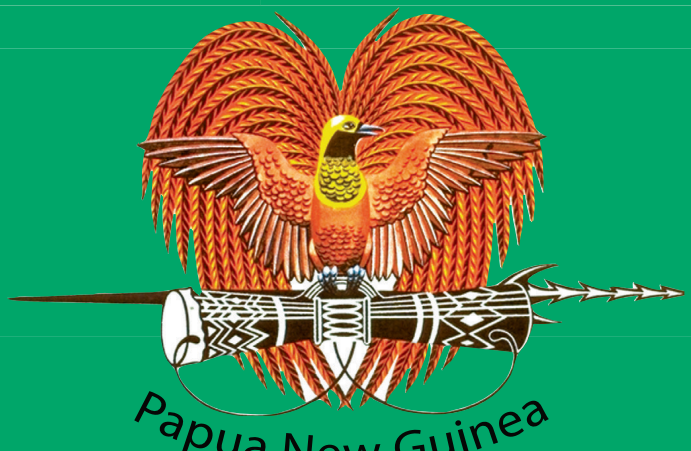
Science

Grades 9 and 10

Syllabus

Standards-Based



Department of Education

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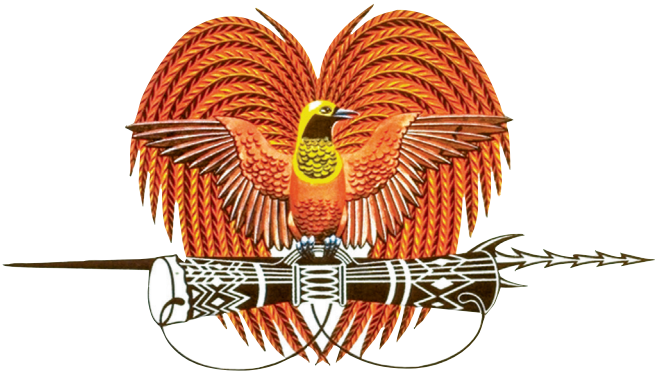

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Contents

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Acronyms

AAL	Assessment As Learning
AFL	Assessment For Learning
AOL	Assessment Of Learning
BoS	Board of Studies
CDD	Curriculum Development Division
CP	Curriculum Panel
IHD	Integral Human Development
NDoE	National Department of Education
OBC	Outcome-Based Curriculum
OBE	Outcome-Based Education
PNG	Papua New Guinea
SAC	Syllabus Advisory Committee
SBC	Standards-Based Curriculum
SBE	Standards-Based Education
SCG	Subject Curriculum Group
STEAM	Science, Technology,Engineering, Art and Mathematics

Secretary's Message

The ultimate aim of Standards-Based Education (SBE) in Papua New Guinea (PNG) is to prepare children for careers, higher education, and citizenship. This means that education should focus on developing and equipping children with essential career, higher education, and citizenship readiness knowledge, skills, values, and attitudes that they can use to work, study, and live in the complex, competitive, technology driven, and knowledge-based economy and society of the 21st century. Rigorous and comparable learning standards have been set at the national and grade-levels to enable all children to acquire essential career, higher education, and citizenship proficiencies before leaving school at the end of grade 12.

Education must also aim to motivate and prepare students to pursue Science, Technology, Engineering, Arts, and Mathematics (STEAM) courses in higher education and pursue careers in STEAM related fields. Essential STEAM principles, concepts, processes, and skills have been embedded in the national content standards and grade-level benchmarks to enable all students to learn and use these to solve problems created by both the natural and physical environments by developing creative and innovative solutions.

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. By the end of grade 12, all students will acquire the essential scientific proficiencies and develop the ability to be creative, innovative, productive, and competitive in diverse knowledge and technology-based contexts.

Teachers are encouraged to use the syllabus, in conjunction with the teacher guides and other relevant resources, to teach the science content and enable all students to progressively learn and master the essential scientific knowledge, skills, values, and attitudes.

I approve and commend this Grades 9 and 10 Science syllabus to be used by teachers in all Junior High Schools throughout Papua New Guinea.

……..

DR. UKE W. KOMBRA, PhD
Secretary for Education

Introduction

The 21st century is a time of rapid change. New knowledge, tools, and ways of doing and communicating Science continue to emerge and evolve, and impact on our lives in many different ways.

PNG needs to be on par with the rest of the world. The need to understand and use science in everyday life, in schools, and in the workplace has never been greater. Science knowledge, skills, values, and attitudes are needed in a variety of careers, including STEAM related careers, in the 21st century. The 21st century job market is very competitive. Those who do not possess the in-demand proficiencies will find it difficult to get any sort of employment or create and sustain their own career pathways. Thus, it is important that children are encouraged, motivated, and enabled to develop a mathematical attitude of the mind to enjoy learning science and, simultaneously, achieve high academic standards and attain the required career, higher education, and citizenship proficiencies before leaving school.

In this century and beyond, those who understand and can-do science will have more opportunities and options to create and sustain a future of their choice. Scientific competence increases career choices and opens doors to productive and rewarding futures. All students should be provided the opportunity and necessary support to learn science and achieve the expected science standards and proficiencies before leaving school.

Grades 9 and 10 Science learning standards are comparable to regional and global science standards. This syllabus and the teacher guide will provide the bases for all children to progressively learn and master the essential scientific knowledge, skills, values, and attitudes to effectively prepare them for careers, higher education, and citizenship in the 21st century and beyond.

Aims and Goals

The ultimate aim of education in PNG is to prepare children for careers, higher education, and citizenship. To achieve this aim, a number of enabling aims and goals have been formulated based on evidence. The ultimate aim and the enabling aims and goals are closely linked. The enabling or operational aims and goals are described here.

Aims and Goals of Standards-Based Education and Curriculum

Curriculum aims and goals articulate the outcomes that will be achieved in the long-term and the medium-to-long term. They embed the development and educational aspirations of PNG and its citizens. These have been influenced by evidence from the analysis of context and research on teaching and learning, and on social, economic, political, technological, and cultural developments. There is a close link between the aims and goals of the curriculum. This is important for ensuring that the chain of learning results is clear.

Aim 1: Students will acquire essential and relevant knowledge, skills, values, and attitudes that will prepare them for careers, higher education, and citizenship.

Goals

Students will be able to:

(a) acquire essential in-demand knowledge and employability skills, and values, and attitudes required for working, studying, and living in the 21st century.
(b) achieve internationally comparable and high academic standards, and attain essential proficiencies that will enable them to make a smooth transition from secondary to post-secondary institutions, pursue a variety of career pathways, and live purposeful, productive, responsible, and harmonious lives.
(c) acquire and use intellectual, emotional, cultural, physical, creative, vocational, recreational, and spiritual knowledge, skills, values, and attitudes as bases for living fulfilling, purposeful, and productive lives in communities in which they choose to live.

Aim 2: Students will achieve internationally comparable and high academic standards in English, Mathematics, Science, Technology, Engineering, Social Science, Character and Social Development, Citizenship and Christian Values Education, Business and Commerce, Agriculture, Arts, Physical Education, and Industrial Arts and Technology.

Goals

Students will be able to:

(a) read and comprehend a variety of texts, communicate orally and in writing, use different approaches and modes of communication, identify different purposes of communication, and understand and appreciate PNG's languages and the languages of people from different cultures.
(b) understand and apply mathematical reasoning, statistical thinking, processes, formulas, and concepts to solve different mathematical problems.
(c) examine and apply scientific inquiry, reasoning, thinking, processes, and concepts to solve problems and improve real life situations. And understand the importance of logical and abstract thinking in the solving of problems, the importance of mathematics in science reasoning, and recognize the role of science in every aspect of life.
(d) attain Science, Technology, Engineering, Arts, and Mathematics (STEAM) education literacy and become proficient in the use of STEAM principles and skills to solve problems posed by both the natural and physical environments by developing creative and innovative solutions.
(e) acquire fundamental knowledge and skills in computer, communications, and construction technology and attain essential proficiencies that will prepare them for careers and higher education programs in computer, communications, and construction technology related fields.
(f) investigate and develop an in-depth understanding of how people interact and relate to each other and their places, examine the different social, economic, political, environmental, natural, and physical systems, processes, structures, and organisations, and appreciate the cultural and language differences that exist amongst people.
(g) analyse and critically reflect on the essential social and relationship values and skills, health and peace values and attitudes, and problem-solving and conflict management skills needed for social and character development, social cohesion, development of healthy and peaceful families and communities, and caring for the natural and physical environments.
(h) understand the significance and purposes of Biblical values and principles in the shaping of personal character and personal conduct, developing and adhering to moral and ethical standards in one's conduct and relationships, and preparation for eternal life.
(i) examine their civic and citizenship responsibilities, the importance of these responsibilities to harmonious living and maintaining social cohesion, and community and national development and well-being.
(j) develop an in-depth understanding of business and commerce principles, processes, concepts, and practices, including e-business and e-commerce, and use the knowledge, skills, values, and attitudes learnt and mastered to start and manage their own businesses.
(k) acquire knowledge, skills, values and attitudes required for learning and practice of arts, and the application of knowledge and skills to express themselves, promote PNG's cultures, and make a living.
(l) recongnise the importance of healthy mind, body, and spirit, the importance of physical exercise and sport, balanced diet, and regular exercise in living a healthy life style.

(m) attain essential agriculture knowledge, skills, values, and attitudes required for making a living in agriculture related contexts, starting and managing agriculture businesses for personal and family sustainability, and pursing agriculture-oriented livelihoods.

Aim 3: Students will attain both regional and internally comparable standards in literacy and numeracy.

Goals

Students will be able to:

(a) develop fluency in reading and comprehension to enable them to decode, critique, critically analyse, and synthesize a variety of texts.
(b) acquire essential writing and publication proficiencies to enable them to write and publish a variety of texts.
(c) learn and demonstrate proficiency on the essential mathematics knowledge, skills, values, and attitudes and use these to solve problems in real life situations.
(d) attain the expected levels of literacy in Science, Social Science, Character and Social Development, Citizenship and Christian Values Education, Industrial Arts and Technology, Business and Commerce, Agriculture, Arts, Physical Education.

Aim 4:

Students will develop their full potential and empowered to be dynamically involved in the process of freeing themselves from oppressive situations, contribute to promoting the common good and welfare of society, and develop a sense of responsibility for oneself and others.

Goals

Students will be able to:

(a) recognize and critically analyse the situations that oppress and marginalize them and others, and take appropriate individual and collective actions to transform these situations in order to improve their wellbeing and the well-being of others.
(b) develop a positive attitude towards community service and responsibility for the well-being of the community while being responsible for their personal behaviour and conduct and hold others to account for their behaviour and attitudes in the interest of public good.
(c) develop effective communication and social skills, and think critically and rationally when solving problems and making decisions at different stages of their personal development.
(d) interpret language and cultural expressions attributed to oppressed and marginalized groups by dominant and powerful groups and challenge these in order to improve their situations.

Aim 5:

Students will contribute towards the development of knowledge-based economy and society, and the transformation of Papua New Guinea from a developing to a middle income country by continuously learning and applying knowledge, skills, values, and attitudes to improve the prevailing social, economic, political, cultural, scientific, and technological conditions.

Goals

Students will be able to:

(a) value creativity and innovation; the spirit of autonomy and independence; and foster an attitude to knowledge creation and application to improve working, living, and development conditions.
(b) obtain relevant knowledge, skills, values, and attitudes that will enable them to be multi-skilled, lifelong learners, and knowledge-based workers capable of functioning in a changing world and work environment.

