Science

Biology, Chemistry, Physics and General Science

Years 9-12

Samoa Secondary School Curriculum

Curriculum Design and Materials Division
Ministry of Education, Sports and Culture
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Science. Years 9-12
Samoa Secondary School Curriculum

Curriculum Design and Materials Division (CDMD)
Ministry of Education, Sports and Culture (MESC)

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Contents

Introduction

Science is fundamental to an understanding of our physical, chemical and biological world as it affects every aspect of our daily lives. It is a disciplined body of knowledge with a systematic approach to enquiry and problem solving. Science education promotes the use of investigative approaches. It provides opportunities for students to acquire knowledge and understanding by undertaking their own practical investigations and studying the findings of others.

The Science curriculums for secondary education allows students to make connections between what they learn in the classrooms to their everyday lives and local environments. It provides opportunities for stimulation of critical thinking and develops conceptual understanding and applications of science concepts to local and global environments.

Science has always been in our Samoan society and culture. For example, the process of preparing the u'a and weaving of fine mats and tapa is science, making 'umu' is an application of science, making 'fa'amafu' is another application, carving and construction of traditional 'paopao' is also science.

Two imminent threats to our society and islands are climate change which bring to our shores rising sea levels, retreating coastal boundaries, frequent flooding and devastating hurricanes. These have destroyed the livelihoods of our people and villages, and diseases and epidemics like the measles and COVID-19 that have affected our people's well-being and health and currently impacting on our economy respectively. It is therefore increasingly important for our students to be equipped with the knowledge, skills, attitudes and values that will assist them to not only make informed decisions and judgements when confronted by challenges that threaten to uproot our society and people, but also to preserve our traditions and cultures and help ensure the sustainability and proper maintenance of Samoa's limited natural resources.

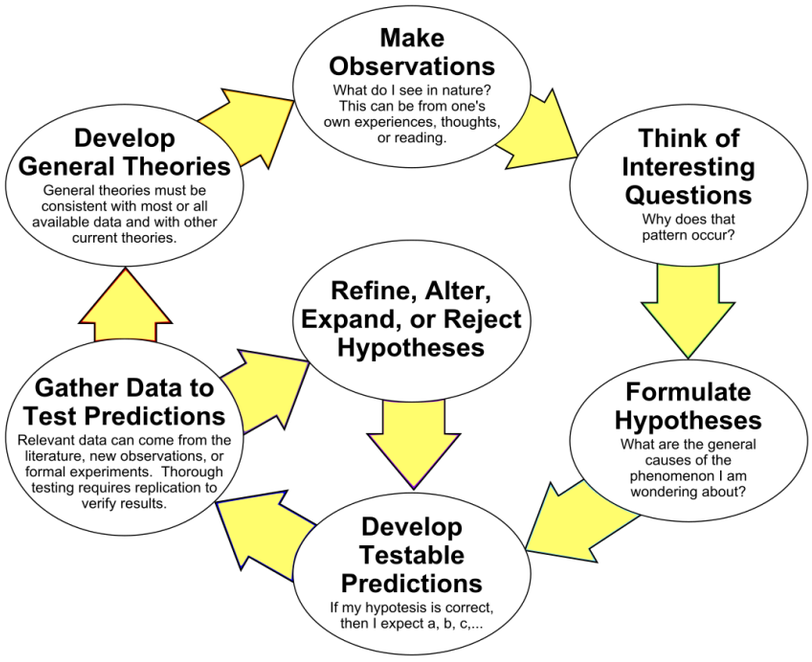
Knowledge is understanding the theories and concepts that comprise science. Skills are the methods of enquiry and investigation in Science derived and developed from the knowledge. Attitudes and values are the appreciation of scientific knowledge and its applications and uses and acknowledging its limitations wherever and whenever such occurs.

It is a fact that science is not an independent discipline as it is closely connected to various fields of study where there are integrating and interrelated principles, facts and concepts as well as applications. For example, Geography, Biology and Chemistry are connected in climate and vegetation as in Agricultural Science.

Science thus revolves around all aspects of life and so the development of scientific knowledge and methods is an ongoing process because new hypotheses and thinking lead to new predictions, new theories and new methods.

FIGURE 1

The scientific method as an ongoing process



Structure of the Science Curriculum

This Science curriculum statement is organized around the following;

- **General Aims:** general statements outlining the purposes of studying Science.
- **Strands:** categories used to organize concepts into branches of learning.
- **Specific aims:** statements relating to several key ideas that are foundational concepts for each strand and expected of students s to understand and learn.
- **Major Learning Outcomes:** descriptions of specific outcomes derived from specific aims that relate to the knowledge or skill that students are expected to understand and achieve.
- **Learning outcomes:** statements of the learning students should be able to demonstrate as a result of a learning experience.
- **Approaches to teaching and learning:** strategies to support the teaching and learning.
- **Assessment and evaluation:** types of assessment and evaluation practices to gauge and measure students' progress as well as the success of teaching methodologies.
- **Essential Skills:** broad skills that are developed throughout the years of schooling.
- **Key and Curriculum Principles:** key and curriculum principles from the National Curriculum Framework.
- **Values:** the internal beliefs and attitudes of an individual or a group of individuals that are used to respond to everyday situations.
- **Language:** the use and maintaining of science language as in contents.
- **Gender:** the behaviours and attitudes that are culturally accepted and respected as the natural ways of being a female and of being a male.
- **Inclusive Education:** the curriculum needs to cater for all students of different calibers and abilities including physical abilities.
- **Time allocation:** minimum hours of teaching required for all levels.
- **Safety:** importance of safety and implications in teaching and learning Science.

The structure of this Science Curriculum is illustrated in the following diagram.

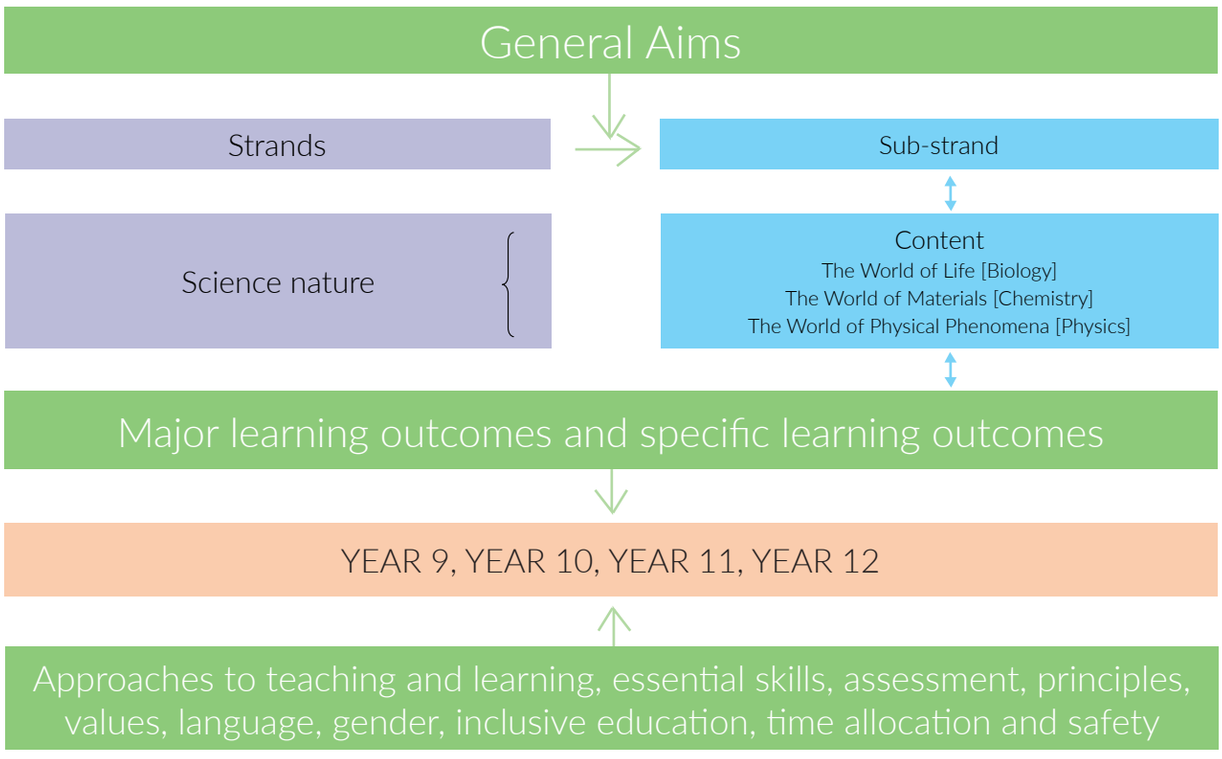


FIGURE 2

The structure of this Science curriculum

Key Principles

The key principles as listed in the National Curriculum Framework underpin all aspects of Samoan education. This includes the development of curriculums. The key principles are:

- **Equity**: equity requires that the system treats all individuals fairly and justly in the provision of educational services.
- **Quality**: educational quality is exemplified by high standards of academic achievement, cultural understanding and social behaviour and results from a complex interplay of professional and technical factors and social and cultural practices.
- **Relevance**: a system that is meaningful, recognized, applicable, and useful to one's life. It should enhance individual and community well-being and ultimately national development.
- **Efficiency**: demonstrated by leadership and management practices that ensure optimum use of resources- human, financial and material- at all levels, efficient service delivery, effective communication and coordinated and transparent decision-making.
- **Sustainability**: the wise use of human, financial and material resources to ensure balanced and continual developments in the system with necessary transparency and accountability in place at all levels.

Science Curriculum Principles

The Science curriculum is based on the Principles of the Samoa Secondary School Curriculum as stated in the Samoa Secondary School Curriculum Overview Document and the key and curriculum principles as outlined in the National Curriculum Framework. The principles are that the curriculum:

- provides a challenge for all students of different calibers and abilities and allows for individualism in learning;
- fosters and enhances the self-concept of all learners, and encourages them to be self-directed in their learning;
- provides all learners with a broad and balanced general science education;
- provides learners with opportunities to localize applications of the Science they learn and apply to the Samoan traditions and environments;
- will be responsive to changes so that it is relevant to needs of the individual learner, the well-being of the community, and ultimately national developments;
- provides for flexibility, taking into account the context in which schools operate and the resources available to them;
- establishes a direction for learning and ensures each learner's school experience progresses in a systematic and coherent way;
- promotes the presentation of essential knowledge by means of a systematic bilingual methodology;
- promotes language learning in all areas of the curriculum;
- encourages the use of good assessment practices;
- reflects the need to be inclusive.

This Science curriculum statement sets out progressions of skills and knowledge for secondary students. This curriculum statement applies to:

- all secondary schools in Samoa;
- all students regardless of gender, ethnicity, belief, ability, social or cultural background;
- years 9-12 of secondary schooling.

Each school provides programmes of learning based on this national curriculum with improvisation, innovation and adaptation where needed in response to availability of both human and teaching/learning resources as well as making use of the local learning surroundings.

The Science curriculum statement should therefore be considered a GUIDE for teachers to plan programmes for teaching Science in secondary schools. The learning programmes must provide learning activities and opportunities for students to achieve as much as possible the standards and learning outcomes set out in this national curriculum.

This curriculum statement covers Year 9 Science, Years 10-12 General Science, Biology, Chemistry and Physics.

Learning Pathways

This Secondary Science curriculum is designed to offer two streams of sciences for students beginning at Year 10:

Stream 1 is the pure sciences (Biology, Chemistry and Physics) for students who opt to follow a career pathway by pursuing post-secondary pure Science education at Foundation Year at the National University or elsewhere, leading to tertiary studies in fields where pure Science background is an entry requirement.

Stream 2 iis the General Science for students who choose to follow a career pathway by pursuing post-secondary education where the depth, level of difficulty and complexity of Science contents are not necessarily required. For example, primary teaching, nursing, TVET or PSET education and trainings.

The approach "Science for all' is taken into consideration to ensure that all students benefit from exposure to some level of Science education so they are equipped with the knowledge that they can use in everyday lives, rather than just those who intend to pursue careers in the pure Sciences stream.

The following diagram illustrates the progression and options offered from Year 9 to Year 12.

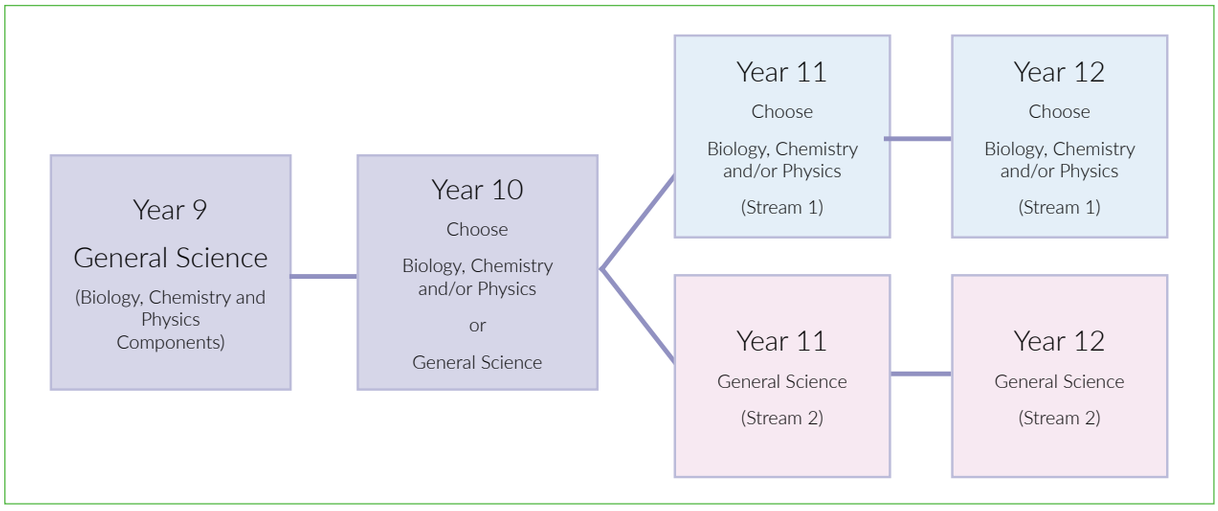


FIGURE 3

Progression and options offered from Year 9 to Year 12

General Aims

The general aims of this Secondary Science curriculum are to provide opportunities for students to:

- develop scientific understanding of the world around them to enable them to make informed and sustainable decisions, judgements and solutions for their own livelihoods;
- foster their scientific literacy skills to enable them to participate in Science- related debate on issues impacting their local environments and lives;
- learn how everything in their environments is integral and linked to science;
- develop critical thinking, investigative and problem solving skills;
- develop a progressive understanding of science concepts to build the foundation for career pathways in science or science related fields;
- understand the links between all areas of science.

Strands

This Secondary Science curriculum is comprised of three strands. The strands are:

- THE WORLD OF LIFE [BIOLOGY]
- THE WORLD OF MATERIALS [CHEMISTRY]
- THE WORLD OF PHYSICAL PHENOMENA [PHYSICS]

Important Notes

The contents of the strand "The World and Beyond" have been integrated into the strand "The World of Life" and the strand 'The World of Materials" depending on the category to which the concepts belong.

The contents of each strand have been rearranged progressively to ensure students achieve one concept and skill before moving to the next. Likewise, the strands for each level have been arranged alongside each other to ensure the logical progression from one level to the next and that the learning outcomes are made explicit.

Sub-strands

Each strand has specific aims. These aims group the achievement objectives at each year or level.

1. In their study of the WORLD OF LIFE students will investigate and develop their scientific knowledge and understanding of the:

- Variety of lLife
- Cell biology
- Animal biology
- Plant biology
- Environment

2. In their study of the WORLD OF MATERIALS students will investigate and develop their scientific knowledge and understanding of:

- The ways materials are structured (atomic structure and bonding)
- The properties and uses of groups of substances (for years 9-10 only)
- The ways materials change
- [Principles of chemical changes/Inorganic Chemistry]
- Quantitative Chemistry (for years 11-12 only)
- Organic Chemistry (for years 11-12 only)
- Principles of Physical Chemistry (for years 11-12 only)
- Environmental cChemistry (for years 11-12 only)

3. In their study of the WORLD OF PHYSICAL PHENOMENA students will investigate and develop their scientific knowledge and understanding of the:

- Energy/waves
- Electricity/electrical energy
- Magnetism/electromagnetism
- Forces and motion

Major Learning Outcomes and Learning Outcomes

Samoa's education curriculums are outcomes-based. An outcomes-based curriculum clearly identifies the knowledge, skills, attitudes and values that all students should be able to acquire and demonstrate at each year level in each subject of study. Teachers are able to teach and students are able to learn effectively when the learning outcomes are made explicit.

The learning outcomes are what students should be able to demonstrate they know and can do using the knowledge and understanding of the contents they learn, and ensure that students realize their individual capability as they progress from one level to next.

The learning outcomes enable teachers to closely monitor the progress of students, so that appropriate counseling and interventions are provided whenever needed and report to parents accordingly. The achievement objectives, relating to the specific aims, are outlined within each strand explicitly showing the knowledge and essential skills which students should develop and achieve as a result of their active engagement with the Science contents through a variety of activities and experiences.

Approaches to Teaching and Learning

Teaching and learning is a process by which new understandings are formulated and constructed. Students learn best in Science when they take action themselves to generate and create meaning of what they are learning, and to apply the new knowledge in relatable situations in their local environments and the global world. The approaches to teaching and learning should focus therefore on:

- creating opportunities for exploration, experimentation, observation and communication of their findings;
- allowing flexibility and freedom for the students to contribute to the planning of their own learning whenever possible;
- allowing opportunities for students to ask questions and receive answers or engage in active discussions with peers on questions raised;
- engaging students in active construction of ideas and activities that develop their abilities to learn;
- creating opportunities and activities in which students can relate to what they are learning and see the relevancy to their own lives and environments;
- creating opportunities to build students' confidence to present their thinking and findings or projects individually or in groups in their own articulate accounts of their experiences or findings.

In addition to the Science-specific approaches above, there are also general approaches that are part and partial of everyday teaching and learning. These approaches include, but not limited to:

- discussing with students the achievement objectives and learning outcomes and success criteria to achieve them;
- recognizing that learning is demonstrated and communicated through oral and written academic language that should be explicit and articulate;
- adopt the three R's – Read, Research and React as a proactive strategy for studying ahead of schedule. Read the material before the teaching is delivered, research by finding out more about what has been read and then react by self testing one's own understanding, and noting down what is not understood to discuss with teachers;
- allowing ample time to provide feedback and formulate responses and actions to eliminate obstacles to students' progress and/or enhance successful learning.

Assessment and Evaluation in Science

The National Curriculum framework recognises the relationship between all aspects of a curriculum and methods of assessment because assessment is the cornerstone of outcomes-based learning in all subjects, and it is an integral part of teaching and learning in every classroom. It is the process of collecting and evaluating evidence of students' learning in order to determine the progress of students, and to inform judgements and interventions to improve students' performances.

An outcomes-focused Science approach to assessment should involve, but not limited to the following:

- constructing a range of assessment practices to provide useful information on students' progress against the achievement

objectives stated in the curriculum;

- encouraging the use of local resources and improvising by using what is available for projects, experiments, and research;
- promoting and encouraging skills and knowledge internal assessments such as independent or individualized research/projects, oral presentations to test articulate Science language and confidence, practical experimenting with oral and written communication of findings etc.;
- keeping assessment and evaluation as an ongoing process where feedback comments are provided to the students on a timely basis and interventions and other support are provided wherever and whenever needed;
- timely reporting to parents or guardians of students' performances so that parental support is involved in the push to improve where needed;
- providing opportunities for students to be involved in the planning of the assessment of their own work;
- construction of written assignments, tests and examinations to include questions that tests individual interpretations of a situation i.e., where there is no set right answer. Such assessments encourage the students to think beyond just rote recalling of formulae, calculations and concepts;
- providing opportunities for students to explore and experience the applications of science in their local environments and in the country and report on their observation and findings. For example, field trips to Taula or Vailima Breweries to observe and learn about the making of beer and sodas, to SROS to witness the making of flour from breadfruits, the making of whiskey from talo, to Faleolo Airport to learn about the Solar Energy panels, to Afulilo to learn how electricity is produced, to Moataa mangroves to learn about the conservation of marine life there, to TV stations to learn about technology use in broadcasting etc.

Assessment, learning and teaching as an ongoing process is illustrated by the following diagram:

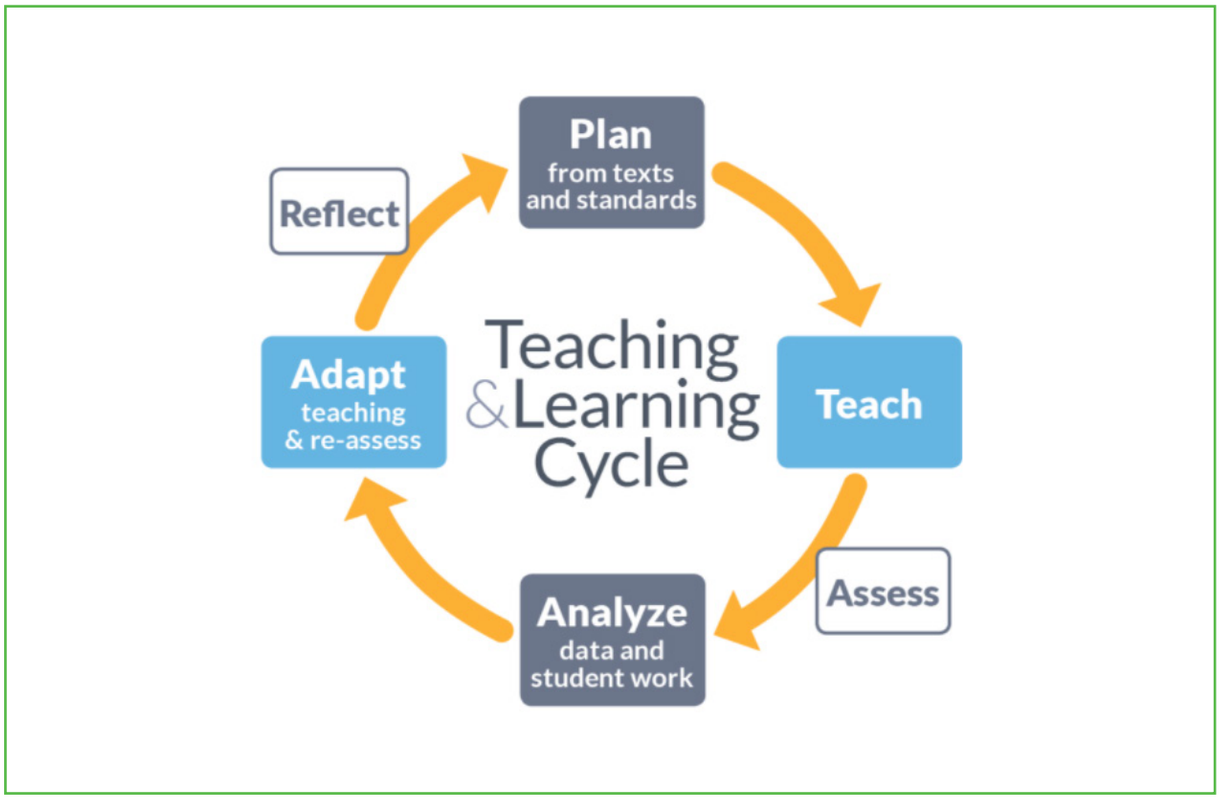


FIGURE 4

Assessment, learning and teaching as an ongoing process.

There are three purposes for assessment:

I. **Assessment for learning:** these assessments should be diagnostic and feedback assessments (classroom activities/ homeworks/ assignments) so the teacher can improve the teaching and learning by diagnosing the learning strengths and weaknesses of students before the teaching and learning continues. The results of diagnosis should enable the teachers to give constructive feedback and formulate activities and responses to improve the learning where needed and ensuring the learning proceeds satisfactorily.

II. **Assessment as learning:** these assessments are learning outcomes based. Activities are constructed to test the students' understanding of the learning outcome expected of them. Constant and timely feedback must be provided so the students are aware of their responsibilities as learners.

III. **Assessment of learning:** these assessments are summative tests and examinations that take place at the end of a unit or strand or end of a term. It is equally important as the other assessments above, that the feedback for students to be constant and timely so that ample opportunities and time for students to react and contribute to correcting or improving their own learning are provided.

Good assessment practices should be fair, valid, open, reliable and manageable.

Essential Science Skills

Essential skills are the broad skills that should be developed and acquired throughout the years of schooling. Such skills involve, but not limited to:

i. Communicating effectively and articulately
ii. Problem solving
iii. Using aesthetic judgement or visual aids or arts
iv. Social and cultural skills and attributes
v. Work and study skills
vi. Integrating knowledge
vii. Using technology effectively

In Secondary Science, the broad skills are developed and applied in various ways as the learning progresses throughout the years of schooling at all levels.

Students experience success in learning science when learning programmes provide opportunities for them to build on their current knowledge and to develop essential skills as they investigate and explore science concepts.

Table One below shows the linkages between what the students will do (actions) and the skills they will gain from learning Science.

What students will do	Science skill
- formulate their own questions - answer their own questions through investigations - develop "fair" testing procedures	Planning
- gather raw data and information from a range of sources	Recording data Gathering information
- process data and information - present information in tables, graphs and text	Processing information Presenting information
- interpret information	Interpreting information
- discuss their ideas - report on their findings	Reporting

TABLE 1
Action/Skill links.

Table 2 below expands the descriptions of what students should do to demonstrate the progression in skill development from Year 9 to Year 12.

Science skill	Years 9 and 10 Students will be achieving at these levels when they can:	Years 11 and 12 Students will be achieving at these levels when they can:
Planning	• ask a question relating to a problem or observation and write a testable hypothesis; • design "fair tests", simple experiments and surveys with an attempt to control obvious variables.	• ask a series of questions relating to a problem or observation, select one for investigation and write a testable hypothesis; • design "fair tests", experiments and surveys with clear identification and control of variables.
Gathering Information	• gather information from different sources • gather information related to the question or topic	• gather information from a wide range of sources; • gather qualitative and quantitative information related to the question or topic.
Recording data	• record simple data, information, measurement and observations; • use simple formats to record data and information.	• record complex data, information, measurements and observations; • systematically and efficiently record data, information, measurement and observations.
Processing and Presenting information	• use simple information processing techniques to process information related to a question or topic; • use simple information presentation techniques to present information related to a question or topic.	• use complex information processing techniques to process information related to a question or topic; • use complex information presentation techniques to present information related to a question or topic.
Interpreting	• identify simple tends and relationships in processed or presented information; • draw a conclusion from processed or presented information that related to the hypothesis, question or topic.	• identify trends and relationships in processed or presented information; • draw and justify conclusions from processed or presented information related to the hypothesis, question or topic.
Reporting	• report what they did and what they found out in their investigations.	• report their findings that are relevant to the topic and the intended reader in a clear concise manner.

TABLE 2
Skill development progression.

Language Learning in Science

The language associated with learning in science is often abstract and can be demanding for any learner. This is understandable considering the abstract nature of Science concepts and the specialised jargon it uses.

The Secondary Science curriculum demands the use of English as the language of instruction as well as assessment. So learning Science can be complex for most of Samoa's students for whom English is a second language. It is therefore profoundly important that students are assisted to learn the language associated with science as they go through the learning activities in the classrooms.

The Secondary Science Curriculum provides a lot of opportunities for students to develop Science literacy skills; their abilities to think, read, write and speak using Science jargon or language. The use of English should be encouraged as much as possible in oral and written presentations for continual use of English and Science special terminologies to prepare students for not only summative assessments but also for them to relate what they learn to what they see and read in real life worldwide.

Incorporating and integrating the nature of Science into classroom through stories or articles about Science discoveries, events and applications of Science in real life situations is one strategy to develop the English language use in Science classrooms. Activities using stories students read can be modified to connect the Science concepts to what they read and to engage them in discussions about the story or article.

Considering the potential use of the Samoan language as a learning tool to enhance students' understanding in Science, it is imperative that English Science terms be retained at all times alongside the Samoan translations, for clarity and integrity of the Science content.

