SCIENCE in the New Zealand CURRICULUM

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FOREWORD

This curriculum statement replaces the syllabuses *Science Syllabus and Guide: Primary to Standard Four* (1980), *Science for Forms One and Two* (1961), *Science for Forms Three and Four* (1968), and *Science Draft Syllabus and Guide: Forms 1 to 4* (1978). It builds on New Zealand research and curriculum development in science education, and provides the basis for science programmes in schools from year 1 to year 13; that is, from junior classes to form 2 in primary schools and from form 3 to form 7 in secondary schools.

The Minister of Education requested the redevelopment of the science curriculum in 1991, as part of a broad initiative aimed at improving primary and secondary school student achievement. The development process involved a small project team and a number of reference groups. A science advisory group provided guidance at key stages of the project.
A draft statement was prepared and circulated to schools and interested groups for comment and discussion. The views of all those who responded have been taken into account in preparing the final curriculum statement.

There are three major directions in this curriculum statement. It gives special emphasis to continuity and progression in learning in science by specifying clear learning goals expressed as achievement objectives at eight levels through all of the years of schooling. The statement focuses on the use of a range of diagnostic and formative assessment to enhance learning and teaching for all students. Finally, the curriculum statement stresses the need for initial learning in science to be set within contexts which are meaningful to students and which lead to understanding of the interrelationship of science, society, and technology.

I am grateful to all who have contributed to the development of this curriculum statement, especially Ministry staff, the contractor and the writers, the members of the reference groups, and the members of the policy advisory group, all of whom gave freely of their time, expertise, and experience.

Dr Maris O'Rourke

Secretary for Education

INTRODUCTION

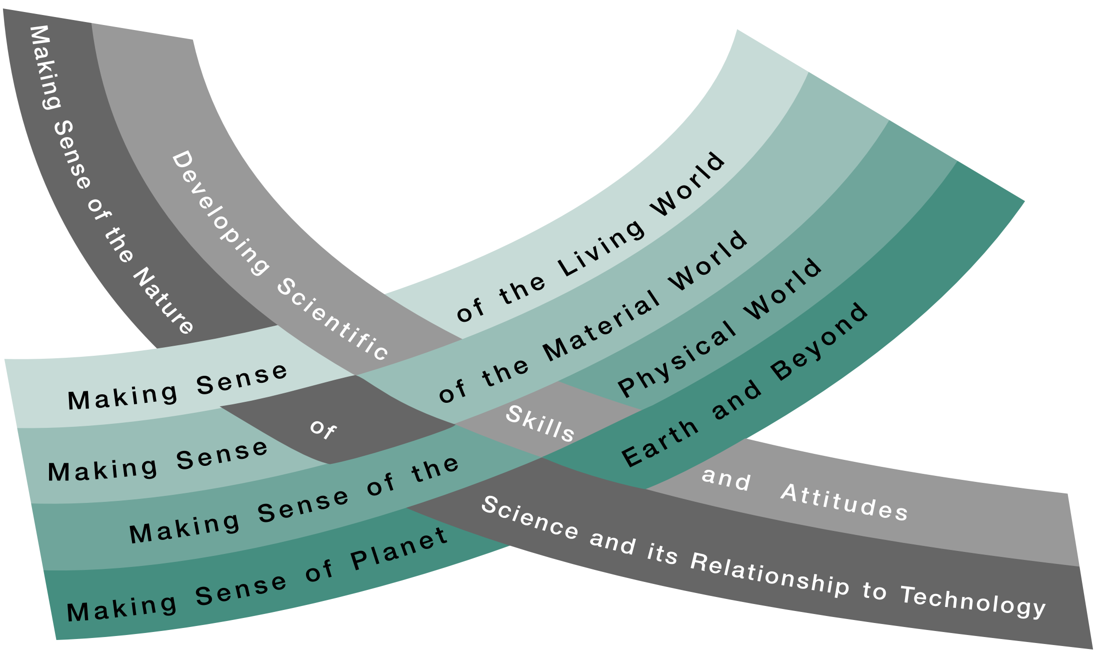
Science involves people investigating the living, physical, material, and technological components of their environment and making sense of them in logical and creative ways. Using systematic and creative processes of investigation, scientists produce a constantly evolving body of knowledge and make an important contribution to the decisions which are shaping our world and the world of future generations.

Learning in science is fundamental to understanding the world in which we live and work. It helps people to clarify ideas, to ask questions, to test explanations through measurement and observation, and to use their findings to establish the worth of an idea.

The science curriculum needs to recognise that science is a universal discipline and to acknowledge the contribution that different cultural perspectives make to the development of understanding in science. In New Zealand, the inclusion of Maori knowledge about the natural and physical worlds will enrich the curriculum for all students.

Science and technology are major influences in many aspects of our daily lives, at work, at play, and at home. Our dependence on science and technology demands a high level of scientific literacy for all New Zealanders and requires a comprehensive science education for all students, as well as for those who will have careers in science and technology.

Accordingly, this curriculum provides a framework of learning in science for all students. To promote a contemporary and comprehensive science education this curriculum statement has been organised into six integrated learning strands. Four of the strands – Making Sense of the Living World, Making Sense of the Physical World, Making Sense of the Material World, and Making Sense of Planet Earth and Beyond – provide the broad learning contexts through which the other two integrating strands are developed. These other two are Making Sense of the Nature of Science and its Relationship to Technology and Developing Scientific Skills and Attitudes.



The curriculum in science is designed to encourage all students to continue their participation in science education beyond the years in which it is a required school subject. Many students with ability and interest in science will further their science education in the senior school. Some will continue to study science as an integrated subject, some will study specialist science subjects, and others may do both.

GENERAL AIMS OF SCIENCE EDUCATION

Science education contributes to the growth and development of all students, as individuals, as responsible and informed members of society, and as productive contributors to New Zealand's economy and future.

The aim of science education in the New Zealand curriculum is to advance learning in science by:

- helping students to develop knowledge and a coherent understanding of the living, physical, material, and technological components of their environment;
- encouraging students to develop skills for investigating the living, physical, material, and technological components of their environment in scientific ways;
- providing opportunities for students to develop the attitudes on which scientific investigation depends;
- promoting science as an activity that is carried out by all people as part of their everyday life;
- portraying science as both a process and a set of ideas which have been constructed by people to explain everyday and unfamiliar phenomena;
- encouraging students to consider the ways in which people have used scientific knowledge and methods to meet particular needs;
- developing students' understanding of the evolving nature of science and technology;
- assisting students to use scientific knowledge and skills to make decisions about the usefulness and worth of ideas;
- helping students to explore issues and to make responsible and considered decisions about the use of science and technology in the environment;
- developing students' understanding of the different ways people influence, and are influenced by, science and technology;
- nurturing scientific talent to ensure a future scientific community;
- developing students' interest in and understanding of the knowledge and processes of science which form the basis of many of their future careers.

Science education, along with the other essential learning areas, contributes to the development of the essential skills described in *The New Zealand Curriculum Framework.* [1]

[1] *The New Zealand Curriculum Framework: Te Anga Marautanga o Aotearoa*, Ministry of Education, Wellington, 1993.

ENHANCING ACHIEVEMENT

The purpose of this curriculum statement is to provide direction for learning in science. Research in science education indicates that this learning is enhanced when:

- students, teachers, peers, families, and the wider community hold high expectations for students' success;
- students have the opportunity to clarify their ideas, to share and compare, question, evaluate, and modify these ideas, leading to scientific understanding;
- students have opportunities to use their new ideas and skills, first in a variety of familiar contexts and later in other challenging situations;
- students are aware of effective ways in which they learn;
- students see the relevance and usefulness of science to themselves and to society;
- teachers and students work within a supportive atmosphere of mutual respect where all the experiences, ideas, and beliefs, which students bring into the learning situation are acknowledged as a basis for learning;
- learning environments are visually stimulating and reflect contemporary science;
- teaching strategies respond to a diversity of learning styles;
- scientific knowledge, skills, and attitudes are first introduced in contexts which are relevant and familiar to the students;
- science is linked with other essential learning areas of *The New Zealand Curriculum Framework.*

Appropriate time, facilities, and resources are also important in learning science and need to be considered in relation to the above factors.

SCIENCE FOR ALL

Science education of the highest standard must be available to all New Zealand students — for those whose formal learning in science will cease when they leave school, for those who develop an interest in a particular aspect of science and may choose a science-related career, and for those who excel at science and may become our future scientists, technologists, technicians, and science educators.

Quality science education for all students requires the removal of barriers to achievement and encourages continuing participation in science. Accordingly, the curriculum in science should recognise, respect, and respond to the educational needs, experiences, achievements, and perspectives of all students: both female and male; of all races and ethnic groups; and of differing abilities and disabilities.

An inclusive curriculum that recognises the perspectives of a particular group of students can enrich education in science for all students.

Girls and Science

Girls can, and do, achieve in science but once they have the choice, many decide not to participate in science courses or seek science-based careers. Many girls view much of school science as outside their life experience and see little use for scientific knowledge and understanding in their future lives.

All students need to feel confident in their ability to succeed. Science education often undervalues the contribution of girls, provides unfamiliar contexts for their learning, and fails to develop their confidence in pursuing studies in this area.

It is important to note that the group "girls" is not homogeneous. Culture and gender factors are inextricably linked and neither should be considered in isolation. The particular perspectives of Maori and Pacific Islands girls should be acknowledged.

A curriculum which is gender-inclusive acknowledges and includes the educational needs and experiences of girls equally with those of boys, both in its content and in the language, methods, approaches, and practices of teaching.

An inclusive curriculum in science provides opportunities for girls to:

- learn science that they value;
- develop a range of skills required for successful learning in science;
- use their language strengths and co-operative learning skills;
- express their experiences, concerns, interests, and opinions;
- examine the historical and philosophical construction of science;
- view science from a range of perspectives;

- interact in an environment where the language and resource materials used are non-sexist;
- share the teacher's time and attention equitably with boys.

Maori and Science

Science education needs to make science more accessible to Maori students. It must make use of teaching strategies which are effective with Maori students and must be responsive to the diversity of their cultural and language backgrounds. Acknowledging tikanga Maori, and valuing the use of Maori language and the experiences of Maori students, affirms their identity and creates a positive learning environment.

An inclusive curriculum in science provides opportunities for Maori students to:

- learn science that they, their peers, their teachers, their whānau, and the wider community value;
- learn science through the medium of te reo Maori;
- learn science which acknowledges and values Maori scientific knowledge;
- develop scientific concepts within Maori contexts;
- use their preferred learning and communication styles, such as co-operative learning and holistic approaches; and have oral contributions recognised for both learning and assessment purposes;
- interact in an environment where the language and resource materials used are non-racist;
- use a wide range of resources in te reo Maori;
- have access to positive Maori role models, including Maori teachers, in their science programme.

Students with Special Abilities in Science

School and classroom programmes in science need to identify and nurture students with special abilities in science. When used flexibly, the curriculum offers talented students both acceleration and enrichment.

An inclusive curriculum in science provides opportunities for students with special abilities to:

- have their special ability in science valued by their peers, their teachers, their families, and the wider community;
- develop their knowledge and skills at their own pace;

- engage in learning activities which encourage higher-order thinking skills, such as analysis, evaluation, and synthesis;

- learn through open-ended activities which encourage imaginative and creative thinking and lateral exploration of ideas;

- use co-operative and problem-solving approaches to learning;

- communicate their ideas with others of similar ability.

Students with Special Needs and Science

Science programmes need to be responsive to all students, including those with special learning needs. This group is diverse and includes students with physical and/or mental disabilities, with specific learning difficulties, and those students yet to achieve fluency in English.

An inclusive curriculum in science for these students is one where:

- they, their peers, their teachers, their families, and the wider community work together to plan and deliver programmes which meet their particular learning needs;

- they are given encouragement and support to enable them to participate as fully as possible;

- appropriate resources, equipment, and technology are used to support their learning.

FORMAT AND PRESENTATION OF THE CURRICULUM IN SCIENCE

In accordance with *The New Zealand Curriculum Framework* the expected learning in science spans eight levels and is described in the form of sets of achievement objectives which are organised within learning strands.

Learning Strands

In this curriculum six learning strands are identified. These are:

The integrating strands

- Making Sense of the Nature of Science and its Relationship to Technology;
- Developing Scientific Skills and Attitudes;

The contextual strands

- Making Sense of the Living World;
- Making Sense of the Physical World;
- Making Sense of the Material World;
- Making Sense of Planet Earth and Beyond.

This division into six strands is a convenient way of categorising the outcomes for science education in schools. It emphasises that there are a number of aspects to science, all of which are important. The division does not mean that learning in each strand is to be developed independently from learning in other strands.

Science is both a process of enquiry and a body of knowledge; it is an integrated discipline. The development of scientific skills and attitudes is inextricably linked to the development of ideas in science. Similarly, as students' ideas evolve, they should be acquiring an understanding of the nature of science and its relationship to technology. Consequently, when planning and implementing a science programme, the integrating strands should be interwoven with the four contextual strands. Teachers should also seek ways to reflect the integrated nature of science by linking achievement objectives and learning experiences across the four contextual strands, and with achievement objectives in other essential learning areas of *The New Zealand Curriculum Framework.*

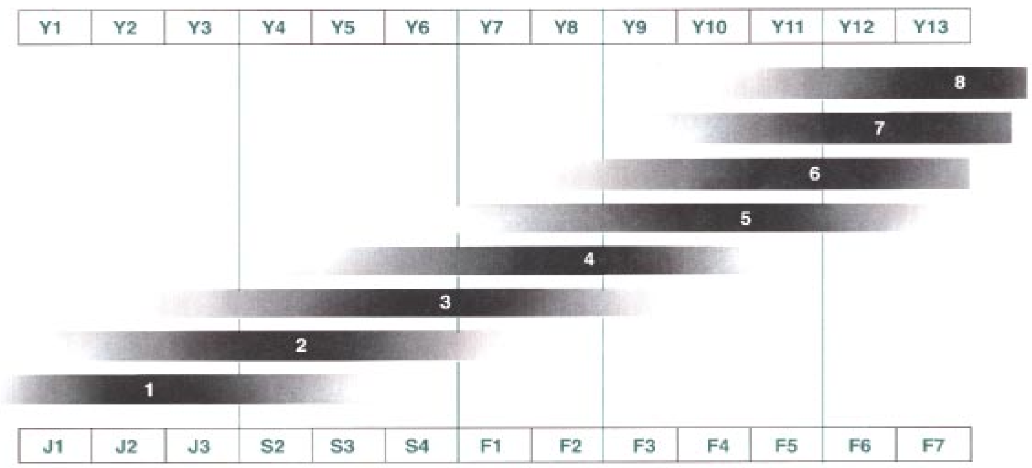
Levels of Achievement

Each strand is divided into eight levels which describe the progression of the science curriculum from junior primary (J1: year 1) to senior secondary (F7: year 13).

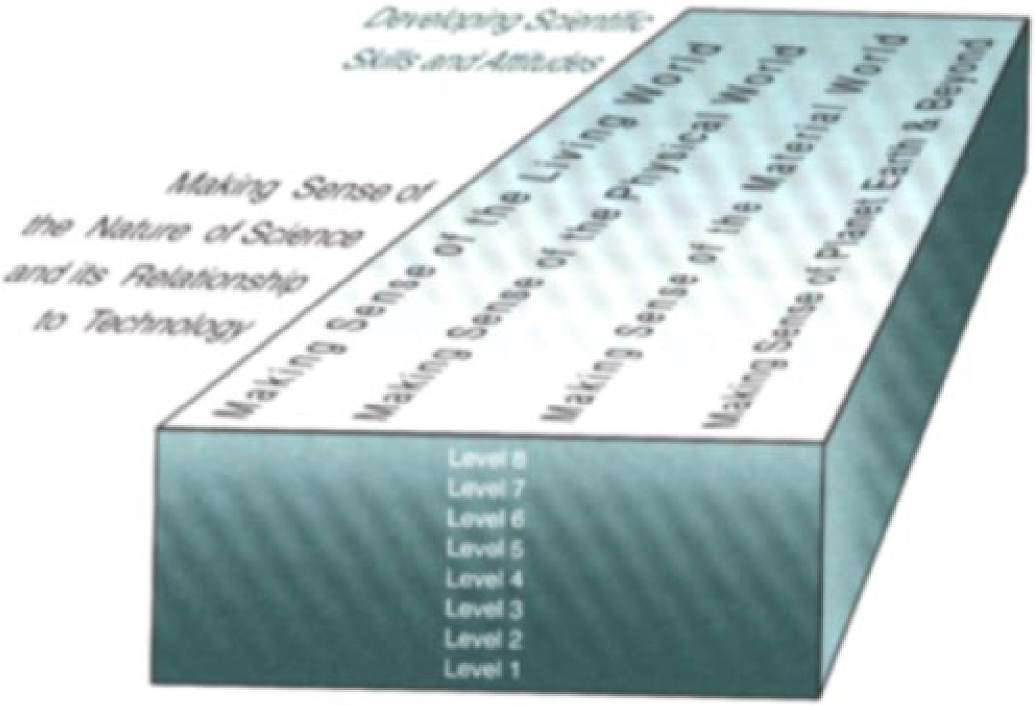
A number of achievement objectives are described in each strand and at each level. This organisation of the expected learning into successive sets of achievement objectives gives direction to the progression of skills, attitudes, and knowledge in science.

The learning described at each of the eight levels is based on the judgment of experienced teachers and on findings from recent research into learning in science. This does not mean that there are eight easily defined stages through which learners pass in their development of scientific understanding.

It is important to recognise students as individuals who learn at different rates and in different ways. It is not expected that all students of the same age will be achieving at the same level at the same time, nor that any individual student will necessarily be achieving at the same level in all strands of the science curriculum.



The curriculum in science can be modelled by a three-dimensional matrix when the eight levels of achievement are set out within the framework of the four contextual strands and the two integrating strands.



It is not intended that each part of this matrix be taught in isolation.

In planning school schemes and classroom programmes teachers are encouraged to meet the needs of their students by developing units of learning based on objectives from various parts of the matrix.

This flexible approach to implementing the curriculum means that a simple relationship between the objectives and teaching time cannot be specified.

In each year of schooling students are expected to have learning experiences drawn from all learning strands.

Note: To achieve at level 8 in each of the contextual strands students are required to carry out an extended investigation. Teachers should recognise the opportunity for students to take an integrated approach by combining their learning from two or more contextual strands in a single investigation. This approach could reduce the number of extended investigations students would carry out.

Achievement Aims

The achievement aims set the goals for each learning strand and provide the themes that link the achievement objectives of one level with those of adjacent levels. This thematic structure of achievement objectives within achievement aims will assist teachers with programme planning decisions. It will help teachers to develop cohesive science schemes, from whole school to individual class levels, that encourage effective learning for all students. Such a structure helps achieve a continuity of learning through the levels and facilitates the planning of a programme where students within a single class are operating at different levels of learning.

Achievement Objectives

The achievement objectives have their origin in the small number of achievement aims which are threaded through each learning strand.

At each progressive level a set of achievement objectives describes the expected learning in science. For levels 1 to 5 the achievement objectives are linked, on average, to a two-year period of learning; for levels 6, 7, and 8 the objectives are linked to a one-year period of learning.

In planning their programme teachers are encouraged to link achievement objectives from different strands to provide integrated learning experiences.

Teachers are expected to derive specific learning outcomes from the achievement objectives and place these outcomes within contexts that are appropriate to the learning needs of their students. These specific learning outcomes provide the criteria against which a student's achievement can be assessed by teachers and students, using a range of assessment procedures. The information gathered from these assessments should be used to monitor each student's learning and, at appropriate times, to make judgments about the student's achievement in relation to the relevant achievement objectives.

Contexts for Learning

Students learn effectively, and see relevance in learning science, when they have opportunities to develop and use their science ideas and skills, first in a variety of familiar contexts and later in other challenging situations.

A range of sample learning contexts is suggested for each level. This allows the achievement objectives to be attained through an integrated learning approach. The integrated approach can be further facilitated by using achievement objectives from both within and across learning strands. Achievement objectives from other essential learning areas can also be used to help direct learning within a particular learning context.

The suggested contexts listed at each level are not intended to be exhaustive. It is expected that teachers will not only select from the sample learning contexts but also identify others which are appropriate to their students and which reflect local community characteristics and resources. Appendix 1, page 124, provides a glossary of the Maori vocabulary included in these sections of this document.

The careful selection of contexts is an effective strategy for the development of an inclusive curriculum.

Learning Experiences

Students need to participate in a wide variety of activities to ensure that they have opportunities to develop the skills, knowledge, and attitudes in science that are described by the achievement objectives. It is important that students experience science as engaging, enriching, and challenging. To provide some initial ideas, a range of possible learning experiences is given at each level in all learning strands.

When the possible learning experiences at any one level are considered collectively, they give guidance about the concepts, language, approaches, techniques, materials, and equipment which are appropriate to the level. They also suggest the scope and depth of expected learning.

Teachers are encouraged to incorporate some of the possible learning experiences into their programmes. In order to achieve a complete and balanced programme in science, all teachers will need to make considered selections and may also include suitable learning experiences other than those listed.

The choice of appropriate experiences will depend on a number of important variables. These include the nature of the targeted achievement objective(s), the class composition, the community of which the school is a part, the teachers' and students' interests, topical events, and the time of year.

Assessment Examples

The primary purpose of school-based assessment is to improve students' learning and the quality of learning programmes. Assessment tasks and procedures should be consistent with the general aims of science education (see also Enhancing Achievement, page 10, and Science for All, page 11) and be compatible with regular classroom activity. In this way assessment will be an integral part of the learning programme.

Examples of assessment tasks have been suggested for all levels in five of the six learning strands. No assessment examples have been suggested for Developing Scientific Skills and Attitudes as the objectives in this strand are to be developed in conjunction with objectives from the other strands.

The assessment tasks listed suggest some appropriate ways of determining students' achievement. It is important to recognise that these lists are neither exhaustive nor definitive. As with the sample learning contexts and the possible learning experiences, the assessment examples indicate the potential nature and range of assessment tasks. Teachers will also need to locate and devise other assessment tasks for their own diagnostic, monitoring, and review purposes.

