

Science Syllabus

Lower Secondary

Express/Normal (Academic)



© Copyright 2007 Curriculum Planning & Development Division.

This publication is not for sale. All rights reserved.

No part of this publication may be reproduced without the prior permission of the Ministry of Education, Singapore.

Year of implementation: from 2008

ISBN 978-981-05-7760-5

CONTENTS

	Page
1 OVERVIEW	
• Science Curriculum Framework	1
• Aims	4
• Syllabus Framework	5
2 TEACHING AND LEARNING	
• Teaching and Learning through Inquiry	12
• Assessing Teaching and Learning	17
3 SYLLABUS CONTENT	19
4 GLOSSARY OF TERMS	40
5 ACKNOWLEDGEMENTS	41

PREAMBLE

This Lower Secondary Science Syllabus is essentially a continuation and further development of the Primary Science Syllabus. It is also a bridge to, and a foundation for, the pursuit of scientific studies at upper secondary levels. The syllabus has also taken into consideration the desired outcomes of education for our lower secondary students as well as the national education emphasis.

This syllabus is based on the *Science Curriculum Framework* and emphasises the need for a balance between the acquisition of science knowledge, skills and attitudes. In addition, as and when the topics lend themselves, the technological applications, social implications and the value aspects of science are also considered. It also emphasises the broad coverage of fundamental concepts in the natural and physical world.

The aims spelt out in the syllabus provide the guiding principles for the suggested teaching approaches and evaluation methods.

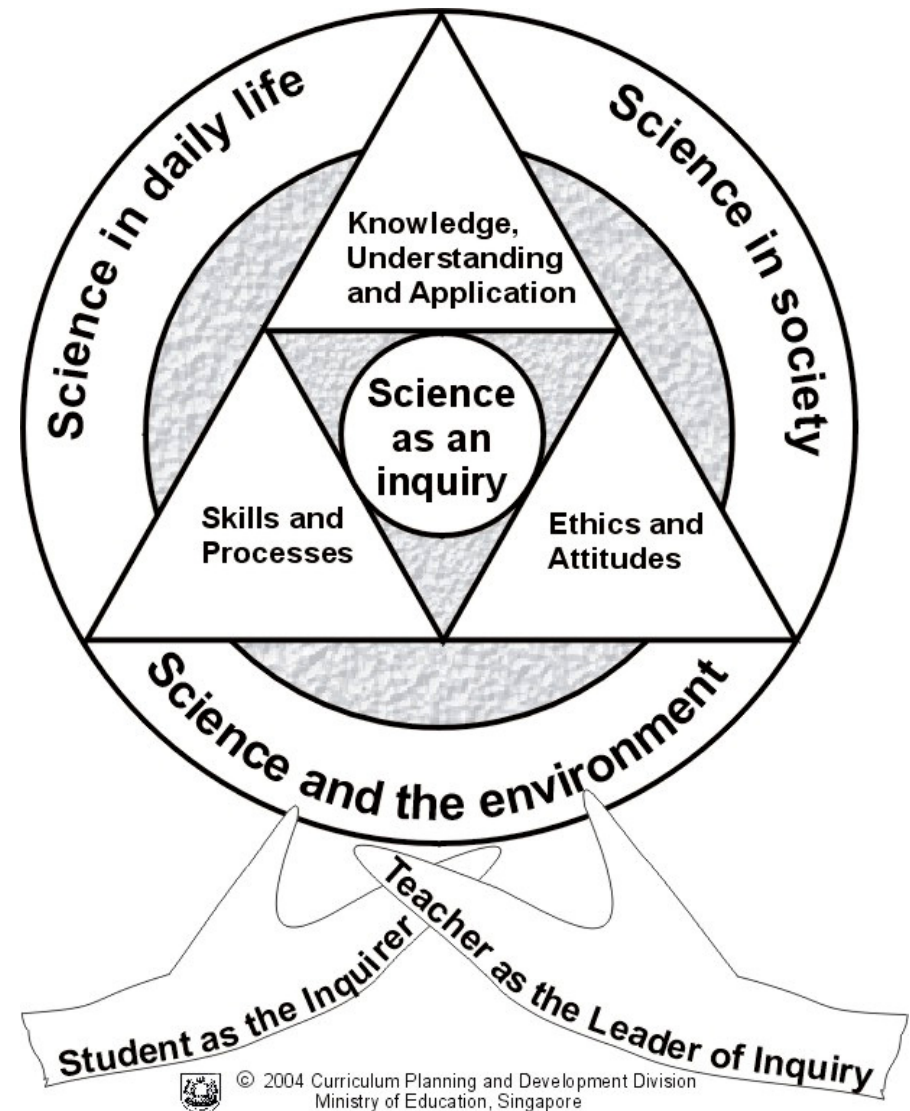
Teachers are advised not to follow the syllabus too rigidly but to exercise their professional judgement in implementing it. Schemes of work should be developed with the interests and abilities of the students uppermost in mind. Teachers are encouraged to use a variety of approaches in their teaching and to incorporate ideas and materials from various sources in order to enhance the learning of science.

Certain parts of the syllabus have been underlined. The topics concerned are optional for the Normal (Academic) course students.

SCIENCE CURRICULUM FRAMEWORK

The *Science Curriculum Framework* is derived from the *Policy Framework for the Teaching and Learning of Science*. It encapsulates the thrust of science education in Singapore to prepare our students to be sufficiently adept as effective citizens, able to function in and contribute to an increasingly technologically-driven world.

Central to the curriculum framework is the inculcation of the spirit of scientific inquiry. The conduct of inquiry is founded on three integral domains of (a) Knowledge, Understanding and Application, (b) Skills and Processes and (c) Ethics and Attitudes. These domains are essential to the practice of science. The curriculum design seeks to enable students to view the pursuit of science as meaningful and useful. Inquiry is thus grounded in knowledge, issues and questions that relate to the roles played by science in daily life, society and the environment.



The science curriculum seeks to nurture the student as an inquirer. The starting point is that children are curious about and want to explore the things around them. The science curriculum leverages on and seeks to fuel this spirit of curiosity. The end goal is students who enjoy science and value science as an important tool in helping them explore their natural and physical world.

The teacher is the leader of inquiry in the science classroom. Teachers of science impart the excitement and value of science to their students. They are facilitators and role models of the inquiry process in the classrooms. The teacher creates a learning environment that will encourage and challenge students to develop their sense of inquiry. Teaching and learning approaches centre around the student as an inquirer.