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Values in Science

Values influence the behaviour of an individual and serves as his guidelines in responding to everyday situations. At the Secondary education level, the values developed and acquired in primary education must be enhanced for continuous appreciation of learning Science by the students. Learning opportunities therefore must be created and provided for students to demonstrate:

- fairness, collaboration, acknowledgement and consultation with peers and appreciation of others' contributions;
- honesty and integrity in the works they produce;
- accuracy and objectivity in data and information they collect to validate their observations and findings;
- wisdom, excellence and perseverance to continue learning to the best they can do;
- responsibility for their own actions, choices and judgements as well as a sense of ownership and responsibility for their environments including their school environments;
- honour and respect to treat others with utmost respect and considering others' opinions and beliefs;
- open-mindedness to accept that Science can have limitations and all knowledge is tentative and so must be prepared to change views if evidence is convincing;
- tolerance and understanding of social, cultural and academic differences and diversity within their learning environment;
- consideration and inclusion of all regardless of abilities;
- curiosity to develop a strong desire to explore beyond the classrooms what they learn and question what they find.

Gender

The Samoa Secondary School Curriculum Overview Document requires education to be gender inclusive. This means that students should not be excluded from developing good self-esteem or from participating fully and successfully in learning because of narrow gender stereotypes.

Materials used with this curriculum must give learners the opportunities to understand how females and males can have a wide range of occupations, tasks and responsibilities. Texts must use gender-neutral language where possible. Many science materials have traditionally focused on the experiences of boys and men. Teachers will have to critically evaluate material for gender appropriateness before using it in their classroom.

School programmes and learning activities in the classroom should reflect the diversity of roles available to females and males. Teachers need to ensure that gender is not an obstacle to learning, success, or individual value. Science programmes must ensure that:

- the interests, perspectives and contributions of both females and males are included in programme content, resources and methods of teaching;
- both females and males use science equipment and take part in investigations and practical work;
- both females and males take active and valued leadership roles in activities;
- both females and males have equitable access to resources, including teachers' time, learning assistance and technological equipment;
- both females and males understand and respect the right of each other to equal opportunity.

Inclusive Education

The Ministry of Education, Sports and Culture is committed to providing high-quality inclusive education to all Samoan students within a school culture based on respect and acceptance.

Science education recognizes and supports the process of inclusive education and will need to identify and develop programmes to ensure all students of different academic, mental and physical abilities and calibers are accommodated and exposed to some level of Science education.

Safety

Safety should permeate all aspects of the teaching of Science. Teachers and students should be aware of the safety implications of exploratory or investigatory work. Safety accessories and wear must be provided for practical activities in laboratories for ALL Science subjects. Students should be encouraged to observe safe and hygienic ways of working during practical activities.

Time Allocation

The Samoa National Curriculum Policy Framework 2006 stipulates 2.5 hours per week for Science teaching at all levels. These suggested hours are only a general guide mostly suitable for primary levels.

It is recommended that the teaching should have a minimum of 3 hours (3 one hour periods) per week of classroom lessons PLUS 1-2 hours of activities such as laboratory/practical experimenting, research for IA projects, field trips, guest speaker once every other week.

The Overview of Curriculum Statements

The next pages (19-21) of this curriculum statement provide the overviews of each subject curriculum: Biology, Chemistry, Physics and their respective component in the General Science curriculum of Years 9-12.

Explanatory notes on options offered for 4 year level Science and learning pathways for Science

The options offered for 4 year level Science and learning pathways for Science are clarified in pages 22-24 as further guides for students and schools.

Explanatory notes on 4 year Level Science Curriculum Statements

Further notes on the realignment and compilation of the 4 year level Science Curriculum Contents are outlined in the pages BEFORE each subject table of strands, achievement objectives and learning outcomes. This information is intended to give teachers' understanding and awareness of changes in the 4 year level curriculums compared to the five year level curriculums. Refer to pages 25-26 for Biology/General Science Biology, pages 68-70 for Chemistry/General Science Chemistry and pages 112-113 for Physics/General Physics.

The Biology Curriculum Overview

The following diagram shows the overview of the pure Biology curriculum and the Biology component for the General Science option.

Biology is the strand WORLD OF LIFE. Students will develop their scientific understanding when they study the sub-strands;

1) Variety of Life
2) Cell Biology
3) Animal Biology
4) Plant Biology
5) Environment

The Chemistry Curriculum Overview

The following diagram shows the overview of the pure Chemistry curriculum and the Chemistry component for the General Science option.

Chemistry is the strand WORLD OF MATERIALS. Students will develop their scientific understanding when they study the sub-strands:

1) The Ways materials are structured [Atomic structure and bonding]
2) The Properties and uses of groups of substances (for Years 9-11 only)
3) The Ways materials change [Principles of chemical changes/Inorganic Chemistry]
4) Quantitative Chemistry (for Years 11-12 only)
5) Organic Chemistry (for Years 11-12 only)
6) Principles of Physical Chemistry (for Years 11-12 only)
7) Environmental Chemistry (for Years 11-12 only)

The Physics Curriculum Overview

The following diagram shows the overview of the pure Physics curriculum and the Physics component for the General Science option.

Physics is the strand WORLD OF PHYSICAL PHENOMENA. Students will develop their scientific understanding when they study the sub-strands;

1) Energy
2) Electricity
3) Magnetism
4) Forces and Motion

The Biology Curriculum Overview

YEAR 9 SCIENCE
Biology Component

1. **Variety of life:** bacteria, fungi, viruses, scientific keys.
2. **Cell Biology:** characterstics of life, MRSCGREN, cellular nature of plants and animals,basic parts of plant and animal cells, light microscope to identify/draw images/objects, genetics-cell division for growth, mitosis and meiosis,variation of features of an individual.
3. **Animal Biology:** main groups of animals, circulatory and respiratory systems, foods.
4. **Plant Biology:** parts of a plant, plant growth and reproduction.
5. **Environment:** feeding realtionships between organisms, adaptations of organisms in relation to habitat and environment.

YEAR 10 BIOLOGY
(STREAM 1)

1. **Variety of life:** effect of pathogen on living things, human use of mircro-organisms.
2. **Cell Biology:** cell processes, genetics; cell division for growth, variation in feature of individuals, use of micriscope to view plant and cell tissues, plant and animal cells, cell division for reproduction, simple monohybrid inheritance patterns.
3. **Animal Biology:** structure and functions of parts of skeleton-muscular system and diegstive system, diseases,excretory and reproductive systems, organ systems, diseases.
4. **Plant Biology:** process involved in the production of glucose, processes involved in the transport of glucose and water.
5. **Environment:** patterns and inter-relationships of organisms, biotic and abiotic factors of the environment, local environment issue.

YEAR 11 BIOLOGY
(STREAM 1)

1. **Variety of life:** classification of living things into 5 kingdoms and the biology of micro-organisms, structure/life processes of viruses, bacteria, and fungi, effects/control of harmful micro-organisms.
2. **Cell Biology:** cellular nature of plants/animals,tsructure of cells, respiration,cell tranposrt, enzymes, functions of cells and their parts in inheristance-mitosis, meiosis, Mendelian inheritance.
3. **Animal Biology:** structure and functions of organ systems, effect of drugs, nutrition,circulation, gas exchange, excertion, movement, endocrine system, nervous system, reproduction, drugs and exercise.
4. **Plant Biology:** photosynthesis, leaf structure, root structure, transpiration, asexual reproduction, sexual reproduction, germination, plant responses.
5. **Environment:** adaptations of organisms in relation to habitat/emvironment, inter-relationships of organisms, conservation.

YEAR 12 BIOLOGY
(STREAM 1)

1. **Variety of life:** classification of living things and biological organisation.
2. **Cell Biology:** cell structure, microscope/wet mounts/cells/tissues, cellular respiration, cell compounds, enzymes, transport processes, genetic material, mitosis, meiosis, Mendelian inheritance, speciation and applications of genetics.
3. **Animal Biology:** nutrition and diet, digestive system, gas exchange, support, transport, homeostasis, excretion, reproduction.
4. **Plant Biology:** photosynthesis, leaf structure,gas exchange in plants, stem and cell structures, root structure, transpiration, reproductive structures.
5. **Environment:** adaptations, populations, communities and ecosystems.

YEAR 10 GENERAL SCIENCE
Biology Component
(STREAM 2)

1. **Variety of life:** effect of pathogens on living organisms, human use of micro-orgainsms.
2. **Cell Biology:** cell processes, genetics; cell division for growth and reproduction, mitosis, meiosis, simple monohybrid, plant/animal cells/tissues.
3. **Animal Biology:** structure and functions of parts of skeleton-muscular system and diegstive system, excretory and reproductive systems, organ systems, diseases.
4. **Plant Biology:** process involved in the production of glucose, transport of glucose and water.
5. **Environment:** patterns and inter-relationships of organisms, biotic/abiotic factors, local environmental issue.

YEAR 11 GENERAL SCIENCE
Biology Component
(STREAM 2)

1. **Variety of life:** classification of living things into 5 kingdoms and the biology of micro-organisms; structure/life processes of viruses, bacteria and fungi, effects/control of harmful micro-organisms.
2. **Cell Biology:** cellular nature of plants and animal, structure of cells, respiration, cell transport, enzymes, use of light microscope to view cellular tissues, functions of cells and their parts in inheristance: mitosis, meiosis, Mendelian inheritance.
3. **Animal Biology:** nutrition, circulation, gas exchange, excretion, movement, nervous system, reproduction, drug and exercises.
4. **Plant Biology:** photosynthesis, leaf structure.
5. **Environment:** adaptations of organisms in relation to habitat/emvironment, inter-relationships of organisms, conservation.

YEAR 12 GENERAL SCIENCE
Biology component
(STREAM 2)

1. **Variety of life:** biological organisation.
2. **Cell Biology:** cell structure, cmicroscope/wetmount/cells/tissues, cellular respiration, ceel compunds,enzymes,transport processes, genetic material, mitosis, meiosis, Mendelian inheritance, applications of genetics.
3. **Animal Biology:** nutrition and diet, digestive system, gas exchnage, support, transport, homeostasis, excretion, reproduction.
4. **Plant Biology:** photosynthesis, leaf structure.
5. **Environment:** adaptations, communities and ecosystems.

The Chemistry Curriculum Overview

YEAR 9 SCIENCE
Chemistry Component

1. Atomic structure, periodic table if elements, properties of compounds and mixtures.
2. The uses and impacts of substances.
3. Different types of chemical reactions, factor affecting chemical reaction, processess used locally to produce familiar materials.

YEAR 10 CHEMISTRY
(STREAM 1)

1. Atomic structure, periodic table if elements, properties of compounds and mixtures, cations, anions formation of compounds, Lewis structure, molecular mass, molar mass, relative molecular mass, electron arrangements of ions, properties of compounds and mixtures, oxides and hydroxides.
2. The uses and impacts of substances, impact of a group of substances on people and environment.
3. Different types of chemical reactions, factors affecting chemical reactions, processes used locally to produce familiar materials, precipitation, neutralization, oxidation/rusting, factors affecting rate of reactions, research on production of coconut oil, corn beef, beer, and purification of water. to produce familiar materials.

YEAR 11 CHEMISTRY
(STREAM 1)

1. **Atomic structure and bonding:** structure of atoms.
2. **Quantitative chemistry:** molar/relative molecular mass, relative atomic mass/number, moles and Avogadro's number, balancing equations, % composition, empirical formula, molecular formula of compounds, water of crystallization, concentrations of solutions titration.
3. **Organic Chemistry:** sources and properties of hydrocarbons, fractional distillation of petroleum, homologous series, isomerism, saturation/unsaturation, addition/substitution of hydrocarbons, Bromine test, ethyne, properties of alcohols, carboxylic acids and esters.
4. **Principles of chemical change:** metals and ions, non-metals, acid-base reactions, physical properties of water, soft and hard water transition elements.
5. **Principles of Physical Chemistry:** exothermic and endothermic reactions, factors affecting the rate of reactions, collision theory, equilibrium.
6. **Oxidation and reduction:** REDOX reactions.
7. **Environmental Chemistry:** the ozone, greenhouse effect and climate change, carbon and nitrogen cycles.

YEAR 12 CHEMISTRY
(STREAM 1)

1. **Atomic structure and bonding:** periodic table, electron configurations, energy levels, electrons, monoatomic ions, ionization energy, atomic and ionic radii, electronegativity, orbitals, properties of atoms and ions, oxides, chlorides, intramolecular bonding, intermolecular bonding, shapes of molecules.
2. **Principles of chemical change:** acids and bases, oxidation and reduction, applications of chemistry in REDOX reactions, precipitation.
3. **Quantitative chemistry:** moles, molar mass, empirical and formulae, stoichiometry, acid-base titrations.
4. **Organic Chemistry:** alkanes, alkynes, polymerization, haloalkanes, alcohols, ketones, aldehydes, carboxylic acids and esters.
5. **Principles of Physical Chemistry:** energy changes, equilibrium, Hess's Law.
6. **Oxidation and reduction:** REDOX reactions.
7. **Environmental Chemistry:** depletion of ozone, volcanoes, greenhouse effects, acid rain renewal energy.

YEAR 10 GENERAL SCIENCE
Chemistry Component (STREAM 2)

1. Atomic structure, periodic table of elements, properties of compounds and mixtures.
2. The uses and impacts of substances.
3. Different types of chemical reactions, factors affecting chemical reactions, processes used locally to produce familiar materials.

YEAR 11 GENERAL SCIENCE
Chemistry Component (STREAM 2)

1. Atomic structure, periodic table of elements, properties of compounds and mixtures.
2. **The uses and impacts of substances:** impact of a group of substances on people and environment.
3. Different types of chemical reactions, factors affecting chemical reactions, processes used locally to produce familiar materials.
4. **Principles of chemical change:** types of chemical reactions, factors affecting rate of reactions, processes to produce a local and familiar material e.g., coconut oil, introduction of acids/bases.
5. **Quantitative Chemistry:** molar mass, relative molecular mass, relative atomic mass/number, moles.
6. **Organic Chemistry:** sources, properties and preparation of hydrocarbons; types, properties and uses of alcohols.
7. **Principles of Physical Chemistry:** physical properties of water soft and hot water, solubility of compounds.
8. **Environmental Chemistry:** the ozone layer and Earth, man-made chemicals and effects.

YEAR 12 GENERAL SCIENCE
Chemistry Component (STREAM 2)

1. **Atomic structure and bonding:** structure of atoms.
2. **Principles of chemical change:** metal and ions, non-metals, acid-base reactions, ph, pOH, hydrogen and hydroxide concentration.
3. **Quantitative Chemistry:** molar/relative molecular mass, relative atomic mass/number, moles and Avogadro's number, balancing equations, % composition, empirical formula, molecular formula of compounds, water of crystallization, concentration of solution, titration.
4. **Organic Chemistry:** sources and properties of hydrocarbons, fractional distillation of petroleum, homologous series, isomerism, saturation/unsaturation, addition/substitution of hydrocarbons, Bromine test, ethyne, properties of alcohols, carboxylic acids and esters.
5. **Principles of Physical Chemistry:** exothermic and endothermic reactions, factors affecting the rate of reactions, collision theory.
6. **Oxidation and reduction:** REDOX reactions.
7. **Environmental Chemistry:** the greenhouse effect and climate change, carbon and nitrogen cycles.

The Physics Curriculum Overview

YEAR 9 PHYSICS

1. **Energy:** forms of energy and energy changes.
2. **Electricity:** electrical energy and energy changes involved.
3. **Magnetism:** magnets and behaviours of magnets.
4. **Forces and motion:** relationship between forces and motion and their uses.

YEAR 10 PHYSICS
(STREAM 1)

1. **Energy:** heat/sound energy and energy changes involved, properties of waves.
2. **Electricity:** electrical circuits, current electricity, series and parallel circuits, circuit diagrams.
3. **Magnetism:** magnets and magnetic fields.
4. **Forces and motions:** linear motion, scalar and vector quantities, distance, speed and time, forces and pressure influence and gases.

YEAR 11 PHYSICS
(STREAM 1)

1. **Energy:** heat energy, sound, light/reflection/mirrors.
2. **Electricity:** electric force/electric static, electric field, current electricity, electrical circuits, circuit diagrams, electrolysis.
3. **Magnetism:** motor effect, electromagnetism, magnetic fields, geomagnetism, magnetic induction.
4. **Forces and motion:** linear motion, scalar and vector quantities, velocity, displacement and time, forces, simple machines, energy/work/power.

YEAR 12 PHYSICS
(STREAM 1)

1. **Energy:** reflection, refraction, diffraction and interference of light/lenses, wave theory, simple harmonic motion, heat energy/pressure.
2. **Electricity:** current electricity, electrical circuits, electric charge, Coulomb's Law, electric fields and energy.
3. **Magnetism:** charges/magnetic fields/conductors, motor effect, magnetic fields and current carrying conductors, electromagnetic electromagnetic induction, nuclear energy/Rutherford and atom/photoelectric effects/isotopes and radioactivity.
4. **Forces and motion:** kinematics, forces, momentum, gravitational force, projectile motion, circular motion, work done/power, kinetic/potential energy.

YEAR 10 GENERAL SCIENCE
Physics Component (STREAM 2)

1. **Energy:** heat/sound energy and energy changes involved.
2. **Electricity:** electrical circuits, current electricity.
3. **Magnetism:** magnets and magnetic fields.
4. **Forces and motion:** linear motion and pressure influence and gases.

YEAR 11 GENERAL SCIENCE
Physics Component (STREAM 2)

1. **Energy:** light energy, heat energy.
2. **Electricity:** electrical circuits, current electricity.
3. **Magnetism:** magnets magnets/magnetic fields, magnetic effect of electric current.
4. **Forces and motion:** velocity/acceleration, forces.

YEAR 12 GENERAL SCIENCE
Physics Component (STREAM 2)

1. **Energy:** properties of waves, sound, light.
2. **Electricity:** electrical energy, electrical curcuits.
3. **Magnetism:** charges/magnetic fields/conductors, magnetic fields, motor effect.
4. **Forces end motion:** linear motion, force/work/power, potential/kinetic energy.

Expalanatory Notes

On options offered for Year 10 to Year 12

- The Year 9 Science curriculum is the same for both streams of learning pathways as outlined in page 9. This means the Year 9 Science does not offer any options. All year 9 students learn this Year 9 Science curriculum as one of their 5 subjects of study.
- The Year 10 Science curriculum offers two options or streams: stream 1 – Pure Biology, Chemistry and/or Physics; or stream 2 – General Science.

  Students choose one option based on their abilities, goals and choices of career pathways together with their teachers' assessments and parents' advices.
- The Years 11 and 12 also offer the same options as in Year 10. Students should be allowed to either continue from their choices in Year 10 or switch to another option at Year 11 if they are unsuccessful with their-original choices (Refer to Learning pathways diagram).
- Recommendations of resources to support this curriculum statement are included at the end of each subject curriculum. These recommendations are only a few of many that are available online, from MESC and bookshops such as SSAB and BSL.
- Refer to explanatory notes on realignments and compilations of each subject (Biology, Chemistry, Physics and General Science) contents before the respective subject strands, achievement objectives and learning outcomes (Pages 25-26, 68-70 and 112-113) for more details on the reshuffle of contents across levels.

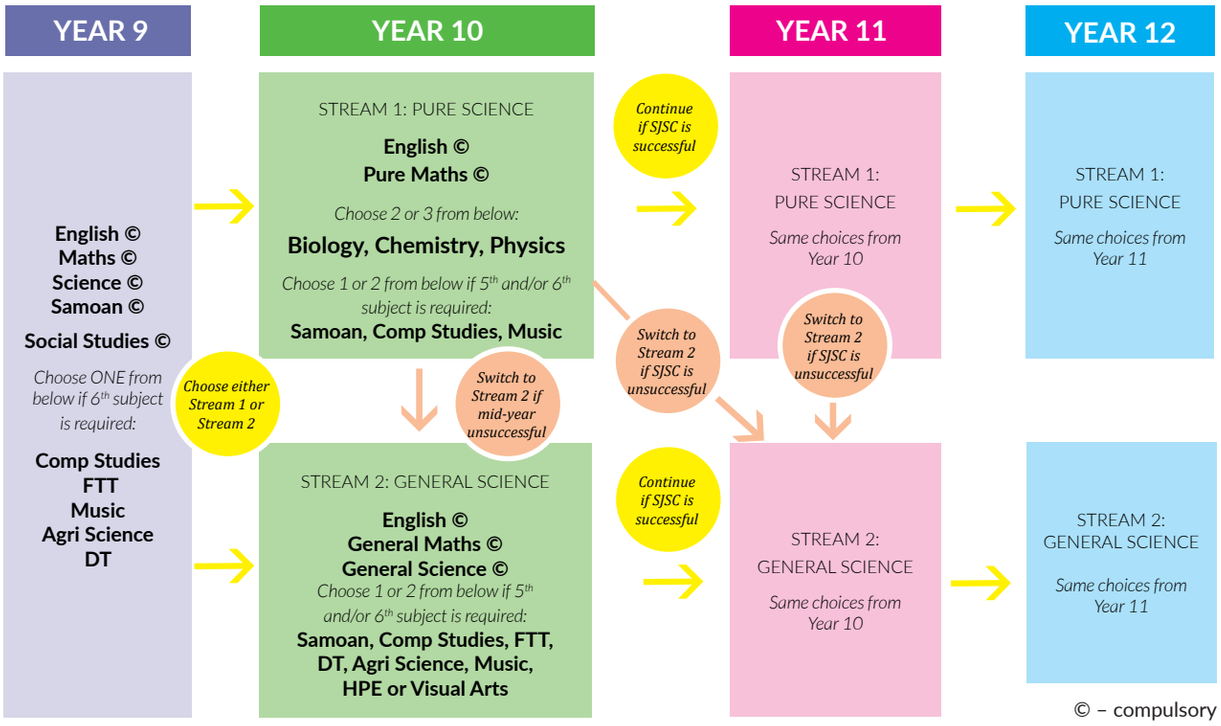


FIGURE 5

Learning pathways for Science students from Year 9 to Year 12 (4 year level)

The diagram shows the range of choices students can choose from when following a learning pathway in Science. It is only intended as a GUIDE for schools to counsel and direct their students to the right pathway most suitable for their choice of future career or goal and for success in secondary Science education.

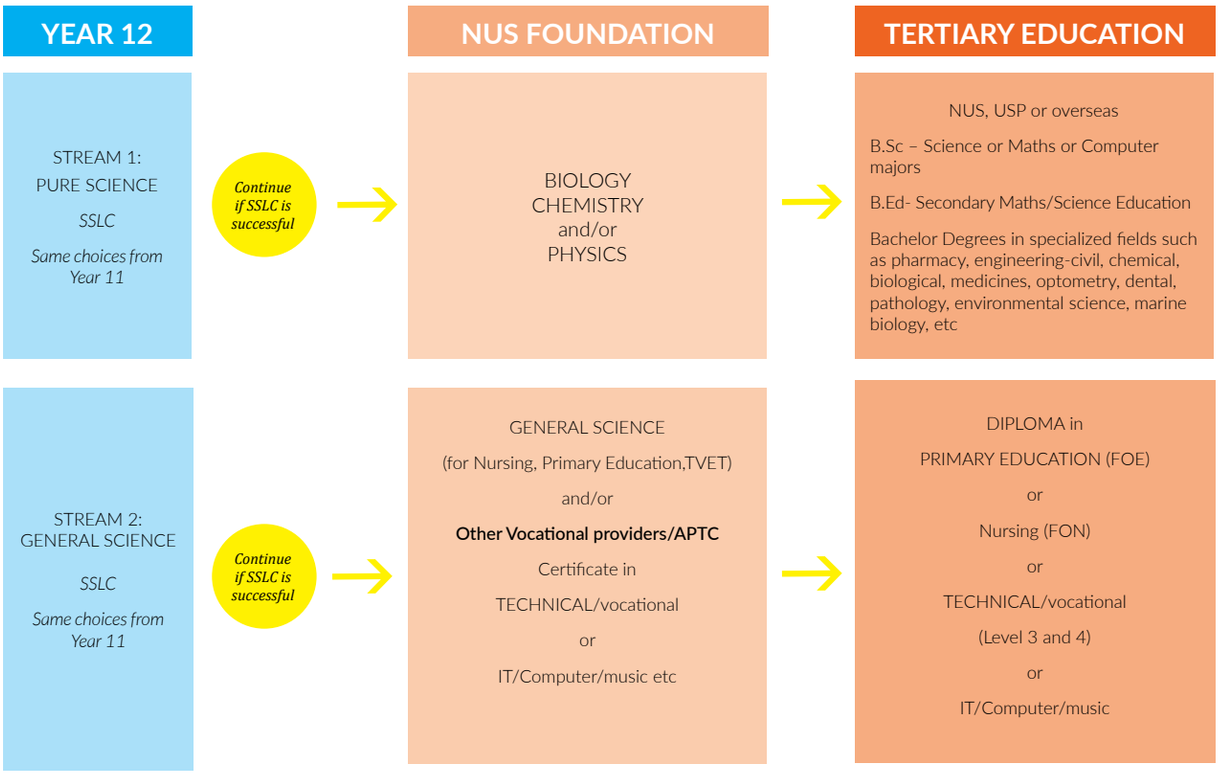


FIGURE 6

Learning pathways for Science students from Year 12 onwards

This diagram is a sample illustration of link of SSLC or Year 13 Science Curriculums to NUS and other post-secondary programs.

Explanatory notes

On realignment and compilation of biology and general science biology component for 4 year level.

The compilation of specific contents for the Biology and General Science Biology component curriculums for the 4 year level of secondary school education is based primarily on the following resources:

- 5 year level Biology and Science curriculums for Years 9-13 compiled and reviewed from 2014-2019 by Science panelists.
- externally reviewed 5 year level Biology curriculum statements from 2018 by external reviewer.
- moderation of the revised secondary Biology and General Science Biology for 4 year level Years 9-12 by External Moderator/ Technical Advisor

The approach in this compilation ensures that for:

1. STREAM 1 – BIOLOGY, the contents as in the 5 year level remain intact but realigned into 4 year level, with the contents reshuffled across Years 10,11 and 12, while the content for Year 9 remain mostly intact. Specifically the reshuffle of curriculum contents is as follows:

- the 5 year level Year 9 Science curriculum mostly remains as it is with a few very basic introduction of Biology concepts that are covered in new 4 Year level Year 10 (mainly in the sub-strand Cell Biology).
- the 4 year level Year 10 Biology Curriculum is a combination and realignment of 5 year

level Year 10 and Year 11 Biology contents which ensures no repetition of contents and achievement objectives while also making sure the contents are pre-requisites for next level up.

- the Year 11 Biology for 4 year level is basically the 5 year level Year 12 Biology curriculum with very few changes to some achievement objectives in the sub-strands Variety of Life and Cell Biology to ensure the flow and connection of content from new Year 10 to this level.
- the Year 12 for 4 year level is also basically the 5 year level Year 13 Biology curriculum with very few changes to some of the achievement objectives in the sub-strand Cell Biology to ensure the flow and connection of content from new Year 11 to this level.

2. STREAM 2 – GENERAL SCIENCE (BIOLOGY component). The Biology component for General Science has been compiled and realigned from the contents of the curriculums for each level in Stream 1 for 4 year level. The General Science Biology Component contents were compiled and realigned as follows:

- the 4 year level Year 9 General Science Biology component remains the same as in Stream 1.
- the 4 year level Year 10 General Science Biology component is similar to that of Stream 1 except for some differences (omissions/ replacements) in sub-strands Cell Biology and Environment compared to Stream 1.
- the 4 year level Year 11 General Science Biology component is similar to that of Stream 1 except for some differences (omissions/ replacements) in sub-strands Variety of Life an Cell Biology.
- the 4 year level Year 12 General Science Biology component is also similar to that of Stream 1 except for a few differences in sub-strand Cell Biology.

For consistency across the four levels in terms of number of strands to be studied, this compilation also groups the current strand “Genetics” under the strand “Cell Biology”, to have 5 strands for each of the four years. This removes the inconsistent pattern of the current five year level Biology curriculums where there are five strands for Year 9 and six strands for Years 10 to 13.