In any programme of learning it is important that assessment information is systematically accumulated to allow judgments to be made about each student's attainment of the full range of knowledge, skills, and attitudes described by the relevant achievement objectives. This will require the use of a diversity of assessment tasks associated with a range of assessment procedures.

In selecting assessment tasks, teachers must be sensitive to the different learning and communication styles of their students. This is a further reason for using a wide range of assessment tasks and procedures.

SCIENCE IN THE SENIOR SCHOOL

A range of science courses will be available in the senior secondary school. *Science in the New Zealand Curriculum* describes the achievement objectives for science at years 11, 12, and 13 (forms 5, 6, and 7). Other curriculum statements describe the achievement objectives for biology, chemistry, and physics.

The New Zealand Qualifications Authority will develop unit standards for credits in the National Certificate qualification. The unit standards will be based on objectives for levels 6, 7, and 8 in these curriculum statements.

Prescriptions for any national examinations in science developed by the New Zealand Qualifications Authority will be based on the achievement objectives that relate to the subject and level of the examination.

IMPLEMENTING THE SCIENCE CURRICULUM

This curriculum statement in science provides the framework for planning and making decisions about a school's science programme. Teachers, with the support of their school community, will use it to develop their school science scheme. It will be the school scheme that sets the specific learning outcomes – derived from the achievement objectives – and structures the learning experiences of classes and individuals.

Teachers should note that some achievement objectives are broad, and may embody a mixture of knowledge, skills, and attitudes. Consequently, the attainment by students of any particular objective will often be dependent upon more than one unit of study, and on units based on several learning strands.

The specific learning outcomes set for a particular unit of study would be expected to be attained. However, the attainment of the broader and more complex achievement objectives will typically require a longer period of time and involve a wide range of learning experiences. For the average student, attainment will involve around two years of learning for objectives for each level in levels 1 to 5, and around one year of learning for objectives for each of levels 6 to 8.

Although the objectives are prescriptive, other aspects of the learning described in the statement are not. The sample learning contexts, possible learning experiences, and assessment examples provide ideas for schools and teachers which they may, or may not, incorporate into their own science schemes. Their purpose is to indicate the scope and depth of learning. The examples in italics that are associated with many of the objectives are, similarly, not prescriptive. However, it is expected that a school's science scheme and/or associated unit outlines will identify which examples will be used in the learning programme.

It is equally valid for teachers and students to approach a unit of study from the objectives in any strand or, in some cases, from another subject. However, it is expected that the "science and its relationship to technology" strand, and the "skills and attitudes" strand, will be integrated into learning contexts within the other four strands. Integration will often extend to other subject areas and is encouraged. Whenever this is done, the science objectives must be specified, and their attainment by students monitored.

Thus, the implementation of this science curriculum requires a number of school-based decisions and actions. In making these decisions, schools and teachers should make full use of the flexibility that exists in how the aims and objectives may be approached. This will result in each school providing a unique science programme that recognises the particular character of their student population, that makes effective use of local resources, and that fits in with other decisions relating to the whole of the school's curriculum.

What will be common across all schools is that their science schemes will target the attainment of the same aims and achievement objectives, and will describe processes to monitor, for every student, the learning described by these objectives.

At appropriate times this assessment information will be processed by teachers to enable the school to report on students' learning in science in relation to the achievement objectives, and to provide themselves with one type of feedback on the effectiveness of the school's science programme.

Curriculum support documents providing assistance in implementation of *Science in the New Zealand Curriculum* are available.[2]

[2] To be published in 1994.

Making Sense of the Nature of Science and its Relationship to Technology

Achievement Aims

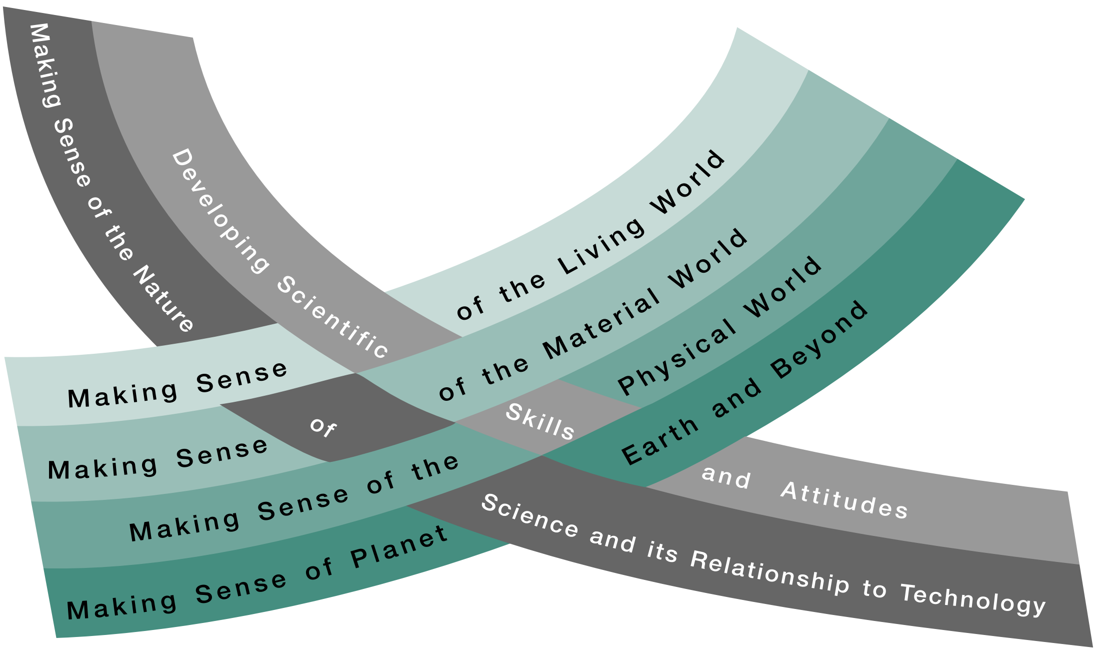
In their study of the nature of science and its relationship to technology, students will use their developing scientific knowledge, skills, and attitudes to:

1. critically evaluate ideas and processes related to science and become aware that scientific understanding is developed by people, whose ideas change over time;

2. explore the relationships between science and technology by investigating the application of science to technology and the impact of technology on science;

3. gain an understanding of personal, community, and global implications of the application of science and technology.

Students should appreciate that social and cultural frameworks influence the way scientists work and that understanding in science changes.



In their study of science and technology as human activities, students explore the nature of science, its relationship to technology, and the impact of science and technology on people and the environment.

Scientific ideas can be clarified and extended through learning experiences which involve investigating technological devices and processes at all levels. Learning can also be advanced through study of the development of scientific ideas or concepts, both historically and within their own community. Examples from the New Zealand context would enhance students' understanding of the role of science and of scientists in society.

The achievement objectives in this learning strand are to be gained through the content and contexts of the other learning strands. For this reason, no learning contexts are given and the learning experiences listed link to the other learning strands. Related learning strands are indicated for each of the learning experiences, for example, "listening to others describe how plants grow (L 1.3)" indicates that the learning experience is linked to the learning strand Making Sense of the Living World, level 1, achievement objective 3.

The codes for the four contextual strands are:

L — Making Sense of the Living World

P — Making Sense of the Physical World

M — Making Sense of the Material World

E — Making Sense of Planet Earth and Beyond.

Making Sense of the Nature of Science and its Relationship to Technology: Level 1

Achievement Objectives

Students can

1 share and compare their emerging science ideas;

2 explore and suggest what simple items of technology do;

3 investigate the uses of familiar technology.

Possible Learning Experiences

Students *could* be learning by:

- listening to others describe how they think plants grow (L 1.3);
- talking about the activities people do in different seasons (E 1.1);
- exploring how a telephone can be used (P 1.4);
- working in small groups to devise a set of questions to ask a dental therapist about the materials she uses (M 1.2);
- sharing ideas when sitting under a tree with their eyes closed and attempting to distinguish individual sounds (P 1.1/2);
- making a big book of the class's ideas about seeds (L 1.3);
- discussing their ideas on when to use scissors (P 1.4);
- giving a talk on how a toy works (P 1.4);
- helping a partner dismantle a toy and sharing ideas about how the different parts work (P 1.4);
- making a toy that floats upright (P 1.4);
- investigating materials to wrap an ice block in to prevent it from melting too quickly (P 1.1);
- discussing the sort of knife that is best for cutting bread (P 1.4).

Assessment Examples

Teachers and students *could* assess the students':

- ability to suggest ideas, when the students explain their understanding about why some people go faster down a slide than other people;
- ability to observe and share ideas, when the students watch the changes in an egg as it poaches or a pikelet as it cooks;
- awareness of requirements for vehicle movement, when the students make a toy car using cardboard boxes, wheels, and axles;
- awareness of the appropriate simple technology used for cutting different materials, when the students choose from a range of pictures of simple cutting instruments.

Making Sense of the Nature of Science and its Relationship to Technology: Level 2

Achievement Objectives

Students can

1 use a variety of methods to investigate different ideas about the same object or event;

2 investigate and describe how simple items of technology work;

3 investigate the way common items of technology have developed.

Possible Learning Experiences

Students *could* be learning by:

- testing students' ideas about how plants respond to light (L 2.4);
- sharing and exploring ideas about where the water goes when things dry (M 2.3);
- working in groups to come up with a report on the range of ideas about what causes day and night (E 2.3);
- discussing how and why we use eating utensils, such as forks, knives, and chopsticks (M 2.2);
- discussing and reporting on what life would be like without zips or velcro (M 2.2, P 2.4);
- dismantling a pencil sharpener and comparing it with others (P 2.4);
- listening to a story about the person who invented the telephone, to appreciate the role of people in such developments (P 2.4);
- visiting a museum to find out about inventions and how people have used them (P 2.4, M 2.4).

Assessment Examples

Teachers and students *could* assess the students':

- understanding that people can hold different ideas about the same thing, when the students prepare a chart displaying a range of ideas they have about shadows;
- knowledge that there can be a number of solutions to a problem, when the students write simple sentences to explain a variety of ways that food can be kept cold;
- knowledge of the development of bicycles, when the students arrange a number of photographs of bicycles in historical order;
- ability to carry out an investigation when students determine (from a range of provided materials) the best type of material from which to make a simple parachute or the best shape for the hull of a toy boat.

Making Sense of the Nature of Science and its Relationship to Technology: Level 3

Achievement Objectives

Students can

1 recognise when simple investigations can be classified as a “fair test” and make decisions about the worth of results;

2 investigate examples of simple technological devices and link these with some scientific ideas, *e.g., can opener and levers, bicycle pumps and air pressure;*

3 investigate the impact of some well-known technological innovation or scientific discovery on people and/or the local environment, *e.g., penicillin, the aerosol can, portable audio systems, stretch fabric.*

Possible Learning Experiences

Students *could* be learning by:

- interviewing an adult about the technology used in his or her job (M 3.4, P 3.4);
- constructing a kete out of a variety of materials and testing it for durability and strength (M 3.2);
- viewing old pictures, to work out how technology has changed the way we do things (E 3.2);
- trying out different methods of preparing and cooking food, including using a microwave oven (M 3.3);
- investigating the history and properties of materials such as soap and cement (M 3.4);
- listening to a visiting Samoan parent describe how smoke can be used to ripen bananas (L 3.4, M 3.3);
- making decisions about the best position for specific plants in the garden (L 3.4).

Assessment Examples

Teachers and students *could* assess the students':

- understanding of the nature of a "fair test" and the value of results, when the students write evaluations of other students' investigations;
- recognition of the purpose of springs in a range of toys, when the students explain how the toys work;
- knowledge of the impact of stretch fabrics in sports, when the students prepare a poster on these.

Making Sense of the Nature of Science and its Relationship to Technology: Level 4

Achievement Objectives

Students can

1. plan and carry out a “fair test” and make decisions about whether the conclusions drawn from an investigation are soundly based;

2. investigate examples of simple technology to clarify some scientific ideas, *e.g., a Maori planting calendar and the Earth’s relationship with the Sun and Moon, hair driers and evaporation, use of yeast in food and drink production;*

3. investigate ways in which developments in science and technology have changed the lives of older members of the community or made life easier for people with specific physical difficulties.

Possible Learning Experiences

Students *could* be learning by:

- working in teams to plan a long-term investigation on effects of naturally produced fabric dyes (M 4.2);
- drawing conclusions from data gathered on the variability of seed numbers per pod in kōwhai species (L 4.3);
- investigating the effect of different wheels on the speed of a skateboard (P 4.4);
- investigating, designing, and constructing an Archimedes' screw to illustrate the principle of its use in water irrigation (P 4.4);
- investigating the science involved in using a photo-electric door opener (P 4.4);
- constructing a paper crinkler from a construction kit and explaining how it works, and why we use it (P 4.4);
- interviewing an older person about their childhood memories of housework (P 3.4);
- carrying out a "fair test" on the reliability of weather reports (E 4.1).

Assessment Examples

Teachers and students *could* assess the students':

- ability to perform appropriate measurements, when the students evaluate the water resistance of different fabrics;
- ability to recognise whether or not a conclusion is soundly based, when the students reflect on three conclusions provided in a report of a "fair test" to determine the best stain remover;
- knowledge of levers, when the students explain the use of levers in cutting instruments;
- ability to plan an interview, when the students list the questions they would like to ask an older person, or a person with a specific physical difficulty, about the way new inventions have changed their lives;
- ability to carry out an investigation, when the students compare the cooking of food in a conventional oven and a microwave oven.

Making Sense of the Nature of Science and its Relationship to Technology: Level 5

Achievement Objectives

Students can

1 (a) relate interpretations of the result of their investigations to their original ideas, questions, and predictions;

(b) explain how different cultures have developed understanding of the living, physical, material, and technological components of the environment, *e.g., Polynesian navigation systems, Maori medicinal plants, Chinese astronomy;*

2 use their knowledge of a scientific idea to identify and describe examples of technology in which that idea is applied;

3 investigate how knowledge of science and technology is used by people in their everyday life, *e.g., knowledge of the nutritional value of food groups and diet, knowledge of effects of drugs on body systems.*

Possible Learning Experiences

Students *could* be learning by:

- researching and writing a case study on topics such as antibiotics, Teflon plastics, the electric fence, and ailerons, to emphasise the link between science and technology (P 5.4, M 5.2);
- interviewing a kuia about Maori herbal remedies (M 5.2);
- negotiating within a group the questions to ask about a Maori fishing calendar (L 5.4);
- tracing the development of drift-net fishing and its impact on the environment (E 5.4);
- investigating the development of the silicon chip and its prevalence in familiar technology (P 5.4);
- using findings from an investigation to justify the selection of products such as acne cream, toothpaste, soap, cereal, or cat food (M 5.2).

Assessment Examples

Teachers and students *could* assess the students':

- ability to relate the results of their investigations to their original ideas, when they explain their conclusions during a "report back" session;
- knowledge of the contribution Pacific Islands people have made to the development of cropping techniques, when the students present a seminar;
- ability to use their scientific knowledge, when the students prepare a historical summary of the technological developments arising from the discovery of radio waves;
- ability to locate and organise information, when the students prepare a speech on achieving a healthy vegetarian diet or on the dangers of smoking.

Making Sense of the Nature of Science and its Relationship to Technology: Level 6

Achievement Objectives

Students can

1. understand the characteristics of a scientific experiment;
2. describe how technology has contributed to, and at times helped change, scientific ideas, *e.g., lens grinding, timing devices, photography, the electron microscope, lasers;*
3. investigate how knowledge of science and technology is used by society when making decisions about environmental issues, *e.g., fish farming, sewage treatment, food irradiation, recyclable packaging, organic farming.*

Possible Learning Experiences

Students *could* be learning by:

- carrying out a "fair test" on the insulating properties of different thicknesses of polystyrene (P 6.1);
- trying out different proportions of gravel, sand, and cement to identify factors which contribute to the strength of concrete (E 6.1/2);
- carrying out peer reviews of their classmates' experiments on the effectiveness of a variety of commercial antacids (M 6.2);
- analysing Pasteur's experimental results with food in closed and open containers, and making predictions about possible causes of these results (L 6.1);
- finding out about the effect of van Leeuwenhoek's work with lenses, which led to our knowledge of microbes (L 6.1);
- presenting a case for a variety of health treatment options being available in the community (L 6.1);
- researching the problems faced by Semmelweiss in getting doctors to adopt the hygienic practices of midwives (L 6.1).

Assessment Examples

Teachers and students *could* assess the students':

- awareness of the need for replication of results, when the students carry out their own experiments on a selected aspect of the living, physical, or material worlds;
- ability to design and carry out an experimental investigation, when the students analyse a range of consumer products;
- ability to describe the role of technology in changing scientific ideas, when the students write a report discussing how the development of telescopes has contributed to changing ideas about the solar system;
- information research skills, when the students present a speech or seminar on the impact of sewage treatment on local waterways.

Making Sense of the Nature of Science and its Relationship to Technology: Level 7

Achievement Objectives

Students can

1. write a historical case study of people's developing ideas in a selected area of scientific knowledge, *e.g., inheritance of genetically controlled characteristics, alternative fuels, planet atmospheres;*

2. investigate the interaction of science and technology, *e.g., theories of conduction and electronics, scientific ideas about human reproduction and birth-related technologies;*

3. research the personal and ethical issues which arise from the impact of science and technology on people and their environment.

Possible Learning Experiences

Students *could* be learning by:

- constructing a flow diagram to illustrate the numerous steps, and people who were involved, in the decoding of DNA (L 7.3);
- finding out about modern developments in the field of genetically linked diseases in humans (L 7.3);
- investigating the scientific theories behind fibre optics and their applications (P 7.4);
- debating a local government issue about the location of a new waste disposal processing plant, taking into account the conflicting claims about the effects on people (E 7.4, M 7.4);
- carrying out an investigation to discover water pollution levels in a river which receives factory or commercial effluents (M 7.4).

Assessment Examples

Teachers and students *could* assess the students':

- information accessing skills and understanding, when the students write a report on the historical development of our understanding of the mobility of the Earth's crust;
- ability to research the scientific basis of foetal monitoring, when the students write an essay on technological developments in ante-natal care;
- ability to give an account of conflicting points of view, when the students write an essay outlining the decision-making process involved in selecting a dam site;
- ability to critically assess, when the students review science items presented in the popular media.

Making Sense of the Nature of Science and its Relationship to Technology: Level 8

Achievement Objectives

Students can

1 write a case study of a current scientific controversy;

2 investigate the complex interaction of science and technology, *e.g., the scientific ideas about matter and spectroscopy, subatomic structure of matter and linear accelerators, plate tectonics and earth movement detectors;*

3 use their scientific knowledge to evaluate the impact of science and technology on people and their environment, *e.g., evaluation of an environmental impact report on nuclear power in New Zealand, evaluation of the use of steroids in sports, depletion of the ozone layer and its effects on the New Zealand environment.*

Possible Learning Experiences

Students *could* be learning by:

- debating the relationship between abuse of alcohol and brain damage (L 8.1, M 8.1/2);
- discussing the evidence for and against global warming (M 8.4);
- investigating the scientific validity of consumer information about food additives such as salt, sugar, anti-oxidants, or food colourings (M 8.1/2);
- finding out about antibiotic use and the development of drug resistance of organisms (L 8.4);
- investigating effects of food technology on the world's food supply (L 8.4, M 7.3);
- critically evaluating the use of nuclear energy for New Zealand's energy needs (E 7.2, P 8.2).

Assessment Examples

Teachers and students *could* assess the students':

- awareness of different scientific views, when the students present a seminar on the evidence for using margarine rather than butter;
- understanding of the way that increasingly energetic bombardment of atoms has provided evidence for subatomic particles, when the students write an essay on the nature of matter;
- ability to use scientific knowledge to critically evaluate the effect of technology on the environment, when the students create a drama where group members assume the role of leaders from countries with conflicting interests about whaling.

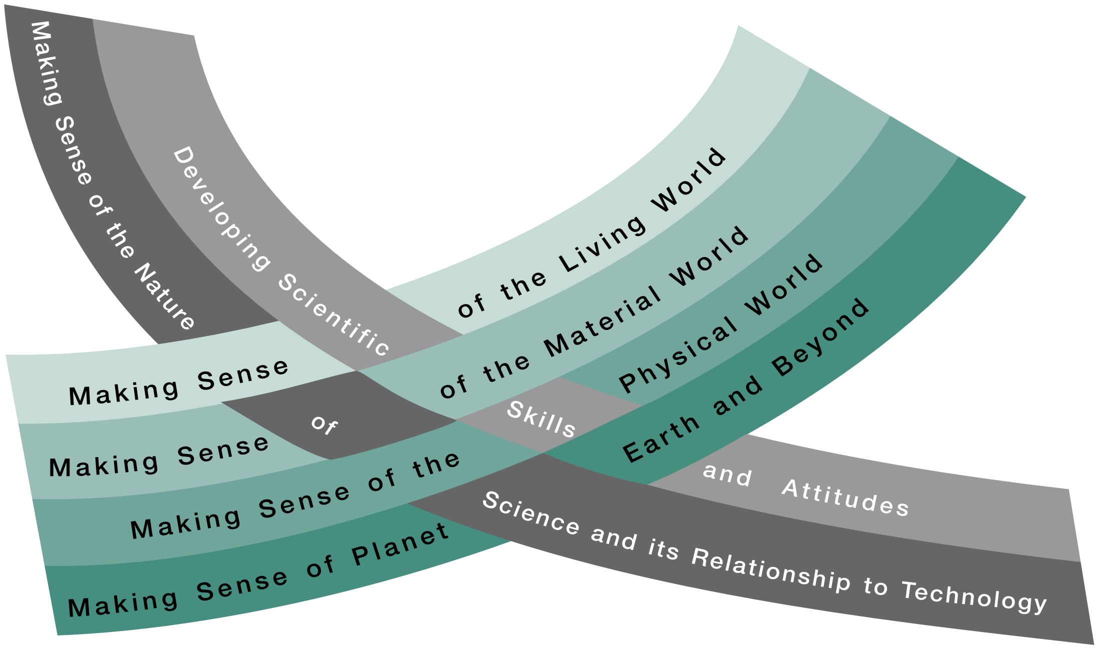
Developing Scientific Skills and Attitudes

Achievement Aim

In their study of science students will use their developing scientific knowledge, skills, and attitudes to:

- further develop their investigative skills and attitudes.

Students will be developing their investigative skills and attitudes within the content and contexts of the other learning strands. For this reason, no learning contexts or assessment examples are given and the learning experiences have been linked to achievement objectives of the other learning strands.



In practice, science as a process involves an integration of knowledge, skills, and attitudes to develop scientific understanding. Practical work in science can include experiencing phenomena, developing practical skills or techniques, and carrying out investigations. Investigations provide key opportunities for students to extend their understanding in science. They also enable students to develop the scientific skills and attitudes required to enhance their ability to explore phenomena and events and to solve problems. It can be expected that, as they learn, students will show an increasing sophistication in the skills they use in their investigations.

Carrying out an investigation in science involves an interaction of many complex skills. These include focusing, planning, information gathering, processing, interpreting, and reporting. Students may be investigating by carrying out a practical investigation of the "real world", by carrying out an investigation of appropriate reference material, or by integrating these approaches.

Problem solving is an essential part of scientific investigation. Problem solving includes identifying and analysing the problem, gathering relevant information, designing alternative solutions, testing the method or device, evaluating the method or device, modifying the method or device, and reaching a decision regarding the merit of the chosen method or device.

As students learn in science, they should be encouraged to develop the attitudes on which scientific investigation depends. These attitudes include curiosity, honesty in the recording and validation of data, flexibility, persistence, critical-mindedness, open-mindedness, willingness to suspend judgment, willingness to tolerate uncertainty, and an acceptance of the provisional nature of scientific explanation.

Other attitudes which arise out of reflection about the past, present, and future involvement of science in social and political affairs should also be encouraged. These include a positive and responsible regard for both the living and non-living components of the Earth's environment, and a desire for critical evaluation of the consequences of the applications of scientific discoveries.

As students are learning in science they will be developing skills and attitudes specific to science. They will also be engaging in experiences which will help them to develop the full range of the essential skills described in *The New Zealand Curriculum Framework.* A breakdown of the essential skills and attitudes that can be developed through learning in science can be found in Appendix 2, page 128.

The possible learning experiences in this section are organised in relation to clusters of specific investigative skills (focusing and planning, information gathering, processing and interpreting, and reporting). Each learning experience is linked to one or more achievement objectives in another learning strand. For example, "establishing the criteria to assess flight characteristics when carrying out a 'fair test' of paper darts (P 3.1/2 N 3.1)" indicates that the learning experience relates to Making Sense of the Physical World, level 3, achievement objective 1/2; and to Making Sense of the Nature of Science and its Relationship to Technology, level 3, achievement objective 1.

The codes for the other learning strands are:

N — Making Sense of the Nature of Science and its Relationship to Technology

L — Making Sense of the Living World

P — Making Sense of the Physical World

M — Making Sense of the Material World

E — Making Sense of Planet Earth and Beyond

Developing Investigative Skills and Attitudes

Achievement Objectives for Focusing and Planning

	Levels 1 and 2	Levels 3 and 4	Levels 5 and 6	Levels 7 and 8
	Students will be achieving at Level 2 when they can:	Students will be achieving at Level 4 when they can:	Students will be achieving at Level 6 when they can:	Students will be achieving at Level 8 when they can:
Focusing and planning	• talk about an object or event and settle on a question to investigate;	• ask questions of themselves, their group, and resource people and identify questions suitable for scientific investigation;	• ask a series of related questions of themselves, their group, and resource people and refine questions to make them suitable for scientific investigation;	• ask a series of related questions of themselves, their group, and resource people and refine questions to make them suitable for scientific investigation;
	• use their science ideas and personal observations to make predictions or suggest possible solutions;	• use their science ideas and personal observations, and those of others, to make testable predictions or to identify possible solutions for trialling;	• integrate their scientific ideas and personal observations with the scientific ideas of others to make testable predictions or to identify possible solutions for trialling;	• integrate their scientific ideas and personal observations with the scientific ideas of others to make testable predictions or to identify possible solutions for trialling;
	• suggest simple trials based on intuitive notions of fair testing and trialling.	• design "fair tests", trials, and surveys with an attempt to control for obvious variables.	• design "fair tests", simple experiments, trials, and surveys, with clear specification and control of likely variables.	• design systematic tests, experiments, trials, and surveys with rigorous identification and control of variables.

Achievement Objectives for Information Gathering

	Levels 1 and 2	Levels 3 and 4	Levels 5 and 6	Levels 7 and 8
	Students will be achieving at Level 2 when they can:	Students will be achieving at Level 4 when they can:	Students will be achieving at Level 6 when they can:	Students will be achieving at Level 8 when they can:
Information gathering	• make observations and simple measurements;	• use appropriate instruments to enhance observation or to introduce quantification;	• select and use measuring instruments to make qualitative and quantitative observations and standard measurements with appropriate precision;	• select and use measuring instruments to make qualitative and quantitative observations and standard measurements with appropriate precision;
	• talk about their observations and measurements;	• record observations and measurements;	• systematically record observations and measurements;	• systematically and economically record observations and measurements;
	• seek information in books and from people;	• locate information in the community or libraries;	• locate information through catalogues, indexes, and computers;	• compare, contrast, and choose between sources of information;
	• use information sources with teacher support.	• use information sources purposefully, asking coherent, directed questions of people and media sources.	• use information-processing techniques to process information related to the purpose.	• use information-processing techniques to process information, evaluate its relevance, and identify its bias.

Achievement Objectives for Processing and Interpreting

	Levels 1 and 2	Levels 3 and 4	Levels 5 and 6	Levels 7 and 8
	Students will be achieving at Level 2 when they can:	Students will be achieving at Level 4 when they can:	Students will be achieving at Level 6 when they can:	Students will be achieving at Level 8 when they can:
Processing and interpreting	• identify trends and relationships in recorded observations and measurements by suggesting links between these; • with teacher support, use their findings to suggest an answer to their selected questions and problems and make a simple evaluation of their investigation.	• identify trends and relationships in recorded observations and measurements by making links within organised data; • use organised data and scientific ideas to suggest an answer to their selected questions and problems, and make an evaluation of their investigation.	• identify trends, relationships and patterns, in recorded data by analysing data using statistical and graphing procedures as appropriate; • set their findings or possible solutions against established scientific theory to draw and justify conclusions.	• identify trends, relationships, and patterns in recorded data by analysing data using statistical procedures as appropriate; reflect on reliability and validity of the findings; • critically evaluate their hypotheses or possible solutions using analysed data and scientific theory, and draw and justify qualified conclusions.

Achievement Objectives for Reporting

	Levels 1 and 2	Levels 3 and 4	Levels 5 and 6	Levels 7 and 8
	Students will be achieving at Level 2 when they can:	Students will be achieving at Level 4 when they can:	Students will be achieving at Level 6 when they can:	Students will be achieving at Level 8 when they can:
Reporting	• share what they did and what they found out in their investigations in whole class situations or in groups.	• present what they did and what they found out in their investigations in ways and forms appropriate to their peer group.	• present well reasoned, complete reports supported by relevant data in ways, and forms, appropriate to nominated audiences.	• present concise, well reasoned, complete reports, supported by relevant and suitably processed data from a number of sources, as necessary, in ways and forms appropriate to nominated audiences.

Notes:

1. The ability to carry out a complete investigation is the key expected outcome of this achievement aim.
2. It is expected that students will develop any specific investigative skills they need when they are carrying out a complete investigation.
3. The processes of investigation are not necessarily sequential. The process may begin at any point in the tables above and will tend to move backwards and forwards. Students should be reflecting on their decisions, actions, and findings and modifying their plans and actions as they are proceeding.

Possible Learning Experiences Related to Focusing and Planning

Focusing and planning in science *may* include:	Students could be learning by:
• using prior knowledge and experiences; • clarifying ideas; • integrating ideas from several sources; • having hunches and making guesses; • being curious and asking questions; • reframing questions so that they can be investigated; • identifying, defining, and analysing the problem; • considering scientific models and laws; • predicting; • observing; • being open-minded; • being co-operative; • designing a systematic investigation (including designing an experiment); • making decisions about the feasibility of an investigation; • being flexible; • deciding whether an "expert" needs to be contacted; • re-designing an experiment when preliminary results are inconclusive; • being persistent.	• clarifying their ideas about objects which sink (P 1.3, M 2.1); • deciding how many leaves to collect in order to show variety in leaf shape (L 1.2); • asking questions about observed changes during the cooking of pikelets (M 1.3); • making predictions about the shape of a shadow when the sun comes out (E 2.2); • sharing ideas about the use of different kinds of plastic materials (M 3.2); • establishing the criteria to assess flight characteristics when carrying out a "fair test" of paper darts (P 3.1/2, N 3.1); • designing a technique for measuring or assessing the relative clarity of different water samples (E 3.1); • guessing the reasons for the distribution of crabs on a rocky shore (L 3.4, L 4.4); • listening to their work partners' reasons for having five trial plots of radishes (L 4.2, N 4.1); • planning an electrical wiring system for a model house (P 4.3); • developing a flow chart to show the expected directions in the process of an investigation into the properties of metals (M 4.2); • deciding where relevant information regarding an endangered New Zealand animal can be found (L 4.2); • asking an expert about experimental methods for determining the most readily available source of vitamin C in a variety of fruits (L 4.4, L 5.2); • designing the structure of a magnetic lock (P 4.3); • asking questions about which factors affect the light intensity of a bulb (P 5.3); • making predictions about the presence of a particular ion in a substance (M 6.2); • predicting which of a range of physical factors influence the scattering of broom seeds (L 7.2); • using library information-search techniques when planning a science project on superconductors (P 7.4); • deciding if it is safe to carry out an investigation into the distribution of a radioactive substance throughout a plant (L 8.4); • reading a range of journals and newspaper articles when beginning a study on the effects of biotechnological developments on medical treatments of genetic diseases (L 8.4, N 8.3).

Possible Learning Experiences Related to Information Gathering

Information gathering in science *may* include:	Students *could* be learning by:
• exploring; • observing; • seeking patterns and/or relationships; • testing ideas, predictions, or explanations; • organising resources; • conducting experiments; • testing methods or devices; • identifying and controlling variables; • constructing or manipulating equipment; • locating, collecting, and recording data; • searching for an answer to a problem or question; • designing a device to meet a specified function; • being honest in the recording and validation of data; • being persistent.	• collecting data from tests of an elastic-propelled vehicle (P 1.1/2); • hunting for insect holes at a road cutting (E 2.1); • sharing the reading of a big book to find out answers to questions about tadpoles (L 2.3); • looking for living things in a compost heap (L 3.4); • recording the pattern a tuning fork makes on water (P 3.3); • seeking reasons why board sailors wear wet suits in the summer (P 4.4); • asking a consultant to comment on predictions made about the number of green tints found in nature (L 5.2); • building a waka, from harakeke, which will hold 500 grams (P 5.1); • collecting data about how much candle is required to heat water for a cup of tea (P 5.1); • sorting metals according to agreed attributes (M 4.1); • identifying the effect of different variables associated with the swing of a pendulum (P 5.1); • conducting a "fair test" into the flammability of a range of materials (M 4.2, M 5.2); • building a model electric motor (P 5.1); • using an oscilloscope to record sound patterns produced by different musical instruments (P 7.1).
• deciding what information is required; • deciding when to ask an "expert"; • selecting information from a variety of sources; • using information-retrieval and information-processing technologies; • recording raw and processed data.	• asking adults about changes in their town (E 1.2); • deciding what questions to ask the school gardener about the trees growing in the gully (L 2.1); • comparing "before and after" views of rusting of iron (M 4.3); • using the local council library to obtain information to prepare for a project on shellfish gathering at the local beach (E 4.4); • using the microfiche/CD ROM in a library to access information about the activity of major volcanoes in New Zealand during the previous 100 years (E 5.1/2); • interviewing a plant breeder to collect information about plant genetics (L 6.2/3); • deciding what information is required to make appropriate planning decisions for an investigation into insect life cycles (L 7.2); • evaluating gathered information about the effect of variable oxygen levels on the fish population in a river (M 8.4).

Note: Students may be gathering information from practical investigations and/or from investigating resource material, and consulting with "experts". The division in this table reflects these different methods.

Possible Learning Experiences Related to Processing and Interpreting

<table>
<tr><th>Processing and interpreting in science may include:</th><th>Students could be learning by:</th></tr>
<tr><td>

processing data;
synthesising data;
linking new and old ideas;
discussing ideas;
negotiating an understanding;
identifying patterns and relationships;
suggesting possible explanations;
criticising the method;
analysing a device;
being critically minded;
being intellectually honest.

evaluating processed data;
trying to resolve any incongruity in ideas and concepts;
justifying inferences in the light of gathered data;
appreciating and expressing limitations of experimental procedures and gathered data;
being open-minded;
detailing a solution to the problem;
reflecting on their own thinking;
being willing to suspend judgment;
being willing to tolerate uncertainty;
accepting the provisional nature of scientific explanation;
accepting the validity of the results and conclusions of others.

</td><td>

discussing ideas about the flat shape of leaves (L 2.1, N 2.2);
making links between a practical experiment which indicates that a hollow ball of plasticine will float and the hollow chambers found in a submarine (P 2.3);
deciding that all observations about spiders indicate that spiders have eight legs (L 2.1, N 2.1);
developing an explanation for the strength of a paper tower (P 3.3);
evaluating findings about which tested method is the most effective for cleaning up a beetroot spill (M 3.2, N 3.1);
interpreting the class's monthly data on inside and outside temperatures (E 4.1);
establishing the relationship between heating effect and the power settings of a microwave oven (P 4.4, N 4.1);
reaching a consensus about the causes of the apparent changes in the shape of the moon over a four-week period (E 4.3);
evaluating processed data from experiments on the conditions required for the best germination of seeds (L 4.2);
deciding whether to endorse the use of chlorofluorocarbons (CFCs) in car air-conditioners (E 5.2, M 5.4);
discussing ideas about processed data on voltage changes in a battery over time (P 5.3);
linking ideas about insects laying eggs and the survival of insects in winter (L 5.2);
putting together gathered data on the time taken by model cars to travel up a variety of inclines (P 6.3);
interpreting a print-out of a seismograph recording (E 6.1/2);
resolving the conflict arising when two patterns emerge in the worked data gathered from experiments into the effectiveness of different hair shampoos (M 6.4, N 6.1);
selecting the best explanation for the relative strengths established from a series of experiments on differently constructed electromagnets (P 6.1);
recognising that the data collected is insufficient to enable confident statements to be made about the relationships between aerosol sprays and the health of a household plant (E 7.4, M 7.4);
identifying the relationship between cicadas' song and the time of day (L 7.2);
evaluating conflicting ideas about evolution (L 8.3, N 8.1);
reflecting on apparently conflicting conclusions on the causes of cot death (L 8.4, N 8.1).

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</table>

Note: Although it is possible to identify different skills which relate to processing and interpreting, in practice the possible learning experiences generally apply to both processing and interpreting and therefore have not been separated in the table.

Possible Learning Experiences Related to Reporting

Reporting in science *may* include:	Students *could* be learning by:
• sharing findings in writing — orally, visually, graphically, symbolically, diagramatically, as models; • using a wide range of media, including computers, videotape recording, audiotape recording, a range of publishing methods, performance arts.	• talking to a classmate about what their pet cat eats (L 1.4); • writing captions about the temperature of different coloured objects placed in the sun (P 2.3); • developing a flow chart for a classroom display about making jewellery from clay (M 3.2); • making a video clip about cloud patterns over a period of time (E 4.1); • using a desk-top publishing program to compile a report on a "fair test" they have carried out on insulating material (P 5.4, P 6.1); • writing an article for the local newspaper about pollution in a local stream (M 6.4, E 6.4); • preparing a display for a science fair summarising their investigation into orchid cloning (L 7.3); • submitting a report to the New Zealand Science Teachers' Association Journal summarising their investigation into the diurnal and territorial behaviour of hedgehogs (L 8.1).

Making Sense of the Living World

Achievement Aims

In their study of the living world, students will use their developing scientific knowledge, skills, and attitudes to:

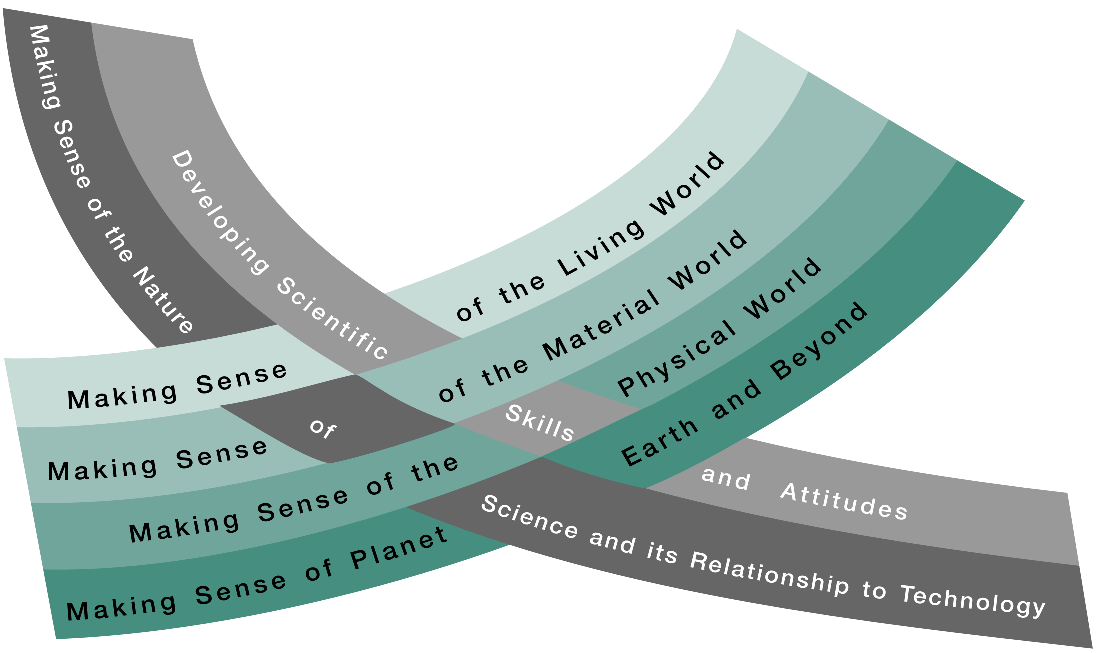
1. gain an understanding of order and pattern in the diversity of living organisms, including the special characteristics of New Zealand plants and animals;

2. investigate and understand relationships between structure and function in living organisms;

3. investigate and understand how organisms grow, reproduce, and change over generations;

4. investigate local ecosystems and understand the interdependence of living organisms, including humans, and their relationship with their physical environment.

Students need to be encouraged to consider the social and ethical implications involved in making responsible decisions about living things.



In their study of the living world, students should be developing an awareness of New Zealand's plants and animals and an appreciation of the special features of the New Zealand environment.

Initially, investigations into the relationships between living things, and between living things and their physical environment, should involve local examples. As their understanding of ecological relationships develops, students should be introduced to examples from other areas of New Zealand and beyond. In this way, students will become aware of New Zealand's place in the global environment and sensitive to the vulnerability of the biosphere.

Although it is required that students will carry out investigations involving live organisms, teachers and students need to carefully consider the social and ethical implications involved, make responsible decisions about living things, and conform to legal requirements in this area. Teachers and students should be guided by advice and requirements set out in *Code of Ethical Conduct for the Care and Use of Animals in School Programmes,* Department of Education, Wellington, 1988.

Making Sense of the Living World: Level 1

Achievement Objectives

Students can

1. share their experiences relating to the living world, and group the living world according to some of its attributes, *e.g., living, non-living; plant, animal; mammal, non-mammal; backbone, no backbone;*

2. observe and identify parts of common animals and plants, *e.g., major parts of the human body, paw, snout, tail, fin, wing, leaf, seed, flower, stem;*

3. investigate and describe the changes in a particular plant or animal over a period of time, *e.g., growth of an animal, diurnal and seasonal opening of flowers, germination of seeds;*

4. accept responsibility for the needs of a house plant and an animal.

Sample Learning Contexts

Myself • Caring for pets • Caring for the school grounds • Small animals • Senses Eating for health • Rock pools • Seagulls • Te ngahere • Going to the farm

Kōhanga • Goldfish • Sparrows

Possible Learning Experiences

Students *could* be learning by:

- observing small animals or plants and reading books about their main features;
- exploring a beach and observing the different plants and animals that live there;
- identifying fruits and vegetables we buy as parts of flowering plants;
- writing about a visit to a farm where they observed a wide variety of living things;
- walking through the bush to observe the variety of plants and animals;
- making leaf rubbings and prints to observe closely the patterns of leaves;
- looking for small animals in the playground, e.g., snails, slaters, and spiders, in order to observe their attributes;
- collecting and growing plants to investigate different kinds of plants and how they grow;
- keeping animals over a period of time, e.g., hatching chickens and recording growth rates to observe the changes that occur;
- growing plants from seeds or bulbs to observe the changes which occur;
- discussing their experiences of keeping pets to show their awareness of the needs of a domestic animal.

Assessment Examples

Teachers and students *could* assess the students':

- skills of comparing and grouping, when the students sort and label appropriate pictures and objects into sets of living and non-living things;
- knowledge and appropriate use of terms, when the students identify the major parts of a plant or animal;
- descriptions of the common attributes of living things, when the students make a collage picture of plants and animals with accompanying captions;
- understanding of patterns of change which occur over a period of time, when they record their measurements of changes, such as height of a plant or opening of flowers;
- knowledge of the conditions needed to sustain life, when the students describe how to care for pets and plants in their home and school environment;
- acceptance of responsibility for the care for a plant, when an individual student keeps a plant in a pot alive for a period of time.