The following table shows the description of each domain which frames the practice of science:

Knowledge, Understanding and Application of	Skills and Processes	Ethics and Attitudes
<ul style="list-style-type: none"> • Scientific phenomena, facts, concepts and principles • Scientific vocabulary, terminology and conventions • Scientific instruments and apparatus including techniques and aspects of safety • Scientific and technological applications 	<p><u>Skills</u></p> <ul style="list-style-type: none"> • Using apparatus and equipment • Posing questions • Observing • Classifying • Comparing • Communicating • Inferring • Formulating hypothesis • Predicting • Analysing • Elaborating • Verifying • Generating possibilities • Defining the problem <p><u>Processes</u></p> <ul style="list-style-type: none"> • Planning investigation • Creative problem solving 	<ul style="list-style-type: none"> • Curiosity • Creativity • Objectivity • Integrity • Open-mindedness • Perseverance • Responsibility

The domains are contextually linked to the roles played by science to establish its relevance and relationship to modern-day living:

Science in daily life - Personal perspective focusing on the individual	Science in society - Social perspective focusing on human interactions	Science and the environment - Naturalistic perspective focusing on man-nature relationship
<ul style="list-style-type: none"> • Using scientific skills in everyday life, e.g. observing trends and patterns and analysing data from media reports • Being adaptable to scientific and technological advances e.g. use of IT tools and on-line resources • Making informed decisions that are related to science and technology e.g. consumption of GM food, health choices 	<ul style="list-style-type: none"> • Engaging in meaningful scientific discourse with others e.g. social and moral issues related to advances in science • Understanding role and impact of science and technology in society e.g. life sciences, computers • Contributing to the progress of science knowledge e.g. working with scientists on research projects 	<ul style="list-style-type: none"> • Understanding the place of humanity in the natural world e.g. man's connections with living things and the environment • Showing awareness of safety and biological issues, e.g. SARS, AIDS, Bird Flu • Demonstrating care and concern for the environment e.g. understanding the causes and effects of global warming

AIMS

The aims of the Lower Secondary Science syllabus are to:

- i) enable students to acquire understanding and knowledge so as:
 - to become confident citizens in a technological world, able to take or develop an interest in matters relating to science and technology;
 - to recognise and appreciate the usefulness and limitations of the scientific method to investigating and solving problems;
 - to be prepared for science studies at upper secondary level and beyond.
- ii) develop abilities and skills that
 - are relevant to the study and practice of science;
 - are useful in everyday life;
 - encourage effective communication;
 - encourage safety consciousness and safe practice.
- iii) develop attributes relevant to the study and/or practice of science such as:
 - concern for accuracy,
 - objectivity,
 - inquisitiveness,
 - initiative,
 - innovativeness,
 - integrity,

- perseverance,
 - critical analysis.
- iv) stimulate
 - curiosity, interest and enjoyment in science and its methods of inquiry;
 - interest in, and care for, the environment.
 - v) promote an awareness:
 - that the study and practice of science are co-operative and cumulative activities and are subject to social, economic, technological, ethical and cultural influences and limitations;
 - that the applications of science are generally beneficial; but the abuse of scientific knowledge can be detrimental;
 - of the importance of the use of IT for communications and as a tool for data collection and analysis.

It is hoped that teachers will incorporate the social, environmental, economic and technological aspects of science whenever possible throughout the syllabus (see Aims (iv) and (v)). Where appropriate, students should also have opportunities to discuss the ethical implications of science and technology.

SYLLABUS FRAMEWORK

The Lower Secondary Science Syllabus comprises:

- The knowledge, skills and attitudes that all students should acquire, which are designed for 85% of the curriculum time.
- The 15% freed up curriculum time, known as the white space, to enable teachers to use more engaging teaching and learning approaches, and/or to implement customised school-based programmes as long as the aims of the syllabus are met. This enables teachers to make learning more meaningful and enjoyable for their students.

A Knowledge, Understanding and Application

The Lower Secondary Science Syllabus is structured in a similar way to the Primary Science Syllabus. The topics in the Physical and Life Sciences are organised into 6 main themes. They are: **Science & Technology; Measurement; Diversity; Models and Systems; Energy; and Interactions.** The latter four themes are similar to those found in Primary Science. The theme Models and Systems is an extension of a similar theme Systems in Primary Science. The concepts introduced in Primary Science under the similar themes are revisited and consolidated in Lower Secondary Science for further development in terms of knowledge, skills and processes.

The Lower Secondary Science Syllabus uses the Scientific Inquiry approach to weave the knowledge, skills, and

attitudes in science throughout the 6 themes. In addition, the applications and impact of science and technology are included wherever appropriate. To help teachers and students appreciate and understand the themes, some key inquiry questions¹ are included for each theme. These questions can guide teachers and engage students in uncovering the important ideas at the heart of each theme. They can also use these questions to raise more specific questions for the respective topics under each theme.

Science & Technology

Students should appreciate that science is the study of our natural world through systematic observation, experimentation, and analysis. Scientists seek to formulate principles, laws and theories that help to explain and increase our understanding of natural phenomena we observe in the world. Through science, we also learn how to use things to make our lives more comfortable and solve problems to improve our surroundings. In this theme, we examine the processes and applications of scientific inquiry in the study and practice of science, and the benefits and limitations of science and technology. Key inquiry questions in Science & Technology include:

- Why did this event, phenomenon or problem happen?
- What conclusions can I make based on my observations and evidence collected?

¹ Reference: Wiggins, J. and McTighe, J. (1998). *Understanding by Design*. Alexandria, Va.: Association for Supervision and Curriculum Development.

Measurement

Students should recognise the need for Man to quantify his interactions with the environment. Man makes estimations and also accurate measurements of quantities not just when he is engaged in scientific inquiry but also in everyday activities. The study of measurement would enable Man to plan the use of resources efficiently. In this theme, we examine how different instruments are used to measure different quantities accurately. Direct measurements of quantities include length, mass, volume and time and calculated quantities include density, speed and rate. Key inquiry questions in Measurement include:

- Why is it important to have clearly defined quantities and units?
- How does the system you want to study determine the way you take measurements?

Diversity

Students should appreciate that there is a great variety of living and non-living things in the world and the importance for Man to understand and maintain the connections with living things and his environment. Man seeks to organise this great variety through common threads and unifying factors to better understand the world in which he lives. The study of living and non-living things in terms of properties and changes is greatly facilitated by putting them into groups. In this theme, we examine the classification of matter according to their properties into groups such as elements, compounds and mixtures, and the classification of plants and animals according to their observable characteristics using dichotomous keys. Key inquiry questions in Diversity include:

- How does the diversity of living and non-living things in the world contribute to our lives?
- How do we classify things in our world?

Models and Systems

Students should appreciate that models are simplified representations of phenomena. These models are constructed to facilitate understanding of the phenomena. There are three types of models in the learning of science, namely, physical, conceptual and mathematical. Examples of models examined in this theme are the atomic model and particulate model of matter.

Students should recognise that a system is a whole consisting of parts that work together to perform a function. There are systems in nature as well as man-made systems. Parts of a system influence one another. Two or more systems can interact with one another to perform a function. Examples of systems in nature examined in this theme are the digestive system and reproductive system. Key inquiry questions in Models and Systems include:

- How do we know that the models used are good representations of the real system?
- How do parts of a system or different systems interact together to perform a function?

Energy

Students should appreciate that energy is necessary for all living and non-living systems. Energy makes changes and movement possible in our daily lives. Living things obtain energy and use it to carry out life processes. There are many forms of energy and one form can be converted to another. It

is our responsibility to show care and concern for living things and the environment as we use energy in its different forms every day. In this theme, we examine different forms of energy such as kinetic and potential energy, light and electricity, and the processes of photosynthesis and respiration in plants. Key inquiry questions in Energy include:

- How can we harness energy to improve our quality of life?
- Why must energy be conserved?

Interactions

Students should appreciate that there are interactions between the living world and the environment at various levels: interactions which occur within an organism; between organisms; and between organisms and the environment. There are also interactions between forces and objects, and energy and matter. In this theme, we examine the interaction of forces and energy between and within living and non-living systems as well as with the environment. Examples of these interactions include transmission of heat, chemical changes, and energy flow through a food chain in an ecosystem. Key inquiry questions in Interactions include:

- How does knowledge of interactions between and within systems help Man better understand his environment?
- What are the interactions between physical phenomena and life processes?

B Skills and Processes

Scientific inquiry involves the use of skills and processes to inquire about things and phenomena in our natural and physical world.

Skills

Using apparatus and equipment

This is the skill of knowing the functions and limitations of various equipment and apparatus, and being able to select and handle them appropriately for various tasks.