The strands are :

1. Variety of Life
2. Cell Biology (with Genetics)
3. Animal Biology
4. Plant Biology
5. Environment

Strands, Sub-strands and Learning Outcomes

Biology

Explanatory notes on realignment and compilation of Biology and General Science Biology component for 4 year level

The compilation of specific contents for the Biology and General Science Biology component curriculums for the 4 year level of secondary school education is based primarily on the following resources:

- 5 year level Biology and Science curriculums for Years 9-13 compiled and reviewed from 2014-2019 by Science panelists;
- externally reviewed 5 year level Biology curriculum statements from 2018 by external reviewer;
- moderation of the revised secondary Biology and General Science Biology for 4 year level Years 9-12 by External Moderator/ Technical Advisor.

The approach in this compilation ensures that for:

1. STREAM 1 - BIOLOGY, the contents as in the 5 year level remain intact but realigned into 4 year level, with the contents reshuffled across Years 10,11 and 12, while the content for Year 9 remain mostly intact. Specifically the reshuffle of curriculum contents is as follows:

- The 5 year level Year 9 Science curriculum mostly remains as it is with a few very basic introduction of Biology concepts that are covered in new 4 Year level Year 10 (mainly in the sub-strand Cell Biology).
- The 4 year level Year 10 Biology Curriculum is a combination and realignment of 5 year level Year 10 and Year 11 Biology contents which ensures no repetition of contents and achievement objectives while also making sure the contents are pre-requisites for next level up.
- The Year 11 Biology for 4 year level is basically the 5 year level Year 12 Biology curriculum with very few changes to some achievement objectives in the sub-strands Variety of Life and Cell Biology to ensure the flow and connection of content from new Year 10 to this level.
- The Year 12 for 4 year level is also basically the 5 year level Year 13 Biology curriculum with very few changes to some of the achievement objectives in the sub-strand Cell Biology to ensure the flow and connection of content from new Year 11 to this level.

2. STREAM 2 - GENERAL SCIENCE (BIOLOGY component). The Biology component for General Science has been compiled and realigned from the contents of the curriculums for each level in Stream 1 for 4 year level. The General Science Biology Component contents were compiled and realigned as follows:

- The 4 year level Year 9 General Science Biology component remains the same as in Stream 1.
- The 4 year level Year 10 General Science Biology component is similar to that of Stream 1 except for some differences (omissions/replacements) in sub-strands Cell Biology and Environment compared to Stream 1.
- The 4 year level Year 11 General Science Biology component is similar to that of Stream 1 except for some differences (omissions/replacements) in sub-strands Variety of Life an Cell Biology.
- The 4 year level Year 12 General Science Biology component is also similar to that of Stream 1 except for a few differences in sub-strand Cell Biology.
- For consistency across the four levels in terms of number of strands to be studied, this compilation also groups the current strand "Genetics" under the strand "Cell Biology", to have 5 strands for each of the four years. This removes the inconsistent pattern of the current five year level Biology curriculums where there are five strands for Year 9 and six strands for Years 10 to 13.

The strands are :

1. Variety of Life
2. Cell Biology (with Genetics)
3. Animal Biology
4. Plant Biology
5. Environment

STREAM 1
Biology Curriculum Statement Years 9-12
FOR THE 4 YEARS SECONDARY EDUCATION

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
	Strand: THE WORLD OF LIFE [BIOLOGY]			
1. VARIETY OF LIFE	From their study of **VARIETY OF LIFE** students will understand **the biology of micro-organisms.** Students will investigate and develop their scientific understanding of: **1. The bacteria, fungi and viruses** when they can: • Describe the parts and functions of the structure of bacteria, fungi and viruses. • Describe the reproduction of bacteria, fungi and viruses. • Classify bacteria and fungi in Kingdoms Monera and Fungi. • Describe the nature of viruses. **2. Scientific keys** when they: Use simple keys to identify objects.	From their study of **VARIETY OF LIFE** students will understand **the biology of micro-organisms.** Students will investigate and develop their scientific understanding of: **1. The effect of pathogens on living organisms** when they can: • Describe the effects of pathogens on living organisms and the methods used to overcome these effects. • Explain how the spread of pathogenic diseases can be controlled. **2. The human use of micro-organisms** when they can: • Explain how the life processes of micro-organisms are used by humans: composting, brewing, baking, food production, antibiotic production. • Carry out a composting activity. • Write a report on a field trip to a brewery OR presentation of a guest speaker for baking *e.g., round pancakes.*	From their study of **VARIETY OF LIFE** students will understand **the classification of living things into 5 kingdoms and the biology of micro-organisms.** Students will investigate and develop their scientific understanding of: **1. Living things** when they can: • Describe the levels of biological organisation – organelle to ecosystem and biosphere. • Identify examples of the different levels of biological organisation • Classify living things into 5 kingdoms. • Describe features of the main phyla/divisions of plants and animals – mosses, ferns, gymnosperms, angiosperms, monocotyledons, dicotyledons, invertebrates – molluscs, arthropods, echinoderms, cnidarians, annelids, vertebrates – chordates. • Use dichotomous keys to identify organisms. **2. The structure and life processes of viruses, bacteria and fungi** when they can: • Describe the structure of viruses, bacteria and fungi (size, shape, organelles and components present or absent). • Culture bacteria and fungi. • Explain how bacteria and fungi carry out the life processes: feeding, growth and asexual reproduction (binary fission, budding, spore formation).	From their study of **VARIETY OF LIFE** students will understand **the classification of living things and biological organisation.** Students will investigate and develop their scientific understanding of: **1. Biological organisation** when they can: • Differentiate between the different levels of biological organisation – organelle to biosphere. **2. Classification** when they can: • Describe the diversity of organisms by stating examples of the following kingdoms, phyla/divisions and classes. *Monera: Bacteria, Blue green algae* *Protista: Unicellular organisms, Algae* *Fungi: Fungi* *Plantae: Mosses, Ferns, Gymnosperms, Angiosperms (monocotyledons, dicotyledons)* *Animalia: Cnidarians, Annelids, Molluscs, Arthropods (Crustaceans, Insects, Arachnids, Myriapods)* *Echinoderms, Chordates* *(Fish, Amphibians, Reptiles, Birds, Mammals)* • Use the Binomial system to name organisms. • Use and design dichotomous keys.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
1. VARIETY OF LIFE			• Discuss how bacteria and fungi are used for economic, environmental and medicinal purposes (making alcohol (fa'amafu), making antibiotics, making compost, making food *e.g., miti, yoghurt, mushrooms*. • Carry out an experiment on reproduction of fungi *e.g., budding in yeast, spores in bread mould*. **3. The effects of harmful micro-organisms** when they can: • Describe examples of harmful micro-organisms. • Explain why viruses are always pathogenic *e.g., reproduction method.* • Describe common diseases caused by viruses, bacteria and fungi *e.g., mumps, influenza, common cold, tinea, ringworm, pneumonia, boils*. • Carry out a research on pathogenic diseases that occur in Samoa *e.g., HIV (AIDS), dengue fever, chicken pox, measles, Chikunguya, Zika, COVID-19 etc.* **4. The control of harmful micro-organisms** when they can: • Discuss the effectiveness of antiseptics, disinfectants or antibiotics. • Describe ways of controlling and curing disease *e.g., antibiotics, vaccination, herbal.* • Explain the development of antibiotic resistance in pathogens and how it can be prevented. • Discuss how the human body defends itself against pathogens. • Describe the effects of HIV on the immune system.	

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. CELL BIOLOGY [GENETICS]	From their study of **CELL BIOLOGY** students will understand **the structure and function of cells.** Students will investigate and develop their scientific understanding of: **1. The characteristics of life** when they can: • Describe the life processes carried out by living things – MRSCGREN. **2. The cellular nature of plants and animals** when they can: • List the levels of biological organization from organelles to organism. • Explain the relationships between organelles, cells, tissues, organs, organ systems and organism. **3. The basic parts of typical plant and animal cells** when they can: • Describe parts and functions of cells – cell membrane, cell wall, nucleus, cytoplasm, vacuole, chloroplast, mitochondrion. **4. The parts and functions of a light microscope** when they can: • Identify and name parts of a light microscope; • Make a wet mount to view under the microscope; • Use a light microscope to draw images/objects; • Calculate total magnification.	From their study of **CELL BIOLOGY** students will understand **cell processes. Students will investigate anddevelop their scientific understanding of:** **1. Cell Processes** when they can: • Describe the functions of cell processes – diffusion, osmosis and respiration. • List the requirements and wastes produced by respiration. From their study of **GENETICS** students will understand **the functions of cells and their part in inheritance.** Students will investigate and develop their scientific understanding of: **2. The process of cell division for growth** when they can: • Describe how the process of mitosis produces more cells while maintaining the chromosome number. **3. The process of cell division for reproduction** when they can: • Describe how the process of meiosis produces gametes with half the chromosome number and results in variation. • Compare meiosis and mitosis. **4. Simple monohybrid inheritance patterns** when they can: • Use genetic terms to describe genetic information and the outcomes of crosses – trait, allele, gene, genotype, phenotype, dominant, recessive, homozygous, heterozygous. • Use Punnet squares and family trees to predict and describe the outcomes of crosses – tongue rolling, left and right handedness, etc.	From their study of **CELL BIOLOGY** students will understand **cell processes.** Students will investigate and develop their scientific understanding of: **1. The cellular nature of plants and animals** when they can: • Describe the advantages and disadvantages of light and electron microscope. • Use a light microscope (low and high power) to view cells and tissues *e.g., plant and animal tissues such as root tip, leaf cross section.* • Draw cells and tissues as seen under the microscope. **2. The structure of cells** when they can: • Review the differences between plant and animal cells. • Explain how the structure of organelles relate to their functions of cell organelles *e.g., cell membrane, cell wall, nucleus, cytoplasm, vacuole, chloroplast, ribosome, endoplasmic reticulum, mitochondria, Golgi bodies, centrioles, lysosomes*. **3. Respiration** when they can: • Write a balanced chemical equation to describe the process of respiration. • Compare anaerobic and aerobic respiration. • Explain how anaerobic respiration results in muscle fatigue. • Carry out an experiment on fermentation in yeast *e.g., carbon dioxide production, effect of temperature.* • Explain the importance of respiration and its relationship with photosynthesis.	From their study of **CELL BIOLOGY** students will understand **cell structure, cellular processes, enzymes.** Students will investigate and developtheir scientific understanding of: **1. Cell structure** when they can: • Create and construct a model of a plant/animal cell to show the different parts. • Relate the structure of each organelle to its function. • Review the differences between plant and animal cells in relation to structures and functions. **2. The microscope** when they can: • Demonstrate a wet mount of a biological specimen. • Draw cells and tissues as seen under a light microscope. • Determine the size of a specimen under a light microscope *e.g., use a plastic ruler to measure field of view, calculation*. **3. Cellular respiration** when they can: • Explain how the removal of or drop in the concentration of one raw material of aerobic respiration affects the process. • Explain how glucose is converted to pyruvic acid during glycolysis. • Explain how pyruvic acid is broken down during the Kreb's Cycle. • Discuss how most ATP is produced during the Respiratory Chain. • Compare anaerobic respiration in muscle cells and in yeast cells. **4. Cell compounds** when they can: • Explain using simple diagrams or symbols to illustrate structures of each of the following: - carbohydrates: monosaccharides (glucose), disaccharides (sucrose), polysaccharides (starch); - lipids: fatty acids, glycerol; - protein: amino acids, peptide and polypeptides.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. CELL BIOLOGY [GENETICS]	From their study of **GENETICS** students will understand **the functions of cells and their part in inheritance.** Students will investigate and develop their scientific understanding of: **5a The process of cell division for growth** when they can: • Define mitosis and meiosis. • Describe the function of mitosis and meiosis. • State the number of new cells produced by each process. • Name examples of cells where these processes occur. **5b Variation in features of individuals** when they can: • Describe variation as continuous or discrete. • Explain the importance of variation to species. • Gather, process and present and report • information on variation – heights of people, lengths of leaves.	**5. Plant and animal cells and tissues** when they can: • Use a light microscope to view prepared slides and wet mounts produced by students using the techniques of cutting, staining and squashing *e.g., onion cells, human skin cells, leaves, soft stems*. • Identify, draw and label cell structures from microscope viewing. • Describe the function of organelles – Golgi bodies, centrioles, endoplasmic reticulum – rough and smooth, ribosomes. • Describe differences between plant and animal cells.	**4. Cell transport** when they can: • Describe the processes of diffusion and osmosis. • Explain the importance of diffusion and osmosis in cell transport. • Compare the processes of diffusion osmosis and active transport in terms of molecules transported, concentration gradient and energy requirements. • Carry out an experiment on the processes of diffusion and osmosis *e.g., osmosis in plant cells.* **5. Enzymes** when they can: • Describe the structure and function of enzymes using lock and key and induced fit models. • Explain the effect of temperature on the structure and function of enzymes. • Carry out an experiment of the effect of temperature on enzyme action. From their study of **GENETICS** students will understand **the functions of cells and their part in inheritance.** Students will investigate and develop their scientific understanding of: **6. Mitosis and meiosis** when they can: • Explain the relationship between chromosomes, DNA, genes and alleles. • Describe the behaviour of chromosomes in mitosis and meiosis. • Explain the importance of meiosis in reducing the chromosome number. • Discuss the role of meiosis and fertilisation in mixing genetic material. • Compare meiosis and mitosis.	• Describe the role of carbohydrates, lipids and proteins in the structure and function of cells. **5. Enzymes** when they can: • Describe how enzymes catalyse biological reactions. • Explain how enzymes function in synthesis and breakdown reactions using the induced fit model. • Carry out an experiment to show the effect of a factor on the rate of an enzyme-controlled reaction *e.g., pH, temperature, concentration of enzyme or substrate*. **6. Transport processes** when they can: • Describe the factors which influence the rate of osmosis and diffusion. • Explain how selective exchange occurs at the cell membrane. • Compare active and passive transport using examples. • Explain how surface area to volume ratio limits substances entering and leaving cells. From their study of **GENETICS** students will understand **genetic material, cell division, Mendelian inheritance, speciation and application of genetics.** Students will investigate and develop their scientific understanding of: **7. Genetic material** when they can: • Describe the structure and function of chromosomes, DNA and RNA. • Describe the process of protein synthesis stating the role of DNA, messenger RNA, transfer RNA and ribosomes. **8. Mitosis and meiosis** when they can: • Explain the roles of mitosis and meiosis in the life cycle of an organism. • Describe the sequence of events in mitosis and meiosis. • Compare meiosis and mitosis. • Discuss the role of crossing over, recombination and independent assortment in producing variation in species.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. CELL BIOLOGY [GENETICS]			**7. Mendelian inheritance** when they can: • Name and describe examples of continuous and discrete variation. • Discuss examples of inheritance patterns in terms of characteristics, traits, genes, alleles, dominant and recessive alleles, genotype, phenotype, homozygous, heterozygous, monohybrid, cross. • Solve monohybrid inheritance patterns involving complete dominance *e.g., family trees and Punnet squares, phenotypic and genotypic ratios.* • Explain the roles of the X and Y chromosomes in determining the sex of the individual.	**9. Mendelian inheritance** when they can: • Solve monohybrid crosses involving complete dominance, co-dominance and incomplete dominance *e.g., Punnett squares, family tree diagrams.* • Explain inheritance patterns using the terms: phenotype, genotype, dominant and recessive alleles, heterozygous, homozygous, ratios. • Explain how the offspring from a test cross may indicate the genotype of an individual. • Explain the effect of multiple alleles on phenotype *e.g., human blood groups.* • Explain how sex is determined in mammals by X and Y chromosomes. • Solve dihybrid crosses involving complete dominance. **10. Speciation** when they can: • Describe the causes of mutation *e.g., high temperature, radiation, carcinogenic materials.* • Explain how mutation may produce variation in a population. • Discuss natural selection as the process in which better adapted individuals are more likely to survive and reproduce. • Explain how speciation results from geographical and reproductive isolation. **11. Applications of genetics** when they can: • Describe how selective plant and animal breeding can produce different genotypes and phenotypes. • Discuss how humans use genetic engineering to produce organisms and substances of benefit to them. • Discuss ethical issues associated with the genetic manipulation of organisms.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
3. ANIMAL BIOLOGY	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems, describe food classes for healthy living and basic classification of the Animal Kingdom.** Students will investigate and develop their scientific understanding of: **1. The main groups of animals** when they can: • Classify and describe the major features of groups of animals: Invertebrates – insects, shellfish. Vertebrates – mammals, birds, fish. **2. The structures and functions of the circulatory and respiratory systems** when they can: • Identify and describe parts of the circulatory and respiratory systems: heart, lungs, blood vessels, composition of blood. • Explain how the parts of the circulatory and respiratory systems function in terms of transport and gas exchange. **3. Foods** when they can: • Classify foods into groups and explain their roles in the maintenance of health – proteins, carbohydrates, fibre, fats/oils, water, vitamins, minerals. • Identify food groups in common foodstuffs by carrying out simple food tests – fats, starch.	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems.** Students will investigate and develop their scientific understanding of: **1. The structure and functions of parts of the skeleton, muscular system and digestive system** when they can: • Explain how parts of the skeleto-muscular and digestive systems function in terms of support and movement and digestion – endoskeleton, exoskeleton, hydrostatic skeleton, muscles, joints, stomach, oesophagus, small intestine, large intestine, liver, pancreas, gall bladder, rectum, anus. **2. The structure and functions of parts of the excretory and the reproductive systems** when they can: • Explain how parts of the excretory and reproductive systems function in terms of excretion and reproduction – kidneys, ureter, urethra, bladder, nephron; testes, penis, sperm duct, prostate gland, scrotum, epididymis, vagina, uterus, Fallopian tubes, ovary, cervix.	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems and the effects of drugs and exercise on the organ systems.** Students will investigate and develop their scientific understanding of: **1. Nutrition** when they can: • Explain the importance of the essential nutrients – carbohydrates, lipids, protein, minerals (iron, calcium, iodine), vitamins (A, B, C, D), fibre and water. • Explain the effects of nutrient deficiencies, incorrect diet and eating disorders on humans. • Explain the structures and functions of the human digestive system. • Carry out food tests for protein and glucose. Recall starch and lipids test (from Year 9). **2. Circulation** when they can: • State the importance of an internal transport system in animals. • Explain the structure and function of blood and blood vessels. • Describe the basic structure of the human circulatory system. • Discuss the roles of the circulatory and lymphatic systems for transport. **3. Gas exchange** when they can: • Explain the difference between respiration, gas exchange and breathing. • Describe the breathing process in humans. • Explain the structure and function of the human respiratory system. **4. Excretion** when they can: • Explain the importance of excretory systems in animals.	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems and the effects of drugs and exercise on the organ systems.** Students will investigate and develop their scientific understanding of: **1. Nutrition and diet** when they can: • Describe the differences between autotrophic and heterotrophic nutrition. • Explain the importance of classes of food in the human diet. • Test for the presence of nutrients in food. • Compare the traditional Pacific diet with more recent diets containing refined and processed food. **2. The digestive system** when they can: • Explain the structure and functions of parts of the digestive system – mouth, oesophagus, stomach, gall bladder, pancreas, small intestine – duodenum, ileum, large intestine, sphincter muscles, hepatic portal vein. • Discuss the processes carried out by the digestive system – ingestion, digestion, absorption, assimilation and egestion. • Compare the gut structures of humans with herbivores and carnivores. • Carry out an experiment on the action of saliva on starch. **3. Gas exchange** when they can: • Explain the difference between respiration, gas exchange and breathing. • Explain the role of the ribs, intercostal muscles and the diaphragm in inhalation and exhalation. • Explain how trachea, mucus, bronchi, alveoli and cilia facilitate gas exchange. • Describe the structure and function of the gas exchange systems in insect and fish. • Compare the structure and function of the gas exchange systems in humans, fish and insects.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
3. ANIMAL BIOLOGY		**3. How organ systems work together** when they can: • Describe how the organ systems: circulatory, respiratory, skeleto-muscular, digestive, excretory and reproductive systems interact to carry out MRSCGREN in humans. **4. Diseases** when they can: • Gather, process and report information on the disease and malfunctions that affect these organ systems – sprains, strains, arthritis, ulcers, diabetes, gout, diarrhea, constipation. • Explain the consequences for the individual of these diseases and malfunctions.	• Describe excretory products and organs in humans *e.g., carbon dioxide and lungs urea and kidneys, sweat and skin.* • Explain the structure and function of the human excretory system – skin, kidneys. **5. Movement** when they can: • Describe the importance of movement for survival in animals. • Explain how the action of voluntary muscles cause movement. • Explain the importance of the skeleton for movement in vertebrates. **6. The endocrine system** when they can: • Explain the role of hormones in animals. • Name endocrine glands and their secretions *e.g., adrenal, pancreas, ovary, thyroid, testes, pituitary.* • Explain the functions of the hormones. **7. The nervous system** when they can: • Describe the importance of human senses. • Explain the central nervous system in humans. • Explain the structure and function of nerve cells – sensory and motor. • Discuss the significance of reflex actions. **8. Reproduction** when they can: • Explain the structure and function of the human male and female reproductive systems. • Describe gametogenesis, fertilisation, implantation and embryonic development. • Explain how materials are exchanged between the mother and the embryo.	**4. Support** when they can: • Explain the advantages and disadvantages of endoskeletons, exoskeletons and hydrostatic skeletons. • Explain the structure and function of the three types of muscles. • Explain how muscles work with the skeleton to allow movement. • Describe the action of antagonistic pairs of muscles in producing movement. **5. Transport** when they can: • Compare and give examples of the open circulatory system (insects), closed single circulatory system (fish), closed double circulatory system (humans). • Explain the structure and function of the human heart. • Describe the effects of smoking, alcohol and obesity in causing coronary heart disease. • Explain the structure and function of the red blood cells, platelets and white blood cells. • Discuss the structure and function of the three main types of blood vessels – veins, arteries and capillaries. **6. Homeostasis** when they can: • Define homeostasis as the keeping of internal body conditions in a stable state. • Explain how a constant internal environment helps cells to function efficiently. • Discuss the following examples of homeostasis: temperature control in mammals, blood glucose levels in humans.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
3. ANIMAL BIOLOGY			**9. Drugs and exercise** when they can: • Describe the effects of drugs on society. • Describe the effects of alcohol, drugs and smoking on the body. • Describe the effects of exercise on the body. • Carry out an experiment to study the effect of exercise on the breathing or pulse rate.	**7. Excretion** when they can: • Describe the processes involved in the production of carbon dioxide, water and nitrogenous wastes. • Discuss the advantages and disadvantages of excreting nitrogen wastes in the form of ammonia (aquatic organisms), uric acid (birds, insects and reptiles), or urea (mammals). • Explain the structure and function of the kidney, urethra, ureter and bladder. • Explain how the structure of the nephron aids the processes of filtration and reabsorption. **8. Reproduction** when they can: • Explain the structure and function of ovary, oviduct (Fallopian tube), uterus (womb), vagina, scrotum, testis, epididymis, sperm duct (vas deferens), prostate gland, seminal vesicle, urethra and penis. • Discuss reproductive development from gamete production, fertilisation, implantation to birth. • Explain how materials are exchanged between the mother and the foetus via the placenta. • Discuss the roles of the hormones oestrogen and progesterone in the development of secondary sexual characteristics in females and in the menstrual cycle. • Discuss the role of the hormone testosterone in the development of secondary sexual characteristics in males.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
4. PLANT BIOLOGY	From their study of **PLANT BIOLOGY** students will understand **the biology of plants.** Students will investigate and develop their scientific understanding of: **1. The arrangement of the parts of a plant** when they can: • Identify and describe the arrangement of the external features of a plant – roots, stem, leaves, branches, flower. • Describe the advantage to the plant of the different arrangements or external features. **2. The processes involved in plant growth and reproduction** when they can: • Describe the processes of germination, growth, sexual and asexual reproduction in plants. • Carry out an experimenton seed germination, asexual reproduction, and the flower.	From their study of **PLANT BIOLOGY** students will understand **the biology of plants.** Students will investigate and develop their scientific understanding of: **1. The process involved in the production of glucose** when they can: • Describe the process of photosynthesis. • Carry out an experiment into an aspect of photosynthesis – the need for sunlight, carbon dioxide or chlorophyll for photosynthesis. • Carry out an experiment on testing a leaf for starch. **2. The processes involved in the transport of glucose and water** when they can: • Describe the processes involved in the transport of glucose and water – absorption, transpiration, translocation. • Carry out an experiment on transpiration using a weight potometer to illustrate water transport. • Explain the relationship between the processes of transport of glucose and water and growth in plants.	From their study of **PLANT BIOLOGY students will understand the biology of plants.** Students will investigate and develop their scientific understanding of: **1. The process of photosynthesis** when they can: • Write a balanced chemical equation to describe the process of photosynthesis. • Explain the importance of photosynthesis to plants and other living things. • Carry out an experiment on leaf pigments – paper chromatography. **2. Leaf structure** when they can: • Draw and label the internal structure of leaves. • Explain the functions of leaf parts *e.g., gas exchange, photosynthesis, transport.* **3. Root structure** when they can: • Describe different types of roots – tap, fibrous, adventitious, lateral. • Explain how roots are adapted to carry out their functions *e.g., pneumatophores, swollen roots – yams, carrots.* • Explain the functions of different regions of a root tip – root cap, meristematic region, region of cell elongation, root hair region. **4. Transpiration** when they can: • Describe the advantages and disadvantages of transpiration. • Explain how environmental factors affect transpiration rate. • Describe adaptations of plants to reduce transpiration. • Carry out an experiment on environmental factors that affect transpiration rate *e.g., wind, humidity, temperature, availability of water.*	From their study of **PLANT BIOLOGY** students will understand **the biology of plants.** Students will investigate and develop their scientific understanding of: **1. Leaf structure** when they can: • Draw, label and identify the internal structure of a leaf – cuticle, epidermis, palisade and spongy mesophyll, vascular bundle, stoma, guard cells, air space. • Explain the functions of leaf parts in photosynthesis, transport of glucose and water, and gas exchange. **2. The process of photosynthesis** when they can: • Write a balanced chemical equation for photosynthesis. • Explain the structure and function of chloroplasts – grana, stroma. • Describe the light and dark phase reactions. • Explain how factors affect the rate of photosynthesis – carbon dioxide, light intensity, water, temperature. • Describe the process of translocation. **3. Gas exchange in plants** when they can: • Describe the exchange of gases for photosynthesis and respiration. • Explain how the guard cells control the movement of gases. • Make slides and view leaf sections – number of stomata on upper and lower surfaces, structure of guard cells and stoma. **4. The role of stem and cell structures** when they can: • Explain why some plants need a system for support and transport of materials *e.g., size and environment.* • Describe the structure of stem tissues *e.g., epidermis, cortex, vascular bundles, lignified fibres.*