Aim 6:

Students will continue to learn throughout their lives and apply the outcomes of learning to improve their personal and collective learning, growth and development, and the quality of life for oneself and others.

Goals

Students will be able to:

(a) think sensibly for themselves and to develop as individual members of a community.
(b) develop and foster an attitude towards continuous learning as a basis for improving one's own knowledge, thinking, practice, value and belief system and hence improve life outcomes.
(c) cultivate a positive attitude towards research, reflection, and critical analysis as bases for lifelong learning.

Aim 7:

Students will acquire essential knowledge, skills, values, and attitudes necessary for the building of peaceful and safe communities, living together, upholding the principles of a democratic state and society, building social cohesion, promoting equity and social justice, and ensuring economic prosperity for all.

Goals

Students will be able to:

(a) value justice, responsibility, equality between men and women, mutual respect and cooperation, and actively contribute to the building and fostering of peaceful, safe, and inclusive communities.
(b) use effective communication skills and think creatively in a rational manner and develop better problem solving and decision-making skills at appropriate levels and ages.
(c) examine in-depth problems at hand by collecting and using evidence to make informed decisions about the best strategies to address the problems and achieve results that are satisfactory to all stakeholders.
(d) become happy, healthy, and useful members of society.
(e) analyse the principles of democracy, how a democratic government works, citizen's democratic rights and responsibilities, and the weaknesses and strengths of the democratic ideology.

Aim 8:

Students will foster an understanding and an appreciation of PNG's many cultures and languages, their influence on the construction and representation of Papua New Guinean's identities, and the value, knowledge, and belief systems that underlie these diverse cultures and languages; while embracing the cultural and linguistic differences, and take actions to sustain the good and eliminate the bad aspects of cultures.

Goals

Students will be able to:

(a) have pride and responsibility towards their cultures and languages, and preserve and promote one's identity through language and culture while at the same time learning, appreciating, and tolerating other cultures and languages, both local and international.
(b) communicate with other people through written and spoken language, through mathematics and through other ways such as art, music and movement.
(c) investigate the underlying knowledge, value, and belief systems of different cultures and languages, and take appropriate individual and collective actions to eliminate aspects of cultures that hinder the building and fostering of healthy relationships and peaceful and safe environments, that are oppressive and detrimental to human development, and detrimental to the promotion of inclusive development and a hindrance to promoting and safeguarding fundamental human rights.

Aim 9:

Students will develop their knowledge and an appreciation and respect for the natural environment and physical and human resources, and the need to develop these in ways that are sustainable for the benefit of current and future generations.

Goals

Students will be able to:

(a) cultivate and maintain an attitude to respect life, care for nature, and contribute to the protection of the environment.
(b) help develop and sustain Papua New Guinea's environment and its physical and human resources, for the benefit of current and future generations.
(c) become wise guardians of Papua New Guinea's resources.
(d) act responsibly and within the spirit of environment sustainability in the use of natural resources with the knowledge that local actions on environment have both local and global consequences.

Aim 10:

Students will develop healthy self-concepts; contribute to the establishment and sustainability of healthy communities; the eradication of common diseases; and improvement in the health status of all citizens.

Goals

Students will be able to:

(a) demonstrate an understanding of the different stages of child development from conception to childhood, adolescence to adulthood.
(b) show awareness and understanding of the importance of building and promoting healthy life styles and healthy communities as prerequisites for healthy living and life style.
(c) investigate common diseases in PNG and their causes and symptoms, appreciate the consequences and impact they have on the citizens, look at what is being done to eradicate these diseases, and know how they can contribute to eradicating these diseases.

Aim 11:

Students will understand that parenthood is a lifelong responsibility however, in exercising this right they should be aware of the impact of uncontrolled population growth and its consequences on families, communities, the environment, available resources, and the nation.

Goals

Students will be able to:

(a) appreciate the importance of having a family unit and show awareness of parental responsibilities, recognize the consequences of the decisions they make regarding the size of their families, recognizing the fact that the quality of life for their children depend on the decisions they make.
(b) aware of the contributing factors to population growth and demonstrate an understanding of the consequences of uncontrolled population growth.

Aim 12:

Students will acquire knowledge, skills, values, and attitudes required for social and economic development, for gainful employment and self-employment, and for transforming individual and collective livelihoods and alleviating poverty.

Goals

Students will be able to:

(a) acquire knowledge, skills, values, and attitudes required for active participation in the formal and informal economy as means for making a sustainable living.
(b) explain and apply the concepts and practices of self-reliance and personal viability to create own employment as an alternative to formal employment.
(c) foster an attitude towards work by acquiring relevant values, knowledge, and skills that will prepare them to pursue vocational skills occupations.

Aim 13:

Students will develop required values and respect for oneself, others, and the community, and use these as a basis for developing effective national and global citizenships traits.

Goals

Students will be able to:

(a) learn about and show awareness about past and present outstanding and model citizens whose character, moral standing, ethical standards, and contributions have shaped PNG and the world.
(b) demonstrate awareness and understanding of their civic and citizenship roles and responsibilities, the importance of performing these responsibilities in a transparent and accountable way for the greater good of PNG and their communities, and the consequences of neglecting these roles and responsibilities.
(c) develop and foster values, behaviours, attitudes, and communication competencies required to live together and in harmony with peoples of other cultures and linguistic groupings.
(d) show awareness and concern for the welfare and the rights of others, contribute to the promotion of justice for all and the empowerment of the oppressed and marginalized people, promote gender and social inclusion as the basis for protecting and promoting the rights of all.

Overarching Curriculum Principles

Curriculum principles identify, describe, and focus attention on the important concerns that must be addressed when developing the curriculum at all levels of schooling. They are based on significant social, economic, political, cultural, religious, philosophical, environmental, and educational values and beliefs. Curriculum principles are evidence-based and influenced by best practice. The following principles underpin the design, development, and implementation of SBC in PNG.

Relevance

The national curriculum should target the national, community, and personal social, economic, political, cultural, environmental, and spiritual, development needs and aspirations. Curriculum should aim to prepare children for careers, higher education and citizenship. Children should be equipped with essential, in demand knowledge, skills, values, and attitudes to meet the demands and challenges of working, studying, and living in a complex, knowledge-based, and technology driven economy and society of the 21st century. This can be achieved through the development of rigorous and comparable learning standards, design, development, implementation, and monitoring of a quality SBC, and embedding of values and critical, creative, decision-making, reasoning, problem-solving, high level, 21st century, and STEAM skills in the curriculum.

The national curriculum will enable teachers to support students' learning by encouraging teaching and learning in real-life contexts, and providing opportunities for students to address the problems posed by the natural and physical environments by developing creative and innovative solutions. This means students will relate and use the knowledge, skills, values and attitudes learnt in different subjects to real life situations.

Multiculturalism

PNG is blessed and fortunate to have so many languages and cultures. The diversity of our cultures is the source of our knowledge, skills, attitudes, and values. As a multicultural society, we must protect, promote, and respect our many cultures and languages. There are many people from our own ethnic groupings and from other countries with their own cultures living and working together in PNG. This is the most multicultural country in the world. We must ensure that we promote and share our cultures with the rest of the world. We must also critically examine and address the problematic aspects of our cultures.

Ethics, Morals, and Values

PNG is striving to create a society in line with democratic liberal traditions. The citizens of PNG should recognise appropriate social relationships based on sound human and religious ethics, morals and values. These are required for interaction with families and people from other provinces and nations. The process of socialisation requires a belief in the ethics, morals and values of the Melanesian extended family, dialogue with and respect for others and a willingness to conserve and promote those aspects of our traditions, which are consistent with studying, working, and living in the 21st century global society. Socialisation also requires an awareness of the interdependence of individuals, societies, and nations in the postmodern world. It requires involvement with family, school, church, community, and the world beyond.

Integral Human Development

Integral human development focuses on the holistic development of every person. National curriculum should provide opportunities for all children to receive an education that will enable them to:

- be dynamically involved in the process of freeing themselves from every form of domination and oppression so that they will have the opportunity to develop as integrated persons in relationship with others. This means that the national curriculum must integrate and maximise socialisation, participation, liberation, and equality;
- be aware of human potential and the willingness to develop and maximize this potential so that each individual can solve his or her own problems, contribute to the common good of society, and maintain, promote, and improve the learning, working, and living conditions of all, and
- acquire and consistently use Biblical and spiritual values, personal, social and sustainability values, and work, relationship, health, and peace values in their lives.

PNG is a rapidly changing society and faces many challenges. To face these effectively, an individual must strive to become an integrated person and to work with others to create a better community.

The process of integral human development calls for a national curriculum, which helps individuals to:

- identify their basic human needs;
- analyse situations in terms of these needs;
- see these needs in the contexts of spiritual and social values of the community; and
- take responsible action in co-operation with others.

The success of a national curriculum requires the integrated involvement of all the agents of education such as the home, church, school, and community.

The Right to Healthy Living

The health status of PNG is very low. All citizens have a right to clean water, a nutritious diet, improved sanitation, and appropriate and better local health services. Students need to learn attitudes; skills, and knowledge that will help them become productive, healthy, and contented citizens of PNG. They need to be given a set of skills that will enable them to improve their own and their community's health in order to improve the health status of PNG. The national curriculum will ensure that students have the opportunity to learn about healthy living and lifestyles.

Nation Building and National Unity

Our nation is young and there is still a great deal of nation building to be done. Students need to be given the skills to undertake this task and participate in nationally organised events. The national curriculum should enable them to understand how Papua New Guinean societies work and how they can be a useful part of these societies. Students should learn that they have a place in PNG and that PNG has a place in the world as a whole. They will be able to help PNG develop a national identity as one nation if they learn to:

- work together with tolerance;
- respect one another, their traditional ways and resolve problems peacefully;
- respect and act in the spirit of the national Constitution;
- recognise their capabilities and develop their own talents;
- participate in the development of the national community; and
- protect and safeguard the national wealth and resources.

Sustainability

The natural environment of PNG is as diverse as its cultures. It is often under threat from uncontrolled exploitation, over logging, abuses associated with mining, over fishing, dynamiting of reefs, and dumping of toxic wastes. Our diverse cultures are also under threat from over exploitation and commercialisation of sacred cultural practices. Our cultural traditions are not being handed down from generation to generation. The national curriculum will guide students to further appreciate, respect, and value their natural environment, cultures, customs, and traditions. It will give them the skills and knowledge to identify problems and issues and to take action to sustain these aspects of life in PNG.

Gender Equity and Social Inclusion

Gender is what it means to be a woman or a man. Gender refers to those behaviours and attitudes that are culturally accepted as ways of being a woman (femininity) and being a man (masculinity). Addressing gender issues goes well beyond ensuring that females have the same opportunities as males to receive an education. A person's experiences determine the way they understand and make sense of the world. Gender is also culturally determined. In PNG, there is a need for sensitivity to local cultural practices and values, with respect to traditional roles for males and females. The national curriculum will provide students with subjects, resources, activities, and experiences that value the needs of both girls and boys.

Females are generally a disadvantaged group in PNG. PNG does not have in place a good record about gender equity for females. Violence against females is widely acknowledged as a serious problem. A number of health and other indicators of human development show that females have a lower quality of life than males. Females have lower literacy rates and lower income levels than males. Males hold nearly all positions of leadership, authority, and decision making.