Posing questions

This is the skill involving the clarification of issues and meaning through inquiry. Good questions focus attention on important information and are designed to generate new information.

Observing

This is the skill of using our senses to gather qualitative as well as quantitative information about a particular object, event or phenomenon. This also includes the use of instruments to extend the range of our senses.

Classifying

This is the skill of grouping objects or events according to common attributes or properties.

Comparing

This is the skill of identifying the similarities and differences between or among objects or entities.

Communicating

This is the skill of transmitting and receiving information presented in various forms - verbal, tabular, graphical or pictorial.

Inferring

This is the skill of interpreting and explaining observations, data or information gathered.

Formulating hypothesis

This is the skill of making a general explanation for a related set of observations or events. It is an extension of inferring.

Predicting

This is the skill of assessing the likelihood of an outcome based on prior knowledge of how things usually turn out.

Analysing

This is the skill of clarifying information by examining parts and relationships contained in the information.

Elaborating

This is the skill of providing details, examples and other relevant information so as to make one's ideas more comprehensible to others.

Verifying

This is the skill of confirming or proving the truth of information, using specific standards or criteria of evaluation.

Generating possibilities

This is the skill of exploring all the alternatives, possibilities and choices beyond the obvious or preferred one.

Defining the problem

This is the skill of consciously clarifying situations that are puzzling in some way. The extent, scope and nature of the problem are identified and clarified.

Processes

Processes are complex operations which call upon the use of several skills.

Planning investigation

This process involves formulating questions or hypotheses for investigating, and devising ways to find answers. It also involves deciding on the type of equipment required and measurements to be made, as well as identifying the variables involved and manipulating the variables so that the effect of only one variable can be observed in any one experiment.

Creative problem solving

This is the process of thinking through a problem and generating and applying criteria to select an innovative solution that meets the requirements. This thinking process is used whenever one faces obstacles and wishes to overcome them so as to arrive at a practical and workable solution.

It must be pointed out that there is no one definite sequence of priority among the skills and processes listed above. For example, observation may lead to hypothesising but at other times a hypothesis can lead to an observation. All the skills and processes listed above are seen as part of the total process of scientific inquiry.

In science teaching and learning, effort should initially be directed at teaching explicitly each of the skills through the use of appropriate activities. Later effort should be directed to helping students integrate some or all of the skills in scientific inquiry.

C Ethics and Attitudes

In all scientific inquiry, the adoption of certain mental attitudes such as *curiosity, creativity, objectivity, integrity, open-mindedness, perseverance* and *responsibility* are advocated. Attempts should also be made to promote safety consciousness among students and to encourage students to adopt safe practices.

Curiosity

This is the attitude of desiring to explore the environment and question what is found.

Creativity

This is the attitude of seeking innovative and relevant ways to solve problems.

Objectivity

This is the attitude of seeking data and information to validate observations and explanations objectively.

Integrity

This is the attitude of handling and communicating data and information with integrity.

Open-mindedness

This is the attitude of accepting all knowledge as tentative and the willingness to change their views if the evidence is convincing.

Perseverance

This is the attitude of pursuing a problem until a satisfactory solution is found.

Responsibility

This is the attitude of showing care and concern for living things and awareness of our responsibility for the quality of the environment.

Opportunities should be provided in the classroom for students to ask questions. Students should be encouraged to ask both closed and open questions. From the type of questions asked by the students, teachers could gather information on their 'frame of mind' and the quality of their understanding.

Table 1 shows an overview of the Lower Secondary Science Express/Normal (Academic) syllabus.

Table 1: Overview of Lower Secondary Science Express/Normal (Academic) Syllabus

Designed for 85% of the curriculum time. ²		White Space
Themes	Topics	The 15% freed up curriculum time is to enable teachers to use more engaging teaching and learning approaches, and/or to implement customised school-based programmes as long as the aims of the syllabus are met. This enables teachers to make learning more meaningful and enjoyable for their students.
Science & Technology	Science processes & applications <ul style="list-style-type: none"> ▪ Scientific inquiry ▪ Science and technology in society 	
Measurement	Making measurements <ul style="list-style-type: none"> ▪ Use of measuring instruments ▪ Physical quantities & units 	
Diversity	Diversity of matter <ul style="list-style-type: none"> ▪ Classification of matter ▪ Elements, compounds & mixtures ▪ Solutions & suspensions Diversity of plant and animal life <ul style="list-style-type: none"> ▪ Classification of plant and animal life 	
Models & Systems	Models of cells & matter <ul style="list-style-type: none"> ▪ Cells – structure, function & organisation ▪ Particulate model of matter ▪ Simple concepts of atoms & molecules Plant & human systems <ul style="list-style-type: none"> ▪ Transport in living things ▪ Digestion in animals ▪ Sexual reproduction in human beings 	

² There is no change in the recommended curriculum time, which remains as 6 periods per week (Express) and 5 periods per week (Normal (Academic)). Each period is 35-40 minutes.

Designed for 85% of the curriculum time. ²		White Space
Energy	Energy forms & uses <ul style="list-style-type: none">▪ Energy forms & conversion▪ Light▪ Electricity▪ Photosynthesis & respiration	
Interaction	Interactions of forces & energy <ul style="list-style-type: none">▪ Concept of force & pressure▪ Moment of a force▪ Work▪ Effects of heat▪ Transmission of heat▪ Chemical changes▪ Simple concepts of populations, community and ecosystem▪ Energy transfer process in the ecosystem▪ Nutrient cycles in the ecosystems	

TEACHING AND LEARNING THROUGH INQUIRY

What is scientific inquiry?

Scientific inquiry may be defined as the activities and processes which scientists and students engage in to study the natural and physical world around us. In its simplest form, scientific inquiry may be seen as consisting of two critical aspects: the what (content) and the how (process) of understanding the world we live in³.

Teaching science as inquiry must therefore go beyond merely presenting the facts and the outcomes of scientific investigations. Students need to be shown how the products of scientific investigations were derived by scientists and be provided opportunities to: ask questions about knowledge and issues that relate to their daily lives, society and the environment; be actively engaged in the collection and use of evidence; formulate and communicate explanations based on scientific knowledge.

Through inquiry learning, students will be able to acquire knowledge and understanding of their natural and physical world based on their own investigations, apply the skills and processes of inquiry and develop attitudes and values that are essential to the practice of science.

³ Reference: Chiappetta, E. L., Koballa, T., Collette, A. T. (2002). *Science instruction in the middle and secondary schools*. Upper Saddle River, NJ: Merrill Prentice Hall.

What are some characteristics of teaching and learning of science as inquiry?

Inquiry-based learning may be characterised by the degree of responsibility students have in posing and responding to questions, designing investigations, and evaluating and communicating their learning (student-directed inquiry) compared to the degree of responsibility the teacher takes (teacher-guided inquiry). Students will best benefit from experiences that vary between these two inquiry approaches.

Essential features of science as inquiry	Amount of Student Self-Direction			
	← More			Less →
	Amount of Guidance from Teacher or Material			
	← Less			More →
Question Students engage with an event, phenomenon or problem when they ...	pose a question	select among questions	sharpen or clarify question provided	accept given question
Evidence Students give priority to evidence when they ...	determine what constitutes evidence and collects it	are directed to collect certain data	are given data and asked to analyse	are given data and told how to analyse

Essential features of science as inquiry	Amount of Student Self-Direction			
	← More		Less →	
	Amount of Guidance from Teacher or Material			
	← Less		More →	
Explanation Students construct explanations when they ...	formulate their own explanation after summarising evidence	are guided in process of formulating explanation from evidence	are given possible ways to use evidence to formulate explanation	are provided with evidence
Connections Students evaluate their explanations when they ...	examine other resources and form links to explanations	are directed toward sources of knowledge	are given possible connections	are provided with connections
Communication Students communicate and justify their explanations when they ...	form reasonable and logical argument to communicate explanations	are coached in development of communication	are provided guidelines for communication	are given steps and procedures for communication

Adapted from *Inquiry and the National Science Education Standards*, National Research Council (2000).

What are some strategies for conducting inquiry-based learning and teaching?

A primary purpose for inquiry-based instruction is for students to learn fundamental science concepts, principles, and theories as well as to develop science process skills and attitudes that are essential for scientific inquiry. Science teachers are already using a variety of teaching strategies in their lessons such as discrepant events, inductive and deductive activities and problem solving to achieve this end.

To further emphasise the learning of science as inquiry, teachers can incorporate in these strategies the essential features of **Question, Evidence, Explanation, Connections and Communication** and provide students with experiences that varies between guided (partial) and open (full) inquiry.

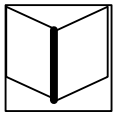
Teachers are also encouraged to use a variety of strategies to facilitate the inquiry process. Selected strategies are highlighted to help teachers plan and deliver lessons that will engage students in meaningful learning experiences and cultivate their interest and curiosity in science. These strategies can be mixed and matched. A brief description of each of these strategies is given as follows:

Strategies for inquiry-based learning and teaching



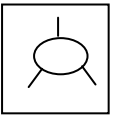
Brainstorming

Brainstorming is a strategy for generating creative ideas and solutions.



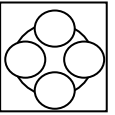
Case Study

The case study approach is a strategy which uses real and hypothetical cases to help students develop critical skills such as analysing, inferring and communicating.



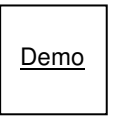
Concept Mapping

Concept mapping is a strategy to present meaningful relationships among concepts. Concept maps are useful in organising and linking concepts or ideas.



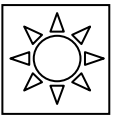
Cooperative Learning

In cooperative learning, activities are structured such that each student assumes certain responsibilities and contributes to the completion of tasks. In working with others, students are exposed to different points of views and solutions in accomplishing a common goal.



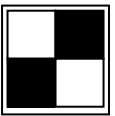
Demonstration

Demonstration is commonly used to scaffold the learning process. This approach is recommended when the learning activity is not safe or too complex for students to set up on their own.



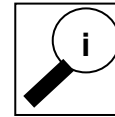
Field Trip

A field trip is any learning activity outside the school. It provides opportunities for students to explore, discover and experience science in everyday life.



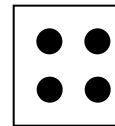
Games

Games engage students in play or simulations for the learning of concepts or skills. This is useful in helping students to visualise or illustrate objects or processes in the real world.



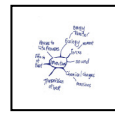
Investigation

In scientific investigation, students engage in activities that mirror how scientists think and what they do in a decision making process, such as asking or posing questions and planning or designing investigations.



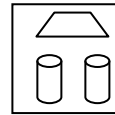
Learning Centres

Learning centres are various stations at which individuals or groups of students carry out selected activities. The activities may be designed to accommodate a variety of learning styles and challenge multiple intelligences.



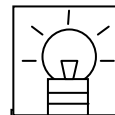
Mindmapping

A mind map radiates from a central image or key word. The branches connect related concepts and ideas to the central image. Every word and image is itself a potential sub-centre of ideas or concepts. The visual presentation of related information enhances understanding. The association would be to facts as well as relationship between the facts.



Model Building

Model building is an activity in which students design and construct a representation of a concept or object.



Problem Solving

Problem solving engages students in finding solutions to problems by applying scientific knowledge and skills.



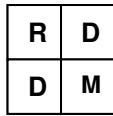
Projects

Projects are learning activities that require students to find out about an object, event, process or phenomenon over a few weeks or even months.



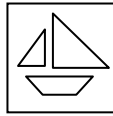
Questioning

Questions are useful tools in the scientific inquiry process. Both teachers and students should engage in cycles of questions-answers-questions throughout the learning process.



Role Play, Drama, Dance and Movement

Role play, drama, dance and movement allow students to express their understanding of scientific concepts and processes in a creative way.



Strategies for Active and Independent Learning (SAIL)

The SAIL approach emphasises learning as a formative and developmental process in which instruction and assessment point the way for students to continuously learn and improve. Learning expectations and rubrics are used to describe what students should know and be able to do. This would help students know where they are in the learning process and how they can improve.

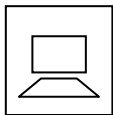
Where appropriate, students should have opportunities to develop attitudes which are relevant to the study of science. Teachers are also encouraged to incorporate the ethical aspect of science wherever possible throughout the syllabus.



Ethics and Attitudes

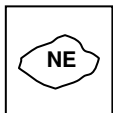
In scientific inquiry, the adoption of certain mental attitudes such as curiosity, creativity, objectivity, integrity, open-mindedness, perseverance and responsibility is advocated. Students can also discuss the ethical implications of science and technology.

Teachers are also encouraged to leverage on the planned learning activities to infuse Information Technology and National Education.



Information Technology (IT)

When used as a tool to support appropriate teaching strategies, IT can enhance the teaching and learning process and lead to engaged learning. For example, teachers can tap on the Internet for alternative resources which can be used to support inquiry-based learning activities. Appropriate IT devices such as dataloggers and other hand-held devices can be used to enhance data collection and speed up data analysis. Abstract concepts in science can also be made more comprehensible with the use of simulations, scenarios and animations.



National Education

National Education is infused into the curriculum to allow students to see how scientific phenomenon and developments can contribute to or affect the nation.

What are some features of an inquiry classroom?

An inquiry classroom is visibly different from a traditional classroom in the following ways:

Traditional	Inquiry
Students often work alone	Students often work in groups
Emphasis on mastery of facts	Emphasis on understanding of key concepts
Follows a fixed curriculum closely	Allows for pursuit of student questions
Activities rely mainly on textbooks and workbook materials	Activities rely on primary sources
Students are viewed as “blank slates”	Students are viewed as thinkers with their own theories about the world
Teachers tend to disseminate information to students	Teachers facilitate an interactive learning environment
Teachers tend to seek correct answers	Teachers seek to understand student learning
Assessment tends to be separate from teaching	Assessment is interwoven with teaching

Adapted from *In search of understanding: the case for constructivist classrooms*, Brooks & Brooks (1993).

What are some misconceptions about inquiry-based learning and teaching?

1: *All science subject matter should be taught through student-directed inquiry.*

Whereas student-directed inquiry will provide the best opportunities for cognitive development and scientific reasoning, teacher-guided inquiry can better focus learning on the development of particular science concepts. Thus, students will best benefit from experiences that vary between these two inquiry approaches.

2: *Inquiry cannot be carried out by students effectively as they will not be able to discover anything worthwhile.*

Although it is important that students are provided with opportunities to pursue their own questions and discover some things for themselves, scientists and students often engage in inquiry to solve problems or understand events by reading relevant materials such as science magazines /journals and on-line scientific literature, and seeking advice from experts in the specific field. They may be engaged in inquiry without actually making their own discoveries.

3: *Inquiry teaching occurs whenever students are provided with hands-on activities.*

Although participation by students in hands-on activities is desirable, it is equally important that they are mentally engaged with scientific reasoning and methods. Research indicates that science process skills are best learnt when used to understand specific scientific content. Understanding content without process or vice versa is insufficient to nurture students as inquirers.

