists might well disagree about the category any single organism falls into.
- These characteristics are usually quantitative- they can be measured
- They result from several genes acting together, or from both genes and the environment

Continuous variations are not so clear-cut. These include height, weight, skin colour and intelligence among others.

Characteristics can be both discontinuous and continuous

Some characteristics are difficult to classify as either discontinuous or continuous variation. Human hair colour, for example, appears in a range from black to blond with many intermediate colours (it shows continuous variation as a result of the involvement of many genes). However, the gene for red hair is masked by every other hair colour gene (which gives a discontinuous situation-hair is either red or not). Eye colour can be identified as brown or not brown, which would classify it as a discontinuous variation, or it can be put in a range of many intermediate classes, which would make it a continuous variation. A simple guideline is: 'if it can be measured and given a numerical value, it is a continuous variation.'

Phenotype and Genotype

Variations in characteristics allow us to recognise different organisms and place them in different categories. The overall appearance of an organism is a result of the characteristics that it has inherited from its parents and the characteristics that result from the effects of the environment.

The following equation summaries this:

Phenotype	=	**genotype**	+	**effects of the environment**
The observable characteristics of an organism		The full set of genes it possesses		

Some characteristics result from both genes and environment. For example, a bean seedling has the genes to develop chlorophyll (and turn green) but it won't unless it receives enough light. A young mammal has the genes to develop a rigid bony skeleton, but it won't do so unless it receives calcium in its diet.

Natural Selection

Beside the variations mentioned above, mutations may also introduce variations. Mutation causes new alleles and /or genes to appear. These new genes may allow organisms to develop beneficial qualities that may allow them to be better suited to the environment. Competition for food, territories, mates, etc., occurs among the different populations of organisms. Nature actually selects those varieties that are more competitive, more resistant to diseases and better adapted to the environment to survive and continue their progeny. Other varieties will thus perish. This process is called natural selection. The theory of natural selection was proposed by Charles Darwin and Alfred Russel Wallace in 1858.

Natural selection can be subdivided into two types:

1. Ecological selection, which arises from the portion of an organism's environment not related to direct sexual competition (such as availability of food, the presence of predators and so forth).
2. Sexual selection which arises from the competition for mates between individuals of the same sex.

In other words, natural selection accounts for the propagation of the 'fitter' organisms in their environment, often called 'the survival of the fittest'. It is also a vehicle of evolution.

Ecological Selection

During the Industrial Revolution,(18th and 19th Century) when the number of coal-burning factories was increasing rapidly in England, it was noticed that the number of melanic (darker coloured) individuals of the species of Peppered Moth (*Biston betularia*) was becoming more common.

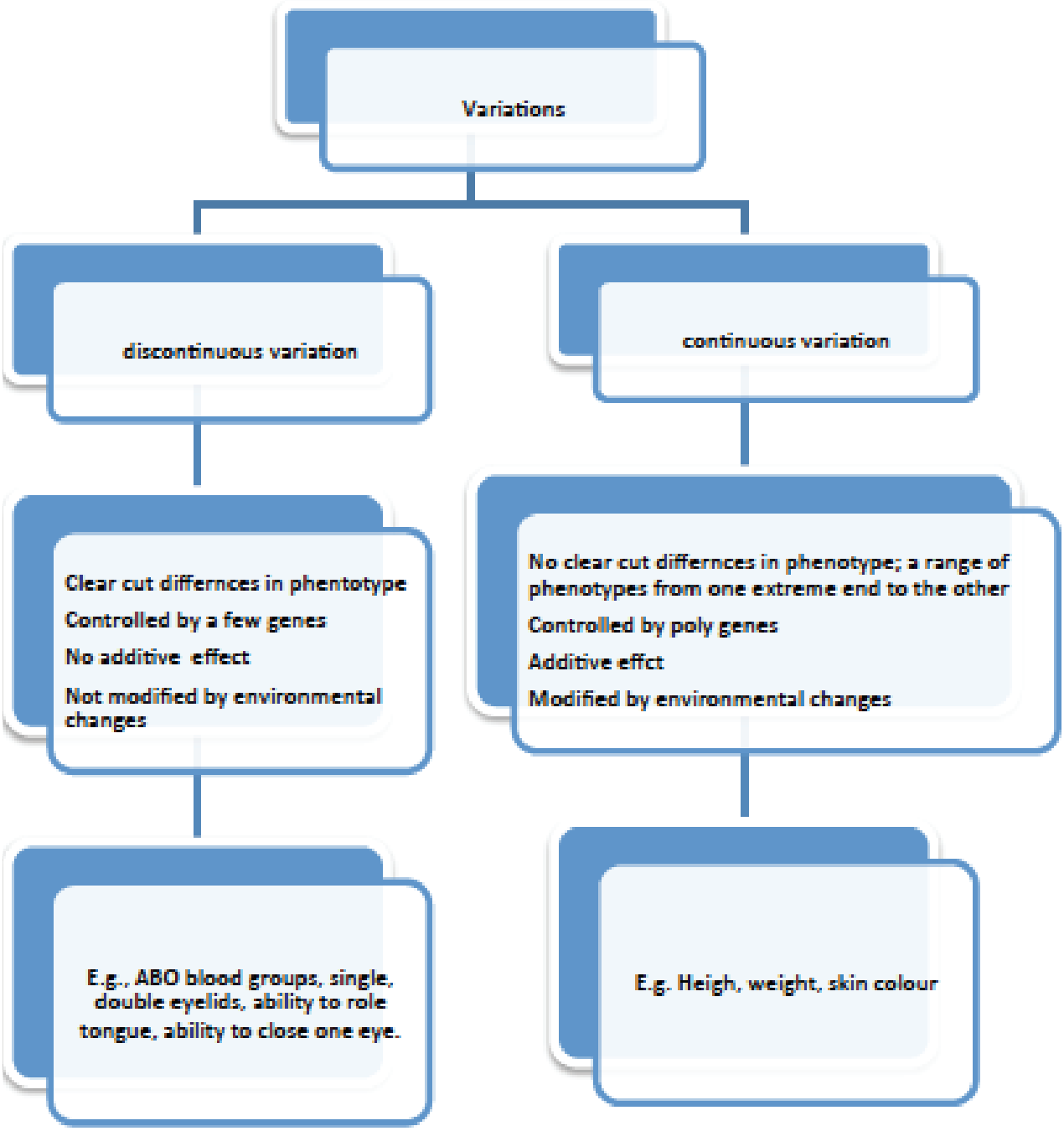
Before the Industrial Revolution, there were two varieties of Biston betularia; a light coloured variety with speckled wings and the melanic (dark) variety. The light coloured variety was more common and abundant as they camouflaged well on the lichen-rich tree trunks in England. However, the Industrial Revolution brought on pollution which killed the lichens and deposited soot on the tree trunks. Originally rare among the population of normally light-coloured moths, the frequency of the melanic form increased in polluted areas until it was over 90%. The number of light-coloured variety dwindled. The change was presumed to be a result of natural selection since the melanic moths in polluted areas better matched the blackened tree trunks where they rested during the day. In polluted forests distant from industrial centres, the tree trunks were not blackened and the light-coloured moths were present in higher numbers.

Sexual Selection

There are numerous examples of sexual selection, which arises from the competition for mates between individuals of the same sex. In animals such as the deer, tigers and bears, it is usually the strongest male who will win the right to mate with females in the herd and to occupy territories. As a result their stronger genes are passed on to the next generation. The weaker males will eventually perish together with their inferior genes.

Natural Selection as a Vehicle for Evolution

A classic example of natural selection as a force for evolution is the case of 'Darwin's finches'. The Galapagos Islands have species found in no other parts of the world, though similar ones exist on the west coast of South America. When Charles Darwin went to the islands, he was struck by the fact that the birds were slightly different from one island to another. He realized that this difference existed because the various species lived in different kinds of environment.



Biotechnology Techniques

Content Standard	**12.2.5** Investigate the process of meiosis, laws of heredity and evaluate social, ethical and environmental implications of genetic research and related technologies.
Benchmarks	**12.2.5.4** Investigate and analyse newer and commonly practiced methods of gene technology and its applications used today.
Essential Question	1. What are the common gene technology use today? 2. How are there applications useful?
Learning Objective	• Define gene technology and explain its historical developments. • Discuss the processes involved in gene technology. • Describe the applications and impacts of gene technology on human society. • Explain how the new gene technologies available function and the practicalities of using them
Knowledge	• What gene technology is and its historical developments. • Processes involved in gene technology. • Applications and impacts of gene technology on human society. • Modern day gene technology has the potential to help alleviate or prevent disorders and diseases in animals and plants or improved growth and development in animals and plants.
Skills	• Learn about new gene methods in theory.
Atitudes & Values	• Recognize the value the value of the new methods in gene technology and how they can become useful if not today, tomorrow.

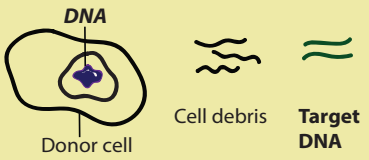
Content Background

Genetic engineering is the deliberate alteration of DNA within a cell nucleus in order to modify an organism or population of organisms. It is used to create new products which are beneficial to science, agriculture, medicine and industry. New uses of genetically engineered organisms are being discovered all the time.

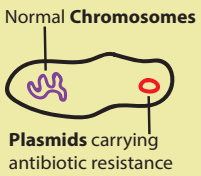
Gene cloning

The main technique of genetic engineering. Desirable genes are duplicated artificially by inserting DNA molecules (containing the genes) into other organisms, such as fast-breeding bacteria, which then reproduce the DNA. Gene cloning is a complex process. The most common method is shown in the next page.

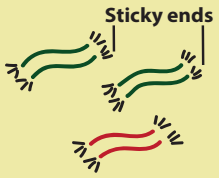
1. ***DNA*** containing a particular desirable ***gene',*** known as ***target DNA,*** is removed from a donor cell.



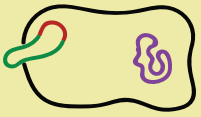
2. Some bacteria contain a **plasmid.** - a ring of DNA seperates from bacteria's **chromosomes'. Plasmids** are capable of inserting themselves into other organisms. Some also give resistance to antibiotics (drugs that destroy bacteria). Plasmids can be obtain by breaking up bacteria that contain them.



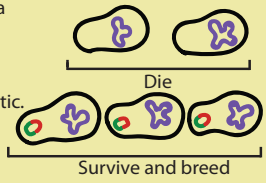
3. The strands of **plasmid DNA** and **target DNA** are treated so that the ends are sticky. When placed together and heated, the plasmid DNA and target DNA join togerther. This is called **gene splicing**. This new DNA is known as **recombinant DNA**.



4. The new plasmids inert themselves into new bacteria not resistant to the antibiotic.



5. As a colony of the bacteria grows, it is treated with this antibiotic. Any bacteria without this new plasmids are destroyed by the antibiotic. Bacteria containing it continue to multiply.



6. The reluctant colony is now made up exclusively of bacteria carrying the antibiotic - resistant plasmids with the target DNA (containing the desired gene) This colony can now be multiplied many times, producing an enormous quantity of gene.

Pharming

The use of plants or animals to produce genetically modified pharmaceutical products. For example a sheep has been genetically engineered to produce milk which contains **alpha-1antitrypsin**, a drug which is beneficial to cystic fibrosis patients.

Protein manufacture

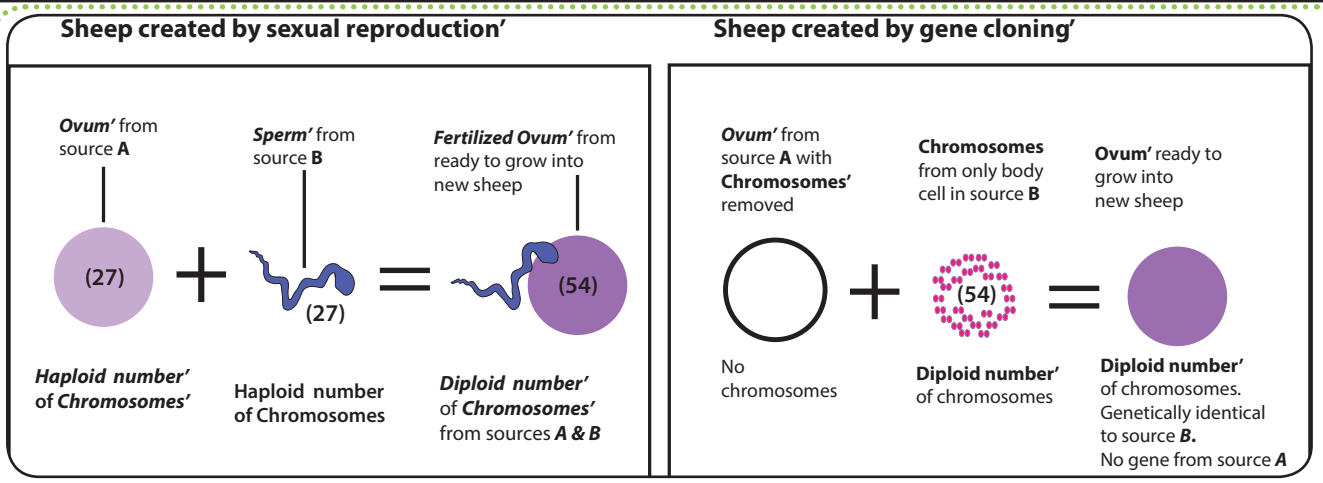
The production, in specially-created bacteria 'factoriees' of medically useful proteins such as insulin to help diabetics and **antihaemophilic globulin** to treat people with haemophilia.

Genetically engineered crops

Plants which have been bred with a greater resistance to disease, pesticides and weather by inserting foreign genes into the their nuclei

Animal cloning

Producing a genetically identical duplicate or clone, of an animal. In 1997, scientists took a cell from a female sheep and placed its chromosomes into another sheep's ovum which had had its own chromosomes removed. The ovum was planted in the second sheep's womb and five months later, a lamp, known to the world as Dolly, was born. This experiment proved it was possible to produce a complex living organism without any kind of sexual reproduction.



Genetics and the future

Human cloning

The theoretical creation of human life, using the same method that created Dolly the sheep. Genetic engineering techniques are now so advanced that any one of a human body's 100 million million cells could be used to create a new human. But, just as appearance, character and intellect are slightly different in identical twins, a clone of another human being would not be a replica, only a person with identical genes. A clone would also be a generation apart in age. Possible uses of this technology include the treatment of infertile couples-couples who are not naturally able to have children.

Genome mapping

Making a detailed list of the nucleotides contained in the genome (genetic code) of any organism. Scientists have already mapped the genome of a yeast cell and a currently mapping the three billion nucleotides contained in a human genome. They intend to complete this task early in the 21st Century. The resulting map will enable to identify every gene in human chromosomes and understand what each one does.

Genetics diagnosis

The identification of illness by examination of genes. Scientists can already identify some gentic disorders, which show up as irregularities in the nucleotide sequence. For example, Huntingdon's chorea (an illness which causes gradual physical and mental deterioration) can now be detected in a foetus. Such research could also make it possible to identify a gene which makes people more susceptible to some cancers. Once identified, treatment could be applied to prevent the cancer from developing.

Organ modification

Introducing genes which encourage body organs to heal themselves . one new technique encourages the hearts of the patients needing bypass surgery to grow new blood vessels themselves.

Theories of Evolution

Content Standard	**12.2.3** Investigate evolutionary processes and analyse scientific evidence that support the theory of evolution.
Benchmarks	**12.2.3.1** Analyse and evaluate theories and evidence of evolution

Essential Question	1. What is Evolution? 2. Which early investigators were trying to explain the origins and diversity of life? 3. What does 'survival of the fittest' mean? 4. How does natural selection shape populations? 5. What are the different types of evolution ?
Learning Objective	• Explore theories behind the origin and diversity of species and list the key persons that contributed to these early works. • Discuss Darwin's theory of evolution. • Discuss Lamarck's theory of evolution. • Investigate Charles Darwin's life and work and his role in the concept behind the origin of species • Explain natural selection and how does that shape evolution of species and population
Knowledge	• All organisms have many biochemical features in common, suggesting a single common ancestor • Competition of resources and changes in physical and chemical environment influence the evolution of plants and animals • There is a genetic change in a population over multiple generations. • Throughout evolution, there have been many periods of mass extinctions followed by diversification of surviving populations. • Concept of Natural Selection preserves the favorable traits and rejects the injurious ones over time.
Skills	• Research and read wider variety of papers or books to understand theories of evolution and related topics. • Draw timelines to show the connections in the chain of events of evolution • Use a globe to mark Darwin's worldwide voyage on the ship Beagle.
Atitudes & Values	• Appreciate how life may have originated from the point of view of early scientist and investigators. • Respect classmates views about the topic

Content Background

CAUTION: Teachers should be aware that some of the theories encounted in the teaching of science may conflict with some students' religious or cultural beliefs. These differing views must be treated with respect.

To encourage in students the ability to discuss OBJECTIVELY such controversial issues as, the origin of life, theory of evolution, birth control and some other topics should be taught as a science topic.

The word OBJECTIVE is very important. Looking at an issue objectively means that you do so with an open mind, not with preformed judgements.

Many people who are "against" evolutionary theory know little or nothing about it and their preformed judgements are nonsensical. As intelligent young people you should not let any other people or institutions think for you. THINK FOR YOURSELF. Look at the facts objectively, then make up your own mind.

We shall start the topic by stating what evolutionary theory is **NOT**:

1. It is not the theory that "life appeared from nowhere", or that living organisms simply "arose by chance"
2. It is not a theory that "people came from monkeys"
3. It is not a theory stating that God does not exist, or that He had nothing to do with the creation of the universe, or of life.

Evolutionary theory states that all organisms have developed from pre-existing organisms. To be more precise, all organisms have a common origin in some initial form of life, which over billions of years of change in many different directions, has given rise to the vast variety of organisms, present and past. Therefore, all living things are fundamentally similar because their basic chemistry has been inherited from this very first organism.

Overtime, different explanations have been put forward to account for Earth's biodiversity. Let's look at some of the historical views on how new species originated.

Where did birds come from? Benoit De Maillet (1656-1738) explained the appearance of birdson Earth in Telliamed (written in about 1715, but not published until 1749) De Maillet's stated that flying fish that were chased out of the water:

…….might have fallen some distance from shore among plants which, while supplying them with food, prevented them from returning to the water. Here, under the influence of the air, their interior fins with their raised membranes transformed into wings…….the ventral fins became limbs, the body was remodelled, the neck and beak became elongated and the fish discovered itself a bird.

Erasmus Darwin

Erasmus Darwin (1731-1802) was a British physician and a leading intellectual. In Zoonomia, published in 1794, Erasmus Darwin argued that all living things originated from a single common ancestor. He wrote:

Would it be too bold to imagine that, in the great length of time since the earth began to exist, perhaps millions of ages before the commencement of history of mankind that all warm-blooded animals have risen from one living filament…….with the power of acquiring new parts….and thus possessing the faculty of continuing to improve…and of delivering these improvements by generation to its prosperity , world without end!

Jean Baptiste Lamarck

In 1809, a French naturalist, Jean Baptiste Lamarck (1744-1829), published his views that:

- Structures in individual organism could change in response to environmental conditions and physiology need.
- These acquired structural changes would be transmitted to the next generation.

Lamarck postulated, for example, that short-necked animals could develop longer necks because of the need to continually stretch their necks to feed on leaves on tall trees and that this trait acquired in the lifetime of individual organisms would be passed to their offspring which would then be born with long necks.

In 1809, Lamarck wrote that evolution occurred as a result of the environment affecting how organisms used various parts of their bodies. Lamarck believed that organs appeared or disappeared according to the use made of them. He thought that use strengthened or enlarged an organ permanently and habitual disuse led to permanent loss. Lamarck proposed that the changes acquired in the lifetime of individual organisms were transmitted to their offspring. Lamarck's views are contained in his discussion of the evolution of snakes:

Snakes have adopted the habit of crawling on the ground and hiding in the grass; so that their body, as a result of continually repeated efforts at elongation for the purpose of passing through narrow spaces, has acquired a considerable length, quite out of proportion of its size. Long legs would have been quite useless to these animals and consequently unused. Legs would have interfered with their need of crawling and very short legs would have been incapable of moving their body, since they could only have had four. The disuse of these parts thus become permanent…and resulted in the disappearance of these same parts… Snakes…chiefly need to see objects that are raised or above them. This need must have had its effect on the position of the organs of sight and accordingly their eyes are situated in the lateral and upper parts of the head…

Evolution can account for the diversity of species, past and present. Evidence from the fossil record and many other fields of study supports the view that species can change and that evolution has occurred. Evolution provides and explanatory framework for many observations. Evolution means that the past and modern species are related and that different kinds of organism living today are descended from various kinds of organism that lived in the geological past.

Darwin's theory

Charles Darwin (1809-1882) abandoned his studies in medicine and theology (religion) to become a naturalist. In 1831, aged 22, he took a position as a naturalist on the HMS Beagle, a ship commissioned to survey and chart the coast of South America. For the next five years, Darwin observed the geographical distributions of plants, animals, fossils and rocks in various parts of the world. He puzzled over the enormous variety and adaptions of the organisms , he saw, and become convinced that different species of the same animal developed from a common ancestral type.

Darwin's finches

On the Galapagos Island, about 1000 kilometres off the coast of Ecuador, Darwin marvelled at the diversity in the flowers , tortoises, iguana and birds fond there. Much of the wildlife differed in small but significant ways from the wildlife differed in small but significant ways from island to island and to those of the mainland.

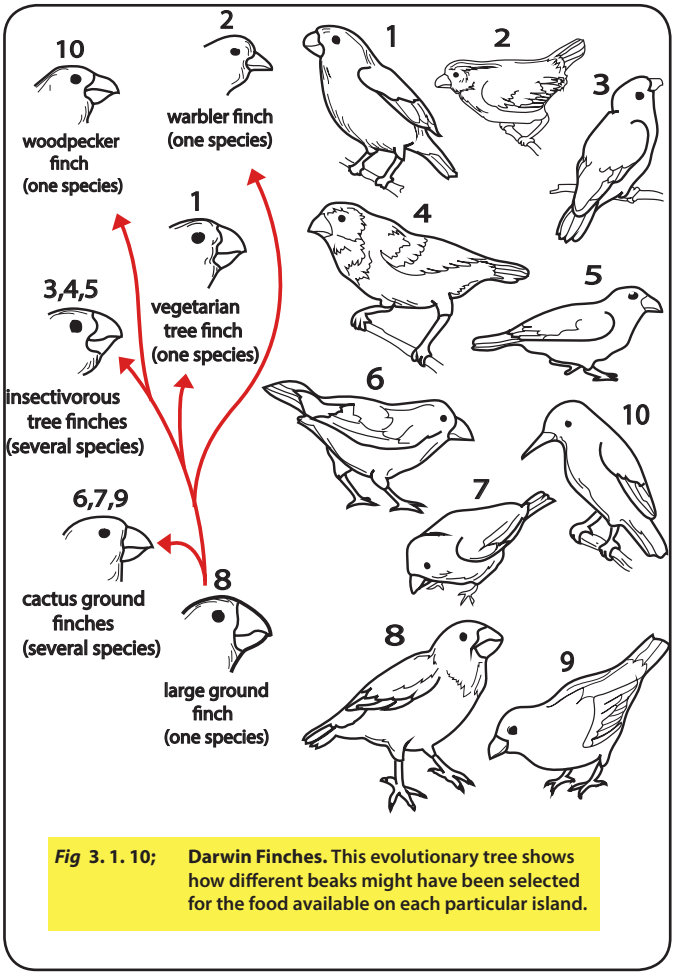


Fig 3. 1. 10; **Darwin Finches.** This evolutionary tree shows how different beaks might have been selected for the food available on each particular island.

The islands were effectively isolated from one another by strong ocean currents, and there were no winds blowing from one island to another. Darwin found fourteen species of finches, all with similar colourings, calls, nests, eggs and courtship displays. They differed, however, in habitat, diet, body size and beak shape. Darwin believed that these fourteen species had come from a common ancestor, and proposed the process of natural selection to explain it.

He suggested that a few finches had arrived at the island sometime in the past. These finches showed natural variation in their beak shape. On one island, those with beaks of one shape were better able to feed on the cacti found there. Finches with other beak shapes found it difficult to survive. On other islands, other beak shapes gave some finches a feeding advantage. The birds most suited to their island 21survived to produce offspring, which inherited that beak shape. This is sometimes called survival of the fittest. The 'fittest' were the birds that were able to feed and reach breeding age. The beak type that gave particular birds on a particular island advantage was 'selected for'. Over many generations, the birds on different islands became sufficiently differently from each other to be recognised as a different species.

The Darwin-Wallace view

Various naturalists in the 17th and early 18th Centuries proposed that species could evolve or be transformed to produce new species, but none of these naturalists identified a testable mechanism to explain how evolution could occur. This changed when Charles Darwin (1809-1882) and Alfred Russel Wallace (1823-1913) proposed their theory of evolution by natural selection.

The power of the Darwin-Wallace theory of evolution by natural selection was that:
- the theory identified a mechanism or a cause of evolution.
- this mechanism was testable by observation and experimentation.

The theory also asserted that individual organisms do not evolve in their lifetimes but the evolutionary change occurs over several generations in populations.

Darwin completes his work

Darwin' major work , published in 1859, had the title On the Origin of Species by Natural Selection or Preservation of Flavoured Races in the Struggle for Life. Although all 1250 copies of the first edition sold out within a day, religious leaders through England denounced his work as heretical (against the word of God). The Bible held that man was formed in the image of God, so how could man have apes as ancestors?

Neo-Darwinism

Darwin was not the first to suggest evolution, but he was the first to give it a scientific explanation. Darwin's explanation that evolution occurs through natural selection is regarded as one of the most important theories of science and is still regarded as essentially correct. At that time there was no understanding of genetic inheritance. Darwin was . therefore, unable to explain the source of variation in species that his theory was based on.
Darwin's theory can be restated in terms of modern genetics. This is sometimes called neo-Darwinism. Evolution is natural selection based upon the natural genetic variations that appears in all populations.

Natural Selection

Natural selection is the process by which the environment 'selects' favourable characteristics, reducing frequency of unfavourable characteristics. Some organisms are better suited to their environment than other. These organisms will be likely to survive and breed than some of their competitors. Because of this, the characteristics they possess will become more common in the species over successive generations. If we consider one such characteristic, for example neck length in antelopes, we should be able to draw a graph showing how this characteristic is distributed in the population. If the environment applies a selection pressure such as limited availability of leaves for food, one part of the population may be favoured. In a few generations' time the graph may look rather different. If the two populations of this antelope were separated from one another, natural selection might favour different adaptations in the two environments. Eventually the two different population of antelopes could have so many different adaptations that they no longer interbreed- they are said to be different species.

Evolution by means of natural selection:

1. **Overproduction**- all organisms produce more offspring than can possibly survive, and yet populations remain relatively stable. E.g. a female peppered moth may lay 500 eggs, but the moth population does not increase by the same proportion!
2. **Struggle for existence**- organisms experience environmental resistance, i.e. they compete for the limited resources within the environment. E.g. several moths may try to feed on the same nectar-producing flower.
3. **Variation**-within the population there may be some characteristics that make the organisms that have them more suited for this severe competition. E.g. some moths might be stronger fliers, have better feeding mouthparts, be better camouflaged while resting or be less affected by rain.
4. **Survival of the fittest**-individuals that are most successful in the struggle for existence (i.e. that are the best suited/adapted to their environment) are more likely to survive than those without these advantages. E.g. peppered moths: dark-coloured moths resting on soot-covered tree trunks will be less likely to be captured by predators than light-coloured moths.
5. **Advantageous characteristics are passed on to offspring** - the well-adapted individuals are more likely to breed than those that are less well-adapted- they pass on their genes to the next generation. This process is called natural selection. E.g. dark coloured moth parents will produce dark-coloured offspring.

Speciation

A species is defined as a group of organism that are normally interbreed in nature to produce fertile offspring. The formation of a new species is called speciation. It can happen through natural selection combined with other factors such as isolation and genetic mutation. Speciation occurs over long periods of time and generally cannot be seen in a human lifetime or even through recorded history of humans.

Step 1: Geographic isolation

Geographic isolation is the first step in speciation. For example a population rabbits being split into two physically and geographically isolated groups. Each group will now experience a different set of circumstances-food type and availability might differ, as might climate and the predators that live there.

Step 2

Although initially the same species, each population will change over many generations through natural selection and the occasional genetic mutations. Eventually the two rabbit population will have their own characteristics, sufficiently different from each other to be called a variety, or subspecies. Subspecies appear different but are still capable of interbreeding.

Step 3

If the population are isolated long enough, the change may be sufficient to make them incapable of interbreeding. They will then have reproductive isolation. At this point a new species has emerged.

Factors that might cause reproduction isolation are:

- A change in colour patterns so that mates are no longer recognised
- A change in mating habits so that mates are no longer recognised
- Seasonal differences in mating times
- A changed chromosome which prevents the sperm of one group from fertilising eggs of the other.

Types of evolution

Divergent Evolution

The Galapagos Island finches are the geographically isolated rabbits illustrate the idea that new forms can evolve from a single ancestor. This is known as a divergent evolution. The idea is that new species will evolve in new environments.

Divergent evolution results in a phenomenon known as adaptive radiation. Ancestral organisms became adapted to their new environments, evolving into new forms suited to them. Australia's marsupial ancestors have evolved and radiated into many different forms , from tree-dwelling, fruit-eating possums into everything from blind, meat-eating underground moles tpo the more familiar kangaroos and koalas.

Convergent Evolution

Evolution can produce similar structures in organisms of quite different origins. Convergent evolution , or convergence , occurs when organisms evolve and develop similar adaptations due to:

- living in similar environments and habitats
- having similar lifestyle and food sources.

In similar habitats, the same types of characteristics are selected for resulting in organisms that look similar despite having very different genes passed down from very different ancestors. These organisms may even have analogous structures; that is, specific body parts that appear similar.

Parallel Evolution

Another type of evolution is parallel evolution, which occurs where related species evolve similar features while separated from each other. The result is organisms that look alike and have

Mechanisms of Evolution

Content Standard	**12.2.3** Investigate evolutionary processes and analyse scientific evidence that support the theory of evolution.
Benchmarks	**12.2.3.2** Identify and explain the mechanism of evolution and its consequences **12.2.3.3** Describe some evolutionary mechanisms and explain how they affect the evolutionary development and extinction of various species
Essential Question	1. Do you think genetic drift would happen more quickly on an island or the mainland? 2. How do fossils keep a record of evolution? 3. In what ways do geographical barriers influence the evolution of species? 4. Exactly how does anatomical comparisons play are role in confirming the process of evolution? 5. In what ways do embryonic development and comparing DNA and protein reveal evolutionary relationships? 6. What are the key factors that contribute to species extinction and the rates of extinction?
Learning Objective	• describe using examples, how the theory of evolution is supported • identify the differe nt types of evidence of evolution
Knowledge	• Types of evidence of evolution. • Patterns of evolution. • The evolutionary relationships of some organisms. • Speciation is the formation of a new species and the three types.
Skills	• Able to explain how species originate using a timeline.. • Use diagrams to explain concept of speciation, barriers to speciation and classification. • Learn how to compare anatomical and embryonic structure when looking at closely related groups of living things
Atitudes & Values	• Realise the trouble early scientist went through to devise these ideas as to the origin of life and species developed over time. • Realse that evolution is continuing as we speak and will continue. • Acknowledge that species we see today the generations to come may not see due to evolution, speciation and extinction. • Cherish life in general

Content Background

Mechanisms of Evolution

The Hardy-Weinberg equilibrium principle says that the allele frequencies in a population will remain constant in the absence of the four factors that could change them. Those factors are natural selection, mutation, genetic drift, and migration (gene flow)

Natural Selection

In evolution the unit of study is not the species but the population, or more specifically, the total number of genes present in the gametes of the population which we call the **gene pool.**

Does the composition of a gene pool remain constant from generation to generation? While it is impossiple to 'tag' each individual allele and keep an eye on its frequency for several generations, many experiments have have been conducted on **natural** as well as laboratory populations involving one or two easily detectable alleles (detectable because they manifest themselves in some obvious phenotypic trait). Such experience has shown that gene pools do change in composition -especially when the environment is changing.

Basically, Evolution is simply: **The changes in frequency of alleles in the gene pool of a biological population due to natural selection**.

Not all individuals in a population have the same chance of survival, and not all those that survive will have the same number of offspring. An organism with a 'good' mutation or which possesses very 'useful' set of genes is more likely to have more offspring thereby increasing the frequency of those genes in the gene pool.

This is what we mean by 'natural selection'- to select by natural means, in other words the environment selects all of those organisms carrying more ADAPTIVE GENOTYPES to be main contributors to the next generation's gene pool.

Alleles are expressed in a phenotype. Depending on the environmental conditions, the phenotype relative to the other phenotypes in the population. If it is an advantage , then that individuals with the other phenotypes, and this will mean that the allele behind the phenotypes, and this will mean that the allele behind the phenotype will have greater representation in the next generation. If conditions remain the same, those offspring, which are carrying the same allele, will also benefit. Overtime, the allele will increase in frequency in the population.

Mutation

Mutation is a source of new alleles in a population. Mutation is change in the DNA sequence of the gene. A mutation can change one allele into another, but the net effect is a change in frequency. The change in frequency resulting from mutation is small, so its effect on evolution is small unless it interacts with one of the other factors, such as selection. A mutation may produce an allele that is selected against, selected for , or selectively neutral. Harmful mutations are removed from the population by selection and will generally only be found in very low frequencies equal to the mutation rate. Beneficial mutations will spread through the population through selection, although that initial spread is low. Whether or not a mutation is beneficial

or harmful is determined by whether it helps an organism survive to sexual maturity and reproduce. It should be noted that the mutation is the ultimate source of genetic variation in all populations-new alleles and therefore, new genetic variations arise through mutation.

Genetic Drift

Another way a population's allele frequencies can change is a genetic drift, which is simply the effect of chance. Genetic drift is most important in small population. Drift would be completely absent in a population with infinite individuals, but of course, no population is this large. Genetic drift occurs because the alleles in an offspring generation are a random sample of the alleles in the parent generation. Alleles may or may not make it into the next generation due to chance events including mortality of an individual, events affecting finding a mate, and even the events affecting the which gametes end up in fertilizations. If one individual in a population of ten individuals happen to die

Gene Flow

Another important evolutionary, force is gene flow, or the flow of alleles in and out of a population resulting from the migration of individuals or gametes. While some populations are fairly stable, others experience more flux. Many plants , for example send their seeds far and wide, by wind or guts of animals; these seeds may introduce alleles common in the source population to a new population in which they are rare.

Role of Competition in Evolution

Competition is the driving force of evolution. Stating the case simplistically, more offspring are born,r hatched, or geminate, than can survive, because resources are limited.

Charles Darwin, the founder of modern evolutionary theory, realized the grave implications of the production of more offspring than can possibly survive. Here is a series of brief extracts from his book ' The Origion of Species'.

" *A struggle for existence inevitably follows from the high rate at which all* ***organic beings*** *tend to increase. Every being, which during its natural lifetime produces several eggs or seeds, must suffer destruction during some period of its life, and some during season or occassional year, otherwise, on the* ***principle of geometric increase,*** *its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are born than can possibly survive, there must in every case be a* ***struggle of existence****, either one individual with another of the same species or with the individuals of distinct species, or with the conditions of life. It is the* ***doctrine of Malthus*** *applied with manifold force to the whole animal and vegetable kingdoms;for in this case there can be no prudential restraint from marriage, or artificial increase of food. Although some species may now be increasing, more or less rapidly, in numbers, all cannot do o, for the world would not hold them."*

Artificial & Sexual Selection

Artificial Selection

Man has been crossing selected plants and animals for thousands of years to produce breeds with characteristics desired by Man. Many of these breeds would have little chance

of survival in the wild. Sheep for example were 'evolved' by crossing especially wooly goats some 3500 years ago.Sheep are such helpless creatures that they would fare poorly in natural environment without man's protection.

A modern aid in the production of new varieties of crops is the induction of mutations by X-rays. Most irradiated individuals die, and many deformed offspring result, but now and again a 'good' mutation apperars from which 'improved' variety can breed.

Sexual Selection

The males and females of most birds, mammals and many insects are markedly different in physical appearance.

Evidence of Evolution

Evidence that living things can change or evolve over time to produce new forms comes from several sources including:

- The fossil record
- Transitional fossils
- Comparative biochemistry
- Comparative anatomy
- Biogeographic distribution

The Fossil Record

Direct evidence for evolution comes from palaeontology, the study of fossils. The fossil record form all over the world provides evidence of continual changes in life forms from over 3500 million years ago until the present. By comparing the fossil layers of sediment from different parts of the world, the sequence from the very earliest life to the present day can be observed. The fossils of sedimentary rocks provide a record of the history of life on Earth. This sequence is called the fossil record.

Fossils provide evidence of the kinds of organisms that lived on Earth. Fossils evidence may be :

- Direct evidence, such as bones, teeth, leaves and shells
- Indirect evidence such as footprints, tooth marks, tracks, burrows and coprolites (fossilized dung).

The fossil record reveals that, over time, changes have occurred in the types of organism living on this planet. At one time, no terrestrial animals or plants existed. Many groups of plants and animals that were abundant in the past , such as trilobites, dinosaurs and giant club mosses, no longer exist. Other groups of living things found today, such as flowering plants and marsupial mammals, are absent from the fossil record of the distant geological past and so are geological 'newcomers'.

Different kinds of organism do not occur randomly in the fossil record but are found in rocks of particular ages only and appear in a consistent order; this is known as the law of fossil succession.

Table below shows the Earth's geological history

(bya=billion years ago; mya = million years ago)

EON	ERA	Period	Began	Major Events in the History of Life
Hadean			4.5 bya	
Archean			3.8 bya	
Proterozoic			2.5 bya	
Phanerozoic			600 mya	
	Palaeozoic	Cambrian	600 mya	Most animal phyla present; diverse algae
		Ordovician	500 mya	Diversification of many animal phyla; first jawless fishes; mass extinction at end of period
		Silurian	440 mya	Diversification of jawless fishes; first bony fishes; invasion of land by plants and animal
		Devonian	400 mya	Diversification of fishes; first insects and amphibians; mass extinction late in period
		Carboniferous	345 mya	Extensive forest; first reptiles; insects radiate
		Permian	290 mya	Pangea (northern land mass) and Gondwana (southern land mass exist; reptiles radiate; amphibians decline; many types of insects; mass extinction, especially of marine forms, at end of period.
Phanerozoic	Mesozoic	Triassic	225 mya	Continents begin to drift; early dinosaurs, first mammals; diversification of marine invertebrates; mass extinction near end of period
		Jurassic	180 mya	Continents drifting; diverse dinosaurs; first birds
		Cretaceous	138 mya	Most continents widely separated; continued dinosaur radiation; flowering plants and mammals diversify; mass extinction at end of period
	Cenozoic	Tertiary	66 mya	Continents nearing current positions; radiation of birds, mammals, flowering plants and pollinating insects
		Quaternary	2 mya	Repeated glaciations; human evolve; extinctions of large mammals

Transitional fossils

If new species arise by evolution from ancestral species, it would be predicted that the fossil record should reveal some fossils that are intermediate between forms. Birds are believed to have evolved from a group of reptiles. If so, the fossil record might be expected to reveal organisms that show both the features of their reptilian ancestors and new features characteristics of birds.

The first unequivocal evidence of birds in the fossil record occurs in the late Jurassic periods, about 150 Myr ago. A fossil skeleton of the earliest known bird Archaeopteryx lithographica was found in a limestone quarry in Bavaria, Germany, in 1861. The fine-grained limestone preserved the faint impressions of feathers. In the absence of feather impressions, these organisms would have been classified as reptiles.

Like modern birds, Archaeopteryx showed the characteristic presence of feathers and a wishbone (furcula). However, it also showed some reptilian features now lost in modern birds: Archaeopteryx had teeth in its beak, claws on its wings, unfused (free) bones in its 'hand' and a long jointed bony tail.

There are many other examples of intermediate forms or 'missing links' that relate an ancestral group with its descendants. These include:

- Primitive amphibians that show a transitional stage between the simple pelvic (hip) girdle present in fish and the complex pelvic girdle in later more advanced amphibians.
- Fossil mammal-like reptiles that show a transitional stage between reptiles with simple conical teeth and mammals with teeth differentiated into incisors, canines, pre-molars and molars.

Comparative Anatomy

Homology: Similar Structures

The first mammals appeared about 200Myr ago and are believed to have evolved from a reptilian ancestor. All the various kinds of mammals that live today share a common ancestry. If mammals are related by evolution from a common ancestor, it would be expected that they would show similarities in structure regardless of their way of life. This similarity of structure can be seen in the forelimbs of various mammals.
Each of these limbs have similar numbers of bones arranged in the same basic pattern. This similarity in basic structure exists, even though the limbs may serve different functions. The mammalian forelimbs are said to be homologous structures.

Analogy: similar function

Consider a fly's wing and a bat's wing. These structures carry out a similar function-flight. Structures that carry out similar functions but are not necessarily similar in basic structure are said to be analogous structures. So, a fly's wing is analogous to a bat's wing, but is not homologous since they are derived from different ancestral structures. Organisms that display analogous structures cannot be assumed to have risen from a common ancestor.

Comparing embryos

In aquatic vertebrates, gill slits form part of the system for taking up dissolved oxygen from the water in which these animals live. Water is taken in, usually through the mouth and flows out through the gill slits. As expected, gill slits appear in the early embryos of jawless fish, sharks and bony fish.
However , some observations about other embryo are less expected including:

- In all terrstrial vertebrates-reptiles, birds and mammals- gill slits are not present; however, non-functional gill slits are seen in the early embryos of these vertebrates.
- A tail is normally absent from a human fetus and a new –born baby; however, a human embryo at one stage shows a primitive tail.