Men hold most senior positions in government departments and the community. It is a similar situation in the Department of Education, provincial education divisions, and schools. The national curriculum will provide students with opportunities to consider these problems and ways of addressing gender issues.

Inclusive Curriculum

The national curriculum is inclusive and designed to meet the needs of all students irrespective of their abilities, gender, geographic locations, and cultural language, or socioeconomic backgrounds. The national curriculum must be implemented by teachers in ways that are inclusive of all students at all levels of schooling. Much more can be achieved if parents, community leaders, churches, and schools co-operate and communicate with each other.

Students learn in different ways. It is best to use a variety of methods to teach them. No one method is best. It is true that students are very different and even the same students learn best from different methods at different times. By using a range of teaching methods, it is more likely that the needs of all students will be met. In order to be inclusive of all students, teachers need to cater for a range of physical, social, cultural, emotional, spiritual, and intellectual needs of their students. This can be achieved through using appropriately and carefully planned learning activities, a range of teaching methods and strategies, and thoughtful use of the language of communication.

To be inclusive, teachers will need to ensure that all girls and boys have the opportunity to participate. Teaching practices, including classroom organisation and management, should ensure that girls and boys are able to participate fully in all learning activities. Participation requires that individuals are motivated to achieve the goal of socialisation fully where they are encouraged to develop

a sense of obligation for the opportunity to contribute. Through participation, individual creativity can be recognised and encouraged, without losing sight of the principle of communal sharing. Participation is the key to social interaction and can lead to social mobility. It can also help to conserve and generate knowledge and cultural values for future generations.

Student-Centred Learning

Student-centred learning recognises the fact that no two classes are alike and no two children are the same with respect to their needs. A teacher who uses a student-centred approach will endeavour to create a classroom environment that will motivate students to discover new skills and knowledge. In such an environment, the teacher might focus on teaching students how to learn and help them discover relevant information. It is essential to teach students how to learn while at the same time teaching them important content. A student-centred classroom will usually involve students working together in small groups using activity centres set up in the classroom while the teacher works more closely with one or two students. The national curriculum describes what all students are expected to learn in all subjects. A student-centred approach allows teachers to be more flexible in determining the most effective ways to help all students achieve these learning outcomes

Lifelong Learning

School is an important part of a student's education but learning continues throughout life. The initial experience that students have with the school curriculum is critical in encouraging them to continue learning throughout their lives. Going to school should be an enjoyable and satisfying experience for the students and should prepare them for life after school. Students know many things when they come to school. They will learn many things outside of school and continue to learn after they leave school. The national curriculum should build on what students already know. Teachers should make use of this knowledge and skills. When students are learning new, unfamiliar things, teachers should relate the new things to what students already understand. This important learning will continue throughout life as students increasingly take responsibility for their own learning. Increasingly, students who leave school will look for opportunities to continue their education and to return to school or some other educational or training institutions in order to improve their qualifications.

Language Development Across the Curriculum

The national curriculum will provide opportunities for language development across the curriculum. Language development across the curriculum should be encouraged because all subject areas provide meaningful contexts for purposeful learning. Specific subjects have different language requirements such as, the vocabulary and language features of science and the written and oral genres to narrate, explain, persuade, report, and discuss the particular content of various subjects. The conventions and differences must be explicitly taught in relevant contexts across the curriculum.

21st Century Knowledge, Skills, Values, and Attitudes for Careers, Higher Education, and Citizenship.

PNG shapes and is being shaped by the 21st century social, economic, political, cultural, religious, and environmental discourses and practices. It is important to provide opportunities for students to learn in-depth and master the 21st century knowledge, skills, values, and attitudes to prepare them for careers, higher education, and citizenship. There is an increasing demand for knowledge-based workers and workers with qualifications in STEAM globally. This cadre of workers is not available in PNG because education is not geared towards preparing this category of workers. PNG children should be equipped with the necessary 21st century and STEAM proficiencies to ensure that they are marketable globally and can contribute meaningfully to the development of PNG.

Science, Technology, Engineering, Arts, and Mathematics Education

The majority of careers in the 21st century is STEAM related. However, demand for STEAM graduates and experienced workers far exceed the supply of this cadre of workers. What is more, although a slow paradigm shift is taking place, careers in STEAM fields are dominated by males. Females are beginning to venture into these careers but at a very slow pace. There is an enormous gender parity gap in this area. Thus, it is critical for STEAM knowledge, skills, values, and attitudes to be taught from prep to post-secondary school level to provide opportunities for all students to attain STEAM related proficiencies before leaving school. The main aim of this education is to shape students' thinking, motivate, and influence them to develop an interest in careers in the STEAM field, and pursue STEAM related academic programs in institutions of higher education.

Standards-Based Curriculum Principles

The principles of SBC include the following:

- Setting of high academic standards and a careful and continuous assessment and reporting of students' performance against these standards will motivate students to perform at a much higher level.
- Standards allow every student, every parent, and every teacher to share in common expectations of what students should know, understand, and be able to do.
- Students will learn more when more is expected of them in school and at home.
- The setting of clear, measurable, and attainable standards is the key to attaining high academic standards and hence the attainment of the desired quality of education.
- All children are capable of learning and achieving high academic standards, regardless of their backgrounds.
- Students can learn in their own ways and at their own rates.

Protection of Children's Rights

It is paramount that children's rights stipulated in national legal and policy frameworks, and international conventions such as the United Nations Convention on the Rights of the Child (UNCRC) are recognised, promoted, protected, and safeguarded by everyone and every organisation working and dealing with children's welfare and well-being. A child is defined by UNCRC as a human being below the age of 18 years. However, definitions of a child may differ based on the socio-cultural contexts of different countries. Notwithstanding the differences in definitions, biologically, a child is generally anyone between birth and puberty. The four core principles of UNCRC underpinning children's rights are:

- non-discrimination.
- devotion to the best interests of the child.
- the right to life, survival and development.
- respect for the views of the child.

Children's rights are human rights and therefore they should be promoted and safeguarded by the whole of the education system. They should permeate all education plans, policies, programs, and activities, and firmly embedded in the school curriculum, teaching and learning practices, and the overall management of the education system

Science Rationale, Aim and Goal, and Guiding Principles

Papua New Guinea (PNG) like any other countries in the world is also making concerted efforts to boost student achievement in literacy, numeracy and Life skills. Science course is no exception since Science is regarded as a key life skill and efforts are aimed at improving science education to develop deep, lasting changes in how students learn this critical yet vital subject.
Across the world, there is an increased demand to pursue careers in science, technology, and engineering that drive the innovation and invention necessary for economic growth and improving the quality of life. To meet this demand, it is increasingly important to prepare significant proportions of students to enter advanced study in these areas.

Their understanding of science should build throughout their schooling so that when, as adults, they are faced with decisions relating to such diverse issues as the treatment of diseases, climate change, and the applications of technology, they are able to act from a sound scientific basis.

Science is tilizati around four main strands – Science as Inquiry, Physical Science, Life Science, and Earth and Space Science. These strands are comparable with the strands used internationally. Therefore, the learning of key science concepts, ideas, processes and inquiry methods should start at the early stage of a child's education. The scientific method should be re-emphasised at various stages of a child's education until the child masters the methods. This will prepare a student well to take on higher studies in science.

Science has been always the main driver for all creativity, innovation, discoveries, inventions or constructions. Science is also fundamental in life because it has direct application to nearly all aspects of life and society, from sustaining humankind survival through the maintenance and improvement of lifestyles and health to understanding and solving local, regional, and global issues.

Ultimate Aims of Science

The Science Course aims are to:

(i) Guide students in acquiring knowledge with understanding for application in their daily lives such that they:

- are motivated to learn science through contextual and hands-on learning;
- are able to problem-solve and use thinking and inquiry processes;
- can communicate effectively;
- develop safety consciousness and safe practice;
- become confident citizens who are able to cope with the changing and progressive nature of science and technology in the world.

(ii) Enable students to develop 21st century competencies which would:

- enable them to acquire problem-solving skills and use thinking and inquiry processes;

- enable them to become responsible individuals and productive citizens;
- enable them to acquire life-long learning skills;
- enable them to show care and concern for people and the environment;
- allow them to use information communication technology (ICT) for communications, collaboration and as a tool for data collection and the analysis of results.

(iii) Enable students to be suitably prepared for post-secondary courses, such that they:

- develop abilities and skills which would also be relevant and useful in the work
- place;
- become aware of the impact of science and technology on society, industry,

Goals of Science

Students will be able to:

- cultivate and maintain an attitude to respect life, care for nature, and contribute to the protection of the environment.
- help develop and sustain Papua New Guinea's environment and its physical and human resources, for the benefit of current and future generations.
- become wise guardians of Papua New Guinea's resources.
- act responsibly and within the spirit of environment sustainability in the use of natural resources with the knowledge that local actions on environment have both local and global consequences.

Guiding principles

The science curriculum principles identify, describe and focus attention on the important concerns that must be addressed when developing and implementing science curriculum. There are the underlying guidelines in which both the teacher and the learner should be aware of and be focused on when teaching or learning Science.

The recipients should be able to develop a certain level of sensitivity to the implications of science for individuals and society and understand that science is a human tilizat with consequent limitations. Students should be guided to create an interest and openness to new ideas, to critically analyse situations, generate new theories and ideas, develop intellectual honesty, integrity and respect for evidence based on data and value the outcome of what is explored and gathered. The science at Junior High School founded on the following guiding principles;

- Community and Student-Centred Science Learning
- Science as inquiry
- Creating and Promoting a Safe Working Environment
- Instructional Technology
- Links to other learning areas (cross-curricular)

Science as Inquiry

Scientists engage in scientific inquiry by following key science practices that enable them to understand the natural world and answer questions about it. Learning science is something that students do, not something that is done to them. Hands-on activities, while essential are not enough. Students must have minds-on experiences in which they become fully engaged in creative scientific thinking.

Students of science 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 systematic way to conduct scientific inquiry. These include students asking questions, make observations, make predictions and carry out experiments to test their predictions. The science practices are fundamental to all science disciplines. When students are engaged, they are:

- Asking questions based on observations
- Generating evidence
- Working with data
- Answering the research question
- Making an argument from evidence

Five practices that are fundamental to scientific inquiry are represented in detail in the Grades 9 and 10 Teachers Guides. In this syllabus the Science as Inquiry recommended for Grades 9 and 10 are provided in the table below and are also expanded in the teachers' guides.

Grade 9 recommended working scientifically skills	Grade 10 recommended working scientifically skills
• Perform tests, collect data, analyse relationships, and display data. • Identify and communicate • Identify and examine possible and reasons • Formulate explanations by using logical thinking and evidence. • Solve scientific problems • Examine the usefulness of data presented	• The locations, sequences, or time intervals • Recognise and assess the issues of statistical variability and the need for controlled tests. • Analyse situations and solve problems • Combining and applying concepts from more than one area of science. • Researching the literature, analyse data, and communicating the findings • Determine when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent.

Nature of Science

Nature of science standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature and can predict potential consequences of actions, but cannot be used to answer all questions.

Monitoring and Mastering Science Inquiry skills

The table below shows the expectation for students studying Science to master the Science Inquiry Skills from Preparatory to Grade 12. It shows:

- **Emerging** – when the student starts
- **Progressing** – when the student shows evidence of progressing and working towards mastering the skill
- **Mastering** – When the student has mastered the skill and is able to apply in all life situations.