ASSESSING TEACHING AND LEARNING

Assessment is an integral part of the teaching and learning process. It involves gathering information through various assessment techniques and making sound decisions. Assessment provides information to the teacher about students' achievement in relation to the learning objectives. With this information, the teacher makes informed decisions about what should be done to improve teaching methods and enhance the learning of the students.

Why Assess?

Assessment measures the extent to which desired knowledge, skills and attitudes are attained by students. While it complements the teaching and learning process, it also provides formative and summative feedback to teachers, students, schools and parents.

- Assessment provides feedback to *students*, allows them to understand their strengths and weaknesses. Through assessment, students can monitor their own performance and progress. It also points them in the direction they should go to improve further.
- Assessment provides feedback to *teachers*, enables them to understand the strengths and weaknesses of their students. It provides information about the students' achievement of learning outcomes as well as the effectiveness of their teaching.

- Assessment provides feedback to *schools*. The information gathered facilitates the placement of students in the appropriate stream or course, and the promotion of students from one level to the next. It also allows the schools to review the effectiveness of their instructional programme.
- Assessment provides feedback to *parents*, allows them to monitor their children's progress and achievement through the information obtained.

What to Assess?

The aims of the Lower Secondary Science are the acquisition of knowledge, understanding and application of the science concepts, the ability to use process skills, and the development of attitudes important to the practice of science. The assessment objectives of the syllabus are aligned to the three domains in the *Science Curriculum Framework* as shown below:

- i. Assessment of Knowledge, Understanding and Application of Science Concepts
- ii. Assessment of Skills and Processes
- iii. Assessment of Ethics and Attitudes

How to Assess?

Assessment measures the extent to which desired knowledge, skills and attitudes are attained by students. As it serves many purposes, it is important to match the type of assessment to the specific purpose for which it is intended. Before making a judgement about a certain aspect of students' performance, the teacher should ensure that the assessment mode used will generate information that reflect accurately the particular aspect of performance the teacher intends to assess.

In an inquiry-based classroom, the assessment can take many forms. In addition to the written tests, teachers can also conduct performance based assessment using the following modes:

- Practicals
- Projects
- Teacher observations
- Checklists
- Reflections / Journals
- Model-making
- Posters
- Games and quizzes
- Debates
- Drama / Show and Tell
- Learning Trails

Teachers can also assess students through the use of portfolio. It is a systematic collection of students' work and provides a comprehensive picture of their achievement. The work collected provides a continuous record of the students'

development and progress in the acquisition of knowledge, understanding of scientific concepts, application of process skills, and development of attitudes. It also provides opportunity for the students to have self-evaluation and reflections by revisiting their own portfolio.

The assessment modes listed above are by no means exhaustive. Adopting a variety of assessment modes enables the teachers to assess different aspects of the teaching and learning.

Guidelines for Assessment

It is essential for assessment to be aligned to the teaching and learning process. School-based assessment, both formative and summative in nature, should be used to provide a complete picture of the students' performance and progress, and the effectiveness of the teaching and learning process.

SYLLABUS CONTENT

The core component includes the knowledge, skills and attitudes that *all* students should acquire. It is organised by **themes** to help students appreciate the big ideas in science. A brief description and **key inquiry questions** for each theme are given with **suggested strategies and activities for inquiry**. It is hoped that teachers would emphasise the underlying organising principle and key inquiry questions of the various themes in their teaching. Learning outcomes which are underlined are *not* required for in the Normal course students.

Theme: Science & Technology Students should appreciate that science is the study of our natural world through systematic observation, experimentation, and analysis. Scientists seek to formulate principles, laws and theories that help to explain and increase our understanding of natural phenomena we observe in the world. Through science, we also learn how to use things to make our lives more comfortable and solve problems to improve our surroundings.		Key Inquiry Questions in Science & Technology include: <ul style="list-style-type: none"> • Why did this event, phenomenon or problem happen? • What conclusions can I make based on my observations and evidence collected?
Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
Science processes & applications - Scientific inquiry <ul style="list-style-type: none"> • recognise that the study and practice of science involve three major elements: attitudes, processes or methods, and products • recognise that the products of science are the tested data collected by scientists for centuries and explain with examples how people working with science have formulated concepts, principles and theories 	<ul style="list-style-type: none"> • use scientific inquiry skills such as posing questions, designing investigations, evaluating experimental results and communicating learning 	<ul style="list-style-type: none"> • show an appreciation that scientific inquiry requires attitudes such as curiosity, creativity, integrity, open-mindedness and perseverance • value individual effort and working in a team as part of scientific inquiry

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<ul style="list-style-type: none"> • show an awareness that science is not confined to the laboratory, but is manifested in all aspects of the world 		
<p>Science processes & applications - Science and technology in society</p> <ul style="list-style-type: none"> • discuss the uses and benefits of science and technology to society • show an awareness of the limitations of science and technology in solving societal problems 	<ul style="list-style-type: none"> • evaluate the benefits and limitations of science and technology • communicate their ideas on the benefits and limitations of science through discussions and presentations 	<ul style="list-style-type: none"> • show an appreciation of the moral and social issues in the applications of science • value individual effort and working in a team as part of scientific inquiry

Theme: Measurement Students should recognise the need for Man to quantify his interactions with the environment. Man makes estimations and also accurate measurements of quantities not just when he is engaged in scientific inquiry but also in everyday activities. The study of measurement would enable Man to plan the use of resources efficiently.		Key Inquiry Questions in Measurement include: <ul style="list-style-type: none"> • Why is it important to have clearly defined quantities and units? • How does the system you want to study determine the way you take measurements?
Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
Making measurements - Use of measuring instruments <ul style="list-style-type: none"> • show an understanding that different instruments are used to measure different physical quantities accurately 	<ul style="list-style-type: none"> • make estimations and/or measurements of length, area, volume, mass and time (including the area of irregular two-dimensional figures, volume and mass of liquids and solids but not of gases) • use common laboratory equipment such as the Bunsen burner, microscope, electronic balance and stop-watch in experimentation 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as precision and accuracy in making measurements
Making measurements - Physical Quantities & Units <ul style="list-style-type: none"> • identify and use the appropriate units for different physical quantities • relate and use the appropriate prefixes, milli- centi- or kilo- in relation to the units of length and mass 	<ul style="list-style-type: none"> • use the appropriate units for length, mass, time and temperature • predict whether objects sink or float using the concept of density • solve problems of objects in motion using the concept of speed 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as objectivity, integrity and open-mindedness in collecting and analysing data

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<ul style="list-style-type: none">• explain what is meant by density• calculate density using the formula: density = mass/volume• explain what is meant by average speed• calculate average speed using the formula: average speed = distance travelled/time taken• determine appropriate units for physical quantities such as area, volume, density and rate		

Theme: Diversity Students should appreciate that there is a great variety of living and non-living things in the world and the importance for Man to understand and maintain the connections with living things and his environment. Man seeks to organise this great variety through common threads and unifying factors to better understand the world in which he lives. The study of living and non-living things in terms of properties and changes is greatly facilitated by putting them into groups.		Key Inquiry Questions in Diversity include: <ul style="list-style-type: none"> • How does the diversity of living and non-living things in the world contribute to our lives? • How do we classify things in our world?
Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
Diversity of matter Classification of matter <ul style="list-style-type: none"> • describe the properties of groups of materials in terms of <ul style="list-style-type: none"> • density • strength • hardness • flexibility • electrical conductivity • thermal conductivity • boiling/melting point • distinguish between the main classes of materials (metals, ceramics, glass, plastics and fibres) in terms of their properties 	<ul style="list-style-type: none"> • classify a number of common everyday objects and recognise that there are many ways of classifying the same group of objects • use data on the properties of different materials to make evaluative judgements about their uses • communicate their findings on classification and justify their reasons 	<ul style="list-style-type: none"> • show an appreciation of man's responsibility to have care and concern for the environment

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Diversity of matter - Elements, compounds and mixtures</p> <ul style="list-style-type: none"> • recognise that substances can be classified as elements, compounds and mixtures • distinguish among elements, compounds and mixtures • identify an element as the basic building block of matter • recognise that elements are classified according to their properties • describe compounds as substances consisting of two or more chemically combined elements • describe mixtures as two or more elements and/or compounds that are not chemically combined • show an awareness of basic principles involved in some separation techniques such as filtration, distillation and paper chromatography • explain how the properties of constituents are used to separate them from a mixture: <ul style="list-style-type: none"> • magnetic attraction • filtration • evaporation • distillation • paper chromatography 	<ul style="list-style-type: none"> • classify elements as metals and non-metals based on their characteristic properties • use separation techniques such as filtration, distillation and paper chromatography 	<ul style="list-style-type: none"> • show an appreciation of the systematic investigations involved in the study of substances • show an appreciation that water is a precious resource and the need to conserve it

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<ul style="list-style-type: none"> • show an awareness of the applications of the various separation techniques in everyday life and industries • show an awareness of the techniques involved in obtaining pure water from sea water in desalination plants (e.g. distillation and reverse osmosis) 		
<p>Diversity of matter - Solutions and suspensions</p> <ul style="list-style-type: none"> • distinguish among solute, solvent and solution • show an awareness of the importance of factors that affect the solubility and rate of dissolving of substances in homes and industries • show an understanding that indicators are substances that change colour when an acid or alkali is added to them 	<ul style="list-style-type: none"> • deduce the nature of solutions and suspensions by simple laboratory tests • investigate the factors that affect the solubility and rate of dissolving of substances • investigate the effect of a variety of acidic, alkaline and neutral solutions on Universal Indicator paper and natural indicators (i.e. obtained from plants) • investigate the effect on Universal Indicator paper when acidic and alkaline solutions are mixed • investigate the properties of acidic and alkaline solutions (action of alkalis on ammonium salts NOT required) 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as objectivity and accuracy in investigations on solubility and pH

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Diversity of plant and animal life - Classification of plant and animal life</p> <ul style="list-style-type: none"> • show an understanding of the need to classify living organisms 	<ul style="list-style-type: none"> • classify living organisms according to commonly observable characteristics • classify living organisms into major taxonomic groups (Students are not required to use Prokaryotic and Eukaryotic classification, only general classification of animals and plants is expected) • construct a dichotomous key • use simplified dichotomous keys in identifying and classifying living organisms 	<ul style="list-style-type: none"> • show an appreciation of the importance for man to understand and maintain the connections among living things • show an appreciation of man's responsibility to have care and concern for living things and the environment

<p>Theme: Models and Systems</p> <p>Students should appreciate that models are simplified representations of phenomena. These models are constructed to facilitate understanding of the phenomena. There are three types of models in the learning of science, namely, physical, conceptual and mathematical. Students should recognise that a system is a whole consisting of parts that work together to perform a function. There are systems in nature as well as man-made systems. Parts of a system influence one another. Two or more systems can interact with one another to perform a function.</p>		<p>Key Inquiry questions in Models and Systems include:</p> <ul style="list-style-type: none"> • How do we know that the models used are good representations of the real system? • How do parts of a system or different systems interact together to perform a function?
<p>Learning Outcomes</p>		
<p>Knowledge, Understanding and Application</p>	<p>Skills and Processes</p>	<p>Ethics and Attitudes</p>
<p>Models of cells & matter - Cells – structure, function & organisation</p> <ul style="list-style-type: none"> • show an understanding of the functions of the different parts of a cell, including the nucleus which contains genetic material that determines heredity. • recognise that multicellular organisms (both plants and animals), cells of similar structures are organised into tissues; several tissues may make up an organ; organs are organised into systems • explain the significance of the division of labour, even at the cellular level 	<ul style="list-style-type: none"> • use the microscope and identify the different parts of a cell viz. <ul style="list-style-type: none"> • cell wall • cell membrane • cytoplasm • nucleus • vacuole • chloroplast • use the microscope and identify the different parts of the animal cell: <ul style="list-style-type: none"> • cell membrane • cytoplasm • nucleus • compare a typical plant cell and a typical animal cell 	<ul style="list-style-type: none"> • show an appreciation of the moral and social issues related to the application of genetic science

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Models of cells & matter - Particulate model of matter</p> <ul style="list-style-type: none"> • show an awareness that matter is made up of small discrete particles which are in constant and random motion using the particulate model • show an understanding of the simple model of solids, liquids and gases, in terms of the arrangement and movement of the particles • explain melting and boiling in terms of conversion of the states of matter 	<ul style="list-style-type: none"> • use of models to understand the behaviour of molecules in the three states of matter • compare and relate the characteristics of the three states of matter (solid, liquid and gas) in terms of the arrangement and movement of the particles • communicate understanding of the particulate model of matter in terms of the arrangement and movement of the particles 	<ul style="list-style-type: none"> • show an appreciation of how in practice, models are constructed, justified and continuously revised as they are used to probe new phenomena and collect additional data • show an appreciation of scientific attitudes such as creativity and open-mindedness in creating models to explain the fundamental nature of things and the willingness to re-examine existing models
<p>Models of cells & matter - Simple concepts of atoms and molecules</p> <ul style="list-style-type: none"> • describe an atom as an electrically neutral entity made up of a positively charged nucleus (protons and neutrons) with negatively charged electrons moving round the nucleus • show an awareness that atoms of the same element contain the same number of protons and those of different elements contain different numbers of protons • recognise that an ion is formed when an atom gains or loses electron(s) 	<ul style="list-style-type: none"> • compare the relative size of an atom to other objects • compare atoms and molecules 	<ul style="list-style-type: none"> • show an appreciation of how in practice, models are constructed, justified and continuously revised as they are used to probe new phenomena and collect additional data • show an appreciation of scientific attitudes such as creativity and open-mindedness in creating models to explain the fundamental nature of things and the willingness to re-examine existing models

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<ul style="list-style-type: none"> • show an understanding of the following: <ul style="list-style-type: none"> • that molecules of an element consist of a fixed number of the same type of atoms combined together • that molecules of a compound consist of a fixed number of different types of atoms combined together • state the number and types of atoms, given the chemical formula of a compound 		<ul style="list-style-type: none"> • value individual effort and working in a team as part of scientific inquiry
<p>Plant & Human Systems - Transport in living things</p> <ul style="list-style-type: none"> • explain the need for a transport system in human beings and plants • explain how diffusion and osmosis are involved in the transport system • describe briefly the process of absorption of water and mineral salts by the root of a plant [Cellular treatment NOT required] • describe briefly the transport of water and manufactured food substances in the plant [Cellular treatment is NOT required] • describe briefly how blood acts as a transport medium 	<ul style="list-style-type: none"> • infer that diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration • infer that osmosis involves the movement of water molecules when two solutions of unequal concentration are separated by a partially permeable membrane 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as curiosity, objectivity and accuracy in investigations on diffusion and osmosis