How might these observations be explained?

We could reasonably explain these observations by assuming that vertebrates share a common ancestor as part of their evolutionary history. The appearance of the embryonic tails in tail-less vertebrates and functionless gill slits in air breathing vertebrates would simply be explained as features that have been retained during the evolution of the various vertebrate groups.

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: Handouts

Lesson Objective: Students will be able to;

- state that all living things are made of cells, which are the basic units of life
- explain that the body can function efficiently by having different types of cells performing specific functions (bone cells, red blood cells, muscle cells)

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 handout. • Ask students to study the plant and animal cells and their properties. • Ask students to stop and give a difference they have identified from a plant or a an animal cell.	• Read the properties of plant and animal cells. • Give one difference of the plant or animal cell. • Let teacher know if they understand what to do.
Independent Practice	
• Ask students to read the plant and animal handout. • Ask students to suggest and defend one process to derive units from standard units.	• Read the plant and animal cell handout and try to explain the difference between the two types of cells. • Suggest similarities and differences of the two cells.
Conclusion	
• Emphasise the importance of cells. • Explain the similarities and differences in animal and plant cell	• Listen to the teacher. • Give reasons to justify their explanations.

Performance Assessment and Standards

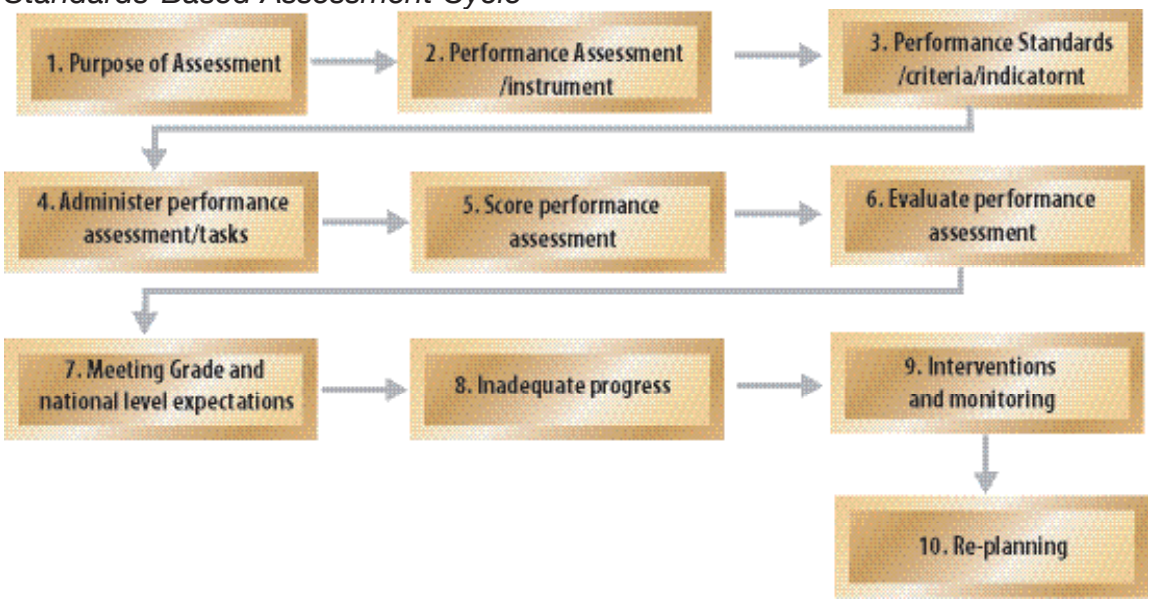
National Content Standard: 11.2.1 Investigate the origins, diversity, principles of scientific classification and cell structure of living things				
Lesson Topic	**Topic**	**Benchmark**	**Performance Assessment**	
Cells	**Cells**	**11.2.1.3.** Investigate cells as the basic structural unit of all organisms including adaptations and their functions		
	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)?

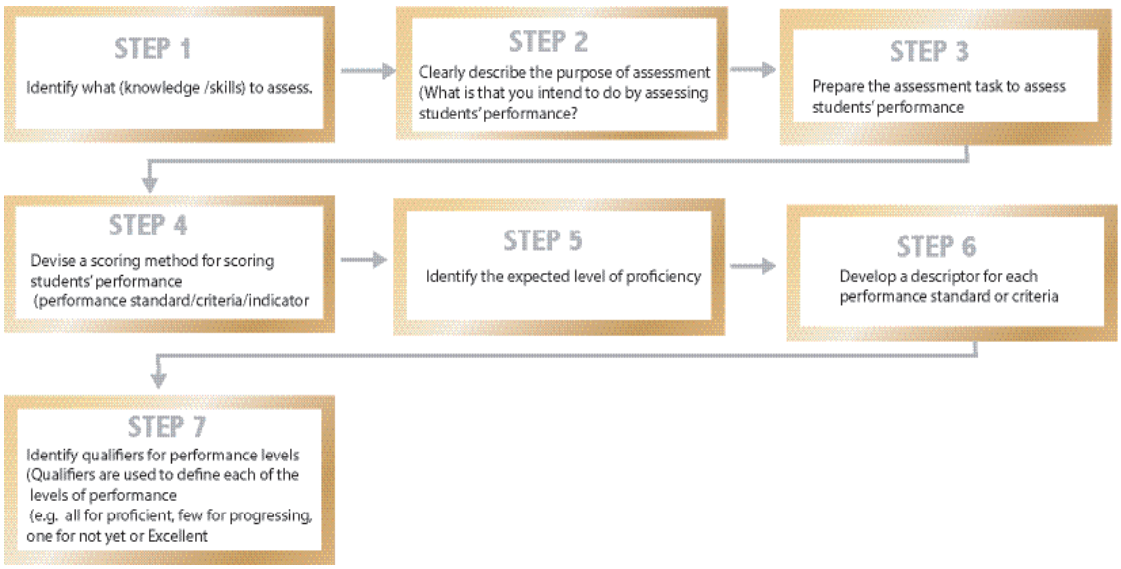
Assessment and reporting is an integral part of the delivery of any curriculum used in the schools. In Standard Based Curriculum (SBC) assessment encourages the use of benchmarks and commended types of assessment that promote standards for a range of purposes.

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;

- emphasised on tasks that should encourage deeper learning,
- 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: 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.

Topic: Object in Motion

Benchmark: 11.2.1.1 Derive and use equations of motion.

Lesson Title What is Kinematics?

Lesson Objective: By the end of the lesson, students should be able to describe
kinematics.

Materials: Motion diagrams

What is to be assessed? (KSAVs)

Knowledge	Skills	Values and Attitudes
• Solviong problems using motion graphs	• Drawing up motion graphs and solve related problems	• Display confidence in drawing up motion graphs • Appreciate the usefulness of objects in motion

Scientific Thinking: Think about how information from a real problem can be displayed onto a motion graph.

Purpose of the assessment

To measure students' proficiency on the achievement of the benchmark and learning objectives.