This practice must be on-going and progressively carried out throughout the child's learning in that particular grade.
Schools are encouraged to use this for each student and should be passed on to the next grade so the students mastery
level of each skill is monitored right throughout their learning from Preparatory to grade 12.

Level of skills	Low				Medium					High			
Inquiry Skills by grades	P	G 1	G 2	G 3	G 4	G 5	G 6	G 7	G 8	G 9	G 10	G 11	G 12
Observing	*	*	**	***	***	***	***	***	***	***	***	***	***
Classifying		*	*	**	***	***	***	***	***	***	***	***	***
Measuring		*	*	**	**	**	***	***	***	***	***	***	***
Inferring				*	**	**	***	***	***	***	***	***	***
Predicting			*	**	***	***	***	***	***	***	***	***	***
Hypothesizing				*	*	**	***	***	***	***	***	***	***
Experimenting				*	**	**	***	***	***	***	***	***	***
Communicating			*	**	**	**	***	***	***	***	***	***	***
Researching				*	*	*	**	***	***	***	***	***	***
Problem-solving				*	*	**	**	***	***	***	***	***	***
Identifying and controlling variables				*	*	*	**	**	**	***	***	***	***
Use/make models			*	*	**	**	***	***	***	***	***	***	***
Use numbers				*	*	**	**	***	***	***	***	***	***
Collect data				*	*	*	**	**	**	***	***	***	***
Analyse relationships						*	*	**	**	***	***	***	***
Use appropriate tools and techniques to make observations and gather data				*	**	***	***	***	***	***	***	***	***
Assess the reliability of data that was generated in the investigation					*	**	***	***	***	***	***	***	***
Formulating questions that can be answered through scientific investigations				*	*	*	**	**	***	***	***	***	***
Formulate explanations by using logical thinking and evidence							*	*	*	**	**	***	***
Proving scientific theories as facts or fraudulent										*	**	***	***
Identifying and explaining mis-conceptions							*	*	*	**	***	***	***
Looking for patterns and meanings								**	**	***	***	***	***
Read, interpret and examine the credibility and validity of scientific claims in different sources of information							*	*	*	**	**	***	***
Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.							*	**	**	***	***	***	***
Explain and distinguish independent and dependent variables including those that are kept constant and those used as controls.							*	**	**	***	***	***	***
Use mathematical operations to analyse and interpret data and present relationships be-tween variables in appropriate forms.							*	**	**	***	***	***	***

Draw conclusions and present plausible explanations based on research data and assess results based on the design of the investigation								*	*	**	**	***	***
Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.					*	*	*	**	**	***	***	***	***
Science as Inquiry/grades	P	G1 G	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Level of skills	**Low**				**Medium**					**High**			

The number of asterisks denotes the amount of emphasis given to each process skill in each year level.

* Emergent ** Progressive *** Mastery

Enhancing Science Teaching and Learning Using Instructional Technology

The use of current and emerging technologies is essential to the P–12 Sciences instructional program. Specifically, technology must accomplish the following:

- Assist in improving every student's functional literacy. This includes improved communication through reading/information retrieval (the use of telecommunications), writing (word processing), organization and analysis of data (databases, spreadsheets, and graphics programs), presentation of one's ideas (presentation software), and resource management (project management software).
- Be readily available and regularly used as an integral and ongoing part of the delivery and assessment of instruction.
- Include instrumentation oriented toward the instruction and learning of science concepts, skills, and processes. Technology, however, should not be limited to traditional instruments of science, such as microscopes, lab ware, and data-collecting apparatus, but should also include computers, robotics, interactive-optical laser discs, video-microscopes, graphing calculators, CD-ROMs, probe ware, global positioning systems (GPS), online telecommunication, software and appropriate hardware, as well as other emerging technologies.
- Be reflected in the "instructional strategies" generally developed at the local school division level.

In most cases, the application of technology in science should remain "transparent" unless it is the actual focus of the instruction. One must expect students to "do as a scientist does" and not simply hear about science if they are truly expected to explore, explain, and apply scientific concepts, skills, and processes.

As computer/technology skills are essential components of every student's education, it is important that teaching these skills is a shared responsibility of teachers of all disciplines and grade levels.

Creating and Promoting a Safe Working Environment

During Science lessons, teachers must be certain that students know how to follow safety guidelines, demonstrate appropriate laboratory safety techniques, and use equipment safely while working individually and in groups. Safety must be given the highest priority in implementing the instructional program for science. Correct and safe techniques, as well as wise selection of experiments, resources, materials, and field experiences appropriate to age levels, must be carefully considered with regard to the safety precautions for every instructional activity. Safe science classrooms require thorough planning, careful management, and constant monitoring of student activities. Class enrolment should not exceed the designed capacity of the room.

Teachers must be knowledgeable of the properties, use, and proper disposal of all chemicals that may be judged as hazardous prior to their use in an instructional activity. The identified precautions involving the use of goggles, gloves, aprons, and fume hoods must be followed as prescribed.

While no comprehensive list exists to cover all situations, the following should be reviewed to avoid potential safety problems. Appropriate safety procedures should be used in the following situations:

- observing wildlife; handling living and preserved organisms; and coming in contact with natural hazards, such as poison ivy, ticks, mushrooms, insects, spiders, and snakes;
- engaging in field activities in, near, or over bodies of water;
- handling glass tubing and other glassware, sharp objects, and lab ware;
- handling natural gas burners, Bunsen burners, and other sources of flame/ heat;
- working in or with direct sunlight (sunburn and eye damage);
- using extreme temperatures and cryogenic materials;
- handling hazardous chemicals including toxins, carcinogens, and flammable and explosive materials;
- producing acid/base neutralization reactions/dilutions;
- handling power equipment/motors, and;
- working with high voltage/exposed wirin

A Coherent and Focused Curriculum

In a coherent curriculum, mathematical ideas are linked to and build upon one another so that students' understanding and knowledge are deepened and their ability to apply mathematics is expanded. An effective mathematics curriculum focuses on important mathematics knowledge, skills, values, and attitudes that will prepare students for further study, to work in different settings, and live in the community. A well-articulated curriculum enables all students to progressive learn, engage in an in-depth study of mathematics, and develop essential mathematics competencies.

Gender Equity and Social Inclusion

All children, regardless of their gender, ability, and other backgrounds, are expected to achieve high academic standards in mathematics. High expectations and strong support for especially female students and children living with disability will enable all children to be actively involved in the learning of mathematics. All students come to school with expectations to learn mathematics that meets their individual interests and needs. Mathematics standards provide a wide range of opportunities for students to acquire and apply mathematical knowledge, processes, concepts, ideas, skills, values, and attitudes in real life. Every student, regardless of race, colour, gender, and ability should have the benefit of quality instructional materials, good libraries, and adequate technology to enable them to effectively learn and attain the expected mathematics outcomes.

Evidence-Based Teaching and Learning

Assessment should focus on improving students' learning of mathematics. Children's progress towards meeting the expected mathematics standards should be assessed and evaluated. Assessment data should be used to report on students' progress towards meeting grade-level expectations and national content standards, identify and assist students who are yet to meet the expected standards, monitor the progress of weak students, and for lesson planning and instruction. Assessment should inform and guide teachers as they make instructional decisions. The tasks teacher's select for assessment convey a message to the students about what kind of mathematical knowledge, skills, values, and attitudes, and performance are valued. Feedback from assessment task helps students' in setting goals, assuming responsibility for their own learning, and becoming more independent learners.

Core curriculum

A core set of common learning's (knowledge, skills, values, and attitudes) have been integrated into the curriculum to provide all students an opportunity to acquire and master these before they are career, higher education, and citizenship ready. The core curriculum includes:

- Cognitive skills (critical and creative thinking);
- Reasoning, problem-solving and decision-making skills;
- High level thinking skills (analysis, evaluation and synthesis);
- 21st century skills;
- STEAM principles and skills;
- Spiritual values and virtues;
- Reading, writing and communication skills, and
- Essential values and attitudes.

The above knowledge, skills, values and attitudes should be taught and assessed by all teachers from prep to grade 12. These are reinforced at each school grade and school level to enable students to become proficient in their application in different careers, higher education and citizenship contexts.

Essential Knowledge, Skills, Values, and Attitudes

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.

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 these essential knowledge, skills, values and attitudes in their lessons, and assess students' performance, proficiency and progression towards the attainment of content standards.

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 deepened 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.

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

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Types of Skills

There are different types of skills. These include:

1. Cognitive (Thinking) Skills

Thinking skills can be categorised 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:	
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.	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.
Key words	**Key words**
Analyse, compare, contrast, classify, distinguish, infer, explain, separate, select, categorise, connect, differentiate, discriminate, divide, order, point out, prioritise, sub-divide, survey, advertise, appraise, breakdown, calculate, conclude, correlate, criticize, devise, deduce, arrange, discover, establish, examine, organize, outline, investigate, examine, simplify, see, research, recognize, highlight, in-depth, discuss, list, find, group, divide, focus, question, experiment, test, illustrate, identify, deconstruct, simplify,	Evaluate, criticize, order, appraise, judge, support, compare, decide, discriminate, recommend , summarise, assess, choose, convince, defend, estimate, find errors, grade, measure, predict, rank, score, select, test, argue, conclude, consider, monitor, check, debate, determine, justify, explain, give reasons, interpret, opinion, validate, value,

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;
Synthesis/Creative 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.
Key words
Categorise, combine, compose, create, devise, design, explain, generate, modify, organize, plan, rearranges, construct, deconstruct, reconstruct, relate, reorganize, revise, rewrite, summarise, tell, write, formulate, invent, hypothesise, develop, compile, prepare, produce, arrange, rearrange, assemble, role-play, anticipate, make, predict, act-out, model, build, convert, discuss, elaborate, solve, propose, visualize, imagine, extend, tabulate, transform, integrate, innovate, maximize, minimize,

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.

Types of Values

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

3. 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.

STEAM Rationale, Aim and Goals, and Guiding Principles

Ultimate Aim

The ultimate aim of STEAM education is to develop a STEAM literate society in which all citizens have the expected level of STEAM literacy. STEAM literacy refers to an individual's:

- knowledge, skills, values, and attitudes to identify problems and questions in life situations, explain the natural and design world, and draw evidence-based conclusions about STEAM issues;
- understanding of characteristic features of STEAM disciplines as forms of human knowledge, inquiry, and design;
- awareness of how STEAM disciplines shape our material, intellectual, and cultural environments, and
- willingness to engage in STEAM related issues and with the ideas of STEAM as a constructive, concerned, and reflective citizen.

Goals

The following are the goals of STEAM.

(i) Provide students with STEAM related experiences and opportunities to use STEAM concepts, ideas, and skills to solve problems relating to the natural and physical worlds, and use the evidence to make informed decisions about the interventions.

(ii) Build positive attitudes and embed essential STEAM values in children thereby motivating them to choose STEAM related careers or undertake STEAM related academic programs or courses of study.

(iii) Provide students opportunities to work in collaboration and partnership with people engaged in STEAM related careers or disciplines to learn about how STEAM skills, concepts, processes, and ideas are applied in real life.

(iv) Build a pool of STEAM workers who can contribute to national and global development and progress.

(v) Enable children to achieve high academic standards

Guiding Principles

Integration and application of knowledge and skills in real life situations

Integration of STEAM knowledge and skills and their application to real-life situations inside and outside of the classroom setting will enable students to explain how STEAM disciplines shape our material, intellectual, cultural, economic, social, and environmental contexts.

Emphasis is on the learning and the application of STEAM knowledge and skills to investigate, explain, and solve problems rather than on content

STEAM education emphasizes the learning and the application of knowledge, and skills to investigate, explain, and solving physical and natural problems rather than on in-depth teaching and learning of STEAM content.

STEAM related knowledge and skills are used to investigate, explain, and solve problems relating to the natural and physical environments

STEAM education focuses on providing the learners real life experiences of how STEAM related skills, concepts, processes, ideas, principles, values, and attitudes are applied and used to identify problems and questions in real life situations, explain the natural and physical world, and draw evidence-based conclusions.

Content Standards, Benchmarks, and Evidence Outcomes

Content standards, benchmarks, and evidence outcomes are all curriculum standards. However, they have specific curriculum purposes. Despite this, these curriculum standards are interconnected and enable the intended learning outcomes to be attained.

Content Standards

Content Standards are broadly stated expectations of what students should know, understand, and be able to do in a particular subject, grade, or school level. They embed essential knowledge, skills, values, and attitudes that all students are expected to learn and master in each strand or unit to prepare them for the next grade or level of schooling.

Benchmarks

Benchmarks are specifications of content standards or more detailed descriptions of a specific level of performance expected of students at particular ages, grades, or levels of development. Benchmarks focus on the essential knowledge, skills, values and attitudes that all students are expected to learn, master and demonstrate proficiency.

Evidence Outcomes

Evidence outcomes are indicators that indicate students' progress towards meeting an expectation at the mastery level. They measure students' mastery and application of knowledge, skills, values, and attitudes at each grade, cluster or school level. They indicate that a student is meeting an expectation or achieving a benchmark at the mastery level. They enable teachers to know if a student can do what he/she was expected to know, understand, and do in real life or relevant situations. Evidence outcomes are given for each strand in each grade to describe what all students should do at the end of the different strands of geology.

Content Standards and Benchmarks Coding

The following is the coding system used to code the content standards and benchmarks to not only make it easier to interpret and understand the relationship between these two learning standards but also to guide lesson planning, instruction, assessment and reporting of students' performance in relation to a benchmark and content standard.

Grade	: Grade is indicated by the first number (*for example,* 9)
Strand	: Strand is indicated by the second number (*for example,* 9.1)
Content Standard	: Content Standard is indicated by the third number (*for example*, 9.1.1)
Benchmark	: Benchmark is indicated by the fourth number (*for example,* (9.1.1.1).

Thus, the code will read as **Content Standard 11.1.1**. and **Benchmark as 9.1.1.1**

Content Overview

This is an overview of the content scope of learning for grades 9 and 10 students given in the grade 9 and 10 Science syllabus. The broad learning concepts are known as strands. From these strands the units are developed and drawn from the units are the topics. The scope below will help you understand the processes in identifying and scoping the content of learning –strands, units, and topics. The topics are translated and expanded into content standards and benchmarks. Sample guided lessons are then developed for each of these lesson titles.

The science strands for grades 9 and 10 are as follows:

(1) Science as Inquiry.
(2) Life Science.
(3) Physical Science.
(4) Earth and Space Science

Grades 9 and 10 Content Overview

Strand 1: Science as Inquiry		
Grades 9 and 10 Units	**Grade 9 Topics**	**Grade 10 Topics**
Unit 9.1 & 10.1 Scientific Tools and Technology	Science Journal	Lab Report
	Balances, Scales and Pulleys	Scientific Calculator
	Microscope	Telescope
	Scientific Research Skills	Scientific Research Skills
Unit 9.2 & 10.2 Measurement and Accuracy	International System of Units (SI)	Scientific Notations
	Telling Locations	Telling time and space in relation to natural phenomena
	Topographic Maps	Geological Maps
	Controls and variables	Sources of Error
	Using Mathematical Functions in Science	Using Mathematical Functions in Science
	Importance of Hypothesis or Misconceptions in science classes	Theories that can be proven as mistaken or fraudulent
Strand 2: Life Science		
Grades 9 and 10 Units	**Grade 9 Topics**	**Grade 10 Topics**
Unit 9.3 & 10.3 Classifying Organisms	Kingdoms of Living Things	Reproduction and Heredity
	Classification of Plants	
	Classification of Animals	
Unit 9.4 & 10.4 Cell Structure and Function	Plant Cells and Animal Cells	Tissues in Plants and Animals
	Cell Transportation in Plants and Animals (Diffusion and Osmosis)	Organs in Plants and Animals
	Using Energy in Plants and Animals	Circulatory System
	Cell Division in Plants and Animals	Musculoskeletal System
		Nervous System
		Endocrine System
Unit 9.5 & 10.5 Interactions and Relationships in the Environment	Food Chains and Food Webs	Cycles in the Biosphere
	Plant and Animal Adaptations	Earth's Ecosystems
	Species, Populations and Habitats	Biodiversity and Succession
	Development versus Pollution	Conservation, Preservation and Restoration

Strand 3: Physical Science		
Grades 9 and 10 Units	Grade 9 Topics	Grade 10 Topics
Unit 9.6 & 10.6 Matter and Energy	Classifying Matter	
	Physical and Chemical Properties of Matter	Chemical Properties of Matter
	Mixtures, Solution and Acids/Bases	Solubility
	Forms and Transformation of Energy	Heat Transfer and Thermal Conductivity of Materials
	Energy and Work	Systems and the Law of Conservation of Energy
	Atoms, Elements and Compounds	Chemical Reactions and Equations
	The Periodic Table	Elements and Chemical Bonds
Unit 9.7 & 10.7 Force and Motion	Common Forces and their Character-istics	Work and Simple Machines
	Forces and Effects	Balance and Unbalance Forces
	Newton's First and Second Laws of Motion	Newton's Third Law of Motion
	The Buoyant Force	Fluid Force
Unit 9.8 & 10.8 Waves, Electricity and Magnetism	Nature and Properties of Waves	Mechanical Waves
	Interaction of Waves with Matter	Electromagnetic Waves
	Properties of Sound	Sound Waves
	Light as Energy	Properties of Light
	Electric Charges and Forces	Electrical Current and Circuits
	Magnets and Magnetic Field	Magnets and Electric Current

Strand 4: Earth and Space Science		
Grades 9 and 10 Units	**Grade 9 Topics**	**Grade 10 Topics**
Unit 9.9 & 10.9 Our Earth	The Earth's Structure	The Rock Cycle
	The Earth's Atmosphere	
	Waters, Seas and Currents	The Fossil Fuel
	Weathering and Erosion	Natural Hazards
	Evidence of Our Past	Causes of Plate Movements
Unit 9.10 & 10.10 Weather and Climate	Local Weather Systems	Global Weather Systems
	Climates and Seasons	
Unit 9.11 & 10.11 Space Science	Earth, Moon and Sun	The Eclipses
	The Sun and the Planets	The Solar System and Beyond
		Space Equipment usage and Functions

Grades 9 and 10 Strands

Strand 1 : Science as Inquiry

Rationale

Scientists engage in scientific inquiry by following key science practices that enable them to understand the natural world and answer questions about it. Learning science is something that students do, not something that is done to them. Hands-on activities, while essential are not enough. Students must have minds-on experiences in which they become fully engaged in creative scientific thinking. Students of science 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 systematic way to conduct scientific inquiry.

Science as inquiry refers to the many ways in which scientists study the natural world. When engaging in inquiry, students make observations by describing objects and events, ask questions, plan their activities, gather information, test ideas and carry out investigations and deducing their own conclusions, communicate their understanding to others and consider alternative explanations

Why this strand cannot be taught as a content strand

This strand is not a stand-alone strand because it is basically skills and processes. However, there are Inquiry concepts such as 'how to carry out Science experiments' which is a standard process/steps that all teaching and learning of Science is based on. In such situations, a separate science lesson needs to be taught. Maybe students need to learn about how to use the microscope correctly or to carry out chemical reaction experiments. In such cases, a separate lesson needs to be taught prior to students using these materials/equipment in the lessons.

Evidence Outcomes

Grade-Level Evidence-Outcomes	
Grade 9	**Grade 10**
At the end of grade 9, all students can: • Select and use appropriate tools and technology to perform tests, collect data, analyse relationships, and display data. • Identify and communicate sources of unavoidable experimental error. • Identify and examine possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. • Formulate explanations by using logic and evidence. • Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions. • Distinguish between hypothesis and theory as scientific terms. • Examine the usefulness and limitations of models and theories as scientific representations of reality. • Read and interpret topographic and geologic maps. • Analyse the locations, sequences, or time intervals that are characteristic of natural phenomena. • Recognise and assess the issues of statistical variability and the need for controlled tests. • Examine the cumulative nature of scientific evidence. • Analyse situations and solve problems that require combining and applying concepts from more than one area of science. • Investigate a science-based societal issue by researching the literature, utilize data, and communicating the findings. • Determine when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent.	At the end of grade 10, all students can: • Select and use appropriate tools and technology to perform tests, collect data, analyse relationships, and display data. • Identify and communicate sources of unavoidable experimental error. • Identify and examine possible reasons for inconsistent results, such as sources of error or uncontrolled conditions. • Formulate explanations by using logic and evidence. • Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions. • Distinguish between hypothesis and theory as scientific terms. • Examine the usefulness and limitations of models and theories as scientific representations of reality. • Read and interpret topographic and geologic maps. • Analyse the locations, sequences, or time intervals that are characteristic of natural phenomena. • Recognise and assess the issues of statistical variability and the need for controlled tests. • Examine the cumulative nature of scientific evidence. • Analyse situations and solve problems that require combining and applying concepts from more than one area of science. • Investigate a science-based societal issue by researching the literature; utilize data, and communicating the findings. • Determine when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent.

Content Standard

Students will be able to explain the nature and the processes of scientific inquiry and use the modes of scientific inquiry and habits of mind to investigate and interpret the world around them.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.1.1.1	Select and use appropriate tools and technology to perform tests, collect data, analyse relationships, and display data.	**10.1.1.1**	Read and interpret topographic and geologic maps.
9.1.1.2	Identify and communicate sources of unavoidable experimental error.	**10.1.1.2**	Analyse the locations, sequences, or time intervals that are characteristic of natural phenomena.
9.1.1.3	Identify and examine possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.	**10.1.1.3**	Recognise and assess the issues of statistical variability and the need for controlled tests.
9.1.1.4	Formulate explanations by using logic and evidence.	**10.1.1.4**	Examine the cumulative nature of scientific evidence.
9.1.1.5	Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.	**10.1.1.5**	Analyse situations and solve problems that require combining and applying concepts from more than one area of science.
9.1.1.6	Distinguish between hypothesis and theory as scientific terms.	**10.1.1.6**	Investigate a science-based societal issue by researching the literature, tilizati data, and communicating the findings.
9.1.1.7	Examine the usefulness and limitations of models and theories as scientific representations of reality.	**10.1.1.7**	Determine when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent.

Strand 2: Life Science

Rationale

The life Science strand is about living things, their life processes, and their interrelationships and their environment. It deals with the structure and behavior of organisms like plants, animals and human beings. It further explores the characteristics of organisms, life cycles of organisms, and the interactions among all components, living and non-living of the natural environment and the interrelationships with each other and the environment.

This strand is further broken down into four main units. These are (1) Plants, (2) Animals, (3) Human Body and (4) Interactions and Relationships in the Environment. These units are elaborated as per the key learning concepts for each of the units.

The Life Science standards are designed to provide students with a detailed understanding of living systems. Emphasis continues to be placed on the skills necessary to examine alternative scientific explanations, actively conduct controlled experiments, analyze and communicate information, and gather and use information in scientific literature. The history of biological thought and the evidence that supports it are explored, providing the foundation for investigating biochemical life processes, cellular organization, mechanisms of inheritance, dynamic relationships among organisms, and the change in organisms through time. The importance of scientific research that validates or challenges ideas is emphasized at this level. All students are expected to achieve the content of the biology standards.

The core content:

- Describe the similarities and the differences in the appearance and the behaviour of plants and animals.
- Identify and examine major structures, characteristics, life cycles, processes, behaviours, and reproduction of plants and animals.
- Identify and examine how light, gravity, touch, or environment stress can affect the germination, growth, and development of plants.
- Explain the relationship between the living things and the environment.

Evidence Outcomes

Grade-Level Evidence-Outcomes	
Grade 9	**Grade 10**
By the end of grade 9, all students can: • Investigate the unity, diversity and the interrelationships between organisms, including their relationships to cycles of matter and energy in the environment. • Investigate and interpret biogeochemical cycles within ecosystems. • Examine the chemical reactions that occur in photosynthesis and cellular respiration and that result in cycling of energy. • Assess dynamic equilibrium in organisms, populations and ecosystems and explain the effect of equilibrium shifts. • Investigate different cell parts, their functions and how they are specialized into different tissue and organs. • Probe how cells are specialized in different tissues and organs. • Differentiate between the processes of mitosis and meiosis. • Investigate how homeostatic balance occurs in cells and organisms. • Examine the components and the functions of a variety of macromolecules active in biological systems. • Critique the theories of evolution and natural selection and cite evidence that supports these theories. • Examine the structural properties of DNA and the role of DNA in heredity and protein synthesis. • Explain how Mendel's laws of heredity can be used to determine the traits of possible offspring. • Examine chromosomal mutations, their possible causes and their effects, on genetic variation. • Research the components of the human body from cell to system and how they work together.	**By the end of grade 10, all students can:** • Investigate the unity, diversity and the interrelationships between organisms, including their relationships to cycles of matter and energy in the environment. • Investigate and interpret biogeochemical cycles within ecosystems. • Examine the chemical reactions that occur in photosynthesis and cellular respiration and that result in cycling of energy. • Assess dynamic equilibrium in organisms, populations and ecosystems and explain the effect of equilibrium shifts. • Investigate different cell parts, their functions and how they are specialized into different tissue and organs. • Probe how cells are specialized in different tissues and organs. • Differentiate between the processes of mitosis and meiosis. • Investigate how homeostatic balance occurs in cells and organisms. • Examine the components and the functions of a variety of macromolecules active in biological systems. • Critique the theories of evolution and natural selection and cite evidence that supports these theories. • Examine the structural properties of DNA and the role of DNA in heredity and protein synthesis. • Explain how Mendel's laws of heredity can be used to determine the traits of possible offspring. • Examine chromosomal mutations, their possible causes, and their effects on genetic variation. • Research the components of the human body from cell to system and how they work together.

Content Standard

Examine and make sense of the development, characteristics, processes, and interactions of living things and the natural environment.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.2.2.1	Investigate and explain the chemical reactions that occur in photosynthesis and cellular respiration and that results in cycling of energy.	**10.2.2.1**	Investigate how homeostatic balance occur ins in cells and organisms.
9.2.2.2	Investigate the different cell parts, their functions, and how they are specialized into different tissue and organs.	**10.2.2.2**	Explain the organization of life on Earth using the modern classification system.
9.2.2.3	Explain how cells are specialized in different tissues and organs.	**10.2.2.3**	Research how matter and energy flow through living systems and the physical environment.
		10.2.2.4	Examine the chemical reactions that occur in photosynthesis and cellular respiration and that result in cycling of energy.
		10.2.2.5	Explain how matter and energy flow through living systems and the physical environment.
		10.2.2.6	Examine the dynamic equilibrium in organisms, populations, and ecosystems and explain the effect of equilibrium shifts.
		10.2.2.7	Research different cell parts, their functions and how they are specialized into different tissue and organs.
		10.2.2.8	Assess how cells are specialized in different tissues and organs.
		10.2.2.9	Differentiate between the processes of mitosis and meiosis.

Unit 2. Animals

Rationale:

Reproduction is an essential biological mechanism for the continuity and diversity of species. Students compare sexual and asexual methods of reproduction in this cluster. They learn how the human reproductive system functions and describe the major stages of human development from conception to birth. Students recognize that the nucleus of a cell contains genetic information and is responsible for the transmission of traits from one generation to the next. They also discuss factors that may change a cell's genetic information, including environmental factors.

Content Standard

Examine and make sense of the development, characteristics, processes, and interactions of living things and the natural environment.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.2.2.4	Probe how cells are specialized in different tissues and organs.	**10.2.2.10**	Compare sexual and asexual reproduction in terms of their advantages and disadvantages for plant and animal species.
9.2.2.5	Investigate the different cell parts, their functions, and how they are specialized into different tissue and organs.		
9.2.2.6	Observe and explain the dynamic nature of cell division		
9.2.2.7	Investigate and describe environmental factors and personal choices that may lead to a genetic mutation or changes in an organism's development.		

Unit 3: Human Body

Rationale:

Reproduction is an essential biological mechanism for the continuity and diversity of species. Students compare sexual and asexual methods of reproduction in this cluster. They learn how the human reproductive system functions and describe the major stages of human development from conception to birth. Students recognize that the nucleus of a cell contains genetic information and is responsible for the transmission of traits from one generation to the next. They also discuss factors that may change a cell's genetic information, including environmental factors.

Content Standard:

Examine and make sense of the development, characteristics, processes, and interactions of living things and the natural environment.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.2.2.9	Outline human development from conception through birth.	**10.2.2.11**	Observe, collect, and analyze class data of single trait inheritance.
9.2.2.10	Describe the structure and function of the male and female human reproductive systems.	**10.2.2.12**	Explain the inheritance of sex-linked traits in humans and use a pedigree to track the inheritance of a single trait.
9.2.2.11	Describe the human menstrual cycle and fertilization and the related side effects on the human body.	**10.2.2.13**	Describe the relationships among DNA, chromosomes, genes, and the expression of traits.
9.2.2.12	Investigate the human skeletal system, functions and how bones heal when broken, including safety measures involved.	**10.2.2.14**	Differentiate between dominant and recessive genes.
9.2.2.13	Investigate the structure and functions of muscles, ligaments and tendons in human body and their roles in relation to movement of bones.	**10.2.2.15**	Investigate PNG and international contributions to research and technological development in the field of genetics and reproduction.
9.2.2.14	Investigate the composition and function of blood and blood cells, blood types and the heart and blood health related problems associated with these.	**10.2.2.16**	Discuss current and potential applications and implications of biotechnologies including their effects upon personal and public decision making.
9.2.2.15	Investigate the structure and functions of the human skin and the importance of care and maintenance.	**10.2.2.17**	Analyse the growth, division, parts and functions of cells and the process in terms of cellular respiration.
9.2.2.16	Investigate respiration as a chemical process in relation to energy release, diet and release of wastes.	**10.2.2.18**	Evaluate the similarities and differences between the different systems of the body and the how these are related to each other.
9.2.2.17	Explore the excretory organs of the body and how the body removes wastes including the kidney related problems and ways of prevention.		
9.2.2.18	Name and describe the components of the human body from cell to system and how they work together.		

Unit 4: Interactions and Relationships in the Environment

Rationale:

In this unit, students examine the complex relationships present in ecosystems in order to further investigate issues of sustainability. The large scale cycling of elements in biogeochemical cycles and the bioaccumulation of toxins in food chains are studied. Population dynamics are examined in the context of the carrying capacity and limiting factors of ecosystems. The concepts and implications of species biodiversity are explored as well. With the knowledge they have gained, students investigate how human activities affect an ecosystem and use the decision-making model to propose a course of action to enhance its sustainability.

Content Standard:

Examine and make sense of the development, characteristics, processes, and interactions of living things and the natural environment.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.2.2.19	Analyse the unity, diversity, and interrelationships between organisms, including their relationships to cycles of matter and energy in the environment.	**10.2.2.19**	Examine the components and the functions of a variety of macromolecules active in biological systems.
9.2.2.20	Investigate and interpret biogeochemical cycles within ecosystems.	**10.2.2.20**	Explore different types of biodiversity in an ecosystem.
9.2.2.21	Assess dynamic equilibrium in organisms, populations and ecosystems and explain the effect of equilibrium shifts.	**10.2.2.21**	Investigate water and carbon cycles in the ecosystem
9.2.2.22	Explore the population of organisms and how energy is transferred and distributed in each of the energy levels between organisms in an ecosystem.		

Strand 3: Physical Science

Rationale

The Physical Science is the study of matter, energy and the changes they undergo. The universe is composed of matter. Some branches of physical science are chemistry and physics. Chemistry is the study of the properties of how matter changes. Whereas, physics is the study of matter, energy, motion and forces and how they interact.

Evidence Outcomes

Grade-Level Evidence-Outcomes	
Grade 9	**Grade 10**
At the end of grade 9, all students can; • Evaluate ways of solving problems that involve constant speed and average speed. • Demonstrate and explain why objects continue to move at a constant speed or stay at rest (Newton's first law). • Apply the law F = ma to solve one-dimensional motion problems that involve constant forces (Newton's second law). • Demonstrate and explain why when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law). • Explain and analyse the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth. • Demonstrate and explain why applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed. • Verify that circular motion requires the application of a constant force directed toward the centre of the circle. • Calculate kinetic energy by using the formula $E=mv^2/2$. • Calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) = mgh (h is the change in the elevation). • Solve problems involving conservation of energy in simple systems, such as falling objects. • Calculate momentum as the product mv. • Solve problems involving elastic and inelastic collisions in one dimension using the principles of conservation of momentum and energy. • Explain that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.	At the end of grade 10, all students can; • Evaluate ways of solving problems that involve constant speed and average speed. • Demonstrate and explain why objects continue to move at a constant speed or stay at rest (Newton's first law). • Apply the law F = ma to solve one-dimensional motion problems that involve constant forces (Newton's second law). • Demonstrate and explain why when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law). • Explain and analyse the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth. • Demonstrate and explain why applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed. • Verify that circular motion requires the application of a constant force directed toward the centre of the circle. • Calculate kinetic energy by using the formula $E=mv^2/2$. • Calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) = mgh (h is the change in the elevation). • Solve problems involving conservation of energy in simple systems, such as falling objects. • Calculate momentum as the product mv. • Solve problems involving elastic and inelastic collisions in one dimension using the principles of conservation of momentum and energy.