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
4. PLANT BIOLOGY			**5. Asexual reproduction** when they can: • Describe natural and artificial types *e.g., tubers, rhizomes, cuttings, tissue culture.* • Explain the advantages and disadvantages of asexual reproduction. **6. Sexual reproduction** when they can: • Explain the structure and function of wind and insect pollinated flowers. • Explain the development of a seed. • Compare different methods and adaptations for seed dispersal. **7. Germination and growth** when they can: • Explain the process of germination. • Discuss the role of meristematic tissue in plant growth. **8. Plant responses** when they can: • Describe the roles of hormones in plants – auxins, gibberellins, ethylene. • Describe plant responses to stimuli – light, gravity, touch, water.	• Discuss the structure and function of the stem tissues in support and transport. • Explain the function of cell turgidity in plant support. **5. Transpiration** when they can: • Explain the role of transpiration in support, transport and cooling of the plant. • Discuss how environmental factors affect transpiration rate: humidity, wind, temperature, water availability. **6. The role of root structure** when they can: • Describe the structure of root tissues – epidermis, cortex, vascular bundle, root cap, root hairs. • Explain the structure and function of root cells and tissues in transport. **7. Reproductive structures and processes** when they can: • Discuss the advantages and disadvantages of sexual and asexual reproduction. • Identify the describe functions of flower parts – sepals (calyx), stamen (filament and anther, pollen), petals (corolla), carpel (stigma, style, ovary, ovule). • Describe the processes of: pollination, fertilisation, seed and fruit development *e.g., mechanisms for cross pollination, pollen tube development, development of the fertilised ovule into seed, ovary into fruit.* • Compare the alternation of sporophyte and gametophyte generations in mosses ferns and angiosperms.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
5. ENVIRONMENT	From their study of **ENVIRONMENT** students will understand **the biology of animals and their environment.** Students will investigate and develop their scientific understanding of: **1. The feeding relationships between organisms** when they can: • Define and describe food chains and food webs. • Design a simple food chain and food web. **2. The adaptations of organisms in relation to habitat and environment** when they can: • Define and name the three types of adaptations. • Describe how an organism's adaptations help it to survive. • Describe with examples Samoa's natural resources.	From their study of **ENVIRONMENT** students will understand **interactions of living things with each other and their environment.** Students will investigate and develop their scientific understanding of: **1. The patterns and inter-relationships of organisms** when they can: • Describe a community pattern and its purpose – succession, stratification. • Describe the inter-relationships of predation and parasitism. • Explain how inter-relationships help to maintain the community and the organisms. • Name and describe population and community. **2. The biotic and abiotic factors of the environment** when they can: • Define biotic and abiotic factors in the environment • Explain the importance of the biotic and abiotic environments for living things – predators, parasites, diseases, water, temperature, sunlight.	From their study of **ENVIRONMENT** students will understand **the relationships between an organism and its environment, the inter-relationships of organisms in a community and conservation and local environmental issues.** Students will investigate and develop their scientific understanding of: **1. The adaptations of organisms in relation to habitat and environment** when they can: • Explain how an organism's adaptations help it survive in a particular habitat or environment – structural, behavioural, functional and life history. • Explain how the activities of humans affect the relationship between an organism and its environment. **2. The inter-relationships of organisms in a community** when they can: • Describe inter-relationships between organisms in a local community – predation, commensalism, mutualism (symbiosis), parasitism. • Explain how the inter-relationships help maintain a community and its organisms. • Explain the different roles of trophic levels in food chains and webs. **3. The importance of conservation in the managing of biological resources** when they can: • Discuss causes and effects, and suggest possible solutions for environmental issues *e.g., deforestation, overuse of chemical pesticides and fertilizers, reclaiming of mangrove areas, waste management, over-fishing, destructive fishing methods, effects of introduced species on local species, endangered species, water resources, sewage disposal, etc.*	From their study of **ENVIRONMENT** students will understand **adaptations, populations, communities and ecosystems.** Students will investigate and develop their scientific understanding of: **1. Adaptations** when they can: • Explain the terms: environment, habitat, ecological niche and adaptation using local examples. • Describe adaptations of any local species. • Discuss the four types of adaptations (structural, physiological, behavioural and life history) and give examples of how they help a species to survive. • Explain the concepts of tolerance, acclimation, Gauses's Principle and Liebig's Law using local examples. **2. Populations** when they can: • Describe local populations. • Describe and discuss characteristics of a population – size, distribution and density using sampling methods *e.g., quadrats, transects*. • Explain the effects of natality and mortality on population growth and how these affect the survivorship curve. • Explain why biodiversity is essential for the continuation of communities. **3. Communities** when they can: • Distinguish between populations and communities. • Discuss ecological patterns in local communities – zonation, stratification, succession. • Compare intra-specific and inter-specific competition in terms of competition for living space (territory and home range), food and reproductive mates (animals), light and nutrients (plants) and how they affect relationships in a community. • Discuss the following inter-relationships using local examples – predation, parasitism, mutualism (symbiosis), commensalism.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
5. ENVIRONMENT		**3. A local environmental issue** when they can: • Name some local environmental issues. • Describe ways in which people can work towards the responsible use of the local environment. • Explain the importance of responsible use of the local environment. • Gather, process, present and report information on Samoa's natural resources and conservation.	• Gather, process, present and report information on a local environmental issue. • Explain why it is important to recycle nutrients using the carbon and nitrogen cycles. • Compare the long-term and short-term effects of using biological controls of pests on the environment and the use of chemical controls.	**4. Ecosystems** when they can: • Describe the living (biotic) and non-living (abiotic) parts of an ecosystem. • Construct and interpret food chains and food webs in a community. • Discuss how energy flows through an ecosystem *e.g., energy flow diagrams, pyramids of numbers, pyramids of energy and biomass.* • Discuss the importance of recycling of nutrients using carbon and nitrogen as examples. • Discuss the impact of development on the environment *e.g., tourism, logging, waste management, commercial fishing, population increase, sand mining, reclamation, agriculture.*

STREAM 2
General Science Curriculum Statement Years 9-12
Biology Component
FOR THE 4 YEARS SECONDARY EDUCATION

<table>
<tr><th>SUB-STRANDS</th><th>YEAR 9</th><th>YEAR 10 (SJSC)</th><th>YEAR 11</th><th>YEAR 12 (SSLC)</th></tr>
<tr><td></td><td colspan="4">Strand: THE WORLD OF LIFE [BIOLOGY]</td></tr>
<tr><td>1. VARIETY OF LIFE</td><td colspan="2">From their study of VARIETY OF LIFE students will understand the biology of micro-organisms. Students will investigate and develop their scientific understanding of:</td><td>From their study of VARIETY OF LIFE students will understand the classification of living things into 5 kingdoms and the biology of micro-organisms. Students will investigate and develop their scientific understanding of:</td><td>From their study of VARIETY OF LIFE students will understand the classification of living things and the biological organization. Students will investigate and develop their scientific understanding of:</td></tr>
<tr><td></td><td>1. The bacteria, fungi and viruses when they can:
• Describe the parts and functions of the structure of bacteria, fungi and viruses.
• Describe the reproduction of bacteria, fungi and viruses.
• Classify bacteria and fungi in Kingdoms Monera and Fungi.
• Describe the nature of viruses.

2. Scientific keys when they:
• Use simple keys to identify objects.</td><td>1. The effect of pathogens on living organisms when they can:
• Describe the effects of pathogens on living organisms and the methods used to overcome these effects.
• Explain how the spread of pathogenic diseases can be controlled.

2. The human use of micro-organisms when they can:
• Explain how the life processes of micro-organisms are used by humans: composting and brewing, baking, food production, antibiotic production.
• Carry out a composting activity.
• Write a report on a field trip to a brewery OR presentation of a guest speaker for baking e.g. round pancakes.</td><td>1. Living things when they can:
• Describe the levels of biological organisation – organelle to ecosystem and biosphere.
• Identify examples of the different levels of biological organisation.
2. The structure and life processes of viruses, bacteria and fungi when they can:
• Describe the structure of viruses, bacteria and fungi – size, shape, organelles and components present or absent.
• Culture bacteria and fungi.
• Explain how bacteria and fungi carry out the life processes; feeding, growth and asexual reproduction – binary fission, budding, spore formation.
• Discuss how bacteria and fungi are used for economic, environmental and medicinal purposes – making alcohol (fa'amafu), making antibiotics, making compost, making food e.g., miti, yoghurt, mushrooms.
• Carry out an experiment on reproduction of fungi e.g., budding in yeast, spores in breadmould.
3. The effects of harmful micro-organisms when they can:
• Describe examples of harmful micro-organisms.
• Explain why viruses are always pathogenic e.g., reproduction method.
• Describe common diseases caused by viruses, bacteria and fungi e.g., mumps, influenza, common cold, tinea, ringworm, pneumonia, boils.
• Carry out a research on pathogenic diseases that occur in Samoa e.g., HIV (AIDS), dengue fever, chicken pox, measles, Chikunguya, Zika, COVID-19 etc.
4. The control of harmful micro-organisms when they can:
• Discuss the effectiveness of antiseptics, disinfectants or antibiotics.
• Describe ways of controlling and curing disease e.g., antibiotics, vaccination, herbal.
• Explain the development of antibiotic resistance in pathogens and how it can be prevented.
• Discuss how the human body defends itself against pathogens.
• Describe the effects of HIV on the immune system.</td><td>1. Biological organisation when they can:
• Differentiate between the different levels of biological organization from organelle to biosphere.</td></tr>
</table>

2. CELL BIOLOGY [GENETICS]

From their study of **CELL BIOLOGY** students will understand **the structure and function of cells.** Students will investigate and develop their scientific understanding of:

1. The characteristics of life when they can:

- Describe the life processes carried out by living things – MRSCGREN.

2. The cellular nature of plants and animals when they can:

- List the levels of biological organization from organelles to organism.
- Explain the relationships between organelles, cells, tissues, organs, organ systems and organisms.

3. The basic parts of typical plant and animal cells when they can:

- Describe parts and functions of cells – cell membrane, cell wall, nucleus, cytoplasm, vacuole, chloroplast, mitochondrion.

4. The parts and functions of a light microscope when they can:

- Identify and name parts of a light microscope.
- Make a wet mount to view under the microscope.
- Use a light microscope to draw images/objects.
- Calculate total magnification.

From their study of **CELL BIOLOGY** students will understand **cell processes.** Students will investigate and develop their scientific understanding of:

1. Cell processes when they can:

- Describe the functions of cell processes – diffusion, osmosis and respiration.
- List the requirements and wastes produced by these cell processes.

From their study of **GENETICS** students will understand **the functions of cells and their part in inheritance.** Students will investigate and develop their scientific understanding of:

2. The process of cell division for growth when they can:

- Describe how the process of mitosis produces more cell while maintaining the chromosome number.

3. The process of cell division for reproduction when they can:

- Describe how the process of meiosis produces gametes with half the chromosome number and results in variation.
- Compare meiosis and mitosis in terms of number of cells produced and total number of chromosomes in each new cell.

From their study of **CELL BIOLOGY** students will understand **cell processes.** Students will investigate and develop their scientific understanding of:

1. The cellular nature of plants and animals when they can:

- Describe the advantages and disadvantages of light and electron microscope.
- Use a light microscope (low and high power) to view cells and tissues. *e.g., plant and animal tissues such as root tip, leaf cross section.*
- Draw cells and tissues as seen underthe microscope.
- Review the life processes carried out by living things-MRSCGREN.

2. The structure of cells when they can:

- Review the differences between plant and animal cells.
- Explain how the structure of organelles relate to their functions *e.g., cell membrane, cell wall, nucleus, cytoplasm, vacuole, chloroplast, ribosome, endoplasmic, reticulum, mitochondria, Golgi bodies, centrioles, lysosomes.*

3. Respiration when they can:

- Write a balanced chemical equation to describe the process of respiration.
- Compare aerobic and aerobic respiration.
- Explain how anaerobic respiration results in muscle fatigue.
- Carry out an experiment on fermentation in yeast *e.g., carbon dioxide production, effect of temperature.*
- Explain the importance of respiration and its relationship with photosynthesis.

4. Cell transport when they can:

- Describe the processes of diffusion and osmosis.
- Explain the importance of diffusion and osmosis in cell transport.
- Compare the processes of diffusion osmosis and active transport in terms of molecules transported, concentration gradient and energy requirements.
- Carry out an experiment on the processes of diffusion and osmosis *e.g., osmosis in plant cells.*

From their study of **CELL BIOLOGY** students will understand **cell structure, cell processes and enzymes**. Students will investigate and develop their scientific understanding of:

1. Cell structure when they can:

- Create/construct a model of a plant/animal cell to show the different parts.
- Relate the structure of each organelle to its function: nucleus, chromosomes, mitochondrin, chloroplast, ribosome, Golgi apparatus, vacuole, cell membrane, cell wall, lysosome, rough and smooth endoplasmic reticulum, nucleolus, nuclear membrane and centriole.
- Review the differences between plant and animal cells.

2. The microscope when they can:

- Demonstrate the preparation of a wet mount of biological specimen.
- Draw cells and tissues as seen under a light microscope.
- Determine the size of a specimen under a light microscope *e.g., use a plastic ruler to measure field of view, calculation.*

3. Cellular respiration when they can:

- Explain how the removal of or drop in the concentration of one raw material of aerobic respiration affects the process.
- Explain how glucose is converted to pyruvic acid during glycolysis.
- Explain how pyruvic acid is broken down during Kreb's Cycle.
- Discuss how most ATP is produced during the respiratory chain
- Compare anaerobic respiration in muscle cells and yeast cells.

4. Cell compounds when they can:

- Explain using simple diagrams or symbols to illustrate structures of each of the following: carbohydrates: monosaccharides (glucose), disaccharides (sucrose), polysaccharides (starch), lipids – fatty acids, glycerol proteinamino acids, peptide and polypeptides.
- Describe the role of carbohydrates, lipids and proteins in the structure and function of cells.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. CELL BIOLOGY [GENETICS]	From their study of **GENETICS** students will understand **the functions of cells and their part in inheritance.** Students will investigate and develop their scientific understanding of: **5a. The process of cell division for growth** when they can: • Define mitosis and meiosis. • Describe the function of mitosis and meiosis. • State the number of new cells produced by each process. • Name examples of cells where these processes occur. **5b. Variation in features of individuals** when they can: • Describe variation as continuous or discrete. • Explain the importance of variation to species. • Gather, process and present and report information on variation: heights of people, lengths of leaves.	**4. Simple monohybrid inheritance patterns** when they can: • Use genetic terms to describe genetic information and the outcomes of crosses trait, allele, gene, genotype, phenotype, dominant, recessive, homozygous, heterozygous. • Use Punnet squares and family trees to predict and describe the outcomes of crosses – tongue rolling, left and right handedness, etc. **5. Plant and animal cells and tissues** when they can: • Use a light microscope to view prepared slides and wet mounts produced by students using the techniques of cutting, staining and squashing *e.g., onion cells, human skin cells, leaves, soft stems.* • Identify, draw and label cell structures from microscope viewing. • Describe the function of organelles – Golgi bodies, centrioles, endoplasmic reticulum – rough and smooth, ribosomes. • Describe differences between plant and animal cells.	**5. Enzymes** when they can: • Describe the structure and function of enzymes using lock and key and induced fit models. • Explain the effect of temperature on the structure and function of enzymes. • Carry out an experiment of the effect of temperature on enzyme action. From their study of **GENETICS** students will understand **the functions of cells and their part in inheritance**. Students will investigate and develop their scientific understanding of: **6. Mitosis and meiosis** when they can: • Explain the relationship between chromosomes, DNA, genes and alleles. • Describe the behaviour of chromosomes in mitosis and meiosis. • Explain the importance of meiosis in reducing the chromosome number. • Discuss the role of meiosis and fertilisation in mixing genetic material. • Compare meiosis and mitosis. **7. Mendelian inheritance** when they can: • Name and describe examples of continuous and discrete variation. • Discuss examples of inheritance patterns in terms of characteristics, traits, genes, alleles, dominant and recessive alleles, genotype, phenotype, homozygous, heterozygous, and monohybrid, cross. • Solve monohybrid inheritance patterns involving complete dominance *e.g., family trees and Punnet squares, phenotypic and genotypic ratios.* • Explain the roles of the X and Y chromosomes in determining the sex of the individual.	**5. Enzymes** when they can: • Describe how enzymes catalyse biological reactions. • Explain how enzymes function in synthesis and breakdown reactions using induced fit model. • Carry out an experiment to show the effect of a factor on the rate of an enzyme-controlled reaction *e.g., pH, temperature, concentration of enzyme or substrate.* **6. Transport processes** when they can: • Describe the factors which influence the rate of diffusion and osmosis. • Explain how selective exchange occur at the cell membrane. • Compare active and passive transport using examples. • Explain how surface area to volume ratio limits substances entering and leaving cells. From their study of **GENETICS** students will understand **genetic material, cell division, Mendelian Inheritance, speciation and application of genetics.** Students will investigate and develop their scientific understanding of: **7. Genetic material** when they can: • Describe the structure and function of chromosomes, DNA and RNA. • Describe the process of protein synthesis stating the role of DNA, messenger RNA, transfer RNA and ribosomes. **8. Mitosis and meiosis** when they can: • Explain the roles of mitosis and meiosis in the life cycle of an organism. • Describe the sequence of events in mitosis and meiosis.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. CELL BIOLOGY [GENETICS]				• Compare meiosis and mitosis. • Discuss the role of crossing over, recombination and independent assortment in producing variation in species. **9. Mendelian inheritance** when they can: • Solve monohybrid crosses involving complete dominance, co-dominance, and incomplete dominance *e.g., Punnett squares, family tree diagrams.* • Explain inheritance patterns using the terms: dominant and recessive alleles, genotype, phenotype, homozygous, heterozygous, ratios. • Explain how the offspring from a test cross may indicate the genotype of an individual. • Explain the effect of multiple alleles on phenotype *e.g. human blood groups.* • Explain how sex is determined in mammals by X and Y chromosomes. • Solve dihybrid crosses involving complete dominance. **10. Applications of genetics when they can:** • Discuss how humans use engineering to produce organisms and substances of benefit them. • Discuss ethical issues associated with genetic manipulation of organisms.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
3. ANIMAL BIOLOGY	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems, describe food classes for healthy living and basic classification of the Animal Kingdom.** Students will investigate and develop their scientific understanding of: **1. The main groups of animals** when they can: • Classify and describe the major features of groups of animals – Invertebrates – insects, shellfish. Vertebrates – mammals, birds, fish. **2. The structures and functions of the circulatory and respiratory systems** when they can: • Identify and describe parts of the circulatory and respiratory systems heart, lungs, blood vessels, and composition of blood. • Explain how the parts of the circulatory and respiratory systems function in terms of transport and gas exchange.	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems.** Students will investigate and develop their scientific understanding of: **1. The structure and functions of parts of the skeleton-muscular system and digestive system** when they can: • Explain how parts of the skeleto-muscular and digestive systems function in terms of support and movement and digestion – endoskeleton, exoskeleton, hydrostatic skeleton, muscles, joints, stomach, oesophagus, small intestine, large intestine, liver, pancreas, gall bladder, rectum, anus. **2. The structure and functions of parts of the excretory and the reproductive systems** when they can: • Explain how parts of the excretory and reproductive systems function in terms of excretion and reproduction – kidneys, ureter, urethra, bladder, and nephron; testes, penis, sperm duct, prostate gland, scrotum, and epididymis; vagina, uterus, Fallopian tubes, ovary, and cervix.	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems and the effects of drugs and exercise on the organ systems.** Students will investigate and develop their scientific understanding of: **1. Nutrition** when they can: • Explain the importance of the essential nutrients – carbohydrates, lipids, protein, minerals (iron, calcium, iodine), vitamins (A, B, C, D), fibre and water. • Explain the effects of nutrient deficiencies, incorrect diet and eating disorders on humans. • Explain the structures and functions of the human digestive system. • Carry out food tests for protein and glucose. • Recall starch and lipids test (from Year 9). **2. Circulation** when they can: • State the importance of an internal transport system in animals. • Explain the structure and function of blood and blood vessels. • Describe the basic structure of the human circulatory system. • Discuss the roles of the circulatory and lymphatic systems for transport. **3. Gas exchange** when they can: • Explain the difference between respiration, gas exchange and breathing. Describe the breathing process in humans. • Explain the structure and function of the human respiratory system. **4. Excretion** when they can: • Explain the importance of excretory systems in animals.	From their study of **ANIMAL BIOLOGY** students will understand **the structure and function of organ systems and the effects of drugs and exercise on the organ systems.** Students will investigate and develop their scientific understanding of: **1. Nutrition and diet** when they can: • Describe the differences between autotrophic and heterotrophic nutrition. • Explain the importance of classes of food in the human diet. • Test for the presence of nutrients in food. • Compare the traditional Pacific/Samoan diet with more recent diets containing refined and processed food. **2. The digestive system** when they can: • Explain the structure and functions of parts of the digestive system-mouth, oesophagus, stomach, gall bladder, pancreas, small intestine-duodenum, ileum, sphincter muscles, hepatic portal vein. • Discuss the processes carried out by the digestive system-ingestion, digestion, absorption, assimilation and egestion. • Compare the gut structures of humans with herbivores and carnivores. • Carry out an experiment on the action of saliva on starch. **3. Gas exchange** when they can: • Review the difference between respiration, gas exchange and breathing. • Explain the role of the ribs, intercostals muscles and the diaphragm in inhalation and exhalation. • Explain how trachea, mucus, bronchi, alveoli and cilia facilitate gas exchange. • Describe the structure and function of the gas exchange systems in insect and fish. • Compare the structure and function of the gas exchange systems in humans, fish and insects. **4. Support** when they can: • Explain the structure and function of the three types of muscles. • Explain how muscles work with the skeleton to allow movement. • Describe the action of antagonistic pairs of muscles in producing movement.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
3. ANIMAL BIOLOGY	**3. Foods** when they can: • Classify foods into groups and explain their roles in the maintenance of health – proteins, carbohydrates, fibre, fats/oils, water, vitamins, minerals. • Identify food groups in common foodstuffs by carrying out simple food tests – fats, starch.	**3. How organ systems work together** when they can: • Describe how the organ systems – circulatory, respiratory, skeleto-muscular, digestive, excretory and reproductive systems interact to carry out MRSC-GREN in humans. **4. Diseases** when they can: • Gather, process and report information on the disease and malfunctions that affect these organ systems – sprains, strains, arthritis, ulcers, diabetes, gout, diarrhea, constipation. • Explain the consequences for the individual of these diseases and malfunctions.	• Describe excretory products and organs in humans *e.g., carbon dioxide and lungs urea and kidneys, sweat and skin.* • Explain the structure and function of the human excretory system – skin, kidneys. **5. Movement** when they can: • Describe the importance of movement for survival in animals. • Explain how the action of voluntary muscles cause movement. • Explain the importance of the skeleton for movement in vertebrates. **6. The nervous system** when they can: • Describe the importance of human senses. • Explain the central nervous system in humans. • Explain the structure and function of nerve cells – sensory and motor. • Discuss the significance of reflex actions. **7. Reproduction** when they can: • Explain the structure and function of the human male and female reproductive systems. • Describe gametogenesis, fertilisation, implantation and embryonic development. • Explain how materials are exchanged between the mother and the embryo. **8. Drugs and exercise** when they can: • Describe the effects of drugs on society. • Describe the effects of alcohol, drugs and smoking on the body. • Describe the effects of exercise on the body. • Carry out an experiment to study the effect of exercise on the breathing or pulse rate.	**5. Transport** when they can: • Explain the structure and function of the human heart. • Describe the effects of smoking, and obesity in causing coronary heart disease. • Explain the structure and function of the red blood cells, platelets and white blood cells. • Discuss the structure and function of the three main types of blood vessels: veins, arteries and capillaries. **6. Homeostasis** when they can: • Define homeostasis as the keeping of internal body condition in stable state. • Explain how a constant internal environment helps cells to function efficiently. • Discuss the following examples of homeostasis: temperature control in mammals, blood glucose levels in humans. **7. Excretion** when they can: • Describe the processes involved in the production of carbon dioxide, water and nitrogenous wastes. • Discuss the advantages and disadvantages of excreting nitrogen wastes in the form of ammonia (aquatic organisms), uric acid (birds, insects and reptiles) or urea (mammals). • Explain the structure and function of the kidney, urethra, ureter and bladder. • Explain how the structure of the nephron aids the processes of filtration and reabsorption. **8. Reproduction** when they can: • Explain the structure and function of ovary, oviduct (Fallopian tube), uterus (womb), vagina, scrotum, testis, epididymis, sperm duct vas deferens), prostate gland, seminal vesicle, urethra and penis. • Discuss reproductive development from gamete production, fertilization, implantation to birth. • Explain how materials are exchanged between the mother and the foetus via placenta. • Discuss the roles of the hormones oestrogen and progesterone in the development of secondary sexual characteristics in females and in the menstrual cycle. • Discuss the role of the hormone testosterone in the development of secondary sexual characteristics in males.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
4. PLANT BIOLOGY	From their study of **PLANT BIOLOGY** students will understand **the biology of plants.** Students will investigate and develop their scientific understanding of: **1. The arrangement of the parts of a plant** when they can: • Identify and describe the arrangement of the external features of a plant – roots, stem, leaves, branches, flower. • Describe the advantage to the plant of the different arrangements or external features. **2. The processes involved in plant growth and reproduction** when they can: • Describe the processes of germination, growth, sexual and asexual reproduction in plants. • Carry out an experiment on seed germination, asexual reproduction, and the flower.	From their study of **PLANT BIOLOGY** students will understand **the biology of plants.** Students will investigate and develop their scientific understanding of: **1. The process involved in the production of glucose** when they can: • Describe the process of photosynthesis. • Carry out an experiment into an aspect of photosynthesis – the need for sunlight, carbon dioxide or chlorophyll for photosynthesis. • Carry out an experiment on testing a leaf for starch. **2. The processes involved in the transport of glucose and water** when they can: • Describe the processes involved in the transport of glucose and water – absorption, transpiration, translocation. • Carry out an experiment on transpiration using a weight potometer to illustrate water transport. • Explain the relationship between the processes of transport of glucose and water and growth in plants.	From their study of **PLANT BIOLOGY** students will understand **the biology of plants.** Students will investigate and develop their scientific understanding of: **1. The process of photosynthesis** when they can: • Write a balanced chemical equation to describe the process of photosynthesis. • Explain the importance of photosynthesis to plants and other living things. • Carry out an experiment on leaf pigments – paper chromatography. **2. Leaf structure** when they can: • Draw and label the internal structure of leaves. • Explain the functions of leaf parts *e.g., gas exchange, photosynthesis, transport.*	From their study of **PLANT BIOLOGY** students will understand **the biology of plants.** Students will investigate and develop their scientific understanding of: **1. Leaf structure** when they can: • Draw, label and identify the internal structure of a leaf – cuticle, epidermis, palisade, and spongy mesophyll, vascular bundle, stoma, guard cells, air space. • Explain the functions of leaf parts in photosynthesis, transport of glucose and water and gas exchange. **2. The process of photosynthesis** when they can: • Write a balanced chemical equation for photosynthesis. • Explain the structure and function of chloroplasts – grana, stroma. • Describe the light and dark phase reactions. • Explain how factors affect the rate of photosynthesis – carbon dioxide, light intensity, water and temperature.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
5. ENVIRONMENT	From their study of **ENVIRONMENT** students will understand **the biology of animals and their environment.** Students will investigate and develop their scientific understanding of: **1. The feeding relationships between organisms** when they can: • Define and describe food chains and food webs. • Design a simple food chain and food web. **2. The adaptations of organisms in relation to habitat and environment** when they can: • Define and name the three types of adaptations. • Describe how an organism's adaptations help it to survive. • Describe with examples Samoa's natural resources.	From their study of **ENVIRONMENT** students will understand **interactions of living things with each other and their environment.** Students will investigate and develop their scientific understanding of: **1. The patterns and inter-relationships of organisms** when they can: • Describe a community pattern and its purpose – succession, stratification. • Describe the inter-relationships of predation and parasitism. • Explain how inter-relationships help to maintain the community and the organisms. • Name and describe population and community. **2. The biotic and abiotic factors of the environment** when they can: • Define biotic and abiotic factors in the environment. • Explain the importance of the biotic and abiotic environments for living things – predators, parasites, diseases, water, temperature, sunlight. **3. A local environmental issue** when they can: • Name some local environmental issues. • Describe ways in which people can work towards the responsible use of the local environment. • Explain the importance of responsible use of the local environment. • Gather, process, present and report information on a local environmental issue.	From their study of **ENVIRONMENT** students will understand **the relationships between an organism and its environment, the inter-relationships of organisms in a community and conservation and local environmental issues.** Students will investigate and develop their scientific understanding of: **1. The adaptations of organisms in relation to habitat and environment** when they can: • Explain how an organism's adaptations help it survive in a particular habitat or environment – structural, behavioural, functional and life history. • Explain how the activities of humans affect the relationship between an organism and its environment. **2. The inter-relationships of oganisms in a community** when they can: • Describe inter-relationships between organisms in a local community – predation, commensalism, mutualism (symbiosis), parasitism. • Explain the different roles of trophic levels in food chains and webs. **3. The importance of conservation in the managing of biological resources** when they can: • Discuss causes and effects, and suggest possible solutions for environmental issues *e.g., deforestation, overuse of chemical pesticides and fertilisers, reclaiming of mangrove areas, waste management, over-fishing, destructive fishing methods, effects of introduced species on local species, endangered species, water resources, sewage disposal, etc.* • Gather, process, present and report information on a local environmental issue. • Explain why it is important to recycle nutrients using the carbon and nitrogen cycles. • Compare the long-term and short-term effects of using biological controls of pests on the environment and the use of chemical controls.	From their study of ENVIRONMENT students will understand adaptations, populations, communities and ecosystems. Students will investigate and develop their scientific understanding of: **1. Adaptations** when they can: • Explain the terms – environment, habitat, ecological niche and adaptations using local examples. • Describe adaptations of any local species. • Discuss the four types of adaptations (structural, physiological, behavioural and life history) and give examples of how they help a species to survive. **2. Communities** when they can: • Discuss the following inter-relationships using local examples – predation, parasitism, mutualism (symbiosis), commensalism. **3. Ecosystems** when they can: • Describe the living (biotic) and non-living (abiotic) parts of an ecosystem. • Construct and interpret food chains and food webs in a community. • Discuss the importance of recycling of nutrients using carbon and nitrogen as examples. • Discuss the impact of development on the environment *e.g., tourism, logging, waste management, commercial fishing, population increase, sand mining, reclamation, agriculture.*

Recommended Resources for Teachers and Students of Biology and General Science Biology

These are only a few of many resources teachers and students can search and use to assist with the teaching and learning.