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Plant & Human Systems - Digestion in animals</p> <ul style="list-style-type: none"> • explain what is meant by digestion • identify the main parts of a digestive system and the processes that take place • explain why most food must be digested • describe how a digestive system helps in digestion of food and the part played by enzymes in digestion (Only classes of enzymes such as amylase, protease and lipase are needed. Specific names of enzymes not required.) 	<ul style="list-style-type: none"> • infer that the end products of digestion are used for cellular processes like respiration, growth and tissue repair 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as curiosity, objectivity and accuracy in investigations on the digestive system
<p>Plant & Human Systems - Sexual reproduction in human beings</p> <ul style="list-style-type: none"> • recognise that heredity is a process where genetic information is transmitted from one generation to another • recognise that in sexual reproduction a new individual is formed through the union of an egg and a sperm • recognise that a new individual formed through sexual reproduction receives genetic information from its mother (via the egg) and its father (via the sperm) • state some of the physical changes that occur during puberty and early adolescence 	<ul style="list-style-type: none"> • evaluate the consequences and issues relating to: <ul style="list-style-type: none"> • abortion • pre-marital sex 	<ul style="list-style-type: none"> • show an appreciation of the social and moral issues relating to abortion and pre-marital sex • show an appreciation of the need for Singapore to develop our only resource – human resource

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<ul style="list-style-type: none"> • describe briefly the structures and functions of human male and female reproductive systems • describe briefly the menstrual cycle and fertilisation • describe briefly a temporary and a permanent method of birth control • state the harmful consequences of sexually transmitted infections like syphilis, gonorrhoea and AIDS. 		

Theme: Energy Students should appreciate that energy is necessary for all living and non-living systems. Energy makes changes and movement possible in our daily lives. Living things obtain energy and use it to carry out life processes. There are many forms of energy and one form can be converted to another. It is our responsibility to show care and concern for living things and the environment as we use energy in its different forms every day.		Key Inquiry questions in Energy include: <ul style="list-style-type: none"> • How can we harness energy to improve our quality of life? • Why must energy be conserved?
Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
Energy forms & uses - Energy forms & conversion <ul style="list-style-type: none"> • state what is meant by energy • describe different forms of energy (e.g. kinetic, potential, light and sound) and how energy changes from one form to another 	<ul style="list-style-type: none"> • infer that energy is conserved and can be transformed from one form to another 	<ul style="list-style-type: none"> • show an appreciation of the need for Singapore, which has no natural resources of her own, to conserve energy
Energy forms & uses - Light <ul style="list-style-type: none"> • explain how reflection is affected by a smooth and rough surface • state the characteristics of the image formed by a plane mirror • describe the effects and uses of reflecting surfaces (e.g. plane and curved) • describe some effects and consequences of refraction • describe the dispersion of white light by a prism • explain how we see the colour of objects in 	<ul style="list-style-type: none"> • compare the speed of light, sound and common moving objects • investigate the effects of reflection and refraction in practical activities and make inferences through observations in everyday life 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as creativity and perseverance in measuring the speed of light to a high degree of accuracy

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
white light and coloured light such as red, blue and green		
<p>Energy forms & uses - Electricity</p> <ul style="list-style-type: none"> • explain what is meant by current, potential difference and resistance, stating their units • draw and interpret circuit diagrams and set up circuits containing electrical sources, switches, lamps, resistors (fixed and variable), ammeters and voltmeters • <u>recognise that the resistance of a circuit can be varied by arranging resistors in series or in parallel</u> [Calculations are NOT required] • explain qualitatively the chemical, heating and magnetic effects of an electric current and list some applications • explain what is meant by power and state its units • discuss the importance of reducing electrical energy wastage • state some electrical hazards and precautionary measures to ensure the safe use of electricity in the home 	<ul style="list-style-type: none"> • <u>investigate the effect of varying resistance on the current in the circuit using fixed or variable resistors</u> • <u>solve simple problems on the cost of using electrical appliances, using kilowatt-hour as a unit of electrical energy consumption</u> • communicate their understanding of electricity and justify their answers to questions on electricity with reasons 	<ul style="list-style-type: none"> • show an appreciation of the need for Singapore, which has no natural resources of her own, to conserve energy

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Energy forms & uses - Photosynthesis and respiration</p> <ul style="list-style-type: none"> • outline the process of photosynthesis by which plants manufacture carbohydrates using raw materials • trace the primary food source in a food chain to the green plant • <u>show an understanding of the conditions necessary for photosynthesis</u> • show an understanding of how plants take in oxygen and remove carbon dioxide • describe aerobic respiration and state its importance and construct a word equation for aerobic respiration 	<ul style="list-style-type: none"> • <u>compare the conditions for healthy growth of ornamental plants and large scale crop production</u> • compare respiration and breathing • compare photosynthesis and respiration 	<ul style="list-style-type: none"> • show an appreciation of the importance for man to understand and maintain the connections among living things • show an appreciation of man's responsibility to have care and concern for living things and the environment

<p>Theme: Interactions</p> <p>Students should appreciate that there are interactions between the living world and the environment at various levels: interactions which occur within an organism; between organisms; and between organisms and the environment. There are also interactions between forces and objects, and energy and matter.</p>		<p>Key Inquiry questions in Interactions include:</p> <ul style="list-style-type: none"> • How does knowledge of interactions between and within systems help Man better understand his environment? • What are the interactions between physical phenomena and life processes?
<p>Learning Outcomes</p>		
<p>Knowledge, Understanding and Application</p>	<p>Skills and Processes</p>	<p>Ethics and Attitudes</p>
<p>Interaction of forces & energy - Concept of force & pressure</p> <ul style="list-style-type: none"> • describe the effects of forces: <ul style="list-style-type: none"> • on the state of rest or motion of a body • on the size and shape of a body • use the Newton as the S.I. unit of force • identify some examples of forces, including gravitational force, frictional force and magnetic force, and predict their effects on an object • relate pressure to force and area, using appropriate every day examples 	<ul style="list-style-type: none"> • use a spring balance as one of the ways to measure force • communicate their understanding of forces and justify their answers to questions on forces with reasons 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as curiosity, objectivity and perseverance in making careful observation and experimentation on force and its related concepts

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Interaction of forces & energy – Moment of a force</p> <ul style="list-style-type: none"> • <u>state what is meant by moment of a force</u> • <u>calculate the moment of a force using the equation:</u> $\text{moment of a force about a point} = \text{force} \times \text{perpendicular distance from the pivot to the line of action of the force}$ [Principle of moments NOT required] • <u>describe the application of forces in levers</u> • <u>identify the application of moment of a force in everyday life</u> 	<ul style="list-style-type: none"> • <u>solve problems related to moment of a force</u> 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as curiosity, objectivity and perseverance in making careful observation and experimentation on force and its related concepts
<p>Interaction of forces & energy – Work</p> <ul style="list-style-type: none"> • state what is meant by work done • <u>calculate work done by a force using:</u> $\text{work done} = \text{force} \times \text{distance moved in the direction of the force}$ [Restrict calculations to cases where the direction of the force is parallel to the direction of the distance moved.] • state the unit of work as the joule 	<ul style="list-style-type: none"> • compare between situations involving forces where work is done and where work is not done 	<ul style="list-style-type: none"> • show an appreciation of scientific attitudes such as curiosity, objectivity and perseverance in making careful observation and experimentation on force and its related concepts

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Interaction of forces & energy – Effects of heat</p> <ul style="list-style-type: none"> describe some effects and applications of expansion and contraction in everyday life such as: <ul style="list-style-type: none"> riveting gaps in bridges, pavement and MRT lines thermostats 	<ul style="list-style-type: none"> infer that generally, solids, liquids and gases expand when heat is absorbed and contract when heat is given out communicate their understanding of the effects of heat with every day examples 	<ul style="list-style-type: none"> show an appreciation of scientific attitudes such as curiosity, objectivity and perseverance in making careful observation and experimentation on heat and its related concepts
<p>Interaction of forces & energy – Transmission of heat</p> <ul style="list-style-type: none"> explain what is meant by conduction, convection and radiation identify and explain applications of heat conduction and convection (e.g. in cooling, heating and insulation) show an understanding that the rate of heat loss or gain through radiation is affected by the temperature and the nature of the surface identify and explain applications of heat radiation (e.g. radiant heaters, solar radiation) 	<ul style="list-style-type: none"> infer that thermal expansion results in a change in volume of the substance and therefore the density of the substance deduce from experiments that different materials have different rates of heat flow 	<ul style="list-style-type: none"> show an appreciation of scientific attitudes such as curiosity, objectivity and perseverance in making careful observation and experimentation on heat and its related concepts

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<p>Interaction of forces & energy – Chemical changes</p> <ul style="list-style-type: none"> • describe a chemical reaction as a process leading to the formation of new products • show an awareness that there are different types of reactions such as combustion, thermal decomposition, oxidation • identify a change which leads to formation of new product(s) as a chemical change. • use word equations to represent chemical reactions 	<ul style="list-style-type: none"> • Investigate the changes that matter (i.e. element, compound or mixture) undergoes through <ul style="list-style-type: none"> • mixing • heating • exposure to light • passing of an electric current 	<ul style="list-style-type: none"> • show an appreciation of the social issues of pollutants in the environment • show an appreciation of man's responsibility to have care and concern for the environment
<p>Interaction of forces & energy - Simple concepts of populations, community and ecosystem</p> <ul style="list-style-type: none"> • explain the terms 'population' and 'community' in a named ecosystem • identify a habitat and some of the organisms associated with the habitat • explain the importance of various physical factors like air, water, temperature, light, minerals and acidity/alkalinity, to the life of the organisms • show an understanding of the interrelationship among the various organisms in a community (Examples of interrelationships are predator-prey relationship, mutualism and parasitism) 	<ul style="list-style-type: none"> • investigate an environment using measurement instruments such as datalogger probes to collect data on physical quantities such as pH, temperature and light intensity 	<ul style="list-style-type: none"> • show an appreciation of the importance for man to understand and maintain the connections among living things • show an appreciation of man's responsibility to have care and concern for living things and the environment

Learning Outcomes		
Knowledge, Understanding and Application	Skills and Processes	Ethics and Attitudes
<ul style="list-style-type: none"> • show an understanding that habitat together with the organisms living in it forms an ecosystem • explain the importance of conserving the environment 		
<p>Interaction of forces & energy - Energy transfer process in the ecosystem</p> <ul style="list-style-type: none"> • describe the process of energy flow through the food chain in a named ecosystem starting with the green plant as a primary food producer 	<ul style="list-style-type: none"> • infer how food consumed by animals and the energy produced during respiration is temporarily stored for use in life processes 	<ul style="list-style-type: none"> • show an appreciation of the importance for man to understand and maintain the connections among living things • show an appreciation of man's responsibility to have care and concern for living things and the environment
<p>Interaction of forces & energy - Nutrient cycles in the ecosystem</p> <ul style="list-style-type: none"> • show an understanding of the concept of recycling of nutrients trapped in living organisms and explain the role of decomposers in these processes 	<ul style="list-style-type: none"> • infer the role of decomposers in recycling of nutrients in the environment 	<ul style="list-style-type: none"> • show an appreciation of the importance for man to understand and maintain the connections among living things • show an appreciation of man's responsibility to have care and concern for living things and the environment

GLOSSARY OF TERMS

S/No	Term	Description of Terms
1.	calculate	to give a numerical answer based on a given formula with working shown
2.	classify	to group things based on common characteristics
3.	compare	to identify similarities and differences between objects, concepts or processes
4.	construct	to write or form something not by factual recall but by using given information
5.	deduce	to draw a conclusion based on the general rules or given information
6.	describe	to state in words (using diagrams where appropriate) the main points of a topic
7.	determine	to obtain the quantity by calculation, substituting measured or known values of other quantities into a standard formula
8.	discuss	to give a critical account of the points involved in the topics
9.	distinguish	to identify and understand the differences between objects, concepts and processes
10.	evaluate	to consider all factors relating to the object/event before making a judgement
11.	explain	to give reasons or make some reference to theory
12.	identify	to select and/or name the object, event, concept or process
13.	infer	to draw a conclusion based on observations
14.	investigate	to find out by carrying out experiments
15.	list	to give a number of points or items without elaboration
16.	outline	to give the main or essential points of the concepts or processes
17.	predict	to state a likely future event based on the given information or rules
18.	recognise	to identify facts, characteristics or concepts that are critical (relevant/appropriate) to the understanding of a situation, event, process or phenomenon
19.	relate	to identify and explain the relationships between objects, concepts or processes
20.	show an appreciation	to recognise and explain the value of a concept or situation
21.	show an awareness	to have superficial knowledge of the concepts or processes
22.	show an understanding	to recall, explain and apply information
23.	state	to give a concise answer with little or no supporting argument

ACKNOWLEDGEMENTS

Members of the Lower Secondary Science Syllabus Review Committee (2004-2005) are:

1. Mdm Chua Mui Mui Linda	Head Sciences	Curriculum Planning and Development Division
2. Dr Christine Chin	Assistant Professor	National Institute of Education, Nanyang Technological University
3. Dr Ho Boon Tiong	Assistant Professor	National Institute of Education, Nanyang Technological University
4. Dr Shawn Lum	Assistant Professor	National Institute of Education, Nanyang Technological University
5. Dr Subramaniam	Assistant Professor	National Institute of Education, Nanyang Technological University
6. Mr Tan Peng San	Lecturer	Institute of Technical Education
7. Ms Pearly Ng	Vice-Principal	Marsiling Primary School
8. Ms Tan Kwee Foon	Vice-Principal	Temasek Primary School
9. Mdm Alice Aw	Master Teacher	Schools Division
10. Mrs Nora Teo	Master Teacher	Schools Division
11. Ms Lui Ling	HOD Science	Fairfield Methodist Primary School
12. Mr Tan Hong Kim	HOD Science	Dunearn Secondary School
13. Mrs Wong Seok Hua	HOD Science	Fuchun Secondary School
14. Mdm Kek Ai Kiew	Teacher	CHIJ St Nicholas Girls' School
15. Ms Miriam Khan	Educational Technology Officer	Educational Technology Division
16. Mr Tang Kok Sing	Educational Technology Officer	Educational Technology Division
17. Mr Ngoh Shay Piao	Assessment Officer	Singapore Examinations and Assessment Board
18. Ms Tan Poh Hiang	Assessment Officer	Singapore Examinations and Assessment Board
19. Mdm Chin Tan Ying	Curriculum Specialist	Curriculum Planning and Development Division
20. Mdm Chua Ye Ling	Curriculum Planning Officer	Curriculum Planning and Development Division
21. Mr Lau Chor Yam	Curriculum Planning Officer	Curriculum Planning and Development Division
22. Mr Lee Seng Hai	Curriculum Planning Officer	Curriculum Planning and Development Division

The Ministry of Education also wishes to acknowledge all Principals, Heads of Department/Subject Heads/Level Heads (Science) and teachers for their invaluable feedback and contributions in the development of this syllabus