Grade 9	Grade 10
• Determine that the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object. • Conclude that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly. • Explain entropy as a quantity that measures the order or disorder of a system and that this quantity is larger for a more disordered system. • Solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings. • Deconstruct the logic of waves carrying energy from one place to another. • Examine transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves). • Verify sound as a longitudinal wave whose speed depends on the properties of the medium in which it propagates. • Establish that radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second). • Solve problems involving wavelength, frequency, and wave speed. • Verify sound as a longitudinal wave whose speed depends on the properties of the medium in which it propagates. • Investigate the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and tilization .	• Explain that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy. • Determine that the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object. • Conclude that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly. • Explain entropy as a quantity that measures the order or disorder of a system and that this quantity is larger for a more disordered system. • Solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings. • Deconstruct the logic of waves carrying energy from one place to another. • Examine transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves). • Verify sound as a longitudinal wave whose speed depends on the properties of the medium in which it propagates. • Establish that radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second). • Solve problems involving wavelength, frequency, and wave speed. • Verify sound as a longitudinal wave whose speed depends on the properties of the medium in which it propagates. • Investigate the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and tilization .

Unit 1: Energy

Rationale:

(Nature of Electricity)The conceptual development of the particle model of electricity underlies an understanding of electrostatics and current electricity. To develop and test this model, students construct simple devices like an electrophorus and investigate electrostatic phenomena. A transition from static to current electricity enables the learner to investigate circuits and make connections to daily applications like the cost of electrical energy and the safety and efficiency of electrical appliances.

Additionally, students investigate hydroelectric power and address sustainability issues associated with the generation and transmission of electricity in PNG.

Content Standard:

Students will be able to explain and examine the structure, properties, and changes of matter as well as sources, uses, conservation, and changes of energy.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.3.3.23	Calculate kinetic energy by using the formula $E=\frac{mv^2}{2}$	**10.3.3.22**	Establish that heat flow and work are two forms of energy transfer between systems.
9.3.3.23	Calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) = mgh (h is the change in the elevation).	**10.3.3.23**	Explain that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.
9.3.3.24	Solve problems involving conservation of energy in simple systems, such as falling objects.	**10.3.3.24**	Determine that the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.
9.3.3.25	Examine how to calculate momentum as the product mv.	**10.3.3.25**	Explain entropy as a quantity that measures the order or disorder of a system and that this quantity is larger for a more disordered system.
9.3.3.26	Explain and differentiate momentum as a separately conserved quantity from energy.	**10.3.3.26**	Establish that the statement "Entropy tends to increase" is a law of statistical probability that governs all closed systems (second law of thermodynamics).

9.3.3.27	Reason that an unbalanced force on an object produces a change in its momentum.	**10.3.3.27**	Solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings.
9.3.3.28	Solve problems involving elastic and inelastic collisions in one dimension by using the principles of conservation of momentum and energy.	**10.3.3.28**	Deconstruct the logic of waves carrying energy from one place to another.
9.3.3.29	Understand the nature of matter and energy, forms of energy, including waves and energy transformations.	**10.3.3.29**	Examine transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
9.3.3.30	Explain how the law of conservation of energy is applied to various systems.	**10.3.3.30**	Solve problems involving wavelength, frequency, and wave speed.
9.3.3.31	Compare transverse and longitudinal waves and their properties.	**10.3.3.31**	Verify sound as a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
9.3.3.32	Explain and provide examples of electromagnetic radiation and sound using a wave model.	**10.3.3.32**	Establish that radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×□10□^8 m/s (186,000 miles/second).
9.3.3.33	Explain the parallel circuits, the components, and the safety aspects of household wiring.	**10.3.3.33**	Investigate the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.
9.3.3.34	Use appropriate instruments and units to measure voltage (electric potential difference), current, and resistance.	**10.3.3.34**	Examine how conservation of energy is appli8d to various systems.
9.3.3.35	Analyze the electrical energy consumption of a household appliance.	**10.3.3.35**	Explain how elements are arranged in the periodic table and analyse trends among elemental properties.
9.3.3.36	Compare and contrast voltage (electric potential difference) and current in series and parallel circuits.	**10.3.3.36**	Investigate how conservation of energy is applied to various systems.
		10.3.3.37	Demonstrate and explain the like nature of electrostatics and current electricity.
		10.3.3.38	Construct one or more electrostatic apparatus and explain how they function using the particle model of electricity.
		10.3.3.39	Investigate and describe qualitatively the relationship among current, voltage (electric potential difference), and resistance in a simple electric circuit.
		10.3.3.40	Define voltage (electric potential difference) as the energy per unit charge between two points along a conductor and solve related problems. Include: V = E / Q

Unit 2: Force and Motion

Rationale:

In order to develop an understanding of the physics of motion, the outcomes of this unit are examined within the context of the automobile. The relationships among displacement, velocity, acceleration, and time are analyzed in conceptual, numerical, graphical, and symbolic modes. Students investigate the qualitative aspects of inertia, force, impulse, and momentum as they relate to automobile safety. The conservation of energy in car collisions and braking distance is explored. Using the knowledge they have gained, students use the decision-making process to address issues related to safe driving conditions and public safety.

Content Standard:

Students will be able to explain and examine the structure, properties, and changes of matter as well as sources, uses, conservation, and changes of energy.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.3.3.37	Evaluate ways of solving problems that involve constant speed and average speed.	**10.3.3.41**	Establish that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
9.3.3.38	Examine the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth.	**10.3.3.42**	Apply the law F = ma to solve one-dimensional motion problems that involve constant forces (Newton's second law).
9.3.3.39	Demonstrate and explain why applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (e.g., Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).	**10.3.3.43**	Verify that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).

Unit 3: Matter

Rationale:

This unit provides students with the opportunity to examine the interactions among elements as they form compounds through chemical reactions. Students become familiar with the formulas and naming of binary compounds, and investigate the Law of Conservation of

Mass. The recognition that mass is conserved in chemical reactions allows students to balance equations with both words and symbols, and classify them by type. The principles of acid-base chemistry are studied and extended to large-scale environmental interactions. Students investigate the use of chemistry in biological, industrial, and domestic settings, recognizing that chemical use is pervasive in modern society.

This cluster builds on the particle theory of matter learned in previous grades. Students become familiar with the basic constituents of matter by learning about the historical development of the atomic model and the periodic table. Various investigations of the properties of elements and compounds will acquaint students with chemical symbols and families, as well as with natural phenomena and everyday technologies that demonstrate chemical change.

Content Standard:

Students will be able to explain and examine the structure, properties, and changes of matter as well as sources, uses, conservation, and changes of energy.

Grade 9 Benchmarks		Grade 10 Benchmarks	
9.3.3.40	Distinguish between physical and chemical properties.	**10.3.3.44**	Examine how conservation of energy is applied to various systems.
9.3.3.41	Differentiate between elements and compounds.	**10.3.3.45**	Explain how elements are arranged in the periodic table and analyse trends among elemental properties.
9.3.3.42	Distinguish between mixtures and pure substances.	**10.3.3.46**	Investigate how atoms bond using valence electrons.
9.3.3.43	Find the mass of an element in a given compound.	**10.3.3.47**	Relate the properties of materials to their atomic structure.
9.3.3.44	Describe elements and compounds.	**10.3.3.48**	Connect local technologies, including the tilization and preservation of materials, to either causing or controlling changes in matter.
9.3.3.45	Establish and validate the basic assumptions of the atomic theory.	**10.3.3.49**	Name and write chemical formulas and balance chemical equations.
9.3.3.46	Investigate the properties of different states of matter in terms of the motion and regulation of atoms and molecules	**10.3.3.50**	Determine and explain the empirical formulas of compounds.
9.3.3.47	Analyze properties and composition of different groups of elements in the periodic table.	**10.3.3.51**	Calculate empirical formulas.
9.3.3.48	Investigate electrical conductivity of ions in solutions	**10.3.3.52**	Analyze relationship between the structure, bonding and properties of matter.
9.3.3.49		**10.3.3.53**	Examine the basic characteristics of acids, bases, salts and organic and inorganic compounds.

Assessment, Monitoring, and Reporting

The relationship between content standards, benchmarks and performance standards is that they all define students' expected level of proficiency or education quality but at different levels of schooling. Content standards describe the national expectations that all Papua New Guinean children are expected to meet while benchmarks describe the grade-level expectation that all students in a particular grade must meet before proceeding to the next grade. Conversely, performance standards describe students' level of proficiency in a specific knowledge, skill, value or attitude taught in a lesson and measure students' progress towards meeting grade-level expectations and the content standards. Effective instruction and assessment are aligned to performance standards, grade-level expectations, and national content standards.

What is Assessment?

The term "assessment" is generally used to refer to all activities that teachers use to assess students' mastery of what is learned, and to measure and monitor students' progress towards meeting grade-level expectations and the content standards. Assessment is an on-going process of gathering and interpreting information about students' performance and progress towards meeting grade-level expectations as well as the achievement of the content standards described in the subject syllabuses. Data should also be used to help and guide students who are yet to meet grade-level and national expectations to make the required progress towards meeting these expectations.

What is Standards-Based Assessment?

In standards-based curriculum, 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) and measuring, monitoring, evaluating, and reporting their progress towards meeting grade and national-level expectations. Assessment is viewed not only as a measurement activity that is performed after a course or a curriculum topic has been taught (summative), but more importantly, as a continuous process (formative) that provides students' performance data to teachers and students regarding their progress towards achieving the intended standards. Timely and ongoing assessment of student's learning and mastery of what is learned are key to the learning process and the attainment of the desired learning outcomes.

Throughout the year, teachers will be assessing students' performance and progress towards meeting each grade-level benchmark (grade-level expectation) and each content standard (national-level expectation), and using the data to identify areas where a student or a group of students need more attention, and monitor their progress towards meeting the required standards.

Purpose of Assessment

The primary purpose of assessment is to improve students' learning and teachers' teaching. The other purposes of assessment are to:

- improve students' learning, levels of proficiency, and progress towards meeting the expected standards;
- provide data that teachers, schools and Department of Education can use to make informed decisions about how to improve the quality of teaching and learning in the education system;
- inform teachers about the progress of students towards meeting grade-level and national expectations (standards) and enable them to adjust their lesson planning, instruction, and assessment to improve student learning and proficiency levels;
- inform parents and guardians about their children's achievements and status of progress towards meeting national standards; and what needs to be done to close the gaps and enable children to make the progress required to meet these standards, and
- provide information for schools and systems about teaching strategies, resource allocations and curriculum; and other educational institutions, employers and the community about the achievements of students in general or of particular students.

Whatever its purpose, assessment is seen as an integral part of the teaching and learning program rather than a separate process.

Types of Assessment

The following types of assessment have been adopted to assess and monitor students' achievement of the education standards.

- Assessment FOR learning
- Assessment OF learning
- Assessment AS learning

Assessment for and assessment of learning are also known as formative and summative assessments.

Assessment FOR Learning

Assessment for learning, also known as classroom assessment is different. It is an ongoing process that arises out of the interaction between teaching and learning. It is not used to evaluate learning but to help learners learn better. It does so by helping both students and teachers to understand:

- the performance standards, grade-level benchmarks and content standards that students are expected to meet to achieve the desired level of proficiency or quality of education;
- where each learner is in relation to the national curriculum standards;

- where they need to be, and
- what they need to do to make progress towards meeting the expected standards.

Assessment OF Learning

Assessment of learning is the use of a task or an activity to measure, record, and report on a student's level of achievement in regards to specific learning expectations such as unit tests and end of term or year exams. It is normally referred to as Summative Assessment.