Textbooks and booklets:

1. Book 1 Year 9 Science; CDMD, MESC
2. Level 1-3 Biology AME Workbook, for exam revision and practicing exam questions; Cara Scott, updated 2019, ESA Publications
3. NCEA Level 3 Biology internals; T. Greenwood, L Bainbridge-Smith, K.Pryor, R.Allan, 2nd edition 2017, BIOZONE ISBN: 978-1-927309-61-2
4. Various NCEA Science and Biology textbooks available on scitext.co.nz. For examples:
    - ESA Study Guide Level 1 Biology; M.Sinclair – also available on scitext.co.nz
    - AME Year 11, year 12, year 13 (Level 1-3) NCEA Biology textbooks or booklets
5. Samoa SchoolNet & Community Access Project Model Learning Activities, Biology Years 12/13, RTI international & SchoolNet and MESC
6. Year 12 Biology Teachers Workshop 2016, Module 1: Micro-organisms
7. Environmental Science, The Natural World Around us, Year 11 Students' Booklet, CDMD, MESC
8. Learning about climate change the Pacific way; A guide for Pacific teachers; Samoa; SPC & GIZ and MESC
9. Oceans Rising: A teaching unit for Years 8-12 children; SEREAD (Scientific Educational Resources and Experience Associated with the Development of Argo).

Online webs (a few of many online resources with notes, videos, guides for teachers and students):

- mesc.gov.ws
- www.bioedonline.org
- www.nsf.gov
- www.actionbioscience.org


Chemistry

Explanatory notes on realignment and compilation of Chemistry and General Science Chemistry component for 4 year level

This compilation of specific contents for the Chemistry curriculums for the four year levels of secondary school education is based primarily on the following resources:

- Current 5 year level overview Science curriculums for Year 9-13.
- Chemistry strands, aims and achievement objectives progression for years 9-13 as reviewed and compiled by subject panelists 2016.
- External review report 2019 for Year 12 and 13 by external reviewer Dr Taema Imo-Seuoti.

This compilation ensures that for:

1. STREAM 1 – CHEMISTRY, the curriculums as currently studied and recently reviewed for the 5 year level remain intact but realigned into 4 year level, with the contents reshuffled across Years 10,11 and 12, while the content for year 9 remains intact. Specifically, the reshuffle of curriculum contents is as follows:

- the current Year 9 Chemistry component of the Science curriculum for the 5 year level remains as it is when shifting to the 4 year level with first Year 9 cohort in 2021.
- the whole current Year 11 (of the 5 year level) Chemistry curriculum is combined with current year 10 Chemistry to make up the curriculum for the Year 10 Chemistry of the 4 year level. This reshuffle ensures that there is no repetition of contents and achievement objectives when combining the two current Years 10 and 11 curriculums.
- the whole current Year 12 (of the 5 year level) Chemistry curriculum is now Year 11 Chemistry (of the 4 year level) but with very few contents moved from the current Year 12 curriculum to be introduced at this level and one sub-topic REDOX Reactions was moved to form the new strand Oxidation and Reduction as per recommendations by external reviewer or technical advisor.
- the whole current Year 13 (of the 5 year level) Chemistry curriculum is now Year 12 Chemistry (of the 4 year level) but with very few contents moved from the current Year 12 curriculum to be introduced at this level and one sub-topic REDOX Reactions was moved to form the new strand Oxidation and Reduction as per recommendations by external reviewer or technical advisor.

1. STREAM 2 – GENERAL SCIENCE, its Chemistry component is compiled to make sure contents is suitable for students who will choose this option (instead of the pure Chemistry option in Stream 1) beginning at Year 10, then Years 11-12, and ultimately leading to post-secondary studies in the fields of primary education, nursing or TVET. The General Science curriculum contents was thus compiled as follows:

    - the Year 9 Chemistry component (for the 4 year level) remains the same as in Stream 1.
    - the Year 10 Chemistry component (for the 4 year level) is the same Year 10 Chemistry curriculum currently used for the 5 year level.
    - the Year 11 Chemistry component (for the 4 year level) is the same Year 11 Chemistry curriculum currently used for the 5 year level, but with very few contents moved from the current Year 12 curriculum to be introduced at this level and one sub-topic REDOX Reactions was moved to form the new strand Oxidation and Reduction.
    - the Year 12 Chemistry component (for the 4 year level) is the same Year 12 Chemistry curriculum currently used for the 5 year level but with one sub-topic REDOX Reactions moved to form the new strand Oxidation and Reduction as per recommendations by external reviewer or technical advisor.

Unlike the Physics and Biology curriculums, the Chemistry curriculum for 5 years level is dif-

ficult to be rearranged into a consistent number of strands across all four levels, due to the different breakdown of strands of the current Years 12 and 13 compared to strands for the current Years 9,10 and 11 curriculums. There are only 3 strands for Years 9-11 and 6 strands for years 12-13 for the 5 years level.

Nevertheless to bring the number of strands under some common grounds, the new arrangement of strands for Chemistry is as follows:

For Years 9-10

1. The ways the materials are structured
2. The properties and uses of groups of substances
3. The ways the materials changed (Principles of Chemical Change or Inorganic Chemistry)

For Years 11-12

1. The ways the materials are structured (Atomic Structure and Bonding)
2. Quantitative Chemistry
3. Organic Chemistry
4. Principles of Chemical Change (Inorganic Chemistry)
5. Principles of Physical Chemistry
6. Oxidation and Reduction
7. Environmental Chemistry

The 7th Strand "Environmental Chemistry" is a new strand recommended to be added for students to learn the link of Science concepts to their environment and the other Science subjects.

STREAM 1
Chemistry Curriculum Statement Years 9-12
FOR THE 4 YEARS SECONDARY EDUCATION

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
	Strand: **THE WORLD OF MATERIALS [CHEMISTRY]**			
1. WAYS THE MATERIALS ARE STUCTURED [1.ATOMIC STRUCTURE AND BONDING]	From their study of **STRUCTURE OF MATERIALS** student will investigate and develop their scientific understanding of: **1. The atomic structure** when they can: • Describe particle nature of matter (solid, liquid and gas phases). • Describe the building block of matter – structure of the atom. • Identify electrons, protons, nucleus of the atom. **2. The periodic table of elements** when they can: • Introduce Dmitri Mendeleev (1834), formulated the Periodic Law (elements 1–20). • Introduce periodic table of elements, names, symbols of elements 1–20. • Describe the properties of elements (1–20).	From their study of **STRUCTURE OF MATERIALS** students will investigate and develop their scientific understanding of: **1. The atomic structure and bonding** when they can: • Describe atomic number, mass number and number of neutrons. • Introduce ions. • Differentiate between atoms and ions. • Introduce chemical bonding. • Describe cations and anions. • Describe ionic bonds and covalent bonds. • Describe the formation of compounds *e.g., $Na^+ + Cl^- \rightarrow NaCl$.* • Introduce the Lewis structure *e.g., shared paired of electrons.* **2. The periodic table of elements** when they can: • Introduce groups and elements;	From their study of **THE STRUCTURE OF ATOMS** students will investigate and develop their scientific understanding of: **1. The atomic structure and bonding** when they can: • Identify atomic structure (protons, neutrons, electrons, isotopes) of a given atom or ion *e.g., ^{27}Al, $^{27}Al^{3+}$, $^{35}_{17}Cl$, $^{35}_{17}Cl$.* • Introduce Octet Rule. • Explain how an atom changes to an ion and the combining power of an atom that causes that change. • Describe electron arrangement/ configuration. • Draw Lewis structures of molecules *e.g., O_2, H_2, Cl_2, H_2O, CH_4, N_2.* • Describe the shape of molecules *e.g., HCl, H_2O, NH_3, CH_4, CO_2.* • Describe polar and non-polar molecules and bonding. • Comparing ionic, covalent and metallic bonding.	From their study of **THE STRUCTURE OF ATOMS** students will investigate and develop their scientific understanding of: **1. The periodic table** when they can: • Write electron configurations using *s, p, d* notations. • Use the principle energy levels to identify atoms in the same period. • Use valence electrons to identify elements in the same group. • Relate the charge on monoatomic ions to their positions on the periodic table. • Define the following terms: (i) ionization energy (ii) atomic radii (iii) ionic radii (iv) electronegativity. • Define orbitals and give examples. • Explain the trends in (i)-(iv) above, across periods 2 and 3 and within groups. • Use the trends in the periodic table to explain the properties of atoms and ions. • Explain, relate and describe: a) Oxides (illustrated by Na_2O, MgO, Al_2O_3, SiO_2) as follows: (i) explain the ratio of the atoms in the oxides as it relates to the position of the element in the periodic table; (ii) relate the ionic and covalent oxides to their position in the periodic table; (iii) describe the trend from basic oxides to acidic oxides; (iv) write balanced equations which demonstrate the acidic, amphoteric or basic properties of an oxide.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
1. WAYS THE MATERIALS ARE STUCTURED [1.ATOMIC STRUCTURE AND BONDING]	**3. The properties of compounds and mixtures** when they can: • Introduce the concept of compounds and mixtures. • Identify everyday materials that change states. • Investigate the change in physical properties when materials change states (melting, freezing, evaporation, condensation, sublimation).	• Introduce electron arrangement using diagram and numerical sequence of elements/atoms (1–20);. • Introduce molecular mass, molar mass, relative molecular mass of elements (1–20 elements). • Introduce electron arrangements of ions (1–20 elements). • Compare electron arrangements of ions and atoms (1–20 elements). **3. The properties of compounds and mixtures** when they can: • Compare elements, compounds and mixtures. • Prepare compounds in a school laboratory (CO_2, H_2, O_2). • Identify the uses of compounds such as CO_2, H_2 and O_2. • Describe the properties of compounds and mixtures. • Introduce metal compounds (oxides, hydroxides etc).	**2. The periodic table of elements** when they can: • Introduce groups and elements. • Introduce group 17 and group 18 transition elements. **3. Valence electrons and the periodic table** when they can: • Demonstrate how valence electrons are arranged across a period and down a group.	b) Chlorides (illustrated by NaCl, $MgCl_2$, $AlCl_3$, PCl_3, HCl) as follows: (i) explain the ration of the atoms in the chlorides in relation to the position of the element in the period from Na-P; (ii) relate the melting points and the electrical conductivities of chlorides to their structure and bonding; (iii) write balanced equations which demonstrate the reaction of chlorides with water. **2. The intramolecular bonding (ionic, covalent and metallic)** when they can: • Explain intramolecular bonding. • *[ionic bonding]* (i) describe ionic bonding in terms of electron transfer; (ii) describe the properties of ionic substances: electrical conductivity, solubility, boiling/melting points, brittleness; (iii) relate the physical properties of ionic substances to their structures and bonding. • *[covalent bonding]* (i) describe a covalent bond as a shared pair of electrons (coordinate bonding); (ii) distinguish between polar and non-polar covalent bonds; (iii) describe the continuum in the distinguish of electrons moving from non-polar through polar to ionic bonding; (iv) describe the polarity of the water molecule and the process of hydration of ionic substances; (v) describe the physical properties of discrete molecular substances and infinitely extended covalent networks. Physical properties to be limited to electrical conductivity, melting point/boiling point, solubility; (vi) relate these physical properties to their structures and bonding. • *[metallic bonding]* (i) describe the metallic bond as a lattice of positive ions and delocalized electrons; (ii) describe the physical properties of metallic substances. Physical properties to be limited to: electrical conductivity, melting point, boiling point, malleability, ductility, lustre; (iii) relate these properties to their structures and bonding.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
1. WAYS THE MATERIALS ARE STUCTURED [1.ATOMIC STRUCTURE AND BONDING]				**3. The intermolecular bonding** when they can: • Describe intermolecular bonding. • Explain non-polar particles attracted to non-polar particles. Temporary dipole attracted to induced dipole. • Explain polar molecule attracted to polar molecule. Permanent dipole attracted to permanent dipole. • Explain hydrogen bonding molecule attracted to hydrogen bonding molecule. • Explain the formation of hydrogen bonding. It occurs only with 3 atoms, mainly fluorine, oxygen, nitrogen. • Discuss the relative strength of the types of intermolecular bonds. **4. The shapes of molecules** when they can: • State the octet rule and use it to draw Lewis structures for covalent molecules and ions. • Deduce the shape of simple covalent molecules using electron pair repulsion theory (VSEPR). • Name and draw molecules with the following shapes: (i) linear *e.g.*, *HCl*, CO_2 (ii) bent (v-shaped) *e.g.*, H_2O (iii) triangular pyramid *e.g.*, NH_3 *and trigonal planar e.g.*, CH_2O (iv) tetrahedral *e.g.*, CH_4, CCl_4 • Use the molecular shape and electron distribution to determine whether the molecules are polar or non-polar.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. THE PROPERTIES AND USES OF GROUPS OF SUBSTANCES	From their study of **THE ROPERTIES AND USES OF GROUPS OF SUBSTANCES** students will investigate and develop their scientific understanding of: **The uses and impacts of substances** when they can: • Gather processes and present information on the physical properties (shiny, conductivity, malleability, ductile) of metals (iron nail, aluminium, magnesium strip) and non-metals (sulfur, candle, hydrogen gas). • Carry out investigations on the chemical properties of metals (rusting iron nail and burning of magnesium strip) and non-metals (burning of candle). • Explain the physical and chemical properties of metals and non-metals and determine their uses.	From their study of **THE ROPERTIES AND USES OF GROUPS OF SUBSTANCES** students will investigate and develop their scientific understanding of: **The uses and impacts of substances** when they can: • Gather processes and present information on the safe and appropriate uses of groups of substances found in home or community (household cleaners, detergents, fertilizers, cosmetics, plastics). • Describe how to use household substances in a safe and appropriate way. • Describe the uses of household substances *e.g., household cleaners, plastics, perfumes, detergents.* • Identify the impact of household substances *e.g., household cleaners, plastics, perfumes, detergents* • Research on the impact of a group of substances on people and the environment *e.g., fertilizers, fuels, household cleaners, plastics, detergents (to name a few).*		
4. THE WAYS THE MATERIALS CHANGE	From their study of **THE WAYS THE MATERIALS CHANGE** students will investigate and develop their scientific understanding of: **1. The different types of chemical reactions and write a balanced equation for the reaction** when they can: • Describe chemical reactions using word equations (burning of magnesium strip, rusting of iron, reaction of metals with acids). **2. The factors affecting chemical reactions** when they can: • Investigate ways of producing physical (dissolving, heating, grinding) and chemical changes (burning, rusting) in everyday materials. • Describe processes that occur during physical and chemical changes (colour change, heat change, bubbling or fizzing, precipitation). **3. Processes used locally to produce a familiar material** when they can: • Investigate to identify steps in the production of fine mats, Samoan oil, banana chips. • Describe steps in a process used locally to produce familiar materials (examples above).	From their study of THE WAYS THE MATERIALS CHANGE students will investigate and develop their scientific understanding of: **1. The different types of chemical reactions and writea balanced equation for the reaction** when they can: • Describe chemical reactions using chemical symbols (burning of magnesium strip, rusting of iron, reaction of metals with acids). • Balance chemical equations using chemical symbols. • Describe chemical reactions: precipitation and neutralization. • Introduce oxidation *e.g., rusting.* **2. The factors affecting chemical reactions** when they can: • Define the rate of a chemical reaction. • Introduce the factors that affect the rate of chemical reactions *e.g., temperature, surface area, concentration, enzymes.* • Describe the factors that affect the rate of chemical reactions *e.g., temperature, surface area, concentration, enzymes.* • Explain how these factors affect reaction rate *e.g., speed up the reaction, slow down the reaction, for example – rusting, burning of a candle, boiling water.* **3. Processes used locally to produce a familiar material** when they can: • Describe changes that occur during the steps in the production of fine mats, Samoan oil, banana chips. • Research on the production of coconut oil, corn beef, beer, purification of water.		

SUB-STRANDS	YEAR 11	YEAR 12 (SSLC)
3. QUANTITATIVE CHEMISTRY	From their study of **QUANTITATIVE CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The molar mass, relative molar mass, relative atomic mass/number, moles** when they can: • Define relative atomic mass, relative molecular mass, molar mass, moles and Avogadro's constant/number 6.0 x 10^{23}. • Calculate mass, molar mass and moles using *e.g.*, $n = \frac{m}{M}$ • Balance equations (atoms and number of moles). • Write balanced chemical equations in terms of relative amounts of reactants and products involved in a reaction. • Calculate the percentage composition, empirical formula, molecular formula of compounds. • Calculate the water of crystallization *e.g.*, $MgSO_{4.x}H_2O$ *and* $CuSO_{4.x}H_2O$. • Calculate the concentration of solutions in mol/L and g/L using $c = \frac{n}{v}$ or $c = \frac{m}{v}$ or $C_1V_1 = C_2V_2$ • Introduce the concept of titration (limit to apparatus *e.g., pipette, burette, conical flask*).	From their study of **QUANTITATIVE CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The mole/(s) and molar mass** when they can: • Define amount of substance in moles and molar mass. • Recall that the molar mass of an element is numerically the same as its relative atomic mass. • Carry out simple calculations involving mass (g), molar mass (g/mol), amount (moles), Avogadro's number and chemical formulae using: moles (n), Avogadro's number (6.0 x 10^{23}), relative atomic mass (Ar), molar mass (M), relative molecular mass (Mr). **2. The empirical and molecular formulae** when they can: • Distinguish between an empirical formula and a molecular formula. • Calculate: (i) percentage composition *e.g., water of crystallization, elements in a compound*; (ii) empirical formula of a compound given its percentage composition (and vice-versa); (iii) molecular formula from empirical formula and molar mass (and vice-versa). **3. Stoichiometry** when they can: • Use the symbols to describe states of molecules in chemical equations [(g) gas, (l) liquids, (aq) aqueous solution]. • Carry out stoichiometric calculations based on mass, number of moles, concentration and volume. $c = \frac{n}{v}$, $c = \frac{m}{v}$, $c = m/M$ $C_1V_1 = C_2V_2$ • Calculate percentage yield when doing preparative chemistry % yield = experimental yield divided by theoretical yield times 100% Experimental yield = mass of product obtained Theoretical yield = mass of product calculated from balanced equations *Note: stoichiometry–mathematical relationship* **4. Acid-base titrations** when they can: • Define standard solution, titre, aliquot, equivalency, end point. • Calculate: (i) concentration to specified dilutions in terms of g/L and mol/L or M [molarity]. (ii) mass required to make a standard solution given the size of volumetric flask and molar mass. (iii) unknown concentration based on titration data. • Identify and use all the equipment used for volumetric analysis. • Prepare a standard solution. • Carry out a titration and dilution. • Describe the colour changes of common indicators *e.g., methyl orange, phenolphthalein and bromothymol blue.* • Introduce other units of concentration: pert per million (ppm), parts per billion (ppb) and parts per trillion (ppt).

SUB-STRANDS	YEAR 11	YEAR 12 (SSLC)
4. ORGANIC CHEMISTRY	From their study of **ORGANIC CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The occurrence, properties and preparation of hydrocarbons (alkanes, alkenes and alkynes)** when they can: • Investigate sources of the naturally occurring hydrocarbons. • Name straight chain alkanes, alkenes, alkynes and with branch chains and their chemical properties. • Define the following terms: homologous series, isomerism, functional groups, saturation and unsaturation. • Name and write molecular formula and draw structural formula for hydrocarbons (carbon 1 – carbon) IUPAC. • Describe the physical and chemical properties of alkanes, alkenes and alkynes. • Investigate the addition (alkenes & alkynes) and substitution (alkanes) and polymerization (polyethene) reactions. • Carry out test for unsaturation/Bromine Test (acidified $KMnO_4$/Bromine solution). • Investigate the laboratory preparation of ethyne. • Introduce polymers. **2. The properties of alcohols, carboxylic acids and esters** when they can: • Name and write molecular formula and draw structural formula of alcohols (carbon 1 – carbon 5). • Investigate the production of ethanol from the hydration of ethene. • Name the three types of alcohols (primary, secondary and tertiary). • List the uses of alcohols (solvents, fuel etc). • Name and write molecular formula and draw the structural formula of carboxylic acids (carbon 1 – carbon 5). • Investigate the properties (chemical & physical) of carboxylic acids. • Reactions of carboxylic acids with alcohols to form esters. • Describe esterification and saponification and naming esters. • Describe physical and chemical properties of alcohols.	From their study of ORGANIC CHEMISTRY, students will investigate and develop their scientific understanding of: **1. Alkanes, alkenes and alkynes** when they can: • Use the general formula to determine the molecular formulae and structural formulae of alkanes C1-C8, alkenes C2-C5 and alkynes C2-C5. • Apply the concept of 'structural isomerism' to alkanes and alkenes. • Apply the concept of 'geometrical isomerism' to alkenes (carbon 2 – carbon 5). • Use the IUPAC rules to name hydrocarbons (carbon 1 – carbon 8). • Identify the functional groups of alkanes, alkenes and alkynes. • Test for unsaturation using acidified potassium permanganate and Bromine water solution/water. • Recognise and write equations for: (i) substitution reactions of alkanes with halogens. (ii) addition reactions of alkenes and alkynes with halogens (halogenation), water (hydration), and hydrogen (hydrogenation). *Note: the mechanism of electron transfer will NOT be examined.* • Describe the laboratory preparation of ethene (by steam cracking and by dehydration), and ethyne (from calciumcarbide), and write balanced equations for each. **2. Polymerization** when they can: • Explain using structural formulae, the production of polythene and PVC. • Give examples of the use of PVC and polythene. • Describe the environmental problems caused by PVC and polythene products. **3. Haloalkanes** when they can: • Identify and name the three types of haloalkanes (primary, secondary and tertiary). • Write balanced equations for the formation of simple primary alkyl halides from a reaction between hydrogen halides and alkenes. **4. Alcohols, ketones, and aldehydes** when they can: • Identify the functional groups for alcohols, ketones and aldehydes. • Use the IUPAC rules to name alcohols, ketones and aldehydes (carbon 1 – carbon 5). • Deduce the products formed from the oxidation of the three types of alcohol. • Carry out tests for ketones and aldehydes. • Prepare aldehydes and ketones by oxidation of alcohol –tests to distinguish between aldehydes and ketones **5. Carboxylic acids and esters** when they can: • Recognise the functional group. • Describe the acidic behaviour of ethanoic acid. • Write equations to show the reaction of ethanoic acid with aqueous sodium hydroxide. • Carry out the laboratory preparation of an ester. • State the characteristic properties of esters. • Name esters. • Describe carboxylic acid derivatives.

SUB-STRANDS	YEAR 11	YEAR 12 (SSLC)
5. PRINCIPLES OF CHEMICAL CHANGES [INORGANIC CHEMISTRY]	From their study of **THE PRINCIPLES OF CHEMICAL CHANGE [IN ORGANIC CHEMISTRY]** students will investigate and develop their scientific understanding of: **1. Metals and ions and precipitation reactions** when they can: • Investigate and identify the physical properties of metals *e.g., K, Na, Ca, Mg, Al, Zn, Fe, Pb, Cu, Ag.* • Investigate the chemical properties of metals through their reactions with air, water, and dilute acids and their displacement in metallic salts solutions. • Define precipitation. • Use the solubility rules/grid to identify precipitation reactions (tests for cations (Al^{3+}, Mg^{2+}, Fe^{2+}, Cu^{2+}, Fe^{3+} and Ag^{+}) and anions (Cl^{-}, SO_4^{2-}, CO_3^{2-} and NO_3). **2. Non-metals** when they can: • Investigate the preparation and uses of carbon and its compounds (CO_2, CO and CO_3^{2-}). • Name the allotropes of carbon (diamond and graphite) and their respective properties and uses. • Investigate the occurrence, properties, preparation and uses of nitrogen (NO_2, HNO_3, NH_3). • Investigate the occurrence, and uses of sulphur compounds (SO_2, SO_3). • Outline the extraction of sulphur by the Frasch process. • Name the allotropes of sulphur and respective uses *e.g., monoclinic and rhombic.* • Outline the Contact process for the manufacture of sulphuric acid. • Investigate the occurrence, properties, preparation and uses of chlorine (HCl, Cl_2, HOCl, NaCl). • Introduce chlorination. **3. Acid-base reactions** when they can: • Define acids as proton donors and bases as proton acceptors. Outline the chemical and physical properties of acids and bases. • Investigate the chemical reactions of acids and bases with metals. • Carry out simple tests for acids and bases using common indicators such as litmus paper, methyl orange, phenolphthalein and universal indicator. • Introduce the pH scale to classify the following: strong acids, weak acids, neutral, weak bases and strong bases. • Explain the difference between strong and weak acids (H_2SO_4, HCl, CH_3COOH) & strong and weak bases (NaOH, KOH, NH_3). • Introduce reactions of amphoteric substances such as Al_2O_3 and ZnO, $Zn(OH)_2$ and $Al(OH)_3$ and with water with acids and bases. **4. Physical properties of water** when they can: • List the physical properties of water. • Investigate soft and hard water using soap.	From their study of **THE PRINCIPLES OF CHEMICAL CHANGE [IN ORGANIC CHEMISTRY]** students will investigate and develop their scientific understanding of: **1. The acids and bases** when they can: • Define acids as proton donors and bases as proton acceptors. • Identify acid-base conjugate pairs. • Describe the behaviour of strong and weak acids and bases in terms of H and OH. • Determine the strength of an acid or base using universal indicator *e.g., HCl, HNO_3, H_2SO_4, CH_3COOH, Na_2CO_3, NH_3.* • Describe the properties of hydroxides and write equations to indicate such properties. • Use equations to show that water can behave as an acid and as a base (amphiprotic). • Describe the equilibrium reaction for water and its ionic product (KW) represented by: $[H_3O]$ [OH] = 10 or [H] [OH] = 1 x 10-14. • Use pH + pOH = 14 to deduce pOH or pH. Calculate pH and pOH given the hydrogen ion and hydroxide ion concentrations (and vice-versa). **2. Precipitation reactions** when they can: • Describe precipitate is a type of chemical change which produces an insoluble precipitate which is a new substance. • Carry out practicals to determine the solubilities of nitrates, sulphates, chlorides carbonates, hydroxides, salts of Group I metals and ammonium salts. • Apply formulae and recognise the appearance of the following complex ions $[Cu(NH_3)_4]^{2+}$, $[Ag(NH_3)_2]+$, $[Al(OH)_4]$, $[Zn(OH)_4)^{2-}$. Apply knowledge of solubilities and complex ions to carry out tests for the presence of: Mg^{2+}, Ag^{+}, Fe^{2+}, Fe^{3+}, Cu^{2+}, Al^{3+}, CO, Cl, SO, Zn^{2+}, Pb^{2+}, I, OH and describe the observations made. • Write balanced ionic equations to represent the reactions which occur during the test above.