Expected level of proficiency

Design Motion graphs and display information in order to find solutions to given problems.

Assessment Strategy

This assessment can be conducted in one lesson as an assessed lesson exercise.

Performance Task

Draw a Motion graphs to represent given information to solve problems.

Assessment Tool

An exercise will be used to measure their level of 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 a lesson exercise.

Performance standards/ Criteria	**A**	**B**	**C**	**D**	**Score**
	Advance 10	Proficient 9 - 5	Progressing 3 - 4	Not Yet 2	__/10 Marks
Draw a Motion graphs to represent given information to solve related problems. **10 marks**	Correct sketch of the Motion graphs and represented all information correctly and answered all the related questions with clear calculation steps	Correct sketch of the Motion graphs and represented all information correctly and answered all the related questions.	Satisfactory sketch of the Motion graphs and represented most information correctly and answered some of the related questions.	Poor sketch of the Motion graphs and represented few information and answered only one of the related questions.	

Recommended Resources:

- 'Grade 11 Physics Save Book'
- Worksheet
- Essential of Physics

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 $y = A\sin(Bx + C) + D$ or $y = A\cos(Bx + C) + D$ 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"

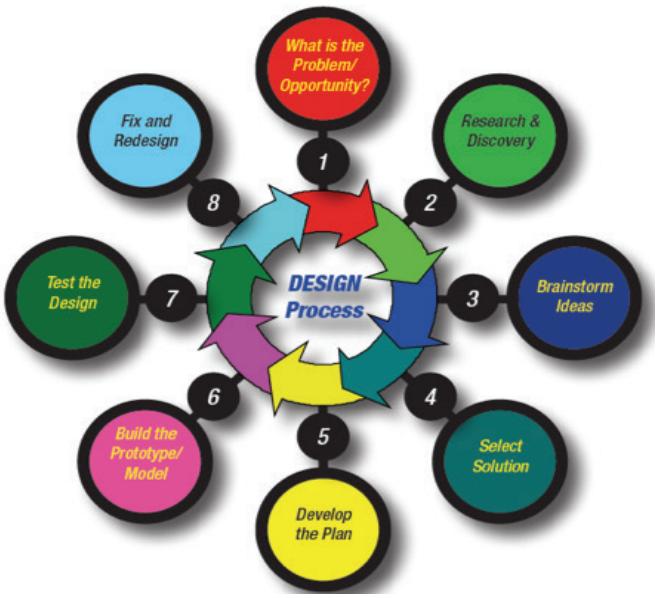
(ii) The teacher then assesses their designs and the best designs now compete with the other best designs from other grade 12 classes.

(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
Abiotic factors	A non-living part of the ecosystem that shapes the environment.
Allele	Any of two or more alternative forms of a gene that occupy the same locus on a chromosome.
Artificial selection	Selection for reproductive success in plants and animals that are directed by humans. Also called selective breeding
Biotechnology	A field of Life Science which involves a set of biological techniques developed through basic research and now applied to research and product development, in particular, the use of recombinant DNA techniques.
Biomes	A large naturally occurring community of flora and fauna occupying a major habitat.
Biotic factors	The living parts of an ecosystem that shapes the environment
Chromosome	Structure that stores an organism's genetic material (DNA). Each species has a different number of chromosomes
Commensalism	A relationship between individuals of two species in which one species obtain food or other benefits from the other without either harming or benefiting the latter.
Community	An interacting group of various species in a common location
Continuous Variation	Variation not represented by distinct classes that occurs over a continuous range in a population
Decomposers	Organisms such as bacteria, fungi, earthworms and vultures that feed on dead animals and plants, as well as other organic wastes and cause them to break down physically and chemically.
Discontinuous Variations	Variation that falls into discrete categories (e.g. the colour of garden peas).
DNA	Deoxyribonucleic acid. The double –stranded, helical molecular chain found within the nucleus of each cell that carries genetic information.
Dominant allele	The form of allele that masks the presence of other alleles for the same trait.
Down syndrome	A genetic disorder caused when abnormal cell division results in an extra full or partial copy of chromosome 21.
Ecological pyramid	A graphical representation of the relationship between different organisms in an ecosystem. Each of the bars that make up the pyramid represents a different trophic level and their order, which is based on who eats whom, represents the flow of energy.
Gene	A unit of inheritance. A gene is an ordered sequence of nucleotides located in a particular position on a particular chromosome that encodes a specific functional product.
Genotype	An individual 's genetic make-up.
Habitat	The natural home of a plant or animal

Incomplete dominance	Is when a dominant allele, or form of a gene does not completely mask the effects of a recessive allele, and the organism's resulting physical appearance shows a blending of both alleles. Also called semi-dominance or partial dominance.
Inheritance	The process by which genetic information is passed on from parent to child.
Inter specific competition	A form of competition in which individuals of different species compete for the same resources in an ecosystem
Intra specific competition	Is an interaction in population ecology, whereby members of the same species compete for limited resources
Meiosis	A special form of cell division in which each daughter cell receives half the amount of DNA as the parent cell. Meiosis occurs during formation of egg and sperm cell in mammals.
Mitosis	The replication of a cell to form two daughter cells with identical sets of chromosomes
Mutation	A permanent change, a structural alteration , in the DNA or RNA of an organism.
Mutualism	Mutualisms are defined as interactions between organisms of two different species, in which each organism benefits from the interaction in some way.
Niche	A niche refers to the way in which an organism fits into an ecological community or ecosystem
Nitrification	Nitrification is the process by which ammonia is converted to nitrites (NO2-) and then nitrates (NO3-). This process naturally occurs in the environment, where it is carried out by specialized bacteria.
Nitrogen fixation	Nitrogen fixation is a process by which molecular nitrogen in the air is converted into ammonia (NH. 3) or related nitrogenous compounds in soil.
Parasitism	Parasitism is defined as the relationship between different species in which one organism lives on or in the other organism and benefits from it by causing some harm.
Phenotype	The observable expression of the genes present in an individual.
Population	Is all the organisms of the same group or species who live in a particular geographical area and are capable of interbreeding.
Species	A group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.
Succession	Succession is a series of progressive changes in the composition of an ecological community over time.
Symbiosis	Interaction between two different organisms living in close physical association, typically to the advantage of both.

Reference

NDOE Upper Secondary Biology Syllabus, 2008, NDOE

NDOE Upper Secondary Biology Teachers Guide, 2008, NDOE

NDOE Senior High School Biology Syllabus, 2020, NDOE

NDOE, Microbiology Teachers Guide,1988, NDOE

NDOE, Evolution, Science Resource Material, 1982, NDOE

Ibrahim Imran, Biology Expression- 'O' Level, Panpac Education Private Limited, 2007

Jeffery Caroline, Ross Pauline, NSW Biology, Macmillan, 2007

Roberts M.B.V, Biology: A Functional Approach, Fourth Edition, Education Low-Priced Books Scheme (ELBS) 1986,

Kinnear Judith & Martin Marjory, Nature of Biology Book 2, Third Edition, 2006, John Wiley & Sons

Pickering Ron, Complete Biology for Cambridge IGCSE, Second Edition,2006, Oxford University Press

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>
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<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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