Assessment AS Learning

Assessment as learning is the use of an assessment task or an activity by the teacher in his/her everyday teaching. This strategy provides students with opportunities to understand what they have learnt or are having difficulties with. Self and peer assessments allow students to reflect on their own learning and identify areas of strengths and weaknesses. These tasks offer students the chance to set their own personal goals to improve their own learning.

Diagnostic Assessment

Apart from these three main types of assessment, teachers are expected to do the diagnostic test/assessment to identify strengths and weaknesses in students. This can be done before any teaching and learning of a new content and for new entry levels for students.

Diagnostic assessment is a form of pre-assessment that allows a teacher to determine students' individual strengths, weaknesses, knowledge, and skills prior to instruction. It is primarily used to diagnose student difficulties and to guide curriculum and lesson planning.

Assessment Methods

These are some methods that teachers can use to assess students' performance.

- Observing students during the lesson
- Conferencing with students
- Student's Portfolio
- Tests
- Assignments (projects/reports/quizzes/presentations/practical work samples)

Recording and Reporting

Recording

Teachers must keep accurate records of students' performance and achievements. They must report these achievements in fair and accurate ways to parents, guardians, teachers and students. Examples of recording methods include:

- anecdotal notes in a journal or diary;
- checklists;
- portfolios of students' work;
- progressive records, and
- work samples with comments written by the teacher.

Reporting

Reporting is communicating clearly to students, parents, guardians, teachers and others the information gained from assessing students' learning.

Students' reports should be based on assessment information collected from ongoing assessments. Schools will decide on how best the reports will be presented to suit the needs of their communities. Methods will include interviews and written reports. Written reports should include:

- a written record of progress made towards meeting grade-level expectations and the attainment of content standards by each student since the previous report;
- a written record of each student's learning and mastery problems and what needs to be done to make the required progress towards meeting grade-level benchmarks and national content standards, and
- information about students' attitudes, values and general behaviour.

Monitoring and Evaluation

Assessment information should be used to make judgments about students' achievements and monitor their progress towards meeting grade-level expectations and national content standards.

Monitoring

Data from performance assessment should be used to monitor and report on students' performance towards meeting grade-level and national expectations. Performance standards or indicators should be used to report and keep a tab on each students' progress towards meeting the expected level of proficiency or competency. Teachers should develop a clear and measurable set of performance standards or indicators to monitor and report on students' progress and achievements on a regular basis.

Evaluation

Teachers should use assessment data to evaluate the effectiveness of their teaching and their students' learning, and make improvements to their teaching practices in order to improve student learning outcomes. Evaluation tools such as written records, questionnaires, logs and diaries, submissions or records of meetings and discussion with general staff members, teaching staff, parents and other community members should be used to evaluate students and teachers' competency levels, and make informed decisions about how these could be improved.

Glossary of terms

Terms	Definitions
Abiotic factor	The nonliving part of an ecosystem
Allele	One of different forms of a gene for a trait
Ampere (A)	The units used to measure the amount of electric current flowing in a conductor
Amplitude	The maximum distance a wave varies from its rest position
Angiosperm	A vascular plant that produces seeds from flowers
Assessment	Activities given to students to measure the progress of their learning
Assessment Strategies	Different styles and ways of assessing students work
Assessment Tasks	Test of knowledge and skills gain throughout the particular unit or topic
Benchmark	Assessment of content standards at the end of each level of schooling
Biochemistry	The study of chemistry of living things such as plants, animals or people
Biomass	Once- living matter that can be used as an energy source
Biotechnology	The use of cells and bacteria in chemical processes, especially in food and chemical industries
Buoyant force	An upward force applied by a fluid on an object in the fluid
Chromosomes	Thread-like structures found in the nucleus of cells. They contain the instructions to run the cell. The number of chromosomes in the nucleus is constant for each species, eg, humans have 46.
Concentration	The amount of a particular solute in a given amount of solution
Conferencing	A conversation between the teacher and student or in small groups
Constants	The factors in an experiment that remain the same
Content Standards	Statements that describe what students should know and do in each subject area
Control test	A test or experiment where controls and variables are used
Convection current	A loop of moving gas or liquid caused by rising warm gas or liquid and sinking cool gas or liquid
Cytoplasm	Materials that surround the internal parts of the cell
Decibel (dB)	The units used to measure the loudness of sound
Diagnostic Assessment	An assessment given to identify child's strengths and learning needs for improvement.
Dichotomous key	A tool used to identify organisms based on contrasting pairs of characteristics
Diffusion	Process that spreads substances through a gas or liquid from higher to lower concentration
Displacement	The difference between the initial, or starting position and the final position of an object that has moved
DNA	Deoxyribonucleic acid- the genetic material of all living things
Doppler effect	The change of pitch when a sound source is moving in relation to an observer
Efficiency	The ratio of output work to input work
Electromagnetic spectrum	The band of radiation that includes radio waves, microwaves, infrared radiation, visible light, x-rays, ultraviolet light, and gamma rays
Electron	A negatively charged particle in an atom
Endothermic reaction	A reaction in which energy is absorbed
Enzyme	A chemical found in living things that helps control which chemical reactions are to take place

Enzyme	A catalyst that speeds up chemical reactions in living things
Epicenter	A point on the Earth's surface directly above the location of initial plate boundary movement during an earthquake
Fission	A nuclear reaction in which atomic nuclei split and release energy
Frequency	The number of wavelengths that pass by a point each second
Fusion	The forcing of two small atomic nuclei to join together thus releasing energy
Gene	A part of a cell that is passed on from parent to child and that controls particular characteristics
Genetic code	The sequence of three (3) bases (called a triplet or codon) along the DNA or RNA that specifies the next amino acids in the protein
Global Positioning System (GPS)	A worldwide navigation system that uses satellite signals to determine receiver's location
Gymnosperm	A vascular plant that produces seeds, but not flowers or fruits
Hazards	A situation that poses a level of threat to life, health, property or environment
Heterogeneous	Mixed unevenly
Homogeneous	Mixed evenly
Homologous structures	Structures that are similar in different species
Hormone	The chemical message that travels through the blood and carries special information for certain cells
Hydrocarbon	A compound that contains only carbon and hydrogen atoms
Hydroelectric energy	Electric energy generated from moving water
Hypothesis	A theory or suggested explanation for something that has not yet been proven.
Immune system	An organ system that fights disease and foreign agents
Inertia	The tendency of an object to resist a change in its motion
Ion	An atom that has a different number of electrons than protons
Isotopes	Atoms with the same number of protons but different number of neutrons
Longitudinal wave	A wave in which particles move back and forth in the same direction as the wave travels
Meiosis	Cell division that reduces the number of chromosomes by half.
Menstruate	The special type of cell division which produces the sex cells (sperm and ova). Each sex cell contains half the number of chromosomes normally found in a body cell.
Metalloid	To have a monthly flow of blood from the uterus
Mitosis	An element that has physical and chemical properties of both metals and nonmetals
Molecules	The stage in the cell cycle during which the nucleus divides
Momentum	The smallest unit of a substance, consisting of one or more atoms.
Mutation	When something continues to move, speed or gain speed.
Mutation	Any change in a genome or a chromosome
Natural phenomena	A permanent change in the genes of an organism, or an organism with such a change
Natural selection	Things that happen naturally such as movement of stars, tides, and
Natural selection	The process by which the organisms that are best adapted to their environment survive and reproduce
Nitrogen fixation	The way the plants and animals die when they are weak or not suitable for the pace where they live, while the stronger ones continue to exist.
Nonvascular	The process of Nitrogen gas changing into usable nitrogen compounds

Nuclear energy	Is the energy stored in the nucleus of an atom. It is the energy that holds the nucleus together. The nucleus of Uranium atom is an example of nuclear energy.
Nucleus	A part of a cell that directs all activities and carries information for cell reproduction
Observations	A careful watch over and experiment using Science as Inquiry skills
Opaque	Not letting light pass through
Optical telescope	An instrument that gathers light to form an enlarged image of a distant object
Organ	Two or more type of tissue that work together to perform a function
Organelle	A structure that has a specific task within the cell
Osmosis	A type of diffusion that allows water to pass but not the solutes in the water
Parasitism	The relationship in which one organism lives in or on another organism and harms it in some way.
Performance Standards	What students must do to demonstrate proficiency
Periodic table	The table that arranges the elements according to atomic number
pH scale	System of measuring the strength of different acids and bases
Phagocyte	A cell that consumes harmful invading organisms in your body
Photon	A particle of electromagnetic radiation
Plate boundary	The edge of a tectonic plate
Polymer	A substance made of giant molecules formed by the joining of many simple molecules (monomers). For example, the addition polymer polyethylene, or the condensation polymer nylon
Portfolio	Collections of student work that exhibit the students' efforts, progress and achievements in one or more areas
Practical Tasks	Activities involving students to display or do both indoor and outdoor
Precipitation	Any form of water that falls to earth's surface from clouds
Predation	Interaction in which one organism catches and feeds on an organism of another species
Pressure	The amount of force exerted per unit area
Protist	A single-celled or multicellular organism that may share characteristics with plants, fungi and animals
Proton	A positively charged particle in the nucleus of an atom
Radiation	When a substance emits electromagnetic waves that carry energy
Rarefaction	The region of a longitudinal wave where the particles of the medium are farthest apart
Recording	An act of collecting and entering of raw scores from students through assessable tasks
Reflection	Light bouncing off a surface
Refraction	The bending of light rays when they bounce from one material to another
Relationships	The connection between two or more organisms and their involvement with one another including their abiotic environment
Replication	The process of making identical copies of DNA
Reporting	to present parents and guardians correct information about students' academic performance
Revolution	Complete orbit around an object
Ribosome	A cell structure where proteins are manufactured
Rotation	A complete turn about an axis
Science process skills	Is the energy stored in the nucleus of an atom. It is the energy that holds the nucleus together. The nucleus of Uranium atom is an example of nuclear energy.

Sea-floor spreading	A part of a cell that directs all activities and carries information for cell reproduction
Secondary succession	A careful watch over and experiment using Science as Inquiry skills
seismic	Not letting light pass through
Seismic wave	An instrument that gathers light to form an enlarged image of a distant object
Self – Assessment	Two or more type of tissue that work together to perform a function
Sonar	A structure that has a specific task within the cell
Sound	A type of diffusion that allows water to pass but not the solutes in the water
Students Records	The relationship in which one organism lives in or on another organism and harms it in some way.
Sustainability	What students must do to demonstrate proficiency
Symbiosis	The table that arranges the elements according to atomic number
Tectonic plate	System of measuring the strength of different acids and bases
Tests	A cell that consumes harmful invading organisms in your body
Thermal equilibrium	A particle of electromagnetic radiation
Thermal expansion	The edge of a tectonic plate
Transverse wave	A substance made of giant molecules formed by the joining of many simple molecules (monomers). For example, the addition polymer polyethylene, or the condensation polymer nylon
Transverse wave	Collections of student work that exhibit the students' efforts, progress and achievements in one or more areas
Trophic level	Activities involving students to display or do both indoor and outdoor
Use variable	Any form of water that falls to earth's surface from clouds
Vaporization	Interaction in which one organism catches and feeds on an organism of another species
Variable	The amount of force exerted per unit area
Wavelength	A single-celled or multicellular organism that may share characteristics with plants, fungi and animals
X-ray	A positively charged particle in the nucleus of an atom

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