SUB-STRANDS	YEAR 11	YEAR 12 (SSLC)
5. PRINCIPLES OF PHYSICAL CHEMISTRY	From their study of **PRINCIPLES OF PHYSICAL CHEMISTRY,** students will investigate and develop their scientific understanding of: 1. **The physical changes in chemistry** when they can: • Describe exothermic and endothermic reactions. • Investigate the factors affecting the rate of reactions *e.g., temperature, concentration, surface area and catalyst.* • Introduce Collision Theory. • Introduce equilibrium (in terms of reversible reactions). • Explain weak acids and bases with equilibrium.	From their study of **PRINCIPLES OF PHYSICAL CHEMISTRY,** students will investigate and develop their scientific understanding of: 1. **Energy changes** when they can: • Describe enthalpy change (ΔH). • Recognise exothermic and endothermic reactions. • Relate amount (n) to energy change (ΔH) in a thermochemical equation: ΔH reaction = ☐ΔH products – ☐ΔH reactants. • Construct and interpret energy profile diagrams in terms of: - activation energy; - energy changes in a reaction (ΔH); - catalysed pathways. • Apply Hess's Law to calculate the energy change for a chemical reaction. 2. **Equilibrium** when they can: • Define dynamic equilibrium. • Use the equilibrium expression aA + bB cC + dD & to calculate Kc. • Recognise a closed, open and an isolated system. • Infer that equilibrium can only occur in a closed system. • Use Le Chatelier's principle to explain the qualitative effects of changing: (i) temperature and heat change; (ii) pressure and volume change; (iii) concentration. • Describe the effect of catalysts on equilibrium systems. • Explain how Le Chatelier's principle is applied in the Haber process (ammonia production) and Contact process (sulphur trioxide) as commercial examples of equilibrium reactions.

SUB-STRANDS	YEAR 11	YEAR 12 (SSLC)
6. OXIDATION AND REDUCTION	From their study of **OXIDATION AND REDUCTION**, students will investigate and develop their scientific understanding of: 1. **Redox reactions** when they can: • Define oxidation, reduction, oxidizing agents (oxidant), reducing agents (reductant). • Calculate the oxidation number (or state) in atoms, molecules and ions. • Write half ion equations to describe reducing agents. write half ion equations to describe oxidizing agents. • Balance overall half ion equations. • Use the "activity series" to list the metal in order of how easily they are oxidized.	From their study of **OXIDATION AND REDUCTION**, students will investigate and develop their scientific understanding of: 1. **Oxidation and reduction** when they can: • Determine the oxidation state/number of each atom in a given element, molecule and ion. • Recognise and explain oxidation and reduction in terms of changes in oxidation states/number. • Recognise oxidant and reductant in a chemical reaction. • Identify the common oxidizing agents (oxygen, chlorine, metals with dilute acids, hydrogen peroxide, permanganate, and dichromate). • Identify the common reducing agents (zinc, magnesium and iron, carbon, sulphur dioxide, carbon monoxide). • Identify the colour change of permanganate and dichromate under acidic conditions. • Formulate and balance half equations using the ion-electron method. • Combine half equations for the redox reactions. 2. **Applicatons of chemistry in redox reactions** when they can: • Apply oxidation and reduction processes to the electrolysis of some ionic solutions *e.g., NaCl(aq)* and molten ionic compounds *e.g., NaCl(l).* • Predict and describe observations made at the electrodes (anode and cathode) during electrolysis. • Recognise and interpret instances of oxidation and reduction in settings commonly found in society and the environment *e.g., batteries of vehicles, corrosion of metals in vehicles, buildings and bridges, oxidation of foods, galvanic protection with sacrificial electrodes, fuels, breathalyses test.*

SUB-STRANDS	YEAR 11	YEAR 12 (SSLC)
7. ENVIRONMENTAL CHEMISTRY	From their study of **ENVIRONMENTAL CHEMISTRY**, students will investigate and develop their scientific understanding of: **1. The ozone** when they can: • Investigate the occurrence and properties of molecular oxygen and ozone. • Discuss the ozone layer and its importance to the Earth. • Describe the effect of man-made chemicals *e.g., CFC's on the ozone layer.* • Describe layers of the atmosphere *e.g., troposphere, stratosphere, mesosphere and thermosphere.* **2. The greenhouse effect and climate change** when they can: • Explain the greenhouse effect. • Describe the causes of the greenhouse effect and its effect on small islands in the Pacific *e.g., Samoa, Tuvalu etc.* • Explain the global warming. • Investigate the impact of sea level rising due to global warming. • Discuss the impact of deforestation and reforestation. **3. The carbon and nitrogen cycles** when they can: • Outline the carbon cycle. • Outline the nitrogen cycle and including the use of bacteria and fertilizers. • Introduce the 3R's (recycle, reuse and reduce).	From their study of **ENVIRONMENTAL CHEMISTRY**, students will investigate and develop their scientific understanding of: **1. The depletion of ozone in the stratosphere** when they can: • Explain the absorption of solar radiation in the stratosphere by O_2 and O_3 molecules. • Explain the effect of UV-radiation on humans and plants. **2. Volcanoes** when they can: • Explain the effects of volcanic eruptions on climate. • Classify the reaction between H_2S and SO_2 that leads to the formation of sulphur at the site of a volcanic eruption. **3. Greenhouse effect** when they can: • Explain the criterion for classifying greenhouse gases. • Explain ways that deforestation contribute to greenhouse effect. • Recognize and explain the effects of CFCs and their substitutes have on Earth's temperature. **4. Acid rain** when they can: • Identify gases that is/are largely responsible for the acid rain phenomenon. • Identify detrimental effects of acid rain. • Discuss industrial processes that leads to acid rain. **5. Renewable energy** when they can: • Distinguish between renewable and non-renewable energy sources. • Recognise the need and importance of renewable energy sources in Samoa. • Discuss how to utilize local energy resources (renewable and non-renewable) to achieve the sustainable energy system.

STREAM 2
General Science Curriculum Statement Years 9-12
Chemistry Component
FOR THE 4 YEARS SECONDARY EDUCATION

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
	Strand: THE WORLD OF MATERIALS [CHEMISTRY]			
1. WAYS THE MATERIALS ARE STUCTURED [1.ATOMIC STRUCTURE AND BONDING]	From their study of **WAYS THE MATERIALS ARE STUCTURED** students will investigate and develop their scientific understanding of: **1. The atomic structure** when they can: • Describe particle nature of matter (solid, liquid and gas phases). • Describe the building block of matter-structure of the atom. • Identify electrons, protons, nucleus of the atom. **2. The Periodic Table of elements** when they can: • Introduce Dmitri Mendeleev (1834), formulated the Periodic Law (elements 1-20). • Introduce Periodic Table of elements, names, symbols of elements 1-20. • Describe the properties of elements (1-20). **3. The properties of compounds and mixtures** when they can: • Introduce the concept of compounds and mixtures. • Identify everyday materials that change states. • Investigate the change in physical properties when materials change states (melting, freezing, evaporation, condensation, sublimation).	From their study of **WAYS THE MATERIALS ARE STUCTURED** students will investigate and develop their scientific understanding of: **1. The atomic structure and bonding** when they can: • Describe atomic number, mass number and number of neutrons. • Introduce ions. • Differentiate between atoms and ions. • Introduce chemical bonding. **2. The Periodic Table of elements** when they can: • Introduce groups and elements. • Introduce electron arrangement using diagram and numerical sequence of elements/atoms (1-20). **3. The properties of compounds and mixtures** when they can: • Compare elements, compounds and mixtures. • Prepare compounds in a school laboratory (CO_2, H_2, O_2). • Identify the uses of compounds such as CO_2, H_2 and O_2.	From their study of **WAYS THE MATERIALS ARE STUCTURED** students will investigate and develop their scientific understanding of: **1. The atomic structure and bonding** when they can: • Describe cations and anions. • Describe ionic bonds and covalent bonds. • Describe the formation of compounds *e.g.*, $Na^+ + Cl^- \rightarrow NaCl$. • Introduce the Lewis structure *e.g.*, *shared paired of electrons*. **2. The Periodic Table of elements** when they can: • Define molecular mass, molar mass, relative molecular mass, relative atomic mass/number, moles of elements (1-20 elements). • Introduce electron arrangements of ions (1-20 elements). • Compare electron arrangements of ions and atoms (1-20 elements). • Introduce Group 17 and Group 18 Transition elements. **3. The properties of compounds and mixtures** when they can: • Describe the properties of compounds and mixtures. • Introduce metal compounds (oxides, hydroxides etc).	From their study of **THE STRUCTURE OF ATOMS** students will investigate and develop their scientific understanding of: **1. The atomic structure and bonding** when they can: • Identify atomic structure (protons, neutrons, electrons, isotopes) of a given atom or ion *e.g.*, ^{27}Al, $^{27}Al^{3+}$, $^{35}_{17}Cl$, $^{35}_{17}Cl$. • Explain how an atom changes to an ion and the combining power of an atom that causes that change. • Describe electron arrangement/configuration. • Draw Lewis structures of molecules *e.g.*, O_2, H_2, Cl_2, H_2O, CH_4, N_2. • Describe the shape of molecules *e.g.*, HCl, H_2O, NH_3, CH_4, CO_2. • Describe polar and non-polar molecules and bonding. • Compare ionic, covalent and metallic bonding.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11
2. THE PROPERTIES AND USES OF GROUPS OF SUBSTANCES	From their study of **THE PROPERTIES AND USES OF GROUPS OF SUBSTANCES** students will investigate and develop their scientific understanding of: **The uses and impacts of substances** when they can: • Gather processes and present information on the physical properties (shiny, conductivity, malleability, ductile) of metals (iron nail, aluminium, magnesium strip) and non-metals (sulfur, candle, hydrogen gas). • Carry out investigations on the chemical properties of metals (rusting iron nail and burning of magnesium strip) and non-metals (burning of candle). • Explain on the physical and chemical properties of metals and non-metals and determine their uses.	From their study of **THE PROPERTIES AND USES OF GROUPS OF SUBSTANCES** students will investigate and develop their scientific understanding of: **The uses and impacts of substances** when they can: • Gather processes and present information on the safe and appropriate uses of groups of substances found in home or community (household cleaners, detergents, fertilizers, cosmetics, plastics). • Describe how to use household substances in a safe and appropriate way. • Describe the uses of household substances *e.g., household cleaners, plastics, perfumes, detergents.* • Identify the impact of household substances *e.g., household cleaners, plastics, perfumes, detergents.*	From their study of **THE PROPERTIES AND USES OF GROUPS OF SUBSTANCES** students will investigate and develop their scientific understanding of: **The uses and impacts of substances** when they can: Research on the impact of a group of substances on people and the environment *e.g., fertilizers, fuels, household cleaners, plastics, detergents (to name a few).*
3.THE WAYS THE MATERIALS CHANGED [2. PRINCIPLES OF CHEMICAL CHANGES]	From their study of **THE WAYS THE MATERIALS CHANGED** students will investigate and develop their scientific understanding of: **1. The different types of chemical reactions and write a balanced equation for the reaction** when they can: • Describe chemical reactions using word equations (burning of magnesium strip, rusting of iron, reaction of metals with acids). **2. The factors affecting chemical reactions** when they can: • Investigate ways of producing physical (dissolving, heating, grinding) and chemical changes (burning, rusting) in everyday materials. • Describe processes that occur during physical and chemical changes (colour change, heat change, bubbling or fizzing, precipitation). **3. Processes used locally to produce a familiar material** when they can: • Identify steps in the production of fine mats, Samoan oil, banana chips. • Describe steps in a process used locally to produce familiar materials (examples above).	From their study of **THE WAYS THE MATERIALS CHANGED** students will investigate and develop their scientific understanding of: **1. The different types of chemical reactions and write a balanced equation for the reaction** when they can: • Describe chemical reactions using chemical symbols (burning of magnesium strip, rusting of iron, reaction of metals with acids). • Balance chemical equations using chemical symbols. **2. The factors affecting chemical reactions** when they can: • Define the rate of a chemical reaction. • Introduce the factors that affects the rate of chemical reactions *e.g., temperature, surface area, concentration, enzymes.* **3. Processes used locally to produce a familiar material** when they can: • Describe changes that occur during the steps in the production of fine mats, Samoan oil, banana chips.	From their study of **THE WAYS THE MATERIALS CHANGED** students will investigate and develop their scientific understanding of: **1. The different types of chemical reactions and write a balanced equation for the reaction** when they can: • Describe chemical reactions: precipitation and neutralization. • Describe oxidation *e.g., rusting, oxidizing agents (oxidant).* • Describe reduction and reducing agents (reductant). **2. The factors affecting chemical reactions** when they can: • Describe the factors that affects the rate of chemical reactions *e.g., temperature, surface area, concentration, enzymes.* • Explain how these factors affect reaction rate *e.g., speed up the reaction, slow down the reaction (rusting, burning of a candle, boiling water).* • Investigate the corrosion of iron and its prevention *e.g., galvanizing using zinc.* **3. Processes used locally to produce a familiar material** when they can: • Research on the production of coconut oil, corn beef, beer, purification of water. **4. Acid-base reactions** when they can: • Define acids as proton donors and bases as proton acceptors. • Outline the chemical and physical properties of acids and bases. • Investigate the chemical reactions of acids and bases with metals.

SUB-STRANDS	YEAR 12 (SSLC)
2. PRINCIPLES OF CHEMICAL CHANGES or INORGANIC CHEMISTRY	From their study of THE PRINCIPLES OF CHEMICAL CHANGE (INORGANIC CHEMISTRY), students will investigate and develop their scientific understanding of: **1. Metals and ions and precipitation reactions** when they can: • Investigate and identify the physical properties of metals *e.g., K, Na, Ca, Mg, Al, Zn, Fe, Pb, Cu, Ag*. • Investigate the chemical properties of metals through their reactions with air, water, and dilute acids and their displacement in metallic salts solutions. • Deduce the activity series of metals by investigation carried out above. • Recall precipitation. • Use the Solubility Rules/grid to identify precipitation reactions (tests for cations (Al^{3+}, Mg^{2+}, Fe^{2+}, Cu^{2+}, Fe^{3+} and Ag^{+}) and anions (Cl^{-}, SO_4^{2-}, CO_3^{2-} and NO_3). **2. Non-metals** when they can: • Investigate the preparation and uses of carbon and its compounds (CO_2, CO and CO_3). • Name the allotropes of carbon (diamond and graphite) and their respective properties and uses. • Investigate the occurrence, properties, preparation and of nitrogen (NO_2, HNO_3, NH_3). • Investigate the occurrence, properties and uses of sulphur compounds (SO_2, SO_3). • Investigate the occurrence, properties, preparation and uses of chlorine (HCl, Cl_2, HOCl, NaCl). **3. Acid-base reactions** when they can: • Recall acids as proton donors and bases as proton acceptors. • Recall the chemical and physical properties of acids and bases. • Recall the chemical reactions of acids and bases with metals. • Carry out simple tests for acids and bases using common indicators such as litmus paper, methyl orange, phenolphthalein and universal indicator. • Introduce the pH scale to classify the following: strong acids, weak acids, neutral, weak bases and strong bases. • Explain the difference between strong and weak acids (H_2SO_4, HCl, CH_3COOH) & strong and weak bases (NaOH, KOH, NH_3). • Introduce reactions of amphoteric substances such as Al_2O_3 and ZnO, $Zn(OH)_2$ and $Al(OH)_3$ and with water, with acids and bases. • Describe the properties of hydroxides and write equations to indicate such properties. • Use equations to show that water can behave as an acid and as a base (amphiprotic). • Describe the equilibrium reaction for water and its ionic product (KW) represented by: [H3O] [OH] = 10 or [H] [OH] = 1 x 10-14. • Use pH + pOH = 14 to deduce pOH or pH. • Calculate pH and pOH given the hydrogen ion and hydroxide ion concentrations (and vice-versa).

SUB-STRANDS	YEAR 11 (Strand 4)	YEAR 12 (Strand 3)
4/3. QUANTITATIVE CHEMISTRY	From their study of **QUANTITATIVE CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The molar mass, relative molar mass, relative atomic mass/number, moles** when they can: • Recall (from Strand 1) relative atomic mass, relative molecular mass, molar mass, moles and connect Avogadro's constant/number. • Calculate mass, molar mass and moles using *e.g.*, $n = \frac{m}{M}$	From their study of **QUANTITATIVE CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The moles, atoms, compounds** when they can: • Balance equations (atoms and number of moles). • Write balanced chemical equations in terms of relative amounts of reactants and products involved in a reaction. • Calculate the percentage composition, empirical formula, molecular formula of compounds. • Calculate the water of crystallization *e.g.*, $MgSO_4xH_2O$ *and* $CuSO_4.xH_2O$. • Calculate the concentration of solutions in mol/L and g/L using $c = \frac{n}{v}$ or $c = \frac{m}{v}$ or $C_1V_1 = C_2V_2$ • Introduce the concept of titration (limit to apparatus *e.g.*, *pipette, burette, conical flask*).
SUB-STRANDS	YEAR 11 (Strand 5)	YEAR 12 (Strand 4)
5/4. ORGANIC CHEMISTRY	From their study of **ORGANIC CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The occurrence, properties and preparation of hydrocarbons (alkanes, alkenes and alkynes)** when they can: • Describe hydrocarbons (alkanes, alkenes and alkynes). • Investigate sources of the naturally occurring hydrocarbons. • Describe the physical and chemical properties of alkanes, alkenes and alkynes. **2. The properties and uses of alcohols** when they can: • Name the three types of alcohols (primary, secondary and tertiary). • List the uses of alcohols (solvents, fuel etc). • Name, write molecular formula and draw structural formula of alcohols (carbon 1 – carbon 5).	From their study of **ORGANIC CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The occurrence, properties and preparation of hydrocarbons (alkanes, alkenes and alkynes)** when they can: • Outline the process of fractional distillation of petroleum. • Define the following terms: homologous series, isomerism, functional groups, saturation and unsaturation. • Name and write molecular formula and draw structural formula for hydrocarbons (carbon 1 – carbon) IUPAC. • Investigate the addition (alkenes & alkynes) and substitution (alkanes) and polymerization (polyethene) reactions. **2. The properties of alcohols, carboxylic acids and esters** when they can: • Investigate the production of ethanol from the hydration of ethene. • Name and write molecular formula and draw the structural formula of carboxylic acids (carbon 1 – carbon 5). • Investigate the properties (chemical & physical) of carboxylic acids. • Investigate reactions of carboxylic acids with alcohols to form esters.

SUB-STRANDS	YEAR 11 (Strand 6)	YEAR 12 (Strand 5)
6/5. PRINCIPLES OF PHYSICAL CHEMISTRY	From their study of **PRINCIPLES OF PHYSICAL CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. Water** when they can: • List the physical properties of water. • Investigate soft and hard water using soap. **2. Solubility of compounds** when they can: Define precipitation Use the Solubility Rules/Grid to identify precipitation reactions (tests for cations (Al^{3+}, Mg^{2+}, Fe^{2+}, Cu^{2+}, Fe^{3+} and Ag^{+}) and anions (Cl^{-}, SO_4^{2-}, CO_3^{2-} and NO_3).	From their study of **PRINCIPLES OF PHYSICAL CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The physical changes in chemistry** when they can: • Describe exothermic and endothermic reactions. • Investigate the factors affecting the rate of reactions *e.g., temperature, concentration, surface area and catalyst*. • Introduce Collision Theory. • Recall the physical properties of water and difference between soft and hard water.
6. OXIDATION AND REDUCTION		From their study of **OXIDATION AND REDUCTION** students will investigate and develop their scientific understanding of: **Redox reactions** when they can: • Recall oxidation, reduction, oxidizing agents (oxidant), reducing agents (reductant). • Calculate the oxidation number (or state) in atoms, molecules and ions. • Write half ion equations to describe reducing agents. • Write half ion equations to describe oxidizing agents. • Balance overall half ion equations.
7. ENVIRONMENTAL CHEMISTRY	From their study of **ENVIRONMENTAL CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The ozone** when they can: • Investigate the occurrence and properties of molecular oxygen and ozone. • Discuss the ozone layer and its importance to the Earth. • Describe the effect of man-made chemicals *e.g., CFC's on the ozone layer*.	From their study of **ENVIRONMENTAL CHEMISTRY,** students will investigate and develop their scientific understanding of: **1. The ozone** when they can: • Describe the layers of the atmosphere *e.g., troposphere, stratosphere, mesosphere and thermosphere.* **2. The greenhouse effect and climate change** when they can: • Explain the greenhouse effect. • Describe the causes of the greenhouse effect and its effect on small islands in the Pacific *e.g., Samoa, Tuvalu etc.* • Explain the global warming. • Investigate the impact of sea level rising due to global warming. • Discuss the impact of deforestation and reforestation. **3. The carbon and nitrogen cycles** when they can: • Outline the carbon cycle. • Outline the nitrogen cycle and including the use of bacteria and fertilizers. • Introduce the 3R's (recycle, reuse and reduce).

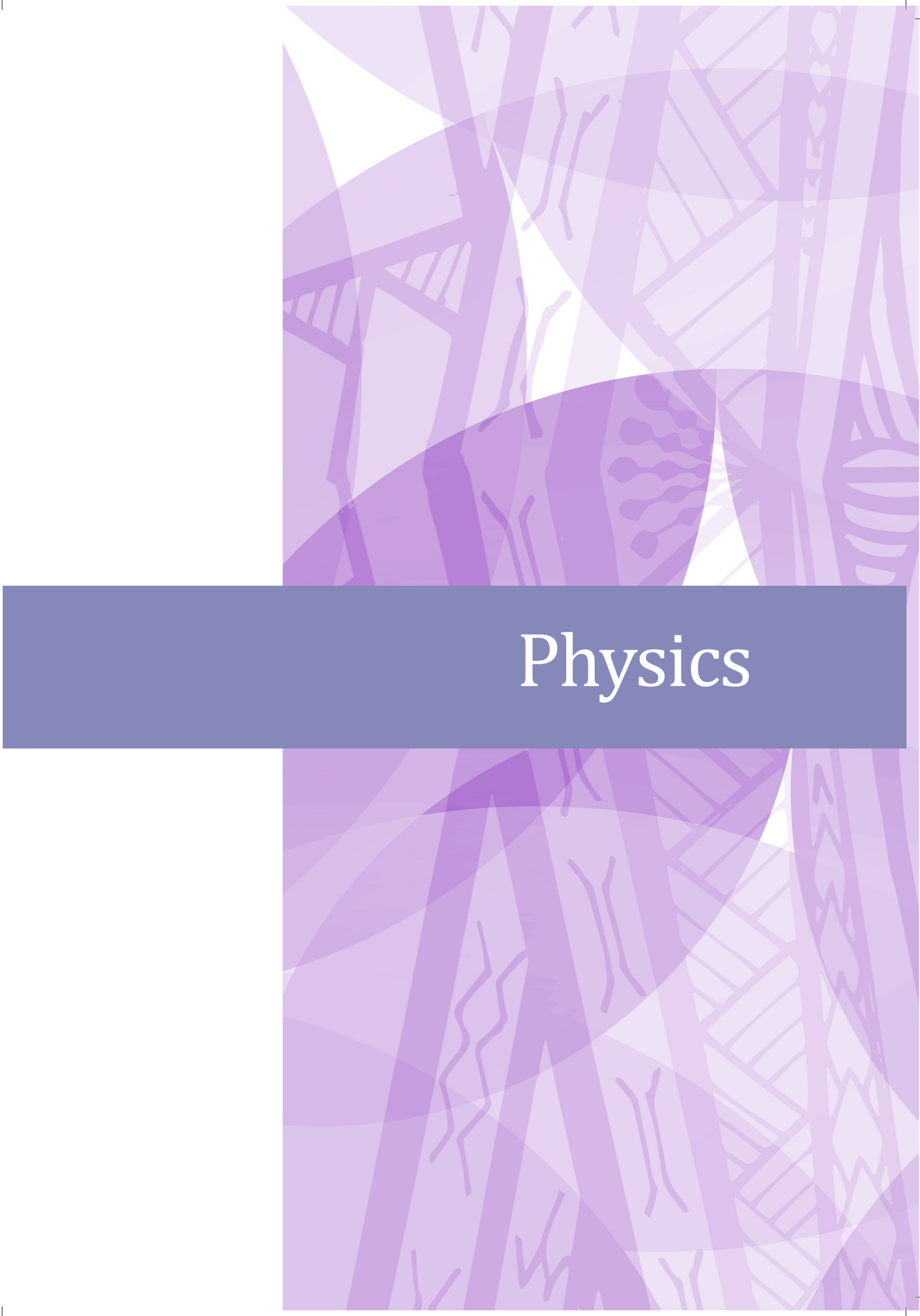
Recommended resources for teachers and students of Chemistry and General Science Chemistry component.

Textbooks and booklets:

1. Book 2 Year 9 Science; CDMD, MESC
2. Samoa SchoolNet &Community Access Project Model Learning Activities Chemistry Years12/13; RTI International, SchoolNet and MESC.
3. The Material World, Level Six Science; Sue Haigh, New House Publishers Ltd.
4. GEF Pacific Persistent Organic Pollutants Release Reduction Project, Chemical Management Training Manual, APPENDIX A; SPREP and UNEP
5. Chemistry Workbook 1; Tomoya Kinugasa, MESC and JOCV/JICA, 2012
6. Chemistry textbooks available on scitect.co.nz (a few of many):
    - Beginning Chemistry workbook, 3rd edition, year 12 workbook, updated 2017
    - Levels 1, 2 and 3 Chemistry Learning workbooks,
    - ESA Study Guides Level 1,2 and 3 Chemistry

Online webs: (a few of many online resources with notes, videos, guides for teachers and students and even parents etc)

- mesc.gov.ws
- acs.org
- chemcalaid.com
- 4masteringchemistry.com
- chemequations.com
- chemguide.co.uk
- chemistryworld.com



Physics

Explanatory notes on realignment and compilation of Physics and General Science Physics component for 4 year level.

This compilation of specific contents for the Physics component of Secondary Science education is based primarily on the following resources:

- 5 year level overview curriculums for Year 9-13;
- updated and recent curriculum reviews by external reviewers and subject panelists contracted to undertake the review process of Science curriculums; and
- unpacked Year 12 and Year 13 curriculums developed by Subject Panelists and CDMD.

The approach is to ensure smooth transition and bridging any gaps in between each year by making certain that the prerequisite knowledge and learning outcomes are achieved by students before progressing to the next level. Generally, the contents are spread across the four levels to ensure achievement of the following:

- Continuation across the four levels of the learning outcomes with level of difficulty increasing from previous level to next.
- The first year of Secondary Physics education is basically introduction to Physics concepts with simple examples, simple problem solving, simple experimenting or investigating while relating and integrating concepts learnt to real life situations or the students' local environments. The curriculum for year 9 therefore remains the same for both streams: Stream 1-Physics and Stream 2-General Science.
- At year 10 where students will choose either Physics or General Science, the two options (Physics and General Science) only differ by the quantity of contents covered, with the contents for General Science specifically selected to be pre-requisite to next level up which is year 11 General Science and onwards, while the contents for the pure Physics are selected contents from the current 5 year level curriculums for year 10-12.
- The last two years (Years 11 and 12) of Secondary Physics education is expansion of the concepts learnt at the lower levels with level of difficulty increasing in problem solving, practical investigating or experimenting for both streams. Introduction of some topics not covered in lower levels takes place mostly at Year 12 -Stream 1 to bridge the gap between Year 12 and Foundation Physics.

Specifically, this compilation ensures that for:

1. STREAM 1 - PHYSICS, the contents for the 5 year level (5YL) remain intact but realigned into 4 year level with the contents spread out across the 4 levels. That is, some contents currently studied in year 10 is now introduced in year 9, contents in current year 11-12 are now introduced in year 10 and some contents in 5YL year 13 is now introduced at the new year 11. The objective is to minimize overloading the last two years (Years 11 and 12) of Secondary Physics education (as is the case currently) and also to make sure that the curriculums are teachable and manageable at these levels.
2. STREAM 2 - GENERAL SCIENCE, the contents of the 5 year level (5YL) also remain intact but realigned into 4 year level with the contents spread out across the 4 levels. In contrast to Stream 1, the contents for the Years 10,11 and 12, are topics selected from Stream 1 -Pure Physics. The selected topics or contents are considered suitable for students who will choose this option beginning at Year 10 in 2022, then Year 11-12 in following years and ultimately leading to post-secondary studies in the fields of primary education, nursing or TVET.

For consistency, this compilation also cluster topics under just four strands, namely ENERGY, ELECTRCICITY, MAGNETISM AND FORCES/MOTION for all four levels, removing the inconsistent pattern of the 5YL Science curriculums where there are four strands for years 9-11 and six strands for years 12-13. Topics or contents are now arranged under the relevant strand according to concepts studied and/or extension or integrated concepts from other strands that is to be studied.

The Strand 1 –Measurement in the 5YL (Years 12 -13) curriculums is removed from this compilation as its content is integrated in all four strands mentioned above, which means the achievement objectives for measurement are covered as they work on achievement objectives of the four strands mentioned above.

STREAM 1
Physics Curriculum Statement Years 9-12
FOR THE 4 YEARS SECONDARY EDUCATION

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
	Strand: **THE WORLD OF PHYSICAL PHENOMENA [PHYSICS]**			
1. Energy [Waves]	Students will investigate and develop scientific understanding of: **1. Different forms of energy and how energy changes involved in various physical processes** when they can: • Identify and describe the sources and uses of energy *e.g., food, biogas, wind, sun, fuels, heat, solar, water, electricity, sound*. • Identify the energy forms *(e.g., chemical, kinetic, magnetic, electrical, heat, mechanical, gravitational, elastic/potential, nuclear)* involved in a simple energy transformation and transfer or energy conversions *e.g., potential energy to kinetic energy, kinetic energy to heat energy etc.* • Investigate one energy transformation and transfer in local environment and demonstrate using models, poster or video presentations *e.g., the energy changes in the falling coconut, or riding a bicycle etc.* • Identify the SI unit for measuring energy (introducing units of measurement). • Carry out a simple practical investigation to measure or compare energy in objects or motions or in foods *e.g., energy in processed foods, energy in different rubber bands (length and thickness), two ball bounce etc.* • Define renewable energy and non-renewable energy, identify sources of each and explain the importance of the wise use of each in local environment for energy conservation and efficiency.	Students will investigate and develop further scientific understanding of: **1. Heat energy and the energy changes involved in processes using heat** when they can: • Describe how heat energy is transferred by conduction, convection and radiation. • Investigate how heat energy is transferred by conduction, convection and/or radiation using a simple practical. • Carry out a simple investigation on an application of heat energy and the energy changes involved in the process *e.g., making umu, chilly bin, baking, making ice-cream*. • Explain the factors that influence the transfer of heat in a process where heat is involved, *e.g., burning paper vs burning wood "why does paper burns faster?", stack of papers VS one sheet of paper etc.* • Describe the difference between heat and temperature and identify their units of measurements. • Investigate the application of heat energy in expansion of solids, liquids and gases. • Describe the behavior of particles in the expansion of solids, liquids and gases. • Explain applications of expansion in everyday situations *e.g., telephone lines, a bottle of water in the freezer.*	Students will investigate and develop further scientific understanding of: **1. Heat energy and the energy changes involved in processes using heat** when they can: • Explain how conductors and insulators influence the rate of heat transfer. • Research and present on how the transfer of heat by conduction, convection and radiation occurs (or is reduced) in a simple application like the gas stove, radiator, coil element, refrigerator, thermos flask. • Interpret information in cooling and heating curves in terms of latent heat and changes of state. • Gather, process and present information about temperature scales and the construction and use of thermometers, *e.g., mercury, alcohol, thermocouples, gas*. • Investigate and demonstrate how a thermometer works as an application of expansion of liquid mercury or alcohol. • Explain the use of the concept of absolute zero and absolute temperature in fixing temperature scales. • Define and investigate the specific heat capacities of different substances using calorimeters or mixtures method *e.g., water, iron, copper, alloy.*	Students will investigate and develop further scientific understanding of: **1. Reflection and propagation** when they can: • Explain and demonstrate the production of shadows in terms of rectilinear propagation. • Construct ray diagrams which locate images produced by plane and curved mirrors. • Use the relationship: $S_i S_o = f^2$ or $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ to calculate the position of an image or an object. • Distinguish between real and virtual images in concave mirrors. • Recognize and apply the terms lateral inversion, pole, focus, focal length and radius of curvature. • Compare and contrast the properties of concave and convex mirrors. • Determine the magnification of images from: $M = \frac{v}{u}$ or $M = \frac{Hi}{Ho}$ **2. Refraction** when they can: • State that a light ray will bend towards the normal (speed changes) as it enters an optically denser material.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
1. Energy [Waves]		**2. Properties of waves** when they can: • Recall that waves carry energy from one position to another. • Investigate and demonstrate the propagation of longitudinal and transverse waves in water *e.g., sea, ripple tank.* • Describe waves in terms of frequency (f), wave length (λ) period (T), velocity (v) amplitude (A). • Apply formula to determine speed of waves i.e. v = fλ. • Compare and contrast the nature of light and sound waves. • Identify that the wave front is perpendicular to the direction of travel. • Explain why the average displacement of vibrating particles involved in wave progress is zero. • Associate differing speeds of sound propagation with qualities of the transporting medium. **3. Sound energy (waves) and the energy changes involved** when they can: • Define what sound energy is and identify how it is measured. • Describe and compare the speed of sound in air, water and solid (string or wire). • Describe and investigate the behavior of sound waves – how it is produced, how it travels.	• Explain applications of differences in specific heat capacity in everyday situations *e.g., land and sea breezes, water cooling of engines, cooking utensils.* **2. Sound** when they can: • Describe the speed of sound in different mediums *e.g., air, water.* • Explain the pitch of sound and its relationship to frequency *e.g., glasses with different volumes of water.* • Investigate applications of reflection of sound *e.g., echoes, scanners.* **3. Light** when they can: • Describe evidence of rectilinear propagation of light *e.g., shadows, eclipses, pin-hole camera.* • Investigate reflection of light in plane and spherical mirrors. • Use ray diagrams to describe images *e.g., size, position, type formed in different types of mirrors e.g., plane, concave, convex.* • Explain the formation of real and virtual images in reflection. • Investigate refraction of light in water, glass block and lenses. • Use ray diagrams to describe images *e.g., size, position, type formed in different types of lenses e.g., concave, convex.*	• Plot a graph of sin θi against sin θr and interpret the gradient as the relative refractive index for the two materials. • Solve various problems that involve using the relationship: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ • Observe the partial reflection that occurs as light rays are mainly refracted at the boundary between two media of differing optical densities. • Observe the condition of critical angle within an optically denser medium whena ray meets the boundary with an optically less dense medium. • Identify that when ø1 is the critical angle, then ø2 is 90o. • Calculate the critical angle for a given pair of substances and describe total internal reflection. • Use and draw ray diagrams to determine the position of images formed by single converging or diverging lenses. • Use one of the lens relationships to determine the position of images or objects: $S_i S_o = f^2$ or $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ • Distinguish between real and virtual images formed by converging lenses. • Compare and contrast the properties of converging and diverging lenses. • Determine magnification of images from: $M = \frac{v}{u}$ or $M = \frac{Hi}{Ho}$ **3. Wave Theory** when they can: • Use wave theory of light to explain reflection and refraction portrayed by the effect of boundaries on incident incident water wave in ripple tank. • Demonstrate dispersion of different frequencies present in white light. • Recall that refraction is greatest in the higher frequency ranges; blue light bends more than red light. • Discuss the corpuscular light model. • Discuss the wave light model. • Discuss the photon light model. • Explain and discuss the dual nature of light. **4. Diffraction and interference when they can** • Use the superposition principle to draw the resultant shape when two waves or pulses are wholly or partly superimposed.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
1. Energy [Waves]		• Describe and classify sound waves in terms of longitudinal waves. • Investigate simple applications or uses of sound energy. *E.g., drum, ukulele or guitar, ear, bell, music speaker, microphone, compact disks, water boiling, waterfall.* • Describe how the ear acts as a receiver of sound energy.	• Explain the formation of real and virtual images in refraction. • Investigate applications of refraction *e.g., microscope, eyes, camera.* • Investigate defects of the eyes and their corrections. • Investigate dispersion of light by prisms. • Explain the formation of rainbows in terms of dispersion of light.	• Predict situations in which diffraction is likely to occur. • Predict what will happen when two diffraction patterns overlap. • Know the value of interference patterns as support for the wave model. • Recognize double slit arrangements from which wavelengths may be estimated. • Use the relationships: $\lambda = \frac{d\Delta x}{L}$ and $\left(n - \frac{1}{2}\right)\lambda = d\sin\theta$. • Define the term *coherent* as applied to a light source. • Investigate the importance of path difference from two sources to a point under consideration in determining the cancellation or reinforcement of light waves (nodal or anti-nodal quality). 5. **Introduction to simple harmonic motion (SHM)** when they can: • Define simple harmonic motion and illustrate with a variety of examples *e.g., a swing, pendulum, bungee jumping, cradle, ear/hearing.* • Identify the characteristics of SHM, i.e body oscillates on a straight line, acceleration of the body is always directed towards a fixed point on a line, magnitude of acceleration is directly proportional to the displacement etc. • Relate and distinguish the relationship of the SHM on a displacement time graph and velocity time graph. • Describe instantaneous velocity in terms of displacement; expressions for time period and frequency of SHM. 6. **Heat energy** when they can: • Describe the requirement of energy change, described as *latent heat*, in order to produce a change of state. • Identify that no temperature change is associated with a change of state. • Interpret temperature-time graphs for substances either gaining or losing energy at a steady rate. • Use the relationship H = mL to solve problems relating to energy supply and change of state. • Use the relationship H = mcΔT and solve problems involving energy required to change the temperature of a particular substance. • Determine specific heat capacity from information yielded by temperature-time graphs where energy change is at a steady rate. • Solve problems involving the interchange of energy between energy manifestations where the sum is conserved.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
1. Energy [Waves]				**7. Pressure** when they can: • Identify and use the Pascal unit. • Identify that the forces producing the pressure of a contained gas come from the collisions of moving gas molecules over the defined area. • Apply P=F/A to explain and solve problems in pressure *e.g. atmospheric pressure, gauge pressure etc.* • Identify the thermodynamic behavior of a gas if one of the variable conditions-volume, pressure and temperature is kept constant *e.g., behavior between pressure and volume when the temperature is kept constant or behavior of pressure and temperature when volume is kept constant etc (i.e. the pressure of a gas is inversely proportional to its volume, with temperature held constant OR the pressure of a gas varies directly with absolute temperature, with volume held constant).* • Use the combined relationship: PV = nRT in solving various problems. • Convert Celsius to Kelvin and vice versa. • Identify that temperature is a measure of the average kinetic energy of the particles of a gas.
2. Electricity [Electrical energy]	Students will investigate and develop scientific understanding of: **Electrical energy or electricity and how the energy changes involved are put to use** when they can: • Define and describe what electricity is – what form of energy it is, what transfer of energy is involved to produce electricity, what the amount of electricity produced depends on and what is SI unit of measurement for electricity.	Students will investigate and develop further scientific understanding of: **1. Electrical circuits** when they can: • Describe what an electrical circuit is and the difference between closed and open circuits. • Identify and describe components of an electrical circuit *e.g., switch, batteries, bulbs, resistors, capacitors etc.* • Draw simple electrical circuit diagrams using electrical symbols. • Construct a simple electrical circuit using a bulb, battery and wire.	**Students will investigate and develop further scientific understanding of:** **1. Electric force/electrostatic** when they can: • Investigate the transfer of electrons and charging a rod by friction or rubbing *e.g., glass rod, plastic rod.* • Investigate the identification of charged and uncharged bodies or conductors and insulators using the electroscope. • Investigate the charging of materials by conduction and by induction.	Students will investigate and develop further scientific understanding of: **1. Current electricity** when they can: • Identify the qualities that make materials good or bad conductors. • Interpret resistances as materials opposing charge movement, and receiving energy from passing charge. • Identify the influence of temperature on resistance wires. • State that charge flows from higher to lower potentials. • Draw a graph of potential difference across, versus current through, a conductor, and interpret the gradient. • Use Ohm's law V = IR in calculation in various problems. • Know that the e.m.f. of a battery is the amount of energy it supplies to each unit of charge. • Recognize that charge and hence current is conserved at all points in a circuit. • Calculate resistance of series and parallel combinations. • Calculate potential differences between points in a circuit.

2. Electricity [Electrical energy]	• Investigate and demonstrate how electricity is produced or generated in local environments *e.g., solar (heat), windmills (wind), hydroelectric plant (water).* • Describe the safety precautions required when using electricity. • Explain factors that affect electrical conductance of a material *e.g. metals.* • Carry out a simple practical investigation that test and compare the conductivity of various objects *e.g., metals like aluminum, copper, silver or stainless steel.*	• Investigate an application of electrical circuit to a process in every day life *e.g., home lights.* • Describe what electrical resistivity is and identify examples of insulators. • Investigate and compare the differences between electrical insulators and conductors, i.e. resistance vs conductance of various objects used in electricity transfer. • Describe the two types of electrical circuits – series and parallel and identify their advantages and disadvantages with examples of applications in local environment *e.g. Christmas lights (series circuit) vs house lights (parallel)* • Describe and demonstrate parallel and series connections or circuits in terms of electrical components. • Draw and interpret various circuit diagrams containing a range of components in series and parallel connections *e.g., power supply, cells, switches, resistors, meters, LED.* **2. Current electricity** when they can: • Investigate the storage of electrical energy using different types of cells *e.g., dry cell, lead-acid cell.* • Investigate potential difference and flow of charge through a conductor.	• Explain examples of electrostatics by applying knowledge of the structure of an atom and positive and negative charges. • Explain the characteristics of charged bodies (attraction and repulsion) and the distribution of a charge on a conductor. • Describe examples and applications of electrostatics *e.g., lightning conductors, atmospheric electric charges, electrostatic screening.* **2. Electric fields** when they can: • Investigate the shape and direction of the electric field between two parallel charged plates and around point charges. • Explain how electric charges can be stored in electric capacitors. **3. Current electricity** when they can: • Identify that current results from movement of charge, in an electric field. • Recognize electrons as the conveyors (carriers) of charge. • Distinguish between the directions of conventional current and electron flow. • Investigate factors affecting resistance of a resistor *e.g., length, temperature.* • Define the terms; voltage, current and resistance and their SI units. • Interpret information on voltage, current and resistance in a circuit. • Calculate voltage (V), current (I) and resistance (R) using Ohm's Law V = I R.	**2. Energy transfer in electrical circuits** when they can: • State the concept of power as energy per unit time in an electrical context, $P = Et^{-1}$. • Interpret the power ratings given to appliances. • Calculate the power output of a resistance using: $P = I2R$. • Calculate the amount of energy carried by a current. • Calculate the energy dissipated as heat in a resistor. **3. Characteristics of electrical charge** when they can: • Identify the unit of charge as the coulomb. • Represent diagrammatically the electric field that surrounds a positive and a negative charge. • Draw the electric fields between like charges and between unlike charges. • Identify the role that friction play in the transfer of charge. • Understand that a charged object holds an imbalance of charge. • Describe the transfer of charge by rubbing. **4. Behavior of materials relating to charge** when they can: • Identify that different materials have a natural tendency either to gain or to lose electrons. • Determine whether two charged materials will attract or repel depending upon the charge type held. • Recall the behavioral differences between conductors and insulators. • State that the earth is a conductor of charge. • State that charged bodies discharge quickly in humid or salty conditions. **5. Coulomb's law for charge** when they can: • Apply Coulomb's law to solve simple problems. • Recall that the electric force between two charges is proportional to the product of the charges. • State that the electric force varies inversely as the square of the distance between the charges. • Identify the similarity between Newton's relationship for gravitation and that of Coulomb for electrical charge. **6. Characteristics of electrical fields** when they can: • Define the concept of an electric field as represented by electric field lines. • Draw the shape of an electric field between two parallel plates.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. Electricity [Electrical energy]			**4. Electrical circuit** when they can: • Recall electrical symbols for electrical components *e.g., switch, resistor, capacitor etc.* • Recall the two types of electrical circuits – series and parallel – and demosntrate their advantages and disadvantages with examples of applications in local environment. • Describe and demonstrate various parallel and series connections or circuits in terms of electrical components. • Draw and interpret various circuit diagrams containing a range of components in series and parallel connections *e.g., power supply, cells, switches, resistors, meters, LED.* • Calculate unknowns in simple examples of resistance in series and parallel by using formulae $^{1}/R_1 = {}^{1}/R_1 + {}^{1}/R_2$..... $R_1 = R_1 + R_2$..... • Calculate unknowns in simple examples by using formular for power *e.g., P = VI.* **5. Electrolysis** when they can: • Investigate electrolysis *e.g., water, copper sulphate solution.* • Describe the process of electrolysis. • Describe the process of electroplating of copper and other metals.	• Distinguish the convention that establishes the direction of an electric field at a point. • Recall that the spacing of field lines is an indication of field strength. • State that field lines begin or end with charged particles. • State that the strength of an electric field is given by the formula $E = \frac{F}{Q}$ • Recall that the ***e*** field is a vector. • Use the relationship $E = \frac{kQ}{r^2}$ to determine the field strength due to a point charge. • Calculate the net electric field or net electric force at a point between two charges. **7. Energy in electrical fields** when they can: • Determine the work done on a charge in moving it through an electric field. • Apply the formulae to solve various problems: W = EQd or W = QV. • State that as a positive charge is moved against the field direction, it gains potential energy, which is stored in the field. • Discuss electrical potential at two different points in the electric field. • Describe the electric potential difference due to different points from the source charge. • Use the relationship: V = Ed to determine the potential difference between two points in a field.

3. Magnetism [Electromagnetism]	Students will investigate and develop scientific understanding of: **Behavior of magnets** when they can: • Define what a magnet is and describe the magnetic fields around magnets. • Identify and differentiate between magnetic, magnetized and non-magnetic materials using a simple experiment. • Describe the effect of poles of magnets (repulsion and attraction). • Identify and investigate examples of real life applications of magnets in local environment and in the world.	Students will investigate and develop further scientific understanding of the behavior of: **1. Magnets and magnetic fields** when they can: • State the law of magnetism: like poles repel and unlike poles attract. • Draw magnetic field lines indicating repulsion between like poles and attraction between unlike poles. • Carry out a simple practical investigation on making magnet or magnetizing an object. • Compare the properties of magnetic and non-magnetic materials *e.g., soft iron, steel, alloys (alnico), aluminium, copper, iron filing, knife.* • Explain how electromagnets work. • Investigate how to make an electromagnet. • Identify the poles of the electromagnet. • Describe examples of electromagnets and temporary magnets. • Describe the factors that electricity produced from magnetism depend on. **2. Magnetic fields** when they can: • Investigate the interaction of magnetic fields using a freely suspended magnet. • Describe methods of making permanent magnets *e.g., single stroke method, divided stroke method, electromagnetic method.*	Students will investigate and develop further scientific understanding of the behavior of: **1. The magnetic effect of electric current, motor effect and electromagnetic induction** when they can: • Investigate the magnetic effect around a conductor *e.g., straight wire, circular coil or a solenoid.* • Draw and describe the magnetic field lines around a conductor: straight wire, circular coil and a solenoid. • Describe applications of the motor effect *e.g., turning force on a rectangular coil, kept in a uniform magnetic field; moving coil meter, D.C electric motor, moving coil loud speakers, force between two parallel conductors carrying current.* • Investigate the production of a current through electromagnetic induction *e.g., a magnet moving into a coil, moving a coil towards a magnet.* • Describe and explain how factors affect the amount of current formed in electromagnetic induction *e.g., speed of movement, strength of magnet, number of turns of a coil.* • Explain the practical application and working principles of examples of electromagnetism *e.g., bicycle dynamo, induction through a primary and secondary coil, ignition coil in a car, magnetic relay, electric bell, telephone microphone, moving iron ammeter.*	Students will investigate and develop further scientific understanding of the behavior of: **1. Charges, conductors and magnetic fields to the motor effect** when they can: • Understand that a current-carrying conductor placed in a magnetic field experiences a force. • Recall that the magnetic force is perpendicular to the current and the field, as demonstrated by the right hand rule. • Determine the direction of the force on a current-carrying conductor when it is in a magnetic field. • Apply the principles of magnetic force to explain and predict the turning effect on a coil conductor mounted in a magnetic field. • Describe the principle of the electric motor and explain how continuous rotation of the coil is achieved. • Describe the moving coil galvanometer and the way it is adapted to offer a reading related to current size. **2. Magnetic fields surrounding current-carrying conductors** when they can: • Draw the magnetic field around a single long current-carrying wire. • Recognize and use the normal symbols that describe the direction of conventional currents and magnetic fields, into or out of the page. • Draw the magnetic field associated with two parallel long wires carrying currents and determine whether the force between the conductors is one of attraction or one of repulsion. • Apply the relationship $B = \frac{kI}{d}$ where appropriate, and recognize k as being a constant. • Apply the relationship: $F = \frac{kI1I2L}{d}$ in order to determine the force on a length of conductor. **3. Electromagnetic induction** when they can: • State the conditions that are necessary to induce a voltage in a straight conductor or a coil. • Predict the effect of changing magnetic field strength, direction of field, rate of cutting through the magnetic field, B, direction of moving through the magnetic field, B. • Apply Lenz's law to predict induced polarity in solenoid. • Understand and apply the relationship: V=Blv. • State that the induced current arises because of the rate of change of magnetic flux. • State that the induced current itself produces a magnetic field.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
3. Magnetism [Electromagnetism]		• Investigate the making of a permanent magnet. • Explain and demonstrate how materials can be magnetized and how they can be demagnetized if possible. • Identify precautions to prevent magnets from being de-magnetized.	• Research and describe how a transformer works. **2. Shapes and direction of magnetic fields and geomagnetism** when they can: • Draw diagrams of magnetic fields around a bar magnet, horseshoe magnet and iron ring. • Investigate the magnetic fields around two bar magnets placed parallel to each other. • Explain the shapes of interacting magnetic fields in terms of repulsion and attraction. • Identify and describe the earth as a magnet and polarity of the equivalent magnet. • Explain how the magnetic field of the Earth is not always parallel to the Earth's surface. **3. Magnetic induction** when they can: • Investigate the induction using a magnet placed near an iron nail or any other magnetic materials i.e. when it is in contact and not in contact. • Explain the magnetic field of earth on iron objects *e.g., railings, flagpole.*	• Recognize that as a conductor is pushed through a magnetic field, an opposing force develops as a result of the induced current. • Relate the induced voltage in the secondary coil to the developing field around the primary coil. • Relate the design of a transformer to induction in the secondary coil. • Explain why commercial transformers cannot operate on DC supply. **4. Nuclear energy** ***4a. Rutherford and the atom*** when they can: • Give a brief description of the Rutherford model of the atom. • Describe the causes of deflection of alpha particles fired at a thin metallic film. • Understand that deflection observations confirmed the presence of the dense nucleus. • Describe the atom in terms of the nuclear bound protons and neutrons, and the electrons at varying energy levels in space around the nucleus. ***4b. Photoelectric effects and consequences*** when they can: • Describe the photoelectric effect. • Identify the support provided by the photoelectric phenomenon for a particle explanation of light. • Understand the concept of photon. • Identify that the frequency of a photon determines its associated energy. • Use the relationship: E = hf to calculate the energy of a photon. • Understand the idea that different materials require different energy amounts to remove electrons away from the surface. • Understand that both emitted photoelectrons and incoming photons possess momentum and that there is overall momentum conservation. ***4c. Isotopes and Radioactivity*** when they can: • Understand the term isotope, and distinguish between isotopes of an element in terms of its neutrons, with reference to mass number, ***A***, and atomic number, ***Z***, with ${}^{A}_{Z}X$ for element ***X***. • Understand that radioactivity involves the emission of particles or electromagnetic waves. • Describe alpha and beta particles, $\alpha={}^{4}_{2}He$, $\beta = {}^{0}_{1}e$ • Describe the characteristics of gamma rays, g.

3. Magnetism [Electromagnetism]				• Identify and use the symbols for alpha and beta particles, protons, neutrons and electrons. • Determine the paths of alpha and beta particles, and neutrons travelling through a magnetic field of given direction. • Compare the penetrating distances of alpha, beta particles and gamma rays. • Understand the concept of half life. • Determine the half life of a substance given its decay curve. • Determine the particle emission during radio-active decay by applying conservation rules. ***4d. Radioactivity influences*** when they can: • Identify that atomic radiation influences the structure of chemicals in living tissue. • Describe the ways in which atomic radiation can be a valuable servant in medicine. • Describe the ways in which radiation can cause serious damage to organisms. • Describe the precautions adopted in nuclear power generation plants and hospitals where radiation equipment is used. • Research and understand the strong arguments for caution in the increased use of atomic energy. • Research and understand the reasons for the 'Nuclear Free Pacific" policy and the counter arguments.
4. Forces and Motion	Students will investigate and develop further scientific understanding of: **Forces and motion and how the relationship between force and motion is put to use** when they can: • Define what force is and identify and classify the types of forces into two groups: contact forces *e.g., friction* and non-contact forces *e.g., magnetic force*. • Describe the effects of forces on shape or motion (direction, movement and speed) of a stationary and moving object in local environment.	Students will investigate and develop further scientific understanding of: **1. Linear motion and the relationship between speed, distance and time** when they can: • Introduce scalar and vector quantities • Introduce vectors as scale lines. • Calculate total/resultant vector using simple problems. • Describe what linear motion is *(Newton's First law of motion).* • Identify SI units for speed, distance and time.	Students will investigate and develop further scientific understanding of: **1. Linear motion and the relationship between velocity, displacement, time and acceleration** when they can: • Distinguish between scalar and vector quantities; distance vs displacement, speed vs velocity, acceleration. • Understand the importance of the direction property of a vector quantity.	Students will investigate and develop further scientific understanding of **concepts and principles of mechanics:** **1. Kinematics** when they can: • Draw and interpret displacement-time and velocity-time graphs and acceleration-time graphs. • Interpret and determine the gradient of both s – t and v – t graphs. • Identify that the area under a v – t graph represents displacement. • Interpret correctly the meaning of negative values attributed to displacements and velocities. • Use the kinematic equations for solving problems. • Determine an average velocity over a particular time period. • Understand the difference between an ***instantaneous velocity*** and an ***average velocity***.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
4. Forces and Motion	• Describe the relationship between force, motion and work e.g., *a moving and stationary ball, impact of a falling object from different heights*. • Carry out a simple practical investigation to measure or describe the effect of force on an object *e.g., stretching and compressing materials like latex foam cylinder or block, rubber band, steel spring, elastic cord (weight force and stretching force), ball and straw - motion of a ball when it moved by air blown through a straw from different directions.** • Define gravitational and upthrust forces and describe their effects on objects floating and sinking in water *e.g., floating coconut, why a boat or paopao floats etc.* • Define friction force and describe its advantages and disadvantages.	• Identify what quantity are speed, distance and time (scalar or vector?) • Carry out a practical investigation o measure distance travelled and time taken. • Use equations to calculate speed, distance and time *e.g., distance (d) speed (v), acceleration (a).* $v = d \div t$; $a = v \div t$ • Present and interpret information on speed, distance and time using tables and graphs. • Investigate an application of linear motion to an every day situation *e.g., track runner or athlete, car driving along a straight road, man pushing a box/furniture across a floor, cycling.* **2. Forces** when they can: • Describe common forces and their effects (from year 9) *e.g., gravitational, magnetic, electric, friction.* • Investigate the effect of balanced and unbalanced forces on the straight-line motion of an object using simple local examples *e.g., a plane taking off and in horizontal flight, a rugby ball being kicked, carrying a baby in a basket.*	• *Represent vectors by scaled lines.* • *Represent vectors numerically.* • *Add vectors to get a resultant.* *[these are to be taught as they pre-requisite skills for learning of following content but they are not to be tested on their own. They are to be tested integrated with the following content.]* • Plot and draw graphs of displacement vs time, velocity vs time and acceleration vs time. • Interpret graphs by relating slope to the variable *e.g., displacement vs time (velocity), velocity vs time (acceleration) and acceleration vs time (constant, deceleration, acceleration).* • Introduce and use kinematic equations to solve simple (single dimension) problems. • Calculate unknowns in various problems using formulae and graphical methods *e.g., displacement (Δs), velocity (v), acceleration (a).* $v = \Delta s \div \Delta t$ *or* $v = \Delta d \div \Delta t$ $a = \Delta v \div \Delta t$ • Describe and explain examples of the application of ideas relating to displacement, velocity and acceleration *e.g., safe stopping distances while driving, speed limits.* **2. Forces** when they can: • Recall common forces and their effects (from years 9 and 10) *e.g., gravitational, magnetic, electric, friction.* • Use formulae (F=ma or F_w=mg), graphical methods and force diagrams to calculate the resultant force on objects. • Investigate effect of friction as a force. • Identify that all objects dropped in the same gravitational field experience the same acceleration.	**2. Vector and Scalar** when they can: • *Resolve single vectors into two components at right angles to each other by construction.* • *Resolve by trigonometry.* • *Interpret vector diagrams.* • *Determine a change value in a vector during a particular period.* *[These are to be taught as they pre-requisite skills for learning of following content but they are not to be tested on their own. They are to be tested integrated with the following content.]* **3. Forces** when they can: • Understand that force is not a general prerequisite for continuing motion. • Understand that the F in the relationship F = ma is a net force applied to a body. • Experimentally verify F = ma. • Calculate a resultant or unbalanced force. • Solve problems involving F= ma. • Calculate the torque of a force, but only in the perpendicular case. • Solve problems where torques act in opposition, and where equilibrium is established. • Interpret "m" as the gradient of a force versus acceleration graph. • Define the Newton in terms of the acceleration given to a unit mass. • Apply vector qualities to forces. **4. Momentum** when they can: • Calculate the momentum of an object. • Calculate the total momentum of two objects. • Identify that in a collision or explosion momentum is conserved. • Calculate the change in momentum of an object owing to an external force. • Solve problems involving conservation of momentum in two dimensions. **5. Gravitational Force** when they can: • Identify that the force of gravity on an object is proportional to its mass, i.e. F = mg • Understand that the weight of an object depends upon the gravitational field in which it is situated.

4. Forces and Motion	• Carry out a simple practical investigation or demonstration on friction as a force *e.g., friction books, measuring friction when dragging an object across a surface, making fire using two pieces of dried woods.*	**3. Pressure in fluids and gases** when they can: • Define and describe what pressure is. • Carry out an investigation into the pressure in fluids and/or gases (atmospheric pressure) *e.g., pressure in liquid - suspended bucket with identical holes all over the surface and water pouring through the holes.* • Investigate an application of pressure in fluid or gas in everyday life *e.g., balloon, weather forecast, construction of water dam, water in a hose, drinking from straw, drawing blood using a syringe etc.* • Investigate the measurements of pressure and density *e.g., variation of pressure in liquids with depths or with density.* • Explain applications of Archimedes Principles of flotation *e.g., why steel ships float.* • Use Archimedes Principle to calculate the weight/ mass of things immersed in liquids).	• Explain the application of ideas relating to friction *e.g., why is it easier to slip on smooth surfaces like Papaseea Sliding Rocks, than on a gravel road?* **3. Simple Machines** when they can: • Investigate the involvement of moments in simple machines *e.g., levers (hammer, pry bar, wheelbarrow), beams (balancing beams as in building construction, see saw), pulley systems (flag pole, blinds), screw (jar lid, bottle caps), wheel and axle (office chairs), wedge (scissors, knife, axe).* • Calculate the efficiency of simple machines *e.g., pulley systems, levers, beams e.g., efficiency is ratio of work output to work input.* • Explain the principles of simple machines *e.g., moving a large load with small effort, moving a small load a large distance, applying a force in a difficult place.* • Investigate effects of torque in simple machines. • Describe applications involving movement in couples and torques. • Use formulae and vectorial methods to solve a variety of problems *e.g., W = Fd.* **4. Energy, Work and Power** when they can: • Recall (from year 9 and 10) the concepts of potential energy and kinetic energy and how one can be converted into the other. • Investigate factors that affect the amount of potential and kinetic energy an object has. • Describe and identify examples of energy conservation principles, *e.g., energy cannot be destroyed only changed in form.* • Apply appropriate formulae to find unknown quantity in a variety of problems, $E_p = mgh$, $E_h = \frac{1}{2}mv^2$.	**6. Projectile motion** when they can: • Describe the motion of an object which moves horizontally into a vertical force field. • State that in the above case: - The horizontal component of velocity remains constant. - The vertical component of velocity increases or decreases uniformly with time. • Describe the path of an object travelling through a gravitational field. • Calculate vertical and horizontal displacement or velocity. • Use the kinematic equations to solve projectile problems. **7. Uniform Circular motion** when they can: • Understand that an object travelling in a path along the circumference of a circle, is accelerating despite the fact that the speed may be constant. • Use the relationship: $a = \frac{v^2}{r}$ and state that this represent a centripetal acceleration, with **v** as the instantaneous velocity perpendicular to the acceleration. • State that the direction of the net centripetal force needed to keep an object in uniform circular motion is towards the center of that motion. • Solve problems involving objects in circular motion. • Identify the use of the universal law of gravitation, and realize that it is an inverse square law. • Understand that the centripetal force maintaining the circular motion of planets and satellites is a force of gravitational attraction. • *Understand the difference between linear and angular speed in circular motion.* • *Convert angles between degree and radian.* • *Calculate the angular speed in a circular motion.* • *Understand the link between linear and angular dimensions of motions.* *[These are introduced at this level to bridge the gap with Foundation Physics.]* **8. Work done and Power** when they can: • Determine the component of the force which is in the direction of movement and thus contributing to the work done. • Identify that the area under a force-displacement graph identifies the work done. • Determine power attributes relating to work activity and machines.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
4. Forces and Motion			• Investigate work, power and how they are related *e.g., measuring the lifting rate of model cranes.* • Apply formulae to find unknown quantity in a variety of problems. W = Fd and P = W/t **5. Momentum** when they can: • Define momentum of an object - when does an object have momentum? *Momentum (p) = mass (m) x velocity (v)* • Identify the unit for momentum. • Identify that momentum is a vector quantity. • Explain that the two variables (mass and velocity) that the amount of momentum of an object is dependent upon. • Identify that it is the velocity which gives the vector quality to momentum.	.9. **Kinetic and Potential energy** when they can: • Calculate kinetic energy problems using: $E_k = \frac{1}{2}mv^2$ • Calculate gravitational potential energy problems using: E_p=mgh. • Draw a graph of force versus extension in a spring and recognize the gradient to be the spring force constant *k*, i.e. F=kx (Hookes Law). • Calculate spring potential energy. • Identify that when work is done on a body, energy is transferred to that body. • Understand the term elastic collision during which there is a conservation of kinetic energy. *[Potential and kinetic energy are studied at previous level. At this level, it is an expansion into more complex problem solving with specific application in a spring.]*

STREAM 2
General Science Curriculum Statement Years 9-12
Physics Component
FOR THE 4 YEARS SECONDARY EDUCATION

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
	Strand: THE WORLD OF PHYSICAL PHENOMENA [PHYSICS]			
1. Energy [Waves]	Students will investigate and develop scientific understanding of: **Different forms of energy and how energy changes involved in various physical processes** when they can: • Identify and describe the sources and uses of energy *e.g., food, biogas, wind, sun, fuels, heat, solar, water, electricity, sound.* • Identify the energy forms (*e.g., chemical, kinetic, magnetic, electrical, heat, mechanical, gravitational, elastic/potential, nuclear*) involved in a simple energy transformation and transfer or energy conversions *e.g., potential energy to kinetic energy, kinetic energy to heat energy etc.* • Investigate one energy transformation and transfer in local environment and demonstrate using models, poster or video presentations *e.g., the energy changes in the falling coconut, or riding a bicycle etc.* • Identify the SI unit for measuring energy (introducing units of measurement). • Carry out a simple practical investigation to measure or compare energy in objects or motions or in foods *e.g., energy in processed foods, energy in different rubber bands (length and thickness), two ball bounce etc.*	Students will investigate and develop further scientific understanding of: **1. Heat energy and the energy changes involved in processes using heat** when they can: • Describe how heat energy is transferred by conduction, convection and radiation. • Investigate how heat energy is transferred by conduction, convection and/or radiation using a simple practical. • Carry out a simple investigation on an application of heat energy and the energy changes involved in the process *e.g., making umu, chilly bin, baking, making ice-cream.* • Explain the factors that influence the transfer of heat in a process where heat is involved *e.g burning paper vs burning wood, "Why does paper burns faster?", stack of papers vs one sheet of paper etc.* • Describe the difference between heat and temperature and identify their units of measurements. • Investigate the application of heat energy in expansion of solids, liquids and gases. • Describe the behavior of particles in the expansion of solids, liquids and gases. • Explain applications of expansion in everyday situations *e.g., telephone lines, a bottle of water in the freezer.*	Students will investigate and develop further scientific understanding of: **1. Light** when they can: • Describe the behavior of light as it strikes different objects (refraction) or enters different mediums (reflection). • Carry out simple practical investigations into the behavior of light as it strikes different objects (refraction) or enters different mediums (reflection). • Investigate an application of concepts or ideas relating to light energy in an object or process *e.g., sun, shadows, mirror, camera, Photosynthesis etc.* **2. Heat energy and the energy changes involved in processes using heat** when they can: • Explain how conductors and insulators influence the rate of heat transfer. • Research and present on how the transfer of heat by conduction, convection and radiation occurs (or is reduced) in a simple application like the gas stove, radiator, coil element, refrigerator, thermos flask. • Interpret information in cooling and heating curves in terms of latent heat and changes of state. • Gather, process and present information about temperature scales and the construction and use of thermometers *e.g., mercury, alcohol, thermocouples, gas.*	Students will investigate and develop further scientific understanding of: **1. Properties of waves** when they can: • Recall that waves carry energy from one position to another. • Investigate and demonstrate the propagation of longitudinal and transverse waves in water *e.g., sea, ripple tank.* • Describe waves in terms of frequency (f), wave length (λ) period (T), velocity (v) amplitude (A). • Apply formula to determine speed of waves i.e. $v = f\lambda$. • Compare and contrast the nature of light and sound waves. • Identify that the wave front is perpendicular to the direction of travel. • Understand that the average displacement of vibrating particles involved in wave progress is zero. • Associate differing speeds of sound propagation with qualities of the transporting medium. **2. Sound** when they can: • Describe the speed of sound in different mediums *e.g., air, water.* • Explain the pitch of sound and its relationship to frequency *e.g., glasses with different volumes of water.* • Investigate applications of reflection of sound *e.g., echoes, scanners.*

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
1. Energy [Waves]	• Define renewable energy and non-renewable energy, identify sources of each and explain the importance of the wise use of each in local environment for energy conservation and efficiency.	**2. Sound energy (waves) and the energy changes involved** when they can: • Define what sound energy is and identify how it is measured (introducing units of measurements). • Describe and compare the speed of sound in air, water and soil (string or wire). • Describe and investigate the behavior of sound waves – how it is produced, how it travels. • Describe and classify sound waves in terms of longitudinal and transverse waves. • Investigate simple applications or uses of sound energy *e.g., drum, ukulele or guitar, ear, bell, music speaker, microphone, compact disks, water boiling, waterfall*. • Describe how the ear acts as a receiver of sound energy.	• Investigate and demonstrate how a thermometer works as an application of expansion of liquid mercury or alcohol. • Explain the use of the concept of absolute zero and absolute temperature in fixing temperature scales. • Define and investigate the specific heat capacities of different substances using calorimeters or mixtures method *e.g., water, iron, copper, alloy.* • Explain applications of differences in specific heat capacity in everyday situations *e.g., land and sea breezes, water cooling of engines, cooking utensils.*	• Research and discuss the involvement of waves properties in earthquakes. • Investigate the propagation of longitudinal and transverse waves *e.g., sea, ripple tank.* **3. Light** when they can: • Describe evidence of rectilinear propagation of light *e.g., shadows, eclipses, pin-hole camera.* • Investigate reflection of light in plane and spherical mirrors. • Use ray diagrams to describe images *e.g., size, position, type formed in different types of mirrors e.g., plane, concave, convex*. • Explain the formation of real and virtual images in reflection. • Investigate refraction of light in water, glass block and lenses. • Use ray diagrams to describe images *e.g., size, position, type formed in different types of lenses e.g., concave, convex*. • Explain the formation of real and virtual images in refraction. • Investigate applications of refraction *e.g., microscope, eyes, camera*. • Investigate defects of the eyes and their corrections. • Investigate dispersion of light by prisms. • Explain the formation of rainbows in terms of dispersion of light by prisms.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
2. Electricity [Electrical energy]	Students will investigate and develop scientific understanding of: **Electrical energy or electricity and how the energy changes involved are put to use** when they can: • Define and describe what electricity is – what form of energy it is, what transfer of energy is involved to produce electricity, what the amount of electricity produced depends on and what is SI unit of measurement for electricity *(introducing units of measurement)*. • Investigate and demonstrate how electricity is produced or generated in local environments *e.g., solar (heat), windmills (wind), hydroelectric plant (water)*. • Describe the safety precautions required when using electricity. • Describe what electrical conductivity is, what its SI unit is (introducing units of measurement) and what factors can affect a material's *(e.g., metals)* electrical conductivity. • Carry out a simple practical investigation that test and compare the conductivity of various objects. *E.g., metals like aluminum, copper, silver or stainless steel.*	Students will investigate and develop further scientific understanding of: **1. Electrical circuits** when they can: • Describe what an electrical circuit is and the difference between closed and open circuits. • Identify and describe components of an electrical circuit *e.g., switch, batteries, bulbs, resistors, capacitors etc.* • Draw simple electrical circuit diagrams using electrical symbols. • Construct a simple electrical circuit using a bulb, battery and wire. • Investigate an application of electrical circuit to a process in every day life *e.g., home lights*. • Describe what electrical resistivity is and identify examples of insulators. • Investigate and compare the differences between electrical insulators and conductors, i.e resistivity vs conductivity of various objects used in electricity transfer.	Students will investigate and develop further scientific understanding of: **1. Current electricity** when they can: • Identify that current results from movement of charge, in an electric field. • Recognize electrons as the conveyors (carriers) of charge. • Distinguish between the directions of conventional current and electron flow. • Investigate factors affecting resistance of a resistor *e.g., length, temperature.* • Define the terms; voltage, current and resistance and their SI units. • Interpret information on voltage, current and resistance in a circuit. • Calculate voltage (V), current (I) and resistance (R) using Ohm's Law V = I R. **2. Electrical circuits** when they can: • Recall and describe the two types of electrical circuits – series and parallel. • Identify advantages and disadvantages of series and parallel circuits with examples of applications in local environment *e.g., Christmas lights (series circuit) vs house lights (parallel).* • Carry out simple practical investigations to measure the differences in flow of electrical energy in series and parallel circuits. • Construct and explain a simple series electrical circuit and/or a parallel electrical circuit using all relevant electrical components. • Draw and interpret circuit diagrams containing a range of components in series and parallel circuits *e.g., power supply, cells, switches, resistors, meters, LED.*	Students will investigate and develop scientific understanding of: **1. Electrical energy or electricity** when they can: • Define the terms voltage, current, resistance and identify their SI units. • Interpret information on voltage, current and resistance in a circuit. • Describe electricity in terms of current (amps), voltage (volts), power (watts) and resistance (ohms). • Calculate voltage (V), current (I) and resistance (R) using Ohm's law. • Investigate a real life application of concepts or ideas relating to electrical energy *e.g., stove, car battery, home lights.* • Apply formulae for power to calculate unknowns in various examples. P= VI • Apply formulae of resistance R in series and parallel circuits to calculate unknowns in simple examples. $^{1}/RT = {}^{1}/R_1 + {}^{1}/R_2$ $Rn = R_1 + R_2$ **2. Energy transfer in electrical circuits** when they can: • Understand the concept of power as energy per unit time in an electrical context, $P = Et^{-1}$ • Interpret the power ratings given to appliances. • Calculate the power output of a resistance using: $P = I_2R$ • Calculate the amount of energy carried by a current. • Calculate the energy dissipated as heat in a resistor.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
3. Magnetism [Electromagnetism]	Students will investigate and develop scientific understanding of : **Behavior of magnets** when they can: • Define what a magnet is and describe the magnetic fields around magnets. • Identify and differentiate between magnetic, magnetized and non-magnetic materials using a simple experiment. • Describe the effect of poles of magnets (repulsion and attraction). • Identify and investigate examples of real life applications of magnets in local environment and in the world.	Students will investigate and develop further scientific understanding of the behavior of: **1. Magnets and magnetic fields** when they can: • Explain why like poles repel and unlike poles attract. • Draw magnetic field lines indicating repulsion between like poles and attraction between unlike poles. • Carry out a simple practical investigation on making magnet or magnetizing an object. • Compare the properties of magnetic and non-magnetic materials *e.g., soft iron, steel, alloys (alnico), aluminium, copper, iron filing, knife.* • Explain how electromagnets work. • Describe the factors that electricity produced from magnetism depend on. • Explain how electromagnets work. • Investigate how to make an electromagnet. • Identify the poles of the electromagnet. • Describe examples of electromagnets and temporary magnets. • Describe the factors that electricity produced from magnetism depend on.	Students will investigate and develop further scientific understanding of the behavior of: **1. Magnets and magnetic fields** when they can: • Define what electromagnetic radiation is. • Describe what the electromagnetic spectrum is in terms of the different forms of energy waves in the spectrum *e.g., radio waves, microwaves, x-rays, gamma rays, light*. • Identify that light is form of electromagnetic radiation or energy, and is a small portion of the electromagnetic spectrum (as introduced in year 10). • Describe an application of electromagnetic radiation *e.g., radio, microwave, x-rays.* • Explain and investigate the dangers of over exposure to some forms of electromagnetic radiation. **2. The magnetic effect of electric current, motor effect and electromagnetic induction** when they can: • Investigate the magnetic effect around a conductor *e.g., straight wire, circular coil or a solenoid.* • Draw and describe the magnetic field lines around a conductor: straight wire, circular coil and a solenoid.	Students will investigate and develop further scientific understanding of the behavior of: **1. Magnetic fields** when they can: • Investigate the interaction of magnetic fields using a freely suspended magnet. • Describe methods of making permanent magnets *e.g., single stroke method, divided stroke method, electromagnetic method.* • Investigate the making of a permanent magnet. • Recall (from year 10) how materials can be magnetized and investigate how they can demagnetized if possible. • Identify precautions to prevent magnets from being de-magnetized. **2. Charges, conductors and magnetic fields to the motor effect** when they can: • Understand that a current-carrying conductor placed in a magnetic field experiences a force. • Recall that the magnetic force is perpendicular to the current and the field, as demonstrated by the right hand rule. • Determine the direction of the force on a current-carrying conductor when it is in a magnetic field. • Apply the principles of magnetic force to explain and predict the turning effect on a coil conductor mounted in a magnetic field. • Describe the principle of the electric motor and explain how continuous rotation of the coil is achieved. • Describe the moving coil galvanometer and the way it is adapted to offer a reading related to current size. **3. Motor effect and its applications** when they can: • Recall what motor effect is. • Research and describe how a transformer works. • Investigate the production of a current through electromagnetic induction *e.g., a magnet moving into a coil, moving a coil towards a magnet.* • Describe and explain how factors affect the amount of current formed in electromagnetic induction *e.g., speed of movement, strength of magnet, number of turns of a coil*.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
4. Forces and Motion	Students will investigate and develop further scientific understanding of: **Forces and motion and how the relationship between force and motion is put to use** when they can: • Define what force is and identify and classify the types of forces into two groups – contact forces *e.g., friction and non-contact forces e.g., magnetic force.* • Describe the effects of forces on shape or motion (direction, movement and speed) of a stationary and moving object in local environment. • Describe the relationship between force, motion and work *e.g., a moving and stationary ball, impact of a falling object from different heights.* • Carry out a simple practical investigation to measure or describe the effect of force on an object *e.g., stretching and compressing materials like latex foam cylinder or block, rubber band, steel spring, elastic cord (weight force and stretching force), ball and straw – motion of a ball when it moved by air blown through a straw from different directions.* • Define gravitational and upthrust forces and describe their effects on objects floating and sinking in water *e.g., floating coconut, why a boat or paopao floats etc.* • Define friction force and describe its advantages and disadvantages. • Carry out a simple practical investigation or demonstration on friction as a force *e.g., friction books, measuring friction when dragging an object across a surface, making fire using two pieces of dried woods.*	Students will investigate and develop further scientific understanding of: **1. Linear motion and the relationship between speed, distance and time** when they can: • Describe what linear motion is (Newton's First law of motion). • Identify SI units for speed, distance and time. • Carry out a practical investigation o measure distance travelled and time taken. • Use equations to calculate speed, distance and time. • Present and interpret information on speed, distance and time using tables and graphs. • Investigate an application of linear motion to an every day situation *e.g., track runner or athlete, car driving along a straight road, man pushing a box/furniture across a floor, cycling.* **2. Pressure in fluids and gases** when they can: • Define and describe what pressure is. • Carry out an investigation into the pressure in fluids and/or gases (atmospheric pressure) *e.g., pressure in liquid - suspended bucket with identical holes all over the surface and water pouring through the holes.* • Investigate an application of pressure in fluid or gas in everyday life *e.g., balloon, weather forecast, construction of water dam, water in a hose, drinking from straw, drawing blood using a syringe etc.*	Students will investigate and develop scientific understanding of: **1. Linear motion and the relationship between velocity and acceleration** when they can: • Define velocity and acceleration and identify their SI units. • Describe the difference between vector and scalar quantities and identify which quantity are velocity and acceleration. • Identify the difference between speed and velocity. • Describe the relationship between velocity and acceleration in terms of an object speeding and an object slowing down i.e their signs or directions (positive and negative). • Carry out an investigation into changes in velocity or acceleration of an object. • Use equations to calculate velocity and acceleration. $v = \Delta s \div \Delta t$ $a = \Delta v \div \Delta t$ • Process, present and interpret information on velocity and acceleration in tables and graphs. • Apply their knowledge of the relationship between velocity and acceleration to real life situations *e.g., a speeding car, sprinter or 100m runner or rugby player.* **2. Forces** when they can: • Recall common forces and their effects (from year 9 and 10) *e.g., gravitational, magnetic, electric, friction.* • Investigate the effect of balanced and unbalanced forces on the straight-line motion of an object.	Students will investigate and develop scientific understanding of: **1. Linear motion and the relationship between velocity, displacement, time and acceleration** when they can: • Recall the differences between scalar and vector quantities; distance vs displacement, speed vs velocity, acceleration. • Understand the importance of the direction property of a vector quantity. • *Represent vectors by scaled lines.* • *Represent vectors numerically.* • *Add vectors to get a resultant.* *[These are to be taught as they pre-requisite skills for learning of following content but they are not to be tested on their own. They are to be tested integrated with the following content.]* • Plot and draw graphs of displacement vs time, velocity vs time and acceleration vs time. • Interpret graphs by relating slope to the variable *e.g., displacement vs time (velocity), velocity vs time (acceleration) and acceleration vs time (constant, deceleration, acceleration).* • Calculate unknowns in various problems using formulae and graphical methods *e.g., displacement (Δs), velocity (v), acceleration (a).* $v = \Delta s \div \Delta t$ or $v = \Delta d \div \Delta t$ $a = \Delta v \div \Delta t$ • Describe and explain examples of the application of ideas relating to displacement, velocity and acceleration *e.g., safe stopping distances while driving, speed limits.* **2. Force, work and power** when they can: • Define what force, work and power are and describe the relationship between force, work and power. • Identify SI units for force, work and power.

SUB-STRANDS	YEAR 9	YEAR 10 (SJSC)	YEAR 11	YEAR 12 (SSLC)
4. Forces and Motion		• Investigate the measurements of pressure and density *e.g., variation of pressure in liquids with depths or with density*. • Explain applications of Archimedes Principles of flotation *e.g., why steel ships float*. • Use Archimedes Principle to calculate the weight/mass of things immersed in liquids.	• Use formulae (F = ma or F_w = mg), graphical methods and force diagrams to calculate the resultant force on objects. • Describe and explain the effects of balanced and unbalanced forces on the motion of an object *e.g., a plane taking off and in horizontal flight, a rugby ball being kicked, carrying a baby in a basket*. • Investigate effect of friction as a force. • Explain the application of ideas relating to friction *e.g., why is it easier to slip on smooth surfaces like Papaseea Sliding Rocks, than on a gravel road*.	• Carry out an investigation to measure force, work and power in a real life situation *e.g., weight lifting, dragging an object across the floor*. • Process, present and interpret information on force, work and power in tables and graphs (integrating measurements). • Calculate work, force or distance using formulas or equations; W= F d, P = W ÷ t. • Apply their knowledge of force, work and power to the use of simple machines which assist human to do work *e.g., levers (hammer, pry bar, wheelbarrow), beams (balancing beams as in building construction, see saw), pulley systems (flag pole, blinds), screw (jar lid, bottle caps), wheel and axle (office chairs), wedge (scissors, knife, axe)*. • Define efficiency of a simple machine. • Calculate the efficiency of a simple machine. i.e. ratio of output work to input work. • Determine the component of the force which is in the direction of movement and thus contributing to the work done. • Identify that the area under a force-displacement graph identifies the work done. • Determine power attributes relating to work activity and machines. **3. The relationship between potential and kinetic energy** when they can: • Describe the changes in the amount of potential and kinetic energy objects have when forces acting on them change *e.g., a cricket ball when hit*. • Carry out an investigation into a factor (or factors) that affects the amount of potential and kinetic energy of an object or objects. • Use equations to calculate the amounts of potential and kinetic energy of various processes *e.g., when a child climbs a tree, when an object is dropped from a height etc.* $E_p = mgh$, $Ek = ½ mv^2$

Recommended Resources for Teachers and Students of Physics

These are only a few of many resources teachers and students can search and use to assist with the teaching and learning.

Textbooks and booklets:

1. Books 3 Year 9 Science; CDMD, MESC
2. Science Circus Pacific Extraordinary Science with Ordinary stuff Workshop Booklet; Walker, Duggan and Shevlin, ANU
3. Physics Learning Guide for Years 12-13; Dr Brian Bennison, NZAID and CDMD, MESC
4. Advanced Physics for You; K. Johnson, S. Hewett, S. Holt and J. Miller, Nelson Thornes (London), 2000 edition (for Year 12)
5. Physics for You; K. Johnson, Nelson Thornes (London), 2000 edition (for Year 11)
6. Physics Workbooks for Years 12 – 13; Hiroaki Matsukawa, JICA and CDMD, MESC
7. Various NCEA Science and Physics textbooks available on scitext.co.nz. For example:
   - AME Level 1 Physics workbooks; P. Bendall
   - AME Level 2 Physics workbooks; D. Hausden
   - AME Level 3 Physics workbooks; P. Bendall

Online webs: (a few of many online resources)

1. mesc.gov.ws
2. physicsclassroom.com
3. www.britannica.com
4. www.khanacadeny.org
5. www.sciencedirect.com
6. www.cnx.org
7. eschooltoday.com
8. brightstorm.com
9. solarschools.net
10. spark.iop.org (Institute of Physics)
11. saps.org.uk

References:

1. Analysis of and comment on the 2017 Year 13 SSLC Physics Examination by GS Boyd: Feb 2018, CDMD, MESC
2. Biology Prescriptions Years 12-13: 2014, CDMD, MESC
3. Chemistry Prescriptions Years 12-13: 2014, CDMD, MESC
4. External Reviewer Report for Chemistry Curriculum by Dr Taema Imo-Seuoti: 2019, CDMD, MESC
5. External Reviewer Report for Physics Curriculum by Rev Muao Fagasua: 2019, CDMD, MESC
6. Reviewed Biology Curriculums Years 9-13: 2014-2019, CDMD, MESC
7. Reviewed Chemistry Curriculums Years 9-13: 2014 -2019, CDMD. MESC
8. Reviewed Physics Curriculums Years 9-13: 2014-2019, CDMD, MESC
9. Samoa Secondary Schools Curriculum Statement , Science Years 9-12 with Years 12-13 Biology, Chemistry and Physics: 2004, CDMD, MESC
10. Science Years 1-8 Primary School Curriculum: 2013, CDMD, MESC
11. SSLC Physics Prescription Year 13: 2013, CDMD, MESC