



Victorian Essential Learning Standards

Discipline-based Learning Strand

SCIENCE

REVISED EDITION JANUARY 2008



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Revised Edition January 2008

This edition incorporates minor amendments to the domain introductions and learning focus statements to indicate their relationship with the National Statements of Learning.

Discipline-based Learning

The domains within the Discipline-based Learning strand form a body of knowledge with associated ways of seeing the world and distinct methods of exploring, imagining and constructing that world.

Broadly in line with academic literature and consistent with practice in many schools, the Victorian Essential Learning Standards identify the Arts, the Humanities, English and Languages Other Than English, Mathematics and Science as the disciplines for the curriculum over the stages of learning from Prep to Year 10.

Within the Discipline-based Learning strand the learning domains are:

- The Arts
- English
- The Humanities – Economics
- The Humanities – Geography
- The Humanities – History
- Languages Other Than English (LOTE)
- Mathematics
- Science

Students who develop a deep understanding of the concepts contained in the discipline-based domains are able to apply their knowledge in many different ways. The degree to which they are able to transfer their knowledge depends largely on the degree to which students have achieved mastery over Physical, Personal and Social and Interdisciplinary learning.

Research suggests that students develop deeper understanding of discipline-based concepts when they are encouraged to reflect on their learning, take personal responsibility for it and relate it to their own world. These approaches are explicitly defined in the Physical, Personal and Social Learning domains such as physical education and personal learning.

Students are better able to develop, demonstrate and use discipline-based knowledge and skills when they are able to employ interdisciplinary knowledge, skills and behaviours described in the domains of Communication; Design, Creativity and Technology; Information and Communications Technology; and Thinking Processes.

Science

Introduction

To be human is to be curious about the world we live in, to wonder why it is that way, and to ask about our place in it. A fundamental goal for science education is to stimulate, respond to and nourish such curiosity, wonder and questioning. Science provides us with one view of the world – a view that changes as our knowledge and understanding of science evolves.

Science is a human process, influenced by and influencing social values. Science has a long and fascinating history of human attempts to appreciate, understand, control and manage our world. Scientists use techniques of scientific investigation to create an understanding of the world. The resulting cumulative knowledge is part of our human heritage.

Science is dynamic and progressive. Our society is being continually confronted, challenged and redirected by ideas borne from people's curiosity, imagination and dreams about what might be possible. The work of scientists such as Newton, Einstein, Curie, Darwin, Florey, Macfarlane Burnet and Oliphant began as 'why' and 'what if'. Their work challenged and subsequently changed accepted opinions in the areas of motion and gravity, radioactivity, evolution, medicine, immunology, structure of the nucleus of the atom, and nuclear energy. This and other accepted science knowledge continues to fuel the dreams of a new generation of scientists as they explore the expanding frontiers of science.

Science has had, and will continue to have, successes and setbacks as technologies that provide people with an improved quality of life are developed and implemented.

It is becoming increasingly important that students understand these challenges and redirections, and the implications of these for their own life choices, the environment and the community (local and global) in which they live. Building students' science capability is critical to help them develop the skills and understanding necessary to meet these challenges and make responsible, informed choices.

Science extends our understanding beyond what affects us to include what we can't see, feel, hear or touch but can only imagine. Science capability is multidimensional, consisting of dispositional facets (interest and curiosity), operational facets (creativity and problem solving) and cognitive facets (reasoning and critical thinking). The extent to which we as citizens understand and appreciate these interactions will shape our future.

A set of values inform and govern how scientists operate including respect for the environment (living and non-living) and the opinions and ideas of others, honesty in collecting and presenting data and evidence, and acknowledgment of the work of others. These values are an integral part of a science curriculum that explores and encourages debate about the relationship between science, society and technology.