Making Sense of the Living World: Level 2

Achievement Objectives

Students can

1 use differences and similarities in external characteristics to distinguish broad groups of living things, *e.g., mammals, frogs, fish, birds, insects, spiders, worms, snails; flowering plants, ferns, mosses;*

2 investigate and understand the general functions of the main parts of animals and plants, *e.g., skin, legs, ears, eyes, heart, stomach, brain, bones, tail, wings; seeds, roots, flowers, cones;*

3 investigate and understand the changes that take place in animals and plants during their life cycles, *e.g., metamorphosis in butterflies, beetles, and frogs; farm animals; flowering plants;*

4 investigate the responses of plants or animals, including people, to environmental changes in their habitats, *e.g., seasonal changes in deciduous trees, bird migration, plants grown in sun and shade, hibernation.*

Sample Learning Contexts

Eating for health • Vegetable growing • Spiders • Insects • Mammals
New Zealand birds and other animals • Frogs • Nga kaimoana • Nga kararehe Aotearoa • Nga pungāwerewere • Te Ao • Tangaroa • Te Aitanga a Tāne
My body • Small animals • Seasons • Fitness • Bee-keeping • Snails and slugs Sharks • Rātā and the birds • Kahukura's story

Possible Learning Experiences

Students *could* be learning by:

- establishing some of the criteria which help to distinguish fish, birds, and insects, and New Zealand trees and ferns;
- drawing different animals that they have found in the school playground;
- sharing their ideas about the differences between ferns, mosses, and flowering plants;
- making a collage of pictures of human body parts on a body outline to show the positions of the main organs;
- preparing the questions to ask a visiting expert about how major internal body organs help us to live;
- collecting a variety of edible plants and identifying which parts of the plant are edible;
- observing and recording the life cycle of an animal to show that changes occur, e.g., frogs, huhu beetles, monarch butterflies, garden snails;
- experimenting to find out how plants respond when they are exposed to different light conditions, e.g., wandering Willie, bean seedlings;
- growing a variety of vegetables and flowers to learn about the needs of plants;
- finding out what happens to the animals in a forest when the trees are cut down;
- reading or writing stories about animals which hibernate in the colder weather.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of the major animal and plant sets, when the students collect pictures and make pictorial identification charts of these;
- knowledge of the position and function of lungs and heart, when the students draw diagrams and write simple explanations of these;
- knowledge of the main parts of a flowering plant, when the students label a diagram correctly;
- knowledge of the relationship of the life cycle of a particular animal with the passage of time, when the students draw an annotated diagram of this;
- observation, measuring, and systematic recording skills, when the students keep a diary recording the growth of a plant over a period of a term;
- inquiry skills, when they investigate and report the responses of a number of plants of the same species put into differing light conditions.

Making Sense of the Living World: Level 3

Achievement Objectives

Students can

1 distinguish between living things within broad groups on the basis of differences established by investigating external characteristics, *e.g., moth, butterfly, bee, fly; shark, trout, flounder; kōwhai, pōhutukawa, rewarewa;*

2 investigate special features of common animals and plants and describe how these help them to stay alive, *e.g., the five senses of people, feet of birds, camouflage and mimicry in insects, animals living in tidal zones, roots, leaves;*

3 research and describe how some species have become extinct or are endangered, *e.g., moa, dinosaurs, kōkako, kākāpō, kauri snail, mountain gorilla, blue whale, cabbage tree;*

4 explain, using information from personal observation and library research, where and how a range of familiar New Zealand plants and animals live.

Sample Learning Contexts

The bush • Estuary • Sandy/rocky shore • Parasitic insects • Social insects
Dinosaurs • Taha moana • Camouflage and survival • Fungi • Te ngahere
Wild life reserve • Wetlands • Swamp • Ponds • Nga ngarara
Te Aitanga a Tāne • New Zealand indigenous animals

Possible Learning Experiences

Students *could* be learning by:

- making observational drawings of mushrooms and toadstools, identifying their characteristics;
- drawing the shapes of different trees to compare and group them;
- establishing a method for classifying insects according to common characteristics;
- keeping a small animal in the classroom to observe how it feeds;
- observing and recording the feeding habits of familiar animals;
- researching the history of the moa to find out possible ways animals have become extinct;
- considering the implications for wildlife of clearing native bush, forests, or wetlands;
- inviting an "expert" to talk to the class about the kiwi;
- composing a chant, rap, or jingle suggesting possible solutions to the problems faced by an endangered native species;
- visiting an estuary to observe the special features of plants and animals which enable them to survive in this particular environment;
- viewing a videotape to clarify ideas about some common New Zealand plants and animals and learn about where they live;
- developing a large wall chart about the habitats of some common New Zealand animals and plants.

Assessment Examples

Teachers and students *could* assess the students':

- ability to recognise the characteristics of an animal group, when they describe the common attributes of the group;
- ability to identify the different parts of a plant and describe their functions, when the students label, and annotate, a diagram of a flowering plant;
- understanding of how plants and animals respond to environmental change, when the students debate a conservation/exploitation issue;
- understanding of how plants are suited to particular habitats, when the students present information on differences in leaf structure;
- understanding of the relationships between the habitat of an organism and its structure and function, when the students design an "animal" or "plant" for a given habitat.

Making Sense of the Living World: Level 4

Achievement Objectives

Students can

1. investigate and classify closely related living things on the basis of easily observable features, *e.g., mussel, pipi, cockle; little spotted kiwi, brown kiwi; blue whale, pilot whale, sperm whale; breeds of cat, dog, horse; kōwhai, kākā beak; rātā, pōhutukawa;*

2. investigate and describe special features of animals or plants which help survival into the next generation;

3. investigate and describe patterns in the variability of a visible physical feature found within a species, *e.g., coat colour in cats, feather colour in budgerigars, human fingerprints, leaf shape and colour;*

4. use simple food chains to explain the feeding relationships of familiar animals and plants, and investigate effects of human intervention on these relationships, *e.g., lettuce leaf, snail, thrush; pollution, food production for people.*

Sample Learning Contexts

Bugs and beetles • Waiora • Fishing • Our polluted stream • Farming
Tangaroa • First aid • New Zealand and introduced animals and plants
Te ngahere • Jabs and shots • Nga kai Maori • Māramataka Maori
Living foods • Nga kaimoana • Bush • Estuary • Pond • Swamp
Agricultural and horticultural management

Possible Learning Experiences

Students *could* be learning by:

- conducting a field survey in the school grounds, bush, scrub, roadside, or zoo to observe the main features of a variety of animals and their feeding habits;
- visiting the SPCA to find out about a range of different types of cats and dogs;
- collecting seeds, pods, berries, and nuts to find out about some of the ways seeds form and are dispersed;
- keeping small animals or pets that reproduce, recording life-cycle changes, food preferences, weight gain, and behaviour;
- recording over time the behaviour of a mother guinea pig caring for her litter ;
- using magnifying glasses to observe the release of spores when fertile fern leaves are warmed gently with a lamp;
- caring for a colony of breeding rats with different coloured coats;
- drawing pie graphs to represent the proportion of selected characteristics of the students in the class, e.g., hair colour, eye colour;
- using magazine pictures to categorise foods we eat;
- investigating plants as food sources for people and animals;
- collecting newspaper articles to find out about an environmental issue;
- debating a global conservation issue to develop an awareness of the possible consequences of human activity on other living things;
- visiting a local recreation area to collect data about the impact of people on the area;
- inviting a kuia or koroua to demonstrate and explain how Maori kai (for example, kānga wai, kumara tao, kānga waru, parāoa rēwena) is prepared;
- making bread with yeast as an example of how people use other living things to produce their food;
- using yoghurt starter cultures to prepare their own yoghurt to demonstrate people’s use of other living things;
- researching and examining some of the solutions to pollution on land and sea;
- researching background information and debating the statement “There should be an open season for gathering shellfish at the local beach.”

Assessment Examples

Teachers and students *could* assess the students’:

- ability to identify by using external features, when the students place given animals and plants in appropriate groups, using a pictorial identification key;
- ability to identify ways different plants disperse their seeds, when the students collect fruit and seeds and explain their method of dispersal;
- understanding of structural changes which occur during reproductive cycles, when the students draw a flow diagram to show these changes;
- understanding of the variability of coat colour in an animal species, when the students discuss the coat colour of guinea pigs or horses;
- knowledge of animal food sources, when the students make a chart or draw three-link chain diagrams to demonstrate these relationships;
- ability to identify feeding relationships, when the students construct a harakeke food web from observations and research;
- understanding of a community conservation issue, when the students write a letter to the editor about litter in a local recreation area.

Making Sense of the Living World: Level 5

Achievement Objectives

Students can

1 investigate, and classify in broad terms, the living world at a microscopic level, *e.g., protists, plant and animal cells;*

2 investigate and describe structural, physiological, and behavioural adaptations which ensure the survival of animals and flowering plants in their environment, *e.g., the organ systems which animals use to locate, catch (or harvest), eat, digest, transport, and use food; territoriality; social behaviour; photosynthesis; osmosis; transpiration;*

3 investigate patterns in the inheritance of genetically controlled characteristics and explain the importance of variation within a changing environment, *e.g., simple monohybrid genetics, human reproduction, genetically controlled human characteristics such as eye colour, asexual and sexual reproduction in plants;*

4 investigate and understand trophic and nutrient relationships between producers, consumers, and decomposers.

Note: Detailed knowledge of the biochemical processes of respiration and photosynthesis is not expected.

Sample Learning Contexts

My body • Waiora • Whakapapa • Food • Fitness • Sport • Fishing
Fads and fashions • Consumer science • Hi-tech medicine
Grafting, budding, and cutting • Te ara o te tangata • Natural and plantation forests Cattle troughs • Stagnant streams • Sports medicine

Possible Learning Experiences

Students *could* be learning by:

- using a microscope to locate the nucleus in plant and animal cells;
- caring for a hearing- or vision-impaired peer for a day to appreciate the needs of others;
- dissecting a sheep's pluck obtained from an abattoir to get a better understanding of the structure of organs;
- debating the topic "Organ transplants are worth the expense" to help clarify ideas and feelings about a current scientific issue;
- doing experiments which investigate the process of food digestion;
- comparing teeth of herbivores and carnivores to make inferences about how and what they eat;
- observing ants to investigate division of labour in a colony;
- surveying physical differences of class members to collect data on human variation;
- recording statistical data of continuous and discrete variation in the class population;
- drawing a family tree of European royal families to show the genetic transfer of haemophilia through the generations;
- designing "fair tests" to investigate their ideas about the factors, such as light intensity, affecting the rate of photosynthesis;
- carrying out investigations regarding the conditions required for photosynthesis;
- drawing a concept map to show how carbon is transferred through an ecosystem;
- designing a game to show how oxygen is cycled through an agricultural ecosystem;
- drawing energy pyramids for selected ecosystems.

Assessment Examples

Teachers and students *could* assess the students':

- ability to distinguish the differences in cell structure, that is, cell wall, chloroplasts, vacuole, when the students sketch and label diagrams of typical plant and animal cells from microscopic observation;
- ability to use a classification key, when the students are asked to identify some given microscopic animals;
- ability to identify and relate adaptive features to survival, when the students write a report about the adaptations of rock crabs;
- understanding of the structure of the human digestive and circulatory systems, when the students assemble and label models of these;
- knowledge of the process of sexual reproduction, when the students describe the functions of labelled parts on diagrams of the human reproductive systems;
- ability to organise and present data, when the students construct graphs to present the results of measurements taken in class to illustrate variation in an inherited characteristic;
- knowledge of how carbon is transferred through an ecosystem, when the students draw a labelled diagram showing the components of the carbon cycle;
- ability to control variables, when they are testing their predictions about how temperature changes affect the rate of photosynthesis.

Making Sense of the Living World: Level 6

Achievement Objectives

Students can

1 investigate and describe examples of different types of helpful and harmful micro-organisms, *e.g., bacteria, fungi, viruses and diseases such as HIV/AIDS or leukaemia, bacteria and fungi in biotechnology;*

2/3 (a) describe cell division and explain how genetic information is passed from one generation to the next, *e.g., chromosomes and DNA, simple Mendelian genetics;*

(b) investigate examples of the contemporary application of genetics, *e.g., animal and plant breeding;*

4 investigate a New Zealand example of how people apply biological principles to plant and animal management, *e.g., hydroponically grown vegetables, fish farming, pine forestry, dairy farming.*

Sample Learning Contexts

Plant breeding • The zoo • Farming • Medicine • Te ngahere • Tōku whānau Orchards • Whanautanga • Whakapapa • Survival • Epidemics • Rongoā Biotechnology • Urban waste disposal • Plantation forestry • Hydroponics

Possible Learning Experiences

Students *could* be learning by:

- making yoghurt, using a starter culture, to test their predictions about the conditions needed for bacterial growth;
- designing and carrying out experiments to test the anti-microbial effectiveness of disinfectants;
- role playing some significant aspect of the work of Pasteur, Semmelweiss, Jenner, Lister, or Fleming to show how these people have contributed to our understanding of the impact of micro-organisms on our lives;
- investigating the DNA helix model, which won Watson and Crick the Nobel Prize, to show how the work of several scientists can be combined to increase our understanding;
- interviewing a plant or animal breeder about plant or animal genetics;
- investigating pandemics, such as HIV/AIDS, to to establish the nature of viruses and modes of virus transfer;
- investigating breeds of sheep that have been selected or bred especially for New Zealand requirements;
- working in groups to research and record the impact of fishing quotas on New Zealand's fishery resources;
- investigating the management of New Zealand's indigenous forests to find out about replanting programmes;
- growing lettuces hydroponically and investigating the effect of adding nitrate to the water.

Assessment Examples

Teachers and students *could* assess the students':

- ability to interpret experimental results, when the students write a consumer report based on their trials on the anti-microbial effectiveness of a range of disinfectants;
- ability to design and carry out experiments, when students test their predictions about the conditions needed for bacterial growth;
- understanding of cell division, when students describe the difference between cell division for growth and cell division for gamete production;
- ability to gather information, when the students prepare a report on breeds of sheep which have been bred for different physical conditions;
- investigation of an artificial environment for growing tomatoes, when the students design, construct, and use a simple hydroponic system;
- ability to carry out a "fair test", when the students investigate the effect of different planting densities on radishes.

Making Sense of the Living World: Level 7

Achievement Objectives

Students can

1. describe and explain the reasons for the special characteristics of New Zealand's plants and animals;

2. investigate factors that affect a living process, *e.g., physical factors of the environment, enzymes, hormones;*

3. describe processes that may lead to genetic variation, and understand the implications of these for plant and animal breeding, *e.g., mutation, crossing over during meiosis, dihybrid crosses, genetically linked diseases in humans; natural and artificial selection, genetic engineering;*

4. research and develop a defensible position, about a selected issue affecting the New Zealand environment, *e.g., population biology of fish, urban waste disposal, renewal of indigenous forests.*

Sample Learning Contexts

Digestion • Homoeostasis • Genetics • Farming • Whakapapa • Livestock industry • Forestry • Sports medicine • Tōku whānau • Water
Te ngahere a Tāne • Poultry farming • Energy management

Possible Learning Experiences

Students *could* be learning by:

- researching the reasons for the special character of the New Zealand bush;
- accessing and interpreting literature relating to the effect of New Zealand's geographical isolation on its endemic bird populations;
- finding out about enzyme activity by designing and carrying out controlled experiments;
- designing an experiment to discover the optimum temperature for starch digestion in the mouth;
- researching the introduction and cultivation of kumara to find out the importance of gene pools;
- drawing diagrams of a dihybrid cross in peas to illustrate concepts of variation;
- visiting a stud farm to find out about the breeding methods used;
- analysing various plant and animal family trees to discover the incidence of dominant, recessive, and incompletely dominant expression of inherited characteristics;
- visiting a horticultural propagation centre and observing the techniques used in propagation, e.g., orchid cloning, pine silviculture;
- visiting the diabetes clinic at the local hospital to find out about the incidence of diabetes in different racial groups;
- researching current biotechnological issues to become informed about a selected biotechnology, e.g., genetic engineering, reproductive technology, cancer research, HIV/AIDS research, food processing, brewing, waste treatment;
- collecting data about a local environmental or conservation issue by carrying out an investigation in the field;
- discovering from literature research, and by asking experts, the factors involved in the energy management of a particular resource;
- analysing data from MAF publications regarding shellfish populations on New Zealand beaches.

Assessment Examples

Teachers and students *could* assess the students':

- knowledge of the indigenous plants and animals of their local area, when the students carry out a field survey of a local ecosystem;
- skills in designing and carrying out a controlled experiment, when the students present an experimental report about an aspect of a living process;
- understanding of dominant, recessive, and incompletely dominant gene expression, when the students answer questions about inherited characteristics by interpreting a family tree;
- ability to present relevant information in an interesting way, when the students present an oral report about some aspect of plant or animal breeding;
- understanding of a topic and their ability to write a scientific article, when the students submit an essay on the significance of genetic technologies in plant and animal breeding;
- skills in collecting, analysing, and evaluating appropriate information and presenting a considered argument, when the students write a report about a current conservation issue with recommendations for action, e.g., deforestation, a polluted estuary, draining a wetland.

Making Sense of the Living World: Level 8

Achievement Objectives

Students can

1/2 carry out an extended investigation, involving a range of techniques, and originating from their own interests, into some aspect of, or issue related to, the Living World;

3 investigate and describe the diversity of scientific thought on the origins of humans;

4 make informed judgments involving the social, ethical, and moral considerations relating to contemporary biotechnological issues, *e.g., birth-related technologies, genetic engineering.*

Note: Teachers should recognise the opportunity for students to take an integrated approach to achieving objective 1/2 by combining their learning from this and other contextual learning strands in a single investigation. This approach could reduce the number of extended investigations students would carry out.

Sample Learning Contexts

Genetic engineering • Evolution • Survival • Agriculture • Kiwi
Research scientists • The Origin of Species • The Great Rift Valley • Food processing

Possible Learning Experiences

Students *could* be learning by:

- investigating the changing starch/sugar concentrations in germinating monocotyledonous seeds;
- investigating the presence of *E. coli* bacteria in the gut of shellfish from differently polluted areas of a harbour;
- investigating the effects of water availability on the growth of lupins, and exploring possible links between their findings and the distribution of lupins in a local habitat;
- investigating the diurnal and territorial behaviour of hedgehogs on a golf course;
- investigating a possible relationship between mating patterns of earthworms and prevailing soil and atmospheric conditions at a variety of sites;
- investigating the biological and chemical processes involved in the fixation of nitrogen by legumes;
- carrying out an integrated biological, physical, and chemical study of the relative efficiency of walking compared with running, in humans;
- holding a debate about evolution and critically evaluating the theories relating to this biological issue;
- investigating Jane Goodall's research into the behaviour of chimpanzees to find out about the life-style of a great ape;
- presenting a seminar about the discovery and suggested lifestyle of *Australopithecus africanis* to develop an awareness of its significance in current theories about human evolution;
- drawing a time line to show the development of the use of tools by people;
- researching the ethical implications of a current biotechnological issue, e.g., genetic engineering, reproductive technology, cancer research, HIV/AIDS.

Assessment Examples

Teachers and students *could* assess the students':

- ability to design, carry out research, interpret data, and reach conclusions, when the students determine the effect of heat on the successful germination of heat-tolerant plants;
- ability to select appropriate information and present it in an interesting way, when the students present seminars which explore the current theories about evolution;
- understanding of the significance of tool technology to human cultural evolution, when the students prepare and discuss an illustrated time line about the development of the use of tools by humans;
- ability to collect appropriate background information and to present a logical argument which takes into account ethical, moral, and social considerations, when the students present an essay about a current biotechnological issue.

Making Sense of the Physical World

Achievement Aims

In their study of the physical world, students will use their developing scientific knowledge, skills, and attitudes to:

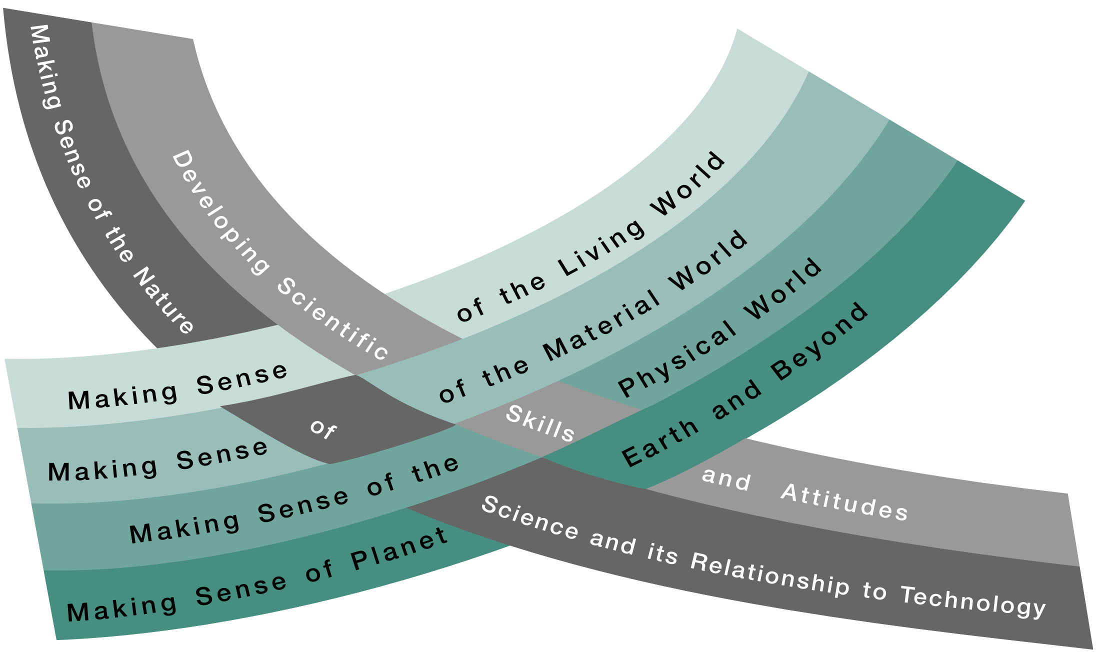
1. gain an understanding of the nature of physical phenomena from practical investigation and the consideration of scientific models;

2. establish scientific concepts of energy and investigate ways in which energy changes can be put to use;

3. explore and establish trends, relationships, and patterns involving physical phenomena;

4. explain how physical phenomena are used in everyday technology and how such technology affects people and their environment.

Physical phenomena to be studied include light, heat, sound, motion, electricity, and magnetism. A desired outcome of the study of these phenomena is an understanding of the interaction and close relationships between them in naturally occurring situations.



In their study of the physical world, students explore natural processes and physical phenomena associated with light, heat, sound, mechanics, electricity, magnetism, and other topics.

The learning emphasis is on a gradual progression of skills development. The emphasis in the first achievement levels is on students exploring and observing physical phenomena, developing the language skills to describe their experiences, and gaining increasing confidence in identifying and describing trends, relationships, and patterns. At later levels, these skills are extended to seeking and understanding more sophisticated explanations and more complex descriptions of relationships and patterns, including those found in measurements and graphs.

It is not expected that all topics will be covered in all classes. Topics chosen for development in primary classes should be those which immediately relate to the personal lives of the students (simple treatment of heat, movement, sound, and light phenomena) and widened for older students to include electricity as their interests extend beyond their personal lives.

It is important that individual schools' science schemes give an overall balanced coverage of the topics relevant to their students. It is not envisaged that all of the topics are covered at each particular level. It is through the content and contexts that the skills are developed. Indications of content coverage for levels 1 to 3, level 4, and levels 5 to 6 can be found on pages 76, 78, and 82.

Making Sense of the Physical World: Level 1

Achievement Objectives

Students can

1/2/3 share and clarify their ideas about easily observable physical phenomena, *e.g., heating, cooling, floating, sinking, magnetism, moving, sound making;*

4 describe uses of items of everyday technology, and, in simple terms, suggest how they work, *e.g., mechanical egg beaters, drills, playground equipment, wind-up toys, rubber bands, snips.*

Sample Learning Contexts

Shadows in the playground • Keeping ourselves warm • Maori musical instruments
Torches • Drying things • Making music • Floating and sinking • Pūoru
Magnets • Ko ahau • Ranginui • Tangaroa • Nga take o te ao • Kōrero

Possible Learning Experiences

Students *could* be learning by:

- making a plasticine boat to carry as many coins as possible;
- making a bottle orchestra to find the pattern that links water level and pitch;
- reporting on the fastest way to melt ice cubes in the classroom;
- making magnetic mazes, and timing students' performances with an egg timer;
- drying a wet cloth in different places around the school to establish the most suitable drying conditions;
- recording results of investigations into objects which float or sink;
- drawing, and talking about, a collection of common household appliances to clarify ideas about how they are used;
- helping establish rules for the safe use of electrical appliances;
- taking a turn at being classroom computer monitor;
- investigating ways of making a brick slide more easily down a gentle slope;
- stacking blocks to form an arch.

Assessment Examples

Teachers and students *could* assess the students':

- ability to identify the link between water level in a bottle and the sound produced when the bottle is tapped, when the students draw where the water level on a bottle would need to be in order to obtain high (and low) notes;
- ability to classify or compare, when the students make a chart of different objects in the classroom which are or are not attracted to a magnet;
- knowledge about the uses of technology, when the students explain how to operate a classroom cassette recorder to record and play back;
- ability to explain how a piece of technology is used, when the students describe what happens when a motorised toy is wound up and released;
- ability to identify the cutting action of a pair of snips, when the students draw a picture of them.

Making Sense of the Physical World: Level 2

Achievement Objectives

Students can

1/2 investigate and describe their ideas about some everyday examples of physical phenomena, *e.g., pushes and pulls, magnetism, electricity, heat, light, sound;*

3 explore trends and relationships found in easily observable physical phenomena, *e.g., colour and heat absorption, flotation and lightness in relation to size, shadow length and time of day;*

4 describe, in simple terms, how items of everyday technology work and affect our lives, *e.g., pens, compasses, cranes, toasters, bicycles, skateboards, oars.*

Sample Learning Contexts

Wind and water • Keeping warm • Bubbles • Toys • Making our own band
Transport • Making work easier • Turning corners • Cooking • Space
How much does it weigh? • Sensing things • Nga mahi • Waka • Ko ahau
Te wera, te mātao

Possible Learning Experiences

Students *could* be learning by:

- using easily available materials, such as rulers, combs, grass, leaves, tissue paper, to play a simple tune;
- building a leaning tower which only just fails to topple;
- reading about the role of electricity in producing light and heat;
- making a string telephone, and writing directions for its use, to explore the conditions in which sound travels;
- constructing simple circuits to make light bulbs glow;
- using a catapult to send marbles up a slide, and observing the effect of "stretch" on the distance a marble goes up a slope;
- dressing puppets, when finding out about how people keep warm or cool in extreme weather conditions;
- working in groups in the playground to draw chalk outlines of children's shadows at different times of the day;
- conducting "fair tests" on the temperature of different coloured objects placed in the sun;
- investigating where different children need to sit in order to balance a seesaw;
- graphing temperature changes in different places and on different days to establish patterns;
- using unconventional measures, such as thicknesses of paper, to test the brightness of different torches;
- measuring the strength of a magnet, using numbers of paper clips;
- working in groups to describe how different types of writing instruments work;
- asking adults to describe how a toaster works;
- drawing pictures of their bicycles to show how the pedals and wheels are connected;
- dismantling an old toaster and following the path of electrical wires inside it;
- comparing pictures or examples of oars for their shape and size.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of how sound can be produced, when the students draw diagrams and write simple explanations of how five different musical instruments work;
- ability to plan an investigation, when the students explain how they would use simple equipment to test for the best material for making a handle for a soup stirrer;
- ability to describe how a person must have been standing in order to produce a particular shadow outline at a particular time of day, when the students demonstrate this;
- ability to communicate, when the students report on an investigation to find out the common characteristics of objects that float;
- ability to evaluate their work, when the students make simple weighing devices and compare them with commercial scales;
- understanding of the basis for an everyday technology, when the students identify uses for magnets around their home;
- understanding of the use of an everyday technological item, when the students explain how wheelchairs assist disabled people to move about.

Making Sense of the Physical World: Level 3

Achievement Objectives

Students can

1/2 investigate and describe their ideas about some commonly experienced physical phenomena to develop their understanding of those phenomena, *e.g., temperature, simple electric circuits, motion, evaporation rates, movement down slides, heat conduction;*

3 explore and identify trends and relationships associated with easily observable physical phenomena, *e.g., speed and stopping distance, bounce and type of ball, flexibility and thickness, bulb brightness and number of cells;*

4 investigate and describe how selected items of everyday technology work and affect our lives, *e.g., mechanical toys, torches, inertial seat belts, burglar alarms, garment insulation.*

Note: By the end of year 6 (standard 4), students should have had learning experiences with light, sound, motion, magnets, and simple electrical circuits involving batteries and bulbs.

Sample Learning Contexts

Toys • Flight • Electricity around us • Music • Moving fast • Shifting water
Staying healthy • How hot is it? • Slipping and sliding • Maori ball games
Falling and flying • Is it safe? • Tāwhirimatea • Mīhini hou • Rerenga

Possible Learning Experiences

Students *could* be learning by:

- compiling a list of instructions for making and using a siphon, along with suggested explanations for why it works in this way;
- constructing simple air thermometers and recording temperatures at different times of the day;
- making Cartesian divers and speculating on reasons why they work;
- finding out about the bounce time of a different number of pupils on a trampoline;
- designing and making simple rubber-band-driven devices and testing their performance;
- investigating the behaviour of falling objects and ways of slowing their fall, e.g., paper parachutes;
- comparing the heat build up in cars parked in the sun when they have their windows either open or closed;
- investigating the bounce height of different balls;
- measuring the apparent loss of weight of a stone in water to gather information on buoyancy;
- writing an explanation of how a water clock works after they have made their own timepieces;
- investigating the connection between the key and the movement of a wind-up car;
- taking a torch to pieces to find out how the bulb is connected to the battery;
- questioning an electrician about the insulation of electrical equipment.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of expansion, when the students explain how a thermometer works;
- ability to work co-operatively in groups, when the students investigate the grip of different types of shoe soles;
- interpretation skills, when the students produce a group report on their findings on the insulation of different materials;
- ability to construct a kite which is easy to launch and control, when they demonstrate how it flies;
- ability to test and record the bounce heights of different types of balls, when they carry out a planned investigation;
- reporting skills, when the students carry out individual studies of how a toy works and report back to the class;
- understanding of how to make a torch bulb glow, when the students present an explanation of their simple circuit for a torch;
- information-gathering skills, when the students write stories about how wool clothes keep them warm in winter after they have done research on the topic;
- ability to link new and old ideas, when the students consider the effects of an electrical power "blackout" lasting two days;
- design and appraisal skills, when the students construct their own torch and compare it with a commercial one.

Making Sense of the Physical World: Level 4

Achievement Objectives

Students can

1/2 investigate and offer explanations for commonly experienced physical phenomena and compare their ideas with scientific ideas, *e.g., sound notes and tones, light and lenses, colours, electric current, condensation, force, speed;*

3 process and interpret information to describe or confirm trends and relationships in observable physical phenomena, *e.g., brightness of lamps in circuits, temperatures of insulated and non-insulated cans, magnetic strength over distance;*

4 investigate and offer explanations of how selected items of technology function and enhance everyday activities of people, *e.g., telephone, switch, spectacles, devices which open supermarket doors, bicycle tyres, bicycle helmets.*

Note: By the end of year 8 (form 2), students should have had learning experiences with light, including mirrors, prisms, and colour; heat absorption and conduction; force as a cause of change in motion; and applications of simple circuits, including torches.

Sample Learning Contexts

Technology all around • Science in the media • Life made easier • Out in space
Falling and flying • Keeping it cool • Is it time? • Counting things fast
Who invented that? • Building and construction • Seeing things
How do they make...? • Communication • The future • Fun with wheels •
Pōtaka Heketanga • Mīhini hou

Possible Learning Experiences

Students *could* be learning by:

- describing how a stick appears bent when it is partially submerged in water to investigate refraction;
- finding which metal from a given sample would be most suitable for making a saucepan;
- investigating the movement of living things, e.g., people walking, running; birds flying, paddling; fish swimming;
- checking out estimations of the weight and volume of different objects by using standard measuring equipment;
- working in groups to find a simple circuit system to use to light a model house;
- working in groups to describe the degree of magnification of different magnifying glasses and of water drops;
- designing and making a poster that illustrates how a telephone works;
- carrying out individual investigations into the workings of no-longer-functioning (and safe) electrically powered devices;
- presenting a group report on a visit to a local factory which makes an item of everyday technology.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of how light helps people see, when the students draw a diagram showing their ideas of how light travels from the sun to help a person see a tree;
- ability to work in a group, when they investigate and report on the effectiveness of group-made timing devices;
- ability to review their work, when the students explain and evaluate their group's attempt to make a package to slow the melting of an ice cube;
- ability to communicate, when individual students investigate and present a report on how a mechanical toy works;
- research skills, when the students find out details about the inventor and invention of an item of everyday technology, such as a telephone.

Making Sense of the Physical World: Level 5

Achievement Objectives

Students can

1. carry out simple practical investigations, with control of variables, into common physical phenomena, and relate their findings to scientific ideas, *e.g., energy content of fuels, reflection/refraction, electromagnets, forces and motion, simple electrical circuits, wave motion;*

2. describe various ways in which energy can be transformed and transferred in our everyday world, *e.g., rockets, electric blankets, hair driers;*

3. investigate and describe the patterns associated with physical phenomena — some patterns may be expressed in graphical terms, *e.g., links between voltages and currents in circuits, heat and temperature, forces and simple levers;*

4. investigate how physical devices or systems can be used to perform specified functions, *e.g., an arch to support a bridge, a moisture tester for house plants, light-emitting diodes as off/on indicators.*

Sample Learning Contexts

Cooking • Road safety • Use of electronics • Greenhouses • Waea kōrero • Toys Electrical wiring in cars • Technology in the home • Pouaka whakaata Nga mīhini • The energy crisis • Building • Dams • Weather and climate Earth’s moving crust

Possible Learning Experiences

Students *could* be learning by:

- investigating the factors which affect the strength of a simple electromagnet;
- making a human shape from cardboard and using a plumb-line to find the position of its centre of gravity;
- working as part of a group to construct a circuit which will use a relay to switch on an electric motor;
- comparing the efficiency of cooking food with different sources of heat by graphing results of boiling water using gas and electricity;
- making a survey of local energy sources and describing people's energy management of these resources;
- describing the pattern of results formed from graphing the effects of applied forces on a spring;
- investigating and reporting on the ways pulleys can be used to lift large weights;
- researching and reporting on the effectiveness of traditional Maori methods of making fire;
- using electrical meters to make measurements of voltage and current in series and parallel circuits, when wiring circuits to light a model house;
- drawing ray diagrams to illustrate the reflection of light from plane and curved mirrors, when investigating the production of optical illusions using reflection of light;
- determining the mechanical advantage of a wheelbarrow in lifting weights by measuring its relevant dimensions and the force of weight and effort in a typical load;
- constructing a simple electronic circuit to be used as a moisture detector for household plants.

Assessment Examples

Teachers and students *could* assess the students':

- ability to control variables in an investigation to determine magnetic strength, when the students construct electromagnets;
- ability to identify the energy transformations occurring in a list of given situations, when the students write answers to test questions;
- ability to collect and analyse data from a variety of sources, when the students present a report on local energy resources;
- ability to draw a graph competently, when the students plot values of extension and load for a spring;
- ability to relate a knowledge of chemistry to their design of a device, when they explain the operation of a moisture detector;
- problem-solving ability, when the students design and construct alternative model bridge spans to carry a given load.

Making Sense of the Physical World: Level 6

Achievement Objectives

Students can

1 carry out practical investigations, with effective control of variables, into common physical phenomena, and relate their findings to scientific theories, *e.g., force and acceleration, insulation, heat capacity of different materials;*

2 demonstrate an understanding of the applications of energy and its transfer and transformation, *e.g., heat transfer, kinetic and potential energy;*

3 investigate and establish patterns in physical phenomena and make useful predictions, *e.g., voltage and current, braking distances under different circumstances, heat retention of various materials, heat and temperature change, food requirements and body shape of animals;*

4 investigate and report on how physical principles are used in some common household appliances, *e.g., a sewing machine, refrigerator, cake mixer, lawn mower, transistor radio, "walkman".*

Note: By the end of year 11 (form 5), students should have had learning experiences with the formation of images, forms of energy, heat transfer, balanced and unbalanced forces, motion, and simple electrical circuits.

They should be starting to use the language of physicists, including the terms: mass, weight, momentum, acceleration, velocity, force, work, power, voltage, current, and resistance.

Sample Learning Contexts

Lighting systems • Cycling • Local industry • New Zealand's power supply
Skindiving • Transport • Waiora • Simple technology in the home and school
Stereos • Āniwaniwa

Possible Learning Experiences

Students *could* be learning by:

- designing a "fair test" on the insulating properties of neoprene material used in wetsuit design;
- setting up appropriate circuits to measure voltage and current through a variety of conductors (resistors, lamps, diodes) and graphing and interpreting the collected data;
- performing experiments to find the braking distance of a bicycle on a variety of surfaces, and relating these results to the energy transformations involved;
- working as part of a group to produce a presentation to peers on the wave nature of sound;
- preparing an article for a local newspaper explaining appropriate clothing for farmers and others who might have to defend their homes against bushfire;
- determining resistance values from current measurements and comparing these with the values indicated by the colour codes of the resistors being used;
- graphing and interpreting data obtained by heating water or cooling paraffin wax;
- investigating which kind of stones have the best heat retention when building a hāngi;
- calculating the power output of a class member during experiments involving press-ups, sit-ups, and running up stairs;
- carrying out a research project on the working of a television;
- drawing a chart showing how a sewing machine makes a zig-zag stitch.

Assessment Examples

Teachers and students *could* assess the students':

- ability to co-operatively plan a "fair test", when the students, in a small group, design an experiment to investigate heat losses from different coloured surfaces;
- knowledge of the behaviour of sound, when the students explain how astronauts can communicate on the moon;
- ability to identify relevant factors of heat insulation, when the students describe the construction of a thermos flask;
- ability to describe the relationship between recorded readings, when the students work in groups to analyse the voltage and current values obtained for a resistor;
- ability to mathematically interpret data, when the students perform calculations on personal power output from running up stairs;
- ability to plan methods of observation, when they suggest ways of making it easier to see how household appliances operate;
- understanding of the design and use of a thermostat, when the students answer written questions.

Making Sense of the Physical World: Level 7

Achievement Objectives

Students can

1. negotiate and carry out a systematic practical investigation of their own choice into some relevant aspect of their physical world, and link their explanations with relevant physical concepts;

2. apply their ideas of energy to novel situations, *e.g., movement of a roller coaster, rocketry, energy pollution;*

3. investigate and deduce patterns in physical phenomena and make useful predictions — some patterns may be expressed in symbolic and numerical terms, *e.g., lifting ability of helium balloons, historical data on weather;*

4. understand the principles involved in some technological device or new development in technology, *e.g., super conductivity, remote controls, cellular phones, microwave ovens.*

Sample Learning Contexts

Mīhini hou • Computers • Helping people with disabilities • Mahi ngahau
Telecommunications • Medicine • Astronomy • Science awards • Transport
Home technology • Safety in the home

Possible Learning Experiences

Students *could* be learning by:

- preparing a project plan for a practical investigation of their own choice;
- investigating how the angle of take-off affects the jumping distance of a long jumper;
- dismantling and explaining the working of a motor or engine;
- debating "Solar panels are the best form of home heating";
- interviewing a Maori historian to find out how observation of ocean waves was used by Maori travellers for navigation;
- finding a relationship between the diameter of a capillary tube and the height a liquid rises up a tube;
- gathering and analysing data from an experiment investigating the heating effect of a microwave at different power settings;
- writing a letter to a friend that outlines the ways in which superconductors could revolutionise methods of transport;
- researching and reporting on the relative merits of different systems used in telecommunications, e.g., landline, microwave links, communication satellites;
- reading resource material and reporting on the principles involved in the working of a hearing aid;
- visiting a local Telecom division to find out about the uses of fibre optics in telecommunications;
- designing a poster that illustrates how to make reading glasses which compensate for long-sightedness;
- evaluating and reporting the evidence relating to the safety of microwave ovens.

Assessment Examples

Teachers and students *could* assess the students':

- ability to plan and carry out an investigation, when the students carry out a systematic investigation into different fabrics to justify the most suitable fabric for use in making flameproof nightclothes;
- ability to apply the principle of energy conservation, when describing the motion of a roller coaster;
- ability to perform numerical calculations, when analysing data on measured intensity of illumination at different distances from a light bulb;
- knowledge of energy absorption in collisions, when the students make a report on safety features in cars;
- ability to reach valid conclusions, when the students analyse data for different batteries to determine which battery is best for use in a "walkman";
- use of relevant sources of information, when explaining the general operation of a cellular telephone network;
- knowledge of the use of fibre optics in medicine, when the students give a class presentation.

Making Sense of the Physical World: Level 8

Achievement Objectives

Students can

1 carry out an extended investigation, involving a range of techniques, originating from their own interests into some aspect of, or issue related to, the Physical World;

2 clarify ideas on the applications and uses of the effects involved in the transfer and transformation of energy, *e.g., motors, compact disc players, solar panels, CT scanners, on the sports field;*

3 gather, analyse, and evaluate data of increasing complexity about physical phenomena — evaluation may include some more complex symbolic and numerical patterns, *e.g., absorption of beta particles by aluminium, data obtained for the cooling of a cup of tea, manufacturer's specifications for a light-dependent resistor;*

4 explain how physical phenomena are used in some examples of everyday technology and how such technology affects people and their environment, *e.g., a temperature alarm for a child's bedroom, a child's safety seat for a car, an electronic egg timer, a "robotic" arm to help a person with a physical disability.*

Note: Teachers should recognise the opportunity for students to take an integrated approach to achieving objective 1 by combining their learning from this and other contextual learning strands in a single investigation. This approach could reduce the number of extended investigations students would carry out.

Sample Learning Contexts

Solar power • Houses of the future • Helping people • Physics of sport
Information technology • Nuclear hazards • Scientists at work
Science award schemes • Weapons • Mīhini hou

Possible Learning Experiences

Students *could* be learning by:

- testing the strengths of various timbers — deciding on variables, their control, and how to test in the best way;
- determining the effectiveness and safety of a range of commercial smoke detectors;
- investigating a medical use of nuclear technology;
- investigating the biophysics and biochemistry of vision in insects;
- designing, constructing, and testing a solar-powered device;
- investigating the effect of temperature on the bounce factor of a squash ball;
- examining the strength and structure of wool fibres twisted in various ways;
- using video to investigate the speed and spin of a moving ball;
- visiting a radiography department in a hospital to see how X-ray machines work and being briefed on energy changes in the body due to X-rays;
- analysing the action of a shot-putter in terms of energy transfer;
- reading articles from a science magazine in preparation for a class seminar on the hazards associated with nuclear waste;
- gathering and plotting data to decide on how the bending of a beam depends on applied weight or other variables;
- observing a Geiger counter response to alpha, beta, and gamma ray sources;
- designing and making a model magnetic door lock;
- evaluating the relative merits of alternative energy systems, including the wise use of available energy resources;
- designing and testing a method of improving the heat retention in a house.

Assessment Examples

Teachers and students *could* assess the students':

- ability to plan and organise scientific investigations effectively, when the students present a project diary;
- ability to use physics principles, when explaining the results of an investigation into the relationship between the thickness of the legs of quadrupeds and the quadrupeds' weight;
- understanding of the energy changes involved in the operation of a fluorescent tube, when they provide explanatory notes to support a seminar on this topic;
- ability to reach a useful conclusion, when the students evaluate data on different windmill designs in order to recommend a particular design for use by a farmer in their local district;
- ability to determine a numerical relationship, when they process and analyse measured data relating to the natural vibration frequency of a piece of wire and its length;
- ability to evaluate the relative merits of testing nuclear weapons in the South Pacific, when the students participate in a group debate;
- ability to make a considered judgment, when they draw conclusions about the safest child's car seat based on measured data and criteria about safety;
- understanding of the physical principles associated with an everyday technological object or process, when the students describe the possible effects of electromagnetic radiation from household appliances.

Making Sense of the Material World

Achievement Aims

In their study of the material world, students will use their developing scientific knowledge, skills, and attitudes to:

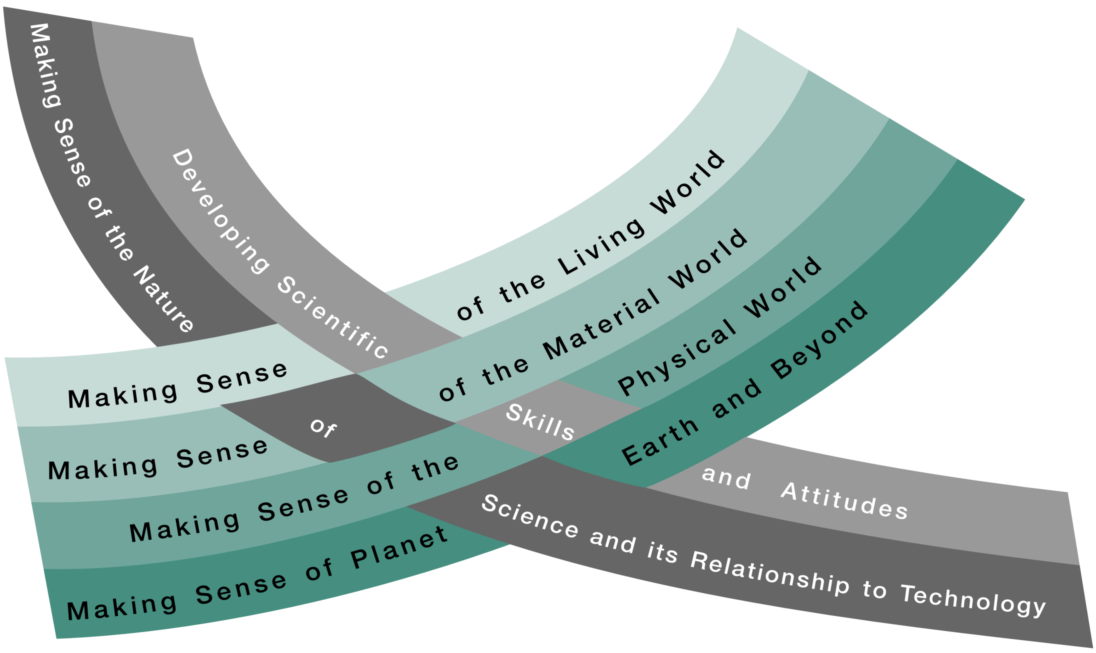
1. investigate the nature and properties of substances, identify patterns in these properties, and understand why chemists group substances in the ways they do;

2. apply their knowledge of the properties of substances to the safe and appropriate use of these in the home, in industry, and in the environment;

3. investigate reactions, and applications of these, in chemical processes;

4. make informed decisions about the interrelationship of chemical substances and processes, with technology, people, and the environment.

The substances that are to be studied are those materials that are relevant to the lives of students. However, at times, the range of substances studied may include previously unfamiliar substances that are appropriate to the continuing learning needs of students.



In their study of the material world, students will become aware of the nature and behaviour of materials.

The learning emphasis is on developing a knowledge and understanding of materials which are directly involved in the lives of people as individuals, as members of local communities, and as New Zealand citizens.

The development of an understanding that all materials, natural and manufactured, are chemical substances. Students need to become aware of the beneficial effects of materials and of possible environmental problems when they are not used in a safe, appropriate, and responsible manner.

Making Sense of the Material World: Level 1

Achievement Objectives

Students can

1 explore simple physical properties and use them to describe and group everyday materials, *e.g., shape, texture, colour, size, and smell;*

2 clarify and communicate their own ideas on appropriate choices of materials for familiar activities based on simple, easily observable properties, *e.g., clothing for wet weather; shoes for walking, running, and working; toys for bath-time;*

3 investigate how familiar materials change when heated or cooled, *e.g., water, meat, eggs;*

4 talk about the use of familiar technology in the home to change or preserve materials, *e.g., cooking and using stoves, cooling and using refrigerators.*

Sample Learning Contexts

Plastics • Garden • Kāinga • Baking rēwena • Shopping • Garage • Kitchen
Rubbish dumps • Swimming • Kai • Hī ika • Camping

Possible Learning Experiences

Students *could* be learning by:

- interpreting a simple graph, made by the class, of the items in a class activity box to develop the skills of identification and grouping of materials;
- sorting objects in the classroom, using simple headings, such as paper, glass, wood, and plastic;
- identifying and categorising objects, using “feely” bags;
- choosing appropriate materials to make a model of an animal from a range of given materials;
- working in a small group to devise a set of questions to ask an expert, such as a dental therapist, health nurse, gardener, builder, baker, or engineer about the materials they use in their work;
- investigating the best materials people could use to wrap either takeaway fish and chips or an ice block which is to be brought home;
- looking at what happens to ice blocks when they are left in the sun;
- clarifying ideas on the ingredients that are needed to bake biscuits during a shared reading of a recipe;
- baking bread, or making flavoured ice blocks, to show how some materials change with changing conditions;
- drying flowers, by using a press, to see how things change when they are dried;
- making paper from newsprint to clarify ideas on appropriate devices needed for its production;
- investigating how things kept in a refrigerator stay fresh longer than if they are kept in a warm room.

Assessment Examples

Teachers and students *could* assess the students’:

- understanding of the properties of an object, when the students describe it in terms of shape, colour, texture, size, and smell so that it can be recognised by a classmate;
- understanding of the simple properties of some materials, when the students select from a range of materials, e.g., boxes, bottles, blankets, those suitable for building a model bridge;
- knowledge of how a common substance can change, when the students draw a picture of what happens when an ice cube is left out of the freezer;
- understanding of appropriate technology to preserve materials, when the students select pictures or photographs of food and explain where each item should be stored.

Making Sense of the Material World: Level 2

Achievement Objectives

Students can

1 group familiar objects, using observable physical properties, *e.g., how hard, how flexible, whether it floats;*

2 investigate and communicate differences in the properties of similar types of materials;

3 investigate and describe everyday changes to common substances, *e.g., evaporation, condensation, dissolving, melting;*

4 use simple technology to demonstrate and explain methods which prevent or promote change in materials, *e.g., food preservation, painting, cooking.*

Sample Learning Contexts

Fridges and freezers • Housework • Swimming pool • Taha moana • Plastics
Hāngi • Classroom materials • Rocky shore • Building sites • Playground
Nga toa hokomaha • Kitchen • Local manufacturing • Flying • Paper in the home

Possible Learning Experiences

Students *could* be learning by:

- predicting, and then recording, whether a range of objects will float or sink as an exercise in the grouping of materials;
- grouping plastics, metals, wood, powders, etc., according to properties such as hardness, flexibility, solubility, or lustre;
- working in groups to investigate different properties, such as the strength of wet and dry paper towels;
- surveying and reporting on the properties of commonly used plastics in the classroom;
- investigating common types of physical change, e.g., dissolving sugar in drinks, making jelly, melting ice;
- making popcorn to observe and describe a way that heat promotes change;
- predicting the effect of leaving different foods in the sun, and working in groups to plan and carry out a "fair test" based on their predictions;
- exploring condensation by writing in the condensation on a window or breathing on a cold mirror and offering explanations for what is happening;
- reading about how people prepare and spin wool to make clothes and carpets;
- using their senses, e.g., smell, to monitor the changes in milk which is refrigerated compared with milk which is left in a warm room.

Assessment Examples

Teachers and students *could* assess the students':

- ability to categorise objects, when the students group a set of objects and justify their decisions;
- understanding of the difference in the properties of similar types of materials, when the students carry out and chart the results of a test to determine the best cloth for mopping up a liquid spill;
- understanding of changes to everyday substances, when the students make a poster showing common substances that are soluble or non-soluble in water;
- ability to investigate the condensation which occurs, when the students have observed condensation forming on an ice-filled jar;
- understanding of ways to prevent change in substances, when the students select from a list the items which should be stored in the refrigerator and explain the reasons for their choice.

Making Sense of the Material World: Level 3

Achievement Objectives

Students can

1. investigate and describe ways of grouping a wide range of unfamiliar materials, using readily observable properties;

2. investigate and describe how the physical properties of materials are related to their use, *e.g., fabrics, metals, and plastics;*

3. investigate and report on temporary and more permanent changes that familiar materials undergo, *e.g., making butter, baking cakes;*

4. research the use and purpose of technology in the disposal, or recycling, of some common materials, *e.g., waste oil, paper, plastics, glass.*

Sample Learning Contexts

Kai tohungia • Cooking • Colours, dyes, and paints • Household packaging Nga tae • Toys • Cleaning • Preserving food • Cars • Fishing • Nga rā makariri Fire stations • Supermarkets • Bathrooms • Cold days

Possible Learning Experiences

Students *could* be learning by:

- visiting a local furniture manufacturer to identify the materials used in the production process;
- designing and testing a container to keep a drink hot or cold, to explore the physical properties of materials;
- consulting a kaumātua regarding the best sort of heating material to use in a hāngi;
- investigating the physical properties and uses of flax;
- investigating the use of rubber bands;
- investigating suitable materials for use in making jewellery;
- using muka to weave bands, then testing their strength;
- boiling an egg to investigate change;
- shaking cream to make butter and describing the changes observed;
- making a crystal garden;
- making hokey pokey to explore ways substances change;
- slowly evaporating a sugar or salt solution to dryness;
- researching the effects of household acids, such as vinegar, on kitchen equipment or building materials;
- visiting a local recycling plant;
- making recycled paper;
- identifying methods for making compost by reading books or by interviewing experts at a local plant centre;
- finding out about what happens to bottles after they are put in glass recycling bins;
- making a poster about the plastics recycling code to display around the school;
- collecting household items made of different plastics and grouping them according to the plastics recycling code;
- interviewing a member of a local waste disposal company to find out their method of disposal of a particular chemical.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of physical properties, when the students group given materials, explaining their criteria for the grouping;
- ability to relate the uses of materials to their physical properties, when the students select, with explanation, appropriate materials from which to make a school bag or a bicycle;
- understanding of temporary and more permanent changes, when the students record their before and after ideas on the effect that heat has on a range of materials, such as candle-wax, eggs, butter, bread, or sugar;
- ability to find out information, when the students use information from the school library to report on the sources of materials which make up their clothes, classroom equipment, etc.

Making Sense of the Material World: Level 4

Achievement Objectives

Students can

1. investigate and group common materials in terms of properties, *e.g., solubility, melting points, acidity, conductivity;*

2. investigate and explain how uses of everyday materials are related to their physical and simple chemical properties, *e.g., fabrics, metals, plastics, household substances;*

3. investigate and describe ways of producing permanent or temporary changes in some familiar materials, *e.g., heating, mixing two or more substances;*

4. investigate the positive and negative effects of substances on people and on the environment, *e.g., petroleum products, fertilisers, acid rain.*

Note: Distinctions between physical and chemical properties and physical and chemical change are not an expected outcome at this level.

Sample Learning Contexts

Consumer science • Pottery • Sewage disposal • Kitchens • Taha tinana
Earth, soils, and rocks • Cooking • Papatuanuku • Refuse centres

Possible Learning Experiences

Students *could* be learning by:

- classifying the items found in the art cupboard at school by their physical properties;
- using extracts of flowers to investigate the colour changes which occur when common household substances, such as ammonia, baking soda, vinegar, or bleach are added;
- reading and summarising a *School Journal* article on preventing corrosion on a metal bridge;
- comparing the effectiveness of commercial insect repellent to that of kawakawa leaf extract;
- finding out about the safe use of some common household materials;
- devising the most effective way to cool a hot cup of tea;
- investigating the rusting of iron to explore ideas on permanent change;
- examining the effects of heat on materials to observe changes;
- visiting a recycling plant or sewage disposal plant to observe waste disposal methods;
- surveying and reporting on the solid forms of pollution on a local recreation area;
- using the results of their own investigations to debate the effect of chemical use on the local environment;
- interpreting a chart depicting the hazards of certain chemicals and procedures in case of accidents or spills.

Assessment Examples

Teachers and students *could* assess the students':

- ability to group common substances, using a simple property, when the students do a home project using cold tea to test the acidity of various household substances;
- understanding of how the use of everyday materials is related to their properties, when the students test the strength of fibres;
- understanding of the effect of combining familiar substances, when the students report on their observations before and after adding baking soda to vinegar;
- understanding of the impact of a waste material on the environment, when the students write a letter to the local council suggesting ways to improve the local environment;
- understanding of the environmental and economic issues involved, when the students research and write an article for a newspaper on the impact of a local industry.

Making Sense of the Material World: Level 5

Achievement Objectives

Students can

1 (a) investigate familiar substances and describe, using the concept of the particle nature of matter, how they may exist as solids, liquids, and gases, *e.g., water, candle wax;*

(b) distinguish between elements, compounds, and mixtures, using simple chemical and physical properties, and describe a simple model of the atom;

2 apply their knowledge of chemical and physical properties of substances to investigate their safe and appropriate use in the home and the community, *e.g., swimming pool chemicals, oven cleaners, fuels;*

3 investigate some important types of substances and the way they change chemically in everyday situations, *e.g., metals, acids, bases, fuels;*

4 research and describe how selected materials are manufactured and used in everyday goods and technology, *e.g., plastics from fossil fuels, glass from sand, paper from wood.*

Note: Students should be starting to use the "language" of chemists, that is, symbols of elements and formulae of simple molecules and compounds.

Sample Learning Contexts

Nga take o te ao • Chemist shop • Fibres, fabrics, and clothing • Hardware
Petrol station • Laundry • Health and me • Using harakeke • Toolshed
Oranga tinana • Cosmetics • Safety with fires

Possible Learning Experiences

Students *could* be learning by:

- photographing local telephone or power lines in winter and summer and observing differences;
- researching actions of solvents and establishing their potential danger when abused by people;
- making and tasting sherbert mixtures to gain an understanding of the reaction of acids and bases;
- working co-operatively in groups to make casein glue, and comparing it with commercial adhesives;
- investigating the use of mordants in dyeing fabrics;
- finding out about the use of sacrificial metals in the boating industry;
- extracting a natural indicator from red cabbage and using it to test the pH of a range of household acids and bases;
- making hokey pokey and identifying what is happening chemically when the baking soda is added;
- investigating the chemicals produced when a candle burns;
- examining the effect of acids and bases on a wide variety of common substances, such as plastics, glass, concrete, marble, gravel, "tin" cans, nails;
- finding out about the paper-making process at a paper mill in New Zealand;
- preparing a classroom poster showing the chain of "events" in the process "from Sun to plastic food-wrap";
- comparing (by properties, appearance, and cost) the use of plastic and glass to make kitchen utensils;
- gathering information on the processes of glass manufacture through literature searches and by visiting glass production industries.

Assessment Examples

Teachers and students *could* assess the students':

- ability to communicate ideas, when they explain their diagrams which represent the arrangement of particles in a candle, in molten wax, and in wax vapour;
- classification of substances as compounds or mixtures, when the students draw particle diagrams;
- understanding of the division of elements into two broad groups, when the students shade in a blank of the periodic table indicating the positions of the metals and non-metals;
- understanding of the care needed in storing substances around the home, when the students produce a poster illustrating this;
- understanding of the difference between chemical and physical change, when the students group, from a list of situations, those that involve physical and/or chemical changes;
- knowledge of the process of neutralisation, when the students are able to prepare common salt from dilute solutions of hydrochloric acid and caustic soda;
- ability to communicate their ideas clearly, when the students give a talk on the impact of a technological advance, e.g., bicycle frames, surfboards, tennis racquets;
- information-gathering skills, when the students carry out an information search on the production of plastics from fossil fuels.

Making Sense of the Material World: Level 6

Achievement Objectives

Students can

1 investigate and understand how familiar chemical substances can be grouped into families which have characteristic chemical properties;

(Metals and common metal compounds such as oxides, hydroxides, and carbonates; non-metallic oxides; hydrocarbons and simple alcohols should be studied.)

2 investigate and relate the physical and chemical properties of a family of substances to their use in the home and the community, *e.g., carbonates, bases, acids, metals;*

3 investigate and understand factors that affect chemical processes, *e.g., factors affecting changing rates of reactions;*

4 investigate and describe the applications and effects of chemical processes in everyday situations, *e.g., corrosion, cosmetic manufacturing, dyeing, petrochemicals.*

Note: Students will be starting to develop ideas about chemical bonding at this level.

Sample Learning Contexts

Forensic science • Pounamu • Plastics • Wine making • Electroplating • Cars
Supermarkets • Fuels • Science, technology, and medicine • Toa hoko parāoa
Dyes and dyeing • Nga kai kōpiro • Piupiu making

Possible Learning Experiences

Students *could* be learning by:

- identifying the carbonates from a range of compounds;
- using chemical formulae to represent chemical compounds, such as laboratory acids and bases, to increase their understanding of chemical language and symbols;
- designing an experiment, and reporting findings, on the effectiveness of a variety of commercial antacids to learn how to make the measurement of the volume of an acid required to neutralise an antacid;
- carrying out an experiment which demonstrates the relative reactivities of a range of common metals and linking these results to the common usage of these metals;
- examining the labels of various household products and using their knowledge of the properties of chemicals to link the substance to their stated function, e.g., strong alkalis to clean fats from ovens or drains;
- observing and discussing a teacher's demonstration of the decomposition of hydrogen peroxide using potassium dichromate as a catalyst in the presence of a detergent;
- investigating the rate of reaction of a whole Redoxin tablet in water compared with a ground tablet in water;
- preparing metallic lead by dipping a glowing matchhead into red lead;
- exploring carbon compounds and fuels to learn about everyday uses of petrochemicals;
- interviewing a boat manufacturer about the use of sacrificial metals on boats;
- investigating and comparing the use of mud and commercial dyes in dyeing piupiu to investigate an application of chemical change.

Assessment Examples

Teachers and students *could* assess the students':

- ability to use an identification test for carbonates, when the students identify the carbonate compound from a group of unknowns;
- ability to recognise common acids, when they name several common acids found at home and in the laboratory;
- understanding of the different classes of compounds, when the students demonstrate the similarity in reactions of a group of common acids;
- understanding of written formulae, when the students identify the type and number of different atoms in a variety of formulae;
- understanding of how the uses of materials are related to their properties, when the students describe the materials they would use to make a can crusher and justify their choice of materials;
- skill at gathering information, when the students present a report on a chemical that is manufactured locally;
- understanding of the application of reactions in everyday situations, when the students investigate and report on the role of baking powder in baking;
- practical skills, when they carry out an investigation into the factors affecting the rates of a chemical reaction;
- understanding of the reactions involved, and factors which affect these, when the students write instructions for a new bike owner on "Preventing rusting";
- understanding of the impact of technology on people and the environment, when the students tell a peer about the pros and cons of using sprays on fruit trees.

Making Sense of the Material World: Level 7

Achievement Objectives

Students can

1. investigate and explain the characteristic chemical and physical properties of one group of commonly used substances, *e.g., fertilisers, foods, perfumes, fuels, cosmetics, organic polymers;*

2. investigate and relate the physical and chemical properties of a family of substances to their use in industry, *e.g., fertilisers, fuels, organic polymers;*

3. research chemical processes involved in the manufacture of a common substance, *e.g., petrochemicals, metals, ammonia, fertilisers, cosmetics;*

4. investigate chemical effects of human activity on the environment, *e.g., lead pollution, water pollution, agricultural fertilisers.*

Note: Students will be extending their ideas about kinds of reactions and chemical principles at this level.

Sample Learning Contexts

Science and ethics • Oil refining • Garden shops • Eating for health • Natural dyes
Nga rongoā o Aotearoa • Supermarkets • Food technology • Plastic products
Rocks, gemstones, and soils • Mining our natural resources • Pollution • Fertilisers

Possible Learning Experiences

Students *could* be learning by:

- analysing the sulphite content of preserved foods and reporting on its function, to investigate chemical processes in a common product;
- researching why certain chemicals are used in the manufacture of cosmetics;
- extracting oil from roses, orange skins, or cloves, using steam distillation;
- testing for the presence of simple ions, such as sulphate, nitrate, iron, and copper in common fertilisers;
- visiting a local paint factory to discover the common properties and chemical composition of paints;
- investigating the evaporation rate of a range of perfumes by measuring changes in mass with time;
- investigating reversible reactions, such as the hydration and dehydration of copper sulphate;
- designing a working breathalyser which detects alcohol;
- drawing a flow diagram of the chemical processes involved in the refining of iron;
- considering the effect of changing temperature and pressure on dynamic equilibria when studying industrial processes, such as the production of ammonia;
- debating a relevant issue, e.g., asbestosis or fluoride in water, to become aware of the effects of some chemicals on our bodies;
- carrying out a fractional distillation of crude oil and analysing the products;
- visiting a local chemical industrial plant;
- accessing a library data base to find out information about petrochemicals;
- carrying out quantitative analysis of lead in a soil sample;
- analysing soil samples from various locations for anions from fertilisers.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of the basic structure of a polymer, when the students construct a model of polythene;
- understanding of the link between a type of chemical and its use, when the students match, from two scrambled lists, the name of a chemical substance to its use in a chemical product;
- ability to perform simple qualitative tests, when the students analyse a fertiliser for the presence of ions, such as sulphates, chlorides, nitrates, or ammonium;
- research and communication skills, when the students present a short seminar on the commercial production of a shampoo;
- ability to understand the chemical processes involved in an industrial process, when the students present a written report of their investigation into the production of a named metal;
- ability to identify a possible effect of human activity on the environment, when the students attempt to establish the presence of phosphates in a local stream;
- qualitative analysis techniques, when the students analyse the oxygen levels in a school swimming pool;
- ability to interpret given data, when they analyse data on temperature and oxygen levels of a river over time.

Making Sense of the Material World: Level 8

Achievement Objectives

Students can

1 carry out an extended investigation involving a range of techniques, originating from their own interests, into some aspect of, or issue related to, the Material World;

2 investigate and relate the chemical and physical properties (of increasing complexity) of a family of substances to their use in the home, industry, and the environment, *e.g., organic acids, mineral acids, metal cations, detergents;*

3 further investigate chemical processes by manufacturing a commonly used substance and comparing its properties with a similar commercial product, *e.g., aspirin, paint, food products, perfumes;*

4 research the functions and use of selected groups of chemicals and describe some effects of these on people and the environment, *e.g., alcohols, food additives, emulsifiers, radio-isotopes, heavy metals, CFCs, agricultural chemicals, trace elements.*

Note: Teachers should recognise the opportunity for students to take an integrated approach to achieving objective 1 by combining their learning from this and other contextual learning strands in a single investigation. This approach could reduce the number of extended investigations students would carry out.

Sample Learning Contexts

Nuclear power • Nga toa hokomaha • Food irradiation • Mīti tahu
Sports medicine • Manufacturing plants • Gardening centres • Hardware
Nga whakaahua whakaroto • Supermarkets • Kumara tao • I roto māra
Breweries • Fertiliser works • Plastics manufacturing • Dairy factories
Water treatment plants • Atmospheric pollution

Possible Learning Experiences

Students *could* be learning by:

- investigating methods of food preservation in New Zealand, from traditional Maori methods to contemporary methods;
- investigating the mediation of naturally occurring enzymes in the breakdown of nitrogen-based fertilisers;
- investigating the biochemistry of muscle contraction;
- investigating the composition of household cleaners and exploring possible links between the findings and their efficiency as antibacterial disinfectants;
- investigating the manufacture and efficiency of synthetic fuels;
- investigating the properties of some viscous liquids and exploring possible links between the findings and the flow and distribution of materials from volcanoes;
- considering the effect of changing temperature and pressure on equilibria when manufacturing a soap;
- making a fertiliser, such as ammonium sulphate, and testing its pH;
- becoming familiar with the methods of expressing the amount and concentration of chemical substances, e.g., ppm, g/l, moles, mol/l, to practise simple quantitative measurements and techniques;
- analysing the amount of acetic acid in a range of commercial vinegars;
- titrating a range of commercially and domestically produced diluted fruit juice with sodium hydroxide to determine total acid content;
- researching the chemistry involved in the synthesis of steroids and their effect on the body when used in sport and contraception;
- interviewing farmers about the trace elements needed on their farms to determine some of the beneficial effects of chemicals on the environment;
- distinguishing between the greenhouse effect and ozone depletion to study the effect of a group of chemicals on the environment;
- designing and building an alternative to a pressurised aerosol can to discover alternative solutions to environmental problems;
- critically analysing a media report on the use of tributyl tin as a keel defoliant.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of how the use of a substance is determined by its properties, when the students research and report on the use and effects of ethyl alcohol;
- understanding of the chemical function of preservatives, when the students give a seminar on techniques used for food preservation;
- ability to carry out a rigorous, systematic investigation, when the students present a report on their manufacture of a product and its fair testing against a similar commercial product;
- understanding of the processes involved, when the students present a laboratory report on the manufacture of aspirin from methyl salicylate (oil of wintergreen);
- quantitative analysis techniques, when the students analyse the amount of sodium bicarbonate in baking powder by gravimetric analysis;
- understanding of the origin and effects of a pollutant, when the students demonstrate qualitatively the presence of lead in petrol and describe its effects on the human body.

Making Sense of Planet Earth and Beyond

Achievement Aims

In their study of planet Earth and beyond, students will use their developing scientific knowledge, skills, and attitudes to:

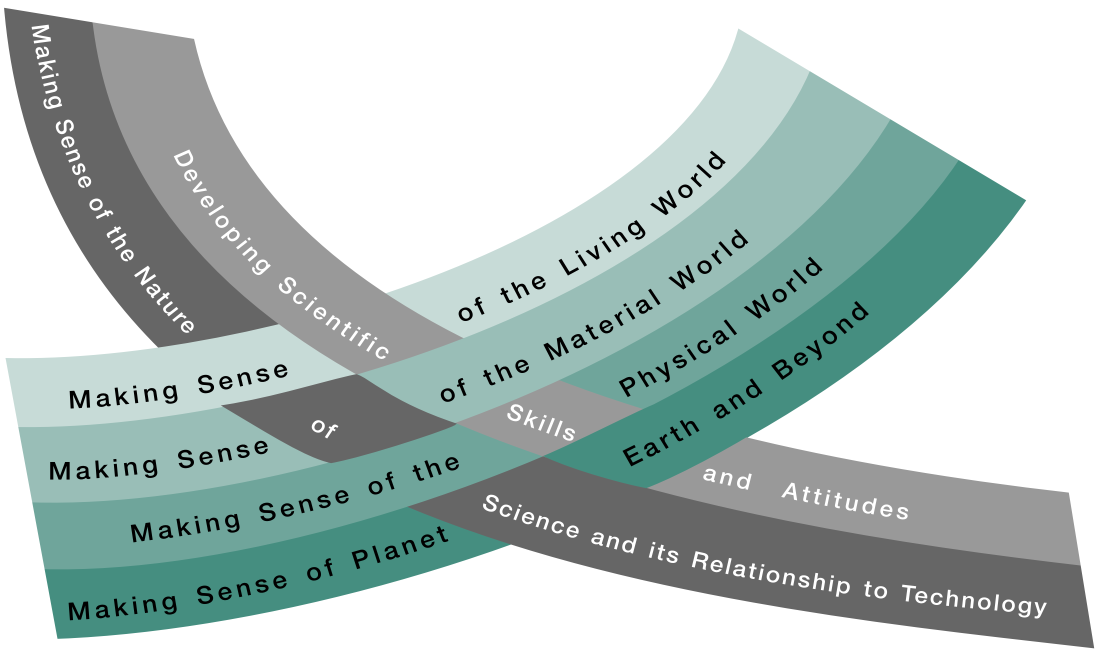
1. investigate the composition of planet Earth and gain an understanding of the processes which shape it;

2. investigate the geological history of planet Earth and understand that our planet has a long past and has undergone many changes;

3. investigate and understand relationships between planet Earth and its solar system, galaxy, and the universe;

4. investigate how people's decisions and activities change planet Earth's physical environment, and develop a responsibility for the guardianship of planet Earth and its resources.

Earth science features of local and national significance should be emphasised.



The learning emphasis is on the development of an awareness of the unique nature of planet Earth within the solar system. Also important is the need to value Earth's resources in ways which recognise that the special environment it provides for living things is constantly changing and vulnerable.

An integrated thematic approach over several subject areas is particularly appropriate for aspects of this achievement aim. It is expected that secondary school teachers of science will work closely with teachers of social studies and geography when they are planning some of the learning experiences which will enhance the learning of the objectives of this achievement aim.

Making Sense of Planet Earth and Beyond: Level 1

Achievement Objectives

Students can

1/4 share their ideas about some easily observable features and patterns that occur in their physical environment and how some of these features may be protected, *e.g., hills, beaches, rivers, cliffs, weather, seasons, tides;*

2 suggest ways that their immediate physical environment was different in the past, *e.g., the school playing fields, land use, river channels, road cuttings;*

3 share their ideas about objects in space and about very noticeable environmental patterns associated with these objects, *e.g., Moon, Sun, stars, day and night, seasons;*

Sample Learning Contexts

Nursery rhymes • Clothing • Maori legends • Te ngahere • Mahi kai
Food collecting • Tangaroa • Ine • Te Marama • A visit to the beach
Keeping warm, keeping cool • Old photographs • Earthworks • Night and day

Possible Learning Experiences

Students *could* be learning by:

- observing temperature change throughout the day, or from day to day, and recording their findings;
- making a group collage to illustrate seasonal behaviour of living things;
- talking about seasonal changes in relation to birthdays, holidays, and seasonal events;
- choosing suitable summer and winter wardrobes;
- talking about and recording the activities that people do in different seasons;
- drawing pictures of trees on hillsides and talking about how tree cover may change with time;
- listening to someone who has lived in the area for many years talk about how the local environment has changed as they have grown up;
- comparing dated photographs of their home or school area to comment on changes in their environment;
- expressing their own ideas about the Moon or Sun and listening to those of others;
- talking about seeing the Moon in the daytime;
- drawing pictures to show the activities that they do at different times over a twenty-four hour period;
- talking about the stars they see in the night sky.

Assessment Examples

Teachers and students *could* assess the students':

- ability to communicate their ideas about environmental changes, when the students role play the elements that make up winter and summer weather;
- awareness of patterns in daily activity, and ability to work as a member of a group, when the students construct a group time line showing that people often do the same things at much the same time on different days;
- appreciation of ways landscapes change, when students describe how their neighbourhood used to look compared with how it looks now;
- awareness of differences between day and night, when the students draw pictures and write simple sentences about this;
- ability to accurately recall main ideas, when the students retell the story of a Maori legend about the Sun;
- ability to recognise different shapes of the Moon, when they talk about diagrams of these.

Making Sense of Planet Earth and Beyond: Level 2

Achievement Objectives

Students can

1/4 investigate easily observable physical features and patterns and consider how the features are affected by people, *e.g., local landscapes, rocks, soils, tides, weather;*

2 understand that Earth is very old and that animals and plants in past times were very different;

3 use their ideas to investigate major objects in our solar system and very noticeable environmental patterns associated with these objects, *e.g., Moon, Sun, planets, day and night, shadow movements, seasons.*

Sample Learning Contexts

Dinosaurs • Fossils • Te ao kōwhatu • Pounamu • School grounds
The local landscape • Early marae sites • Building materials • Gemstones
Space photography • Star gazing • I te tīmatanga • Protection from the Sun
Local rocks • Moa • Beach and river sands and rocks

Possible Learning Experiences

Students *could* be learning by:

- observing and describing a beach scene, particularly changing water levels;
- recording daily weather conditions for a month using instruments such as thermometers, rain gauges, and wind direction indicators, and comparing this record with an equivalent record produced three months earlier;
- comparing their own daily weather records with the weather reports in newspapers, and on radio and television;
- looking at animal tracks on hillsides;
- making soil sample bottles of soils from different locations;
- taking responsibility for the trees and shrubs in a small section of the school grounds;
- viewing and sharing ideas about a significant rock formation in their area;
- making a wall display that shows life-style differences among dinosaurs;
- making a model of a prehistoric animal to show that animals were different in past ages;
- making a clay or plaster fossil to model fossil formation;
- guided reading of a *School Journal* article to extend their ideas about a planet or the stars;
- constructing a simple sundial and using it to tell the time;
- monitoring changes in shadows over a period of time to show change in the position of the Sun;
- sharing a big book about the planets to help develop research skills and teamwork.

Assessment Examples

Teachers and students *could* assess the students':

- ability to identify and locate important local landforms, when the students use a sketch map of the area;
- ability to infer how local landforms may change, when students draw a sea cliff as it may appear many years in the future;
- acceptance of a shared responsibility for their own school environment, when the students plant and maintain a small garden outside their classroom;
- knowledge of Earth's environment in the past, when the students describe where and how a large plant-eating dinosaur might have lived;
- understanding of the cause of shadows, when the students share their ideas about how shadows change shape during the day;
- ideas relating to the Sun's apparent motion, when the students predict where their shadows will fall in one hour's time.

Making Sense of Planet Earth and Beyond: Level 3

Achievement Objectives

Students can

1. investigate the major features, including the water cycle, that characterise Earth's water reserves, *e.g., oceans, rivers, lakes, glaciers, ice-caps, snowfields, clouds;*

2. gather and present information about the origins and history of major natural features of the local landscape, *e.g., volcanic cones, coastal cliffs, river flats, erosion scars, lakes, local soils;*

3. locate and use information obtained from space exploration to clarify, challenge, and extend their ideas about the general nature and behaviour of the Earth, its moon, and the other planets in our solar system, *e.g., Moon missions, satellites, space stations;*

4. justify their personal involvement in a school- or class-initiated local environmental project, *e.g., a school tree-planting project; paper, glass, metal, or plastic recycling.*

Sample Learning Contexts

Space • Natural disasters • Communications • Weather • Global warming
Soils • Whakatere • Weather maps • Parks • Civil Defence • Reservoirs
Volcanoes • Pakiwaitara o Ngatoro-i-rangi • Beaches • Satellites
Voyages of discovery • Rockets • Atlases • Antarctica • Nga momo wai • Te Ātea Glaciers • Avalanches • Water pollution • Geysers • Lakes • Moon probes
Space exploration • Solar power • Science fiction • Space travel • Ngāwhā

Possible Learning Experiences

Students *could* be learning by:

- constructing a concept map linking stages of the water cycle;
- using dyes to investigate the effects of changing temperature on convection currents in water;
- brainstorming, in groups, the recreational uses of water as preparation for the creation of a wall mural;
- investigating Maori tapu as pertaining to wai, awa, and puna;
- constructing a photograph collage of local landforms, such as rivers, lakes, beaches, and mountains, as a means of familiarising themselves with features in their local environment;
- listening to Maori legends to learn more about local landforms;
- offering explanations for some features of the local landscape, e.g., a range of hills, plateau, crater, river, market garden area, or swamp;
- visiting the natural history section of the local museum, or talking to older people, to gather information on a natural local feature or local landform;
- making a model volcano to illustrate its structure;
- discussing ideas about what Earth looks like from the Moon or a space shuttle;
- viewing a video of a space mission to the Moon to increase awareness of the Moon's landscape and/or viewing a video of a space launch to increase awareness of the use of technology in space exploration;
- researching some facts about another planet to help answer students' questions about a planet;
- "adopting" a local beach, roadside, or park to experience personal involvement in caring for the environment;
- developing a video to show at a parents' evening that describes the class's involvement in a recycling project.

Assessment Examples

Teachers and students *could* assess the students':

- understanding of the processes involved in the water cycle, when the students role play, in groups, the experiences of a raindrop;
- ability to apply knowledge about the effects weather can have on human activity, when the students role play in groups appropriate responses of a family to a flood warning that is predicted to affect the homes in their neighbourhood;
- understanding that freezing can damage materials, when the students draw before and after diagrams of a plastic bottle full of water which is placed in a freezer;
- ability to locate and record relevant information, when the students present a simple report on the origins of a local natural feature;
- knowledge about the surface structure of the Moon, when they write questions to use in a role play interview of an astronaut returning from a Moon mission;
- observation skills, when the students compare surface features as shown in a photograph of Earth taken from space with features indicated in a world map;
- awareness of the advantages of wise use of physical resources, when the students write a report outlining the value of recycling a selected material;
- ability to justify their personal involvement in an environmental project when the students write a report for a local newspaper about the school's Arbor Day tree planting.

Making Sense of Planet Earth and Beyond: Level 4

Achievement Objectives

Students can

1 investigate major factors and patterns associated with weather, and use given data to predict weather;

2 collect and use evidence from landforms, rocks, fossils, and library research to describe the geological history of the local area;

3 (a) use simple technological devices to observe and describe our night sky, *e.g., binoculars, simple star maps;*

(b) investigate and use models which explain the changing spatial relationships of the Earth, its moon, and the Sun, and the way different cultures have used these patterns to describe and measure time, and position, *e.g., phases of the Moon, eclipses, tides, seasons, sun clocks;*

4 investigate a local environmental issue and explain the reasons for the community's involvement, *e.g., replanting of a cleared hillside, re-introduction of indigenous birds to a local area.*

Sample Learning Contexts

Natural hazards • Papatuanuku, Rangi, and the children • Te ao kōwhatu • Beaches
Atlases • Floods • Deserts • Monsoons • Fossils • Landforms • Clouds
The ocean • Space probes • Environmental organisations • Maori as conservationists
Antarctica • Space travel • Land reclamation • Fiords • Lakes • Henges
Weather forecasting • The night sky • Navigation

Possible Learning Experiences

Students *could* be learning by:

- using weather maps and/or satellite pictures to construct a table of data, to develop reading and interpreting skills;
- constructing a time line showing dates of natural disasters in New Zealand's history caused by the weather, e.g., Cyclone Bola;
- mapping ocean and wind currents to gain knowledge of world patterns;
- investigating unusual weather patterns linked to geological events such as major volcanic eruptions;
- relating the migration trails of sea-going Polynesians to the ocean currents, winds, and stars;
- making a model barometer to find out how barometers work;
- using barometers to record atmospheric pressure over a period of time;
- mapping climate types or prevailing winds on a world map to show world patterns and to practise map-reading skills;
- preparing a report or interview schedule on traditional Maori weather forecasting;
- using evidence of fossils or rock types to speculate about the geological history of an area;
- preparing questions to ask the local museum curator about the geology of the area;
- designing a mobile to show the relative positions of Sun, Moon, and Earth during solar or lunar eclipses;
- making a simple needle compass and demonstrating how it is used;
- drawing the shape of the Moon on as many different days as possible over a month, then discussing and comparing their results;
- attending a star party at which someone demonstrates the use of telescopes or binoculars to find interesting objects in the night sky;
- investigating the role of rāhui in the guardianship of natural resources;
- writing a letter to the local council justifying why a mangrove swamp or wetland area should be conserved.

Assessment Examples

Teachers and students *could* assess the students':

- ability to interpret data, when the students read a given weather map and write a forecast based on their interpretation of this information;
- ability to record data regularly and accurately, when the students keep a diary of their own weather measurements;
- understanding of the cause of eclipses, when the students use a torch and two balls to simulate an eclipse;
- understanding of the space relationships of the Sun, Moon, and Earth, when the students make a model showing their relative positions;
- familiarity with the night sky, when the students identify several space objects;
- information-gathering ability, when the students prepare questions for, and collate answers from, an interview with the members of a local conservation group;
- personal awareness of a local environmental issue, when the students' individual contributions to a class big book are shared with a junior class.

Making Sense of Planet Earth and Beyond: Level 5

Achievement Objectives

Students can

1/2 investigate and describe processes which change the Earth's surface over time at local and global levels, *e.g., erosion, weathering, earthquakes, volcanoes, continental drift, plate tectonics;*

3 (a) use simple technological devices, such as telescopes and simple star maps, to observe and describe changing patterns in our night sky, *e.g., position of the Moon, orientation of the Southern Cross;*

(b) use information obtained from technological devices, such as radio telescopes and satellites, to clarify, challenge, and extend their ideas about the general characteristics of some near and far space objects, *e.g., structure, size, surface landscape, climate; the Sun and other stars, Earth's moon, planets, comets, meteors, clusters, galaxies; feasibility of life;*

4 research a national environmental issue and explain the need for responsible and co-operative guardianship of New Zealand's environment, *e.g., water reserves, water pollution, soil erosion.*

Sample Learning Contexts

Earthquakes of the Pacific Rim • Alpine faults • Global warming • Black holes
Telescopes • I roto ātea • The solar system • Farming • The Moon • Deltas
Space probes or space missions • Volcanoes • Satellite photography
Gondwanaland • Comets • Fossils • Antarctica • Soils • Ice ages • Sea levels

Possible Learning Experiences

Students *could* be learning by:

- making a poster of geological events such as earthquakes, volcanic eruptions, and landslides recorded in the media over a month;
- using a slinky spring to demonstrate S and P waves;
- plotting the distribution and magnitude of recorded earthquakes in New Zealand;
- constructing a distance-time graph for earthquake waves from data provided;
- constructing a model seismograph and explaining how it records seismic waves;
- drawing a cross section of the interior of the Earth to illustrate its structure;
- plotting major areas of ice cover on a world map, explaining possible reasons for any distribution patterns;
- discussing types of evidence used in determining past positions of continents;
- researching and presenting a report on plate tectonics;
- using a planetarium program on a computer to recreate the night sky;
- making telescopes using lenses, concave mirrors, and cardboard tubes;
- acting out planet orbits to scale on the playing field;
- launching water-powered, plastic soft drink bottle "rockets" with a bike pump and testing variables which affect the flight of such model rockets;
- using the projection method to record sunspot activity;
- researching the latest information available on the nature of extreme outer space;
- investigating the significance of past and future sea-level changes in New Zealand;
- investigating an example of ground or surface water pollution in the local area.

Assessment Examples

Teachers and students *could* assess the students':

- knowledge of the suggested relationship between sites of volcanic and earthquake activity in New Zealand and the Pacific Rim and the position of Earth's crustal plates, when the students draw an annotated diagram to explain their ideas;
- understanding of the changing position of stars in the night sky, when the students identify the Southern Cross at two different times of the night or year;
- ability to visualise the structure of the solar system, when the students place planet diagrams correctly on to a blank map of the solar system;
- ability to understand how telescopes are used, when they provide observational evidence to support their ideas of the surface structure of Mars;
- ability to relate theory to observation, when students prepare a project on a named celestial body;
- awareness of the nature of space objects, when students compare the size and speed of meteors and satellites;
- ability to manipulate equipment correctly and safely, when students focus a clear projected image of the Sun through binoculars or a telescope on to a small screen, taking appropriate precautions;
- ability to communicate, when they report on their findings from an investigation into the significance of past and future sea-level changes in New Zealand;
- understanding of the importance of soil conservation, when the students debate the topic "Soil is a non-renewable resource on a human time scale."

Making Sense of Planet Earth and Beyond: Level 6

Achievement Objectives

Students can

1/2 (a) investigate and classify some common minerals and rocks according to their easily observed properties and relate to their common use, *e.g., calcite, feldspar, quartz, sulphur, magnetite; gemstones, building materials, road aggregates, use in industry;*

(b) investigate how the three major types of rocks are formed (igneous, metamorphic, and sedimentary) and describe how rock sequences provide evidence for past events through geological time;

3 use information from a range of sources, including their own observation, to explain spatial relationships of objects in the night sky and the challenge such spatial relationships present to space exploration, *e.g., distance between and changing positions of objects; theories about the origins of the Universe;*

4 report on an important natural resource in New Zealand, including its method of formation, location, and extraction, as appropriate, and any issues associated with its use, *e.g., water, limestone, coal, natural gas.*

Sample Learning Contexts

Pounamu • Glenbrook steel mill • Geological history of New Zealand
Papatuanuku and Rangi creation stories • Building materials • Jewellery •
Antarctica Resources from the sea floor • Acid rain • Satellite imaging • Water reserves
Gold • Maori tools • Groundwater • Pottery making • Brick making • Oil rigs
Deep sea diving • Rock cycle • Light years • Big Bang Theory • Geothermal energy Black sands • Geological time scale

Possible Learning Experiences

Students *could* be learning by:

- comparing the physical strengths of different rocks used as base metal for roading;
- relating crystal size in igneous rocks to the method of formation;
- investigating heat capacities of different rocks by heating several different rocks in water and using these to heat cold water;
- using a computer key to classify a collection of rock samples;
- experimenting with moulding and baking clay in the form of pots and bricks;
- studying Maori stone tools in the local museum and discovering where the rock type for these tools was quarried;
- grouping samples of rocks or minerals, using common features such as colour, texture, and hardness to practise their skills of classification;
- investigating uses of greenstone by Maori to identify properties and sources;
- varying the proportions of gravel, sand, and cement to test the strength of concrete;
- modelling the formation of sedimentary rocks by allowing sand and silt to settle out in tall containers filled with water;
- preparing, in groups, a chart illustrating how a particular type of rock is formed;
- determining the amount of calcium carbonate present in two grams of local limestone or sandstone, and testing the effect of acid rain on this rock over time;
- visiting a local observatory or planetarium to view objects in the night sky;
- carrying out an information research project on the Big Bang Theory;
- discussing theories about the formation of the Universe with an local astronomer;
- inviting kaumātua to speak on the significance of greenstone in the Maori culture;
- preparing a poster showing how deposits of gold are formed;
- mapping greenstone and obsidian locations in New Zealand and linking these to known archaeological sites.

Assessment Examples

Teachers and students *could* assess the students':

- knowledge of key processes involved in the formation of different types of igneous rocks, when the students construct a concept map to demonstrate their ideas;
- ability to apply their knowledge of rock properties, when the students test the suitability of given rock samples for use as a building material;
- ability to interpret the evidence contained in rock samples, when the students describe where they think the rocks may have come from;
- co-operative learning skills, when the students work in groups to construct a model or poster about the Big Bang Theory of the origin of the Universe;
- ability to evaluate ideas, when the students compare the Big Bang Theory to another theory about the origin of the Universe;
- understanding of the scale of space, when the students can express distance in terms of "spacecraft travel time" and "light travel time";
- ability to critically analyse information relating to an issue, when the students prepare a report on advantages and disadvantages of developing a local resource;
- ability to carry out an information search, when the students research the formation, location, and extraction of natural gas in New Zealand.

Making Sense of Planet Earth and Beyond: Level 7

Achievement Objectives

Students can

1/2 use a range of techniques to infer what events may have shaped local and national landform features, *e.g., field trips, geological maps, remote sensing, and aerial photography; volcano formation, uplifting, faulting, fossils;*

3 examine evidence from a variety of detectors to reach conclusions about the nature of stars and other celestial objects;

4 survey and evaluate the literature relating to an Earth sciences' issue, *e.g., opencast mining, oil spillage, disposal of nuclear waste.*

Sample Learning Contexts

Volcanoes of the Pacific Rim • Natural disasters • Canals on Mars • Maps
World environmental issues, e.g., ozone depletion, oil pollution • Nga take o te ao
Life on other planets • The Moon • Road cuttings • New Zealand's changing shape Spectral fingerprints • The life story of a star

Possible Learning Experiences

Students *could* be learning by:

- preparing a cross section of a local geological feature;
- locating important geographical features in a local region from a topographical map to practise mapping skills;
- constructing simple geological maps, which focus on local features, based on their collected data;
- identifying major geological structures, such as faults and folds, on Landsat and aerial photographs and relating these to regional geological maps;
- developing a photographic record of geological and/or geographical features of the local area to illustrate the information contained in a map of the region that they have prepared;
- collecting and summarising media reports of articles relating to space exploration and possible evidence of life on other planets;
- examining evidence from images of planets to gather data in order to make speculations about the nature of a planet;
- carrying out systematic observations of a celestial object such as the Sun, a planet, or a star;
- analysing the light curve of a variable star;
- debating the pros and cons of fossil fuel use to clarify the issues;
- researching mining in Antarctica to assess how closely nations are adhering to international treaties;
- using role play to highlight the issues involved in transporting oil long distances from its source to where it will be used;
- debating “That economic returns from the mining of minerals justify the major modification of local landscapes”.

Assessment Examples

Teachers and students *could* assess the students’:

- ability to transfer data on to a map, when the students construct a simple geological map;
- ability to interpret Earth sciences’ maps, when the students write an account of the geological history of an area from a given map;
- ability to use group decision-making strategies to formulate a logical survival plan, when the students imagine they have the problem of being space travellers lost on Mars;
- ability to reach conclusions from given evidence, when the students prepare a report on the nature of our Sun;
- persistence, when a student carries out observations of a space object over an extended period of time;
- ability to communicate key points effectively, when the students prepare a display board about the aftermath of a major oil spill;
- ability to identify key issues, when the students prepare pertinent questions to be put to a panel of experts on the question of the effects of opencast mining on a local environment.

Making Sense of Planet Earth and Beyond: Level 8

Achievement Objectives

Students can

1/4 carry out an extended investigation, involving a range of techniques, originating from their own interests into some aspect of, or issue related to, Planet Earth and Beyond;

2 investigate and describe the sequence and characteristics of major events in the Earth's geological past;

3 research and present a report on a current astronomical event or discovery.

Note: Teachers should recognise the opportunity for students to take an integrated approach to achieving objective 1/4 by combining their learning from this and other contextual learning strands in a single investigation. This approach could reduce the number of extended investigations students would carry out.

Sample Learning Contexts

Plate tectonics • Space exploration • Geology of the local area
New Zealand's geological history • New Zealand's rocks
Information skills in science • Science fiction • Nga pukapuka pakiwaitara o pūtaiao Sewage disposal • Marine reserves • Industrial waste • Space stations
Space travel

Possible Learning Experiences

Students *could* be learning by:

- investigating factors contributing to the pollution of a local stream or beach;
- investigating the impact on the environment of a ski-field development in a local mountain area;
- investigating rates of crystal formation in laboratory conditions and exploring possible links between the findings and the formation of crystals occurring naturally in igneous rocks;
- designing a technique for measuring or assessing the relative clarities of different water samples;
- carrying out an investigation into sea-level changes and/or climate changes;
- drawing a sequence of maps showing New Zealand's changing shape over the last 200 million years;
- working in groups to prepare a pictorial representation of geological time;
- preparing a wall chart which sets ideas about the rise and fall of life forms which are of high interest to them against the geological time scale;
- debating "Money on space exploration is well spent" to highlight an issue involved in space exploration;
- preparing a cost-benefit analysis for some aspect of space technology;
- collecting newspaper and magazine articles relating to space exploration and grouping and summarising these;
- attending a local government hearing where submissions are being considered about granting a permit to mine a local mineral, develop a marina, or modernise an existing sewage disposal system;
- preparing a submission for a local government hearing on one of the above issues.

Assessment Examples

Teachers and students *could* assess the students':

- investigation and interpretation skills, when the students carry out an investigation into the factors affecting the rate of crystal formation and make possible links between their findings and the properties of named minerals;
- ability to communicate effectively the key evidence used to support the currently held theory of plate tectonics, when the students prepare a seminar on Gondwanaland for presentation to a form 5 class;
- understanding of geological time, when they describe the main features of a poster representing the sequence and characteristics of major events in Earth's geological past;
- ability to present a balanced argument, when the students write an article for a local paper outlining the reasons for and against the setting up of a marina in a local estuary;
- ability to solve problems, when the students present a group report defending the establishment of a human colony on the Moon;
- awareness of space exploration issues, when the students decide, in groups, on a code of behaviour for disposal of space rubbish;
- ability to appreciate the uncertain nature of scientific theories, when the students explain in their own words how earlier astronomical theories were shown to be incorrect;
- willingness to keep abreast of current events, when the students give seminars on current astronomical events or discoveries.

APPENDIX 1: GLOSSARY OF MAORI VOCABULARY

Maori and Science

page 12

Tikanga Maori	Maori protocol
Whānau	family
Te reo Maori	Maori language

Making Sense of the Nature of Science and its Relationship to Technology

Level 3, page 31

Kete	basket

Level 5, page 35

Kuia	older woman

Developing Scientific Skills and Attitudes

page 49

Waka	canoe
Harakeke	flax

Making Sense of the Living World

Level 1, page 54

Te ngahere	the forest/bush
Kōhanga	nest

Level 2, page 56

Nga kaimoana	seafood
Nga kararehe	animals
Aotearoa	New Zealand
Nga pungāwerewere	spiders
Te Ao	the world
Tangaroa	the sea/sea god
Te aitanga a Tāne	Tāne's children/descendants

Level 3, page 58

Taha moana	seaside or seashore
Te ngahere	the forest/bush
Nga ngarara	insects
Te aitanga a Tāne	Tāne's children/descendants

Level 4, pages 60 -1

Waiora	health
Tangaroa	the sea/ sea god
Te ngahere	the forest/bush
Nga kai Maori	Maori food
Māramataka Maori	Maori calendar
Nga kaimoana	seafood
Kuia	older woman
Koroua	older man
Kānga wai	fermented corn
Kumara tao	dried sweet potato
Kānga waru	cornbread
Parāoa rēwena	potato yeast bread

Level 5, page 62	
Waiora	health
Whakapapa	genealogy
Te ara o te tangata	human characteristics
Level 6, page 64	
Te ngahere	the forest/bush
Tōku whānau	my family
Whanaungatanga	relationship/family ties
Whakapapa	genealogy
Rongoā	medicine
Level 7, page 66	
Whakapapa	genealogy
Tōku whānau	my family
Te ngahere a Tāne	Tāne's forest
Tāne	god of forest

Making Sense of the Physical World

Level 1, page 72	
Pūoru	sound
Ko ahau	me
Ranginui	the sky/sky father
Tangaroa	the sea/sea god
Nga take o te ao	things pertaining to the world
Kōrero	communication
Level 2, page 74	
Nga mahi	tasks
Waka	transport
Ko ahau	me
Te wera, te mātao	heat/cold
Level 3, page 76	
Tāwhirimatea	god of elements/weather
Mīhini hou	modern machinery
Rerenga	flight
Level 4, page 78	
Pōtaka	tops
Heketanga	descent of a hill
Mīhini hou	modern machinery
Level 5, page 80	
Waea kōrero	telephone
Pouaka whakaata	television
Nga mīhini	machinery
Level 6, page 82	
Waiora	health
Āniwaniwa	rainbow
Hāngi	steam/ground cooking (Maori method)
Level 7, page 84	
Mīhini hou	modern machinery
Mahi ngahau	games/fun activities
Level 8, page 86	
Mīhini hou	modern machinery

Making Sense of the Material World

Level 1, page 90

Kāinga	home
Rewēna	Maori bread traditionally cooked in camp oven
Kai	food
Hī ika	fishing

Level 2, page 92

Taha moana	seaside/seashore
Hāngi	steam/ground cooking (Maori method)
Nga toa hokomaha	supermarkets

Level 3, pages 94-5

Kai tohungia	preserved food
Nga tae	dyes
Nga rā makariri	cold weather, cold days
Kaumātua	elder
Hāngi	steam/ground cooking (Maori method)
Muka	prepared fibre of flax

Level 4, page 96

Taha tinana	pertaining to the body
Papatuanuku	Earth mother

Level 5, page 98

Nga take o te ao	things pertaining to the world
Harakeke	flax
Oranga tinana	health

Level 6, page 100

Pounamu	greenstone
Toa hoko parāoa	bakery
Nga kai kōpiro	fermented foods
Piupiu	flax skirt

Level 7, page 102

Nga rongoā o Aotearoa	Maori medicine

Level 8, page 104

Nga toa hokomaha	supermarkets
Mīti tahu	cooked meat preserved in fat
Nga whakaahua whakaroto	X-ray
Kumara tao	cornbread
I roto māra	in the garden

Making Sense of Planet Earth and Beyond

Level 1, page 108

Te ngahere	the forest/bush
Mahi kai	planting/preparing food
Tangaroa	the sea/sea god
Ine	measure/compare
Te Marama	the Moon

Level 2, page 110

Te ao kōwhatu	the stone age
Pounamu	greenstone
Marae	meeting ground
I te tīmatatanga	in the beginning

Level 3, pages 112-3	
Whakatere	navigate
Pakiwaitara o Ngatoro-i-rangi	stories of Ngatoro-i-rangi
Nga momo wai	variety of liquids
Te Ātea	space/Universe
Ngāwhā	geysers
Tapu	sacred
Wai	water
Awa	river
Puna	spring
Level 4, page 114	
Papatuanuku	Earth mother
Rangi	sky father
Te ao kōwhatu	the stone age
Level 5, page 116	
I roto ātea	in space
Level 6, pages 118-9	
Pounamu	greenstone
Papatuanuku	Earth mother
Rangi	sky father
Kaumātua	elder
Level 7, page 120	
Nga take o te ao	things pertaining to the world;
Level 8, page 122	
Nga pukapuka pakiwaitara o pūtaiao to	books about legends, and folklore related science

Appendix 2

page 129	
Rāhui	ban
page 132	
Tangata whenua	local people

Note: To extend their own vocabulary of Maori words and to identify other contexts suitable for science units, teachers will find it useful to refer to *Tihē Mauri Ora! Maori Language, Junior Classes to Form 2, Syllabus for Schools, Ministry of Education, Wellington, 1990, and Nga Kupu Tikanga Pūtaiao: A Selective Maori Science Vocabulary*, Ministry of Education, Wellington, 1992.

APPENDIX 2: DEVELOPING ESSENTIAL LEARNING SKILLS AND ATTITUDES THROUGH SCIENCE

The New Zealand Curriculum specifies eight groupings of essential skills to be developed by all students across the whole curriculum. These are communication skills, numeracy skills, information skills, problem-solving skills, self-management and competitive skills, work and study skills, social and co-operative skills, and physical skills. Information skills and problem-solving skills are embedded in scientific investigation (see pages 44-51). Possible learning experiences related to the other essential skills are listed in this appendix.

Possible Learning Experiences Related to Communication

Communication in science *may* include:	Students *could* be learning by:
• using the means and the media appropriate to message and audience; • using written, spoken, and visual language; • using graphical and symbolic representations; • drawing diagrams, mapping, and constructing models; • recording and presenting data; • using communication technologies; • critically discussing scientific reports.	• making a clay model of an insect (L 1.1, L 2.1); • reporting to a group about where particular animals were found at the beach (L 2.4); • writing poems about why we wear different clothing in different seasons (E 2.3); • audiotaping an interview with an expert on bird song (L 3.2); • making a chart of the different types of rubbish found in the local park (M 2.1, M 3.1); • talking about their ideas after reading a *School Journal* article on plastics (M 3.2, M 4.2); • explaining to friends how a kina moves (L 5.2); • drawing an annotated diagram of a rātā flower (L 5.2); • drawing a poster demonstrating the physics in sailing a yacht (L 5.4); • constructing a concept map to show the relationships between earthquakes, volcanoes, and the Earth's crustal plates (E 6.1); • making a video about growing cut flowers for export (L 6.4); • finding out about the role of rāhui in the guardianship of natural resources (E 7.4, E 8.4, N 5.1(b)); • explaining their ideas about the pollination of a flax flower to their classmates (L 5.2, N 5.1); • drawing a graph relating the strength of concrete to its sand content (M 6.4, E 5.1, N 5.2); • writing instructions on using a computer programme that draws ray diagrams (P 7.4); • presenting a seminar on the science involved in a photocopying machine (P 7.4, N 7.2); • debating New Zealand's use of agricultural pesticides (M 8.4).

Possible Learning Experiences Related to Numeracy

Numeracy in science *may* include:	Students *could* be learning by:
• counting; • estimating and measuring quantities; • calculating; • using calculating aids and measuring instruments; • using mathematical operations and symbols; • expressing patterns as equations, tables, and graphs; • understanding and expressing uncertainties; • using statistical methods when appropriate; • using computer spreadsheets; • determining uncertainty in measurements.	• seriating a collection of leaves according to attributes negotiated by the students (L 1.2); • plotting the position of shady areas in the playground (E 2.3); • counting the number of crabs under a stone (L 3.4); • reading a class-made rain or wind gauge (E 3.1); • measuring the height of the bounce of a ball (P 3.3); • graphing data about the elasticity of a loaded rubber band (P 3.3); • plotting the position of places where cockroaches are found (L 3.4); • quantitatively surveying rubbish left in the school grounds (M 3.1); • measuring the duration of a hum to indicate lung capacity (L 4.3); • measuring the temperature of different-coloured objects left in the sun (P 5.3); • estimating the total surface area of the leaves on a tree (L 5.2); • surveying a rocky shore, using quadrats and transects (L 5.2); • mapping greenstone locations in New Zealand (E 6.4); • plotting data to establish the relationship of the bending of a beam to different applied masses (P 6.3); • using a pH meter to determine the acidity of soil samples (M 6.2, N 6.1); • describing the need for standard units when measuring physical quantities (P 7.3); • calculating the number of moles of a substance produced during a particular reaction (M 8.4); • using a computer spreadsheet program to analyse and plot the relationships between light intensity, area of a solar cell, and the electrical voltage generated (P 8.2).

Possible Learning Experiences Related to Self-management and Competition, and to Work and Study

Self-management and competition, and work and study skills in science *may* include:	Students *could* be learning by:
• working both independently and co-operatively with others; • taking responsibility for personal safety in the science classroom; • organising practical activities carefully to ensure valid conclusions; • being honest when recording and validating data; • repeating tests when unexpected results occur; • persevering when faced with learning difficulties; • learning how to learn; • making personal decisions about one's own learning; • becoming responsible for one's own learning; • entering a science exhibition or science project competition.	• sharing magnifying glasses when studying small animals (L 2.1); • meeting scheduled recording times when measuring temperature over an extended period of time (E 2.3); • asking questions when they have not, at first, understood ideas about density (P 4.1/2); • holding a conference with a partner who is preparing to report to the class on an independent investigation into household acids (M 5.2, M 6.2); • learning how to locate books on single-celled organisms in the library (L 5.1); • fulfilling a negotiated contract in the time allocated, for example, completing a series of experiments on corrosion (M 5.3); • reporting actual results of an experiment on sedimentation (E 5.1/2); • working co-operatively in groups in planning a debate on the designation of an area of commercial forest, which contains a sizeable population of little spotted kiwi, as a National Park (E 5.4); • checking on instructions about the use of a laser when they remain unclear after several readings (P 7.4, N 6.2); • completing a long-term investigation into the chemical composition of different pottery glazes (M 8.1/2); • using a range of information when researching the safety aspects of bungy jumping (P 8.1, N 7.3).

Note: Success and satisfaction in learning are often related to setting realistic goals, and organising time, skills, and resources, both human and material, efficiently and effectively. As self-management skills and work and study skills are closely integrated, these skills are combined in this section.

Possible Learning Experiences Related to Social Relationships and Co-operation and Social Action

Social relationships and co-operation and social action in science *may* include:	Students *could* be learning by:
• working both independently and co-operatively with others; • listening to and acknowledging the views of others; • considering the safety of others when working in a science laboratory; • negotiating particular responsibilities of group members; • knowing how to express concerns confidently, or to ask questions of appropriate people or organisations; • being sensitive to the learning needs of others. • being aware of current scientific issues of concern to society; • caring for the local and global environment; • being able to express an opinion about an issue related to the consequences of the application of scientific knowledge; • caring for plants and animals; • caring for laboratory and classroom equipment; • critically evaluating the consequences of the applications of scientific enquiry.	• reaching a consensus about the likely position of the stomach in the body (L 2.2); • considering the safety of others when using electrical equipment (P 3.4); • coming to a group agreement about the layout of the science table display on everyday materials (M 4.2); • being involved in a project planting indigenous trees (E 3.4, E 4.4); • negotiating particular responsibilities of group members when organising a family science evening on "investigating light" (P 4.1/2); • canvassing local views about a factory which is polluting your neighbourhood (M 4.4); • being an effective member of the group when collecting data as part of a bush study (L 4.4); • establishing the protocol prior to interviewing tangata whenua about the use of a nearby river, lake, or forest (E 5.4, E 6.4, E 7.4); • interviewing members of the community about fluoridation of the local water supply (M 5.4); • critically analysing the scientific claims used to support a product in a television advertisement (N5.3, N6.3); • making a submission to the government on the use of pesticides (N 7.3, M 7.4, E 7.4); • writing a letter to the local newspaper about noise levels adjacent to airports (L 7.4, N 6.3, N 7.3, N 8.3); • reaching an agreed position on the milling of indigenous timber (L 6.4, L 7.4, N 7.3, N 8.3); • using science skills to provide relevant data for a newspaper report on the irradiation of foods (L 8.4, N 8.3); • listening to and evaluating different views on topics such as the use of nuclear energy (E 8.4, N 8.3); • working with a group to design a hand tool for a person with arthritis (P 8.4, N 7.3).

Note:

1 Successful scientific investigation increasingly involves people working in teams as well as independently. The findings of scientific investigations are frequently applied to social contexts. Developing the skills and attitudes involved in being an effective member of a group, and being a responsible member of an increasingly interdependent society, are important outcomes of learning in science.

2 Although it is possible to identify different skills which relate to social relationships and co-operation and social action, in practice the possible learning experiences generally apply to both social relationships and co-operation and social action and therefore have not been separated in the table.

Possible Learning Experiences Related to Physical Co-ordination

Physical co-ordination in science *may* include:	Students *could* be learning by:
• manipulating equipment; • using tools and materials appropriately; • using equipment and materials safely; • making fine measurements.	• making a clay model of an animal (M 1.1, L 1.2); • making a musical instrument out of bottles and water (P 1.1/2); • working in a group to build a tower out of used computer paper and sticky tape when investigating simple structures (P 2.1/2); • finding out about the bounce time of a different number of pupils on a trampoline (P 3.1/2); • using a methylated spirits burner to investigate expansion of metals (M 4.2); • using the microscope to observe plant cells under high power magnification (L 5.1); • preventing contamination when making yoghurt (L 6.1); • using a geological hammer with precision and care when searching for fossils (E 7.1/2); • using pipettes and burettes for volumetric analysis (M 7.4); • taking care when assembling apparatus to manufacture aspirin from methyl salicylate (M 8.3).

Note: Scientific investigation gives students many opportunities to develop fine motor co-ordination skills as they use tools and manipulate equipment in the classroom or in the field with precision, efficiency, and safety. They are also often involved in making fine measurements.

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NOTES