A major goal of science education is to develop citizens who are capable of engaging in informed debate about science and its applications. Increasing emphasis will be placed on the role of science and the work of Australian and other scientists in addressing issues of sustainability at a local and global level. Science education provides opportunities for students to develop the skills and understanding appropriate to service and good citizenship. It also encourages students to articulate science values and accept the ethical principles embedded in science research. While only some students directly pursue a career in science and scientific research, all students need to appreciate the significance of science for the long-term future of our society.

Structure of the domain

The Science domain is organised into six sections, one for each level of achievement from Level 1 to Level 6. Each level includes a learning focus statement and, from Level 3, a set of standards organised by dimension. A glossary is included which provides definitions of or additional information about underlined terms (see page 24).

Learning focus

Learning focus statements are written for each level. These outline the learning that students need to focus on if they are to progress in the domain and achieve the standards at the levels where they apply. They suggest appropriate learning experiences from which teachers can draw to develop relevant teaching and learning activities.

Standards

Standards define what students should know and be able to do at different levels and are written for each dimension. In Science, standards for assessing and reporting on student achievement apply from Level 3.

Definitions of underlined terms are provided in the Glossary (page 24)

Dimensions

Standards in the Science domain are organised in two dimensions:

- Science knowledge and understanding
- Science at work.

These two dimensions include the traditional science disciplines of biology, chemistry, earth science, environmental science, health sciences, neuroscience, physics and space sciences and the emerging sciences including biotechnology, green chemistry, nanotechnology, and synchrotron science. The dimensions build students' understanding of how science knowledge in the disciplines has been constructed through time and is applied in practical contexts.

The development of *Science knowledge and understanding* necessarily involves conceptual and experiential understanding of *Science at work*, and understanding of the ways the concepts, theories and models of science are used throughout the society in which students live.

Science at work involves students learning the processes of science through the ways they undertake and reflect on their own investigations and those of others.

The two dimensions are interrelated in the ways science affects the broader society in which the students live. Students' own experience of science assists them to develop an understanding of these interactions. The two dimensions are also interrelated in ways that are central to both pedagogy and content.

Science knowledge and understanding

The *Science knowledge and understanding* dimension focuses on building student understanding of the overarching conceptual ideas of science. These include understanding:

- the nature of the similarities between, and the diversity of, living things and their sustainable relationships with each other and their environment
- concepts related to matter – its properties and uses, and the production of different substances through chemical change
- concepts of energy and force as a way of explaining physical phenomena
- the place of the Earth in time and space and the interactions between the Earth and its atmosphere
- how scale is important in relating structure to function at microscopic and macroscopic levels.

These understandings enable students to build on their curiosity and answer their own questions about themselves and their interactions with the world while at the same time allowing them to think through contemporary challenges and issues. Through this, students come to understand how science relates to society and the environment.

Science at work

The *Science at work* dimension focuses on students experiencing and researching how people work with and through science. Students learn to be curious and to use scientific understanding and processes to find answers to their questions. They design and pursue investigations ethically and safely; generate, validate and critique evidence; analyse and interpret ideas and link them with existing understanding; work and reason with scientific models and communicate their findings and ideas to others. They identify and practise the underlying values, skills and attributes of science.

Through their investigations, they gain insight into science as a human activity and the relationship between science, technology and society both now and in the future. They explore how science is used in multiple contexts throughout their lives and its pervasiveness throughout the workplace.

National Statements of Learning

The Victorian Essential Learning Standards (VELS) incorporate the opportunities to learn covered in the national [Statements of Learning](http://www.curriculum.edu.au/mceetya/the_statements_of_learning,11893.html) (www.curriculum.edu.au/mceetya/the_statements_of_learning,11893.html). The Statements of Learning describe essential skills, knowledge, understandings and capacities that all young Australians should have the opportunity to learn by the end of Years 3, 5, 7 and 9 in English, Mathematics, Science, Civics and Citizenship and Information and Communication Technologies (ICT).

The Statements of Learning were developed as a means of achieving greater national consistency in curriculum outcomes across the eight Australian states and territories. It was proposed that they be used by state and territory departments or curriculum authorities (their primary audience) to guide the future development of relevant curriculum documents. They were agreed to by all states and territories in August 2006.

During 2007, the VCAA prepared a detailed map to show how the Statements of Learning are addressed and incorporated in the VELS. In the majority of cases, the VELS learning focus statements incorporate the Statements of Learning. Some Statements of Learning are covered in more than one domain. In some cases, VELS learning focus statements have been elaborated to address elements of the Statements of Learning not previously specified. These elaborations are noted at the end of each learning focus statement.

Definitions of underlined terms are provided in the Glossary (page 24)

Safety

Students will be exposed to potentially hazardous materials and practices when undertaking scientific activities and investigations. Beginning with their first year at school, students are made aware of safe practices and are encouraged to act responsibly when conducting investigations. As students progress through their schooling they develop skills in the safe use of scientific apparatus, including heating and electrical equipment, the safe handling of living and non-living organic materials and the correct use and disposal of chemicals.

Standards and practices should be consistent with legal requirements including Occupational Health and Safety (OH&S). Material Safety Data Sheets (MSDS) provide information about the safe handling of hazardous substances used at the workplace. A Scientific Procedures Premises License (SPPL) is required when animals are used to teach science. If keeping animals then the *Prevention of Cruelty to Animals Act 1986* and the *National Statement on Ethical Conduct in Research Involving Humans* – National Health and Medical Research Council (NHMRC) 2001 also apply.

Level 1

Learning focus

As students work towards the achievement of Level 3 standards in Science, they use their senses to explore the world around them; for example, day and night, the seasons, and living and non-living things. They describe their activities and observations using both general and science-specific language; for example, *hard, soft, long, short, big, small, strong and weak*.

Through sorting objects according to basic criteria such as size, shape, colour and weight, they identify and describe the similarities and differences between them. By participating in very simple investigations involving observation and measurement (for example, making and flying kites, saving water and measuring plant growth) they learn about basic procedures and processes, including collecting and recording data. They display, and make generalisations from their data. They become aware of using safe procedures in their activities.

Standards

In Science, standards for assessing and reporting on student achievement are introduced at Level 3. The learning focus statements for Levels 1 and 2 provide advice about learning experiences that will assist students to work towards the achievement of the standards at Level 3.

Definitions of underlined terms are provided in the Glossary (page 24)

Level 2

Learning focus

As students work towards the achievement of Level 3 standards in Science, they observe and describe phenomena; for example, properties of natural and manufactured materials, insect life cycles, phases of the moon, magnets in action, mirrors and seeing around corners, and light and sound from batteries. Students expand their simple scientific vocabulary by using words and terms for concepts such as temperature, life cycles, light and reflection, sound, magnetism and fair testing.

Students begin to generate questions about situations and phenomena, and suggest forms of observations and measurements that are appropriate for the investigation of their questions; for example, 'Which keeps food fresher, paper or plastic?' and 'What makes sounds change?' They continue to practise basic procedures and processes, including those involving safety. They investigate ways of reducing waste in their classroom; for example, recycling and composting.

They repeat observations over time to make predictions; for example, collecting data about the weather. They begin to recognise simple patterns in data and describe them in terms that represent conclusions drawn from the data. Suitable questions may include: 'Does the size of seeds affect the time taken for them to germinate?', 'Does all chocolate melt at the same temperature?' and 'Are shadows the same size?'

National Statements of Learning

This learning focus statement incorporates aspects of the Year 3 National Statement of Learning for Science.

Standards

In Science, standards for assessing and reporting on student achievement are introduced at Level 3. The learning focus statements for Levels 1 and 2 provide advice about learning experiences that will assist students to work towards the achievement of the standards at Level 3.

Level 3

Learning focus

As students work towards the achievement of Level 3 standards in Science, they begin to design and conduct experiments to explore contexts drawn from traditional and emerging sciences. They investigate questions and ideas about the natural world and learn to use scientific vocabulary in place of everyday language to describe and explain their observations and measurements. They begin to understand that the design of experiments is directly related to their questions about things and events. They learn to describe evidence in support of simple scientific ideas.

Students investigate changes they observe; for example, day becoming night, using brakes to stop a bicycle hitting a gate, seed germination and plant growth, and the regeneration of forests after a bushfire. They examine, by referring to energy transformation, the operation of a range of everyday devices; for example, gates, locks, toasters and hot water systems. They investigate the use of solar energy in cooking or lighting or transport. Students learn about the actions of forces on objects that affect their motion and shape in everyday situations such as walking, playing ball games, blowing up balloons, playing with moving toys and riding in cars or aeroplanes. They explore the relationship between distance and the apparent size of an observed object. They participate in activities where they learn to classify a variety of materials using states of matter (solids, liquids, gases) and they learn that some materials are difficult to classify; for example, honey, plaster, jelly and carbonated soft drinks. They explore reversible and non-reversible changes to common substances such as water, vinegar and bicarbonate of soda.

They begin to understand how different parts work together in plants and animals to produce change and to aid in survival; for example, growth and movement. They realise that offspring are similar to their parents. They learn to classify things that they find in their environment as living (biotic) or non-living (abiotic). They investigate how humans affect the survival of living things and change the environment, and how interactions between living things in the environment change. They investigate natural processes that change the environment over short periods of time (tsunami, drought, floods) and long periods of time (weathering and erosion). Students are introduced to the concept of a sustainable environment and their role in contributing to it; for example, involvement in local litter programs and recycling at home and at school.

Definitions of underlined terms are provided in the Glossary (page 24)

Students relate scientific ideas to their own experiences, interests and concerns, and to a variety of personal and community uses of science and links with technology; for example, the location of mobile phone towers or clearing local bushland to build new roads. They examine how scientists work and how science knowledge has developed by visiting scientists at work, listening to guest speakers or conducting research on the Internet. Students discuss safety considerations and a variety of procedures and processes (including fair tests, variables, ethical considerations relating to observing animals, and selecting and using equipment correctly) that could be used when undertaking experiments.

National Statements of Learning

This learning focus statement, with the following elaborations, incorporates the Year 3 National Statement of Learning for Science. It also incorporates aspects of the Year 5 National Statement of Learning for Science.

Elaborations:

- Students investigate changes they observe; for example, day becoming night, using brakes to stop a bicycle hitting a gate, seed germination and plant growth, and the regeneration of forests after a bushfire.
- Students learn about the actions of forces on objects that affect their motion and shape in everyday situations such as walking, playing ball games, blowing up balloons, playing with moving toys and riding in cars or aeroplanes.
- They explore the relationship between distance and the apparent size of an observed object.
- They realise that offspring are similar to their parents.

Standards

Science knowledge and understanding

At Level 3, students classify a range of materials such as solids, liquids and gases according to observable properties, and demonstrate understanding that this system of classification of substances is sometimes problematic. Students describe examples of reversible and non-reversible changes in substances.

Students identify the actions of forces in everyday situations. They use the words *push* and *pull* in discussing how things can be moved and stopped. They identify forms of energy and energy transformations in the everyday world. They use appropriate scientific vocabulary to describe and explain their observations and investigations.

Students identify and describe the structural features of living things, including plants and animals. They identify how these features operate together to form systems which support living things to survive in their environments. They distinguish between biotic and abiotic factors in their environment and describe interactions that occur between them. They describe natural physical and biological conditions, and human influences in the environment, which affect the survival of living things. They describe the relationship between day and night and the rotation of the Earth. Students explain how features of the landscape are altered by processes of weathering and erosion.

Science at work

At Level 3, students plan, design, conduct and report collaboratively on experiments related to their questions about living and non-living things and events. They select and use simple measuring equipment, use a range of appropriate methods to record observations, and comment on trends. They describe the concept of a fair test and identify the variables associated with an experiment. They develop fair tests to make comparisons and explain how they have controlled experimental variables.

Students describe safety requirements and procedures associated with experiments. They explain how scientific knowledge is used, or could be used, to solve a social issue or problem. They describe aspects of the work of scientists and how this has contributed to science knowledge.

Level 4

Learning focus

As students work towards the achievement of Level 4 standards in Science, they develop a more systematic knowledge of science and science concepts drawn from traditional and emerging sciences. They group living things on the basis of observable characteristics. They explore the concept of relationship; for example, food chains and energy flow along food chains in terrestrial and aquatic environments. They link cause and effect (for example, how physical and chemical changes impact on substances) and how using force produces motion (for example, how objects are affected by gravity, how the magnitude of a force affects the motion and the shape of an object, and how forces such as magnetism may act at a distance). They describe how products or tools have been developed. They consider how models are used to explain structures; for example, the arrangement of planets in the solar system, and the layers within the Earth and in the Earth's atmosphere. They contemplate how systems operate; for example, the human body as a large system consisting of smaller separate systems (circulatory, respiratory, digestive, skeletal, reproductive and nervous) working together, and life cycles as systems for survival. Central to this is their understanding that some questions are open to investigation while others require reasoning and discussion, and that science knowledge is improved and changed by the outcomes of new investigations and explorations. They examine the work of Australian scientists to show how science knowledge has developed.

Students practise framing and investigating questions that interest them and are drawn from locally based issues; for example, sustainability of farming practices, comparative efficiencies of alternative forms and sources of energy used in the community, effectiveness of school recycling programs or the use of new technology. They develop skills in identifying the forms of evidence or data that are needed for drawing conclusions and proposing solutions to the particular scientific questions they generate. They reflect on the variety of ways collected data can be represented; for example, graphs, tables or digital images, and on changes they may make to the design of their investigation. They begin to design and build models to demonstrate the application of science concepts; for example, energy transformation and energy transfer in a solar barbecue, the reflection of light in periscopes, the desalination of water, and the double-pump action of the human heart. They complete reports on their investigations and model-building, explaining the science involved using symbols, diagrams and simple equations.

Definitions of underlined terms are provided in the Glossary (page 24)

Students use a variety of measuring instruments, including alcohol and digital thermometers, to develop an understanding of error in measurement, relating to both the instrument and instrument use. They use this understanding to consider the appropriateness of the inferences and solutions drawn from the evidence and data, and to consider their own responsibilities and safety requirements when working with a variety of instruments and materials. They use hand lenses to examine the smaller visible parts that make up materials.

National Statements of Learning

This learning focus statement, with the following elaborations, incorporates the Year 5 National Statement of Learning for Science. It also incorporates aspects of the Year 7 National Statement of Learning for Science.

Elaborations:

- They group living things on the basis of observable characteristics.
- They link cause and effect (for example, how physical and chemical changes impact on substances) and how using force produces motion (for example, how objects are affected by gravity, how the magnitude of a force affects the motion and the shape of an object, and how forces such as magnetism may act at a distance).
- They describe how products or tools have been developed.
- They contemplate how systems operate; for example, the human body as a large system consisting of smaller separate systems (circulatory, respiratory, digestive, skeletal, reproductive and nervous) working together, and life cycles as systems for survival.
- Students practise framing and investigating questions that interest them and are drawn from locally based issues; for example, sustainability of farming practices, comparative efficiencies of alternative forms and sources of energy used in the community, effectiveness of school recycling programs or the use of new technology.
- They use hand lenses to examine the smaller visible parts that make up materials.

Standards

Science knowledge and understanding

At Level 4, students explain change in terms of cause and effect. They identify the characteristics of physical and chemical changes. They describe how substances change during reactions. They identify and compare the properties of the new or changed material/s with those of the original material/s. Students explain the role of chemical change in the production of new materials. They qualitatively describe changes in motion in terms of the forces present.

Students apply the terms *relationships*, *models* and *systems* appropriately as ways of representing complex structures. They identify and explain the connections between systems in the human body and their various functions. They identify and explain the relationships that exist within and between food chains in the environment. Students use everyday examples to illustrate the transforming and transferring of energy. They explain how the Earth and the Moon operate as a simple system within the larger solar system. They describe the composition of layers within the Earth. They explain the function of the layers of the Earth's atmosphere.

Science at work

At Level 4, students analyse a range of science-related local issues and describe the relevance of science to their own and other people's lives. They explain how sustainable practices have been developed and/or are applied in their local environment. They describe the contributions Australian scientists have made to improve and/or change science knowledge.

Students design their own simple experiments to collect data and draw conclusions. They describe the purpose of experiments they undertake, including a statement of ethical considerations, and relate this purpose to the nature of the data that is collected. They design and build simple models and write an account of the science that is central to explanation of the model. They use diagrams and symbols to explain procedures used when reporting on their investigations.

Students approach data collection systematically, and analyse data qualitatively in terms of errors of measurement. They use a range of simple measuring instruments and materials, and demonstrate understanding of their personal responsibility in using them. They identify and describe safety requirements and procedures associated with experiments and the use of standard equipment. Students use the terms *relationships* and *cause and effect* when discussing and drawing conclusions from the data they collect.

Level 5

Learning focus

As students work towards the achievement of Level 5 standards in Science, they develop their understanding of The Law of Conservation of Energy and The Law of Conservation of Mass and apply these laws to familiar and new situations. They expand their knowledge of science to include abstract concepts, theories, principles and models drawn from traditional and emerging sciences. They apply these to particular situations. Examples include: changing the rates of chemical reactions; using gear systems to demonstrate the relationship between force and energy; investigating the formation of rocks and minerals, including fossil fuels; modelling earthquakes as examples of geological processes; explaining tidal patterns; using data to compare the gravitational attraction between objects in space; expanding their ideas of space science to include meteors, comets, stars, galaxies and the Universe; and relating sustainability to the requirements for species survival and the management of resources.

They develop an understanding of themselves as organisms composed of different cells and systems working together. They explore the relationship between system failure and disease, in humans. They investigate disease at the cellular, tissue and human body levels.

Students explore how scientific work has led to the discovery of new knowledge and understanding about the natural world and changed our understanding of ourselves and our future. Examples include the use of fossils and other information to construct a time scale for the history of Earth; the development of a classification system for living things, past and present; and the use of the particle model of matter to explain the behaviour of materials. They compare the use of reusable, renewable and non-renewable resources, including energy. They investigate the effects of forces supporting or opposing each other; for example, floating and sinking, and speeding up and slowing down. They learn that the nature of scientific thinking is not static and relies upon knowledge, cultural perspectives, understanding and skills that are built up over time, shared and reflected upon, while incorporating new ideas, thinking and experimental evidence.

Students develop their understanding through the use of science ideas (theories, laws, principles and models) applied in particular situations; for example, testing formal understandings in controlled studies using appropriate experimental tools. They discuss and elaborate particular theoretical knowledge or ways of working in areas of personal or public concern, interest or career, including researching scientific ideas expressed in science magazines and science fiction texts.

Definitions of underlined terms are provided in the Glossary (page 24)

Students develop skills in measuring mass, volume and density. They learn to use appropriate units of measurement. They participate in activities in which they identify, prepare and separate mixtures and solutions. They learn to use basic sampling procedures when conducting fieldwork. They design and perform controlled experiments. They construct simple electric circuits which include batteries. They develop confidence in justifying their selection of equipment and procedures, the type of data collected, and its relationship to the question under investigation. They use a range of tools (for example, their own or others' computer models, images and simulations) to explain and interpret observations. They learn to present data in appropriate spreadsheet and graphical form. They begin to write balanced chemical equations using symbols. They prepare and present reports of their investigations in a variety of formats, using diagrams and symbols to summarise their procedures. Students practise safe, responsible and ethical behaviour when conducting investigations using standard equipment and chemicals including acids and bases, electric circuit components and metals and non-metals. They develop ideas about the responsible use and disposal of materials using Material Safety Data Sheets (MSDS).

National Statements of Learning

This learning focus statement, with the following elaborations, incorporates the Year 7 National Statement of Learning for Science. It also incorporates aspects of the Year 9 National Statement of Learning for Science.

Elaborations:

- They expand their knowledge of science to include abstract concepts, theories, principles and models drawn from traditional and emerging sciences. They apply these to particular situations. Examples include: ... using data to compare the gravitational attraction between objects in space...
- They compare the use of reusable, renewable and non-renewable resources, including energy.
- They investigate the effects of forces supporting or opposing each other; for example, floating and sinking, and speeding up and slowing down.
- They learn that the nature of scientific thinking is not static and relies upon knowledge, cultural perspectives, understanding and skills that are built up over time, shared and reflected upon, while incorporating new ideas, thinking and experimental evidence.
- They construct simple electric circuits which include batteries.
- Students practise safe, responsible and ethical behaviour when conducting investigations using standard equipment and chemicals including acids and bases, electric circuit components and metals and non-metals.

Definitions of underlined terms are provided in the Glossary (page 24)

Standards

Science knowledge and understanding

At Level 5, students use the particle model to explain structure and properties of matter, chemical reactions and factors that influence rate. They explain the structure and function of cells and how different cells work together.

Students explain the relationships, past and present, in living and non-living systems, in particular ecosystems, and human impact on these systems. They analyse what is needed for living things to survive, thrive or adapt, now and in the future. They explain how the observed characteristics of living things are used to establish a classification system.

Students use everyday examples of machines, tools and appliances to show how the thermodynamic model describes energy and change, and force and motion. They use time scales to explain the changing Earth and its place in space. Students distinguish ideas about the Universe that have a scientific basis from those that do not. They use physical and theoretical models to investigate geological processes.

Science at work

At Level 5, students demonstrate safe, technical uses of a range of instruments and chemicals, and of procedures for preparation and separation. They design investigations that include measurement, using standard laboratory instruments and equipment and methods to improve accuracy in measurement. They make systematic observations and interpret recorded data appropriately, according to the aims of the study.

Students justify their choice of instruments and the accuracy of their measurements, commenting on the reliability of the procedures, the measurements used, and the conclusions drawn against the prediction or hypothesis investigated. They use appropriate diagrams and symbols when reporting on their investigations.

Students make and use models and images from computer software to interpret and explain observations. In field work, they demonstrate use of basic sampling procedures and represent relationships in ecosystems graphically.

Students use simulations to predict the effect of changes in an ecosystem. They work effectively in a group to use science ideas to make operating models of devices. Students identify, analyse and ask their own questions in relation to scientific ideas or issues of interest.

Level 6

Learning focus

As students work towards the achievement of Level 6 standards in Science, they extend their concept of science as a way of knowing to include an understanding of how scientific theories and models drawn from traditional and emerging sciences are based on evidence that may initially be tentative and limited. Examples include atomic structure, natural selection and evolution, development of medicines, genetic inheritance, and the genesis of the Universe. They explore the ways in which scientific theories are both powerful (in guiding thinking and investigation) and tentative (in being open to change) at the same time. They understand that the features of science as a way of knowing lead to it being: empirical and non-empirical, creative and methodical, and speculative and logical. They appreciate that people of diverse cultures have contributed to and shaped the development of science.

Students develop a qualitative and quantitative understanding of the relationships between force, mass and movement. They consider how coordination and regulation of functions occurs in plants and animals. They investigate the adaptive behaviours which enable plants and animals to survive in their environments, and consider possible adaptive behaviours which may be needed for future survival. They explore the role of DNA and genes in determining patterns of inheritance. They investigate how energy may be responsible for the changes observed in biological, chemical and physical processes and applications. Examples include electromagnetism; polarisation of light; the operation of electronic systems; endothermic and exothermic reactions; rate of reaction; production of new materials; photosynthesis and respiration; cell division (mitosis and meiosis); action of micro-organisms; global atmospheric changes; plate tectonics; optics; photonics; transmission of nerve impulses; energy flow through ecosystems; population dynamics; and the cycling of matter (including water, carbon and minerals) in ecosystems.

Students investigate sources of waste generated within the community and consider waste treatment and management options. They learn how wastes are generated in the processing of natural materials (for example, oil, water, brown coal and ores), and how the procedures used to manage these wastes contribute to environmental sustainability. They investigate, create and produce a range of strategies and products that explore, encourage and communicate the responsible use and management of natural and processed resources.

Definitions of underlined terms are provided in the Glossary (page 24)

Students make links across related areas of science; for example, biotechnology (biology and chemistry); communication satellites (physics and astronomy); neuroscience (psychology, biology and chemistry); synchrotron science (biology, chemistry and physics); resource management and green chemistry (chemistry and earth and environmental science); and habitat renewal (earth and environmental sciences and biology). They explore the opportunities for employment in science-related occupations and industries in their community, and consider the dynamic and collaborative nature of these roles.

Students learn that scientific theories are both powerful and never final, that clarity is always assumed to be a significant attribute of science theories, and that the use of a theory to successfully predict the consequences of changes to situations is important in the validation of the theory. Students design and conduct scientific investigations of their choice in ways that lead to the collection, interpretation and presentation of valid data. They explain trends and patterns in data, identify discrepancies in experimental results and suggest improvements to their investigations. They learn to use correct units of measurement when recording quantities. They use Material Safety Data Sheets (MSDS), when appropriate. Using a variety of formats, students prepare investigation reports learning to use symbols and diagrams extensively to illustrate procedures and data analysis, and support the conclusions drawn and presented.

Students develop an understanding of the constancy of the 'big' ideas of science (matter, energy, time and space) and science methodologies across different areas and contexts. They debate, from the basis of scientific knowledge, the merits and problems of science-related issues that are reported in the popular media, particularly those that embrace a clear ethical dimension. They also explore the ways in which science concepts, language and perspectives can be misunderstood and misrepresented. Students cite instances in which social priorities have had an impact on or have been influenced by society. This involves students applying their conceptual understandings to the consideration of issues significant to themselves as individuals and to the broader society in which they live; for example, stem cell research, ecotourism, tourism in space, personal safety, a clean and healthy environment, energy use, ecological footprints, electronic gadgets, robotics, the history and philosophy of science, ethics and science research.

National Statements of Learning

This learning focus statement, with the following elaborations, incorporates the Year 9 National Statement of Learning for Science. Some aspects of the year 9 Statement of Learning are incorporated in the Level 5 learning focus statement.

Elaborations:

- They appreciate that people of diverse cultures have contributed to and shaped the development of science.
- They investigate how energy may be responsible for the changes observed in biological, chemical and physical processes and applications. Examples include ... global atmospheric changes; plate tectonics; ... population dynamics....
- They explain trends and patterns in data, identify discrepancies in experimental results and suggest improvements to their investigations.
- Students cite instances in which social priorities have had an impact on or have been influenced by society.

Standards**Science knowledge and understanding**

At Level 6, students explain the behaviour and properties of materials in terms of their constituent particles and the forces holding them together. They explain how similarities in the chemical behaviour of elements and their compounds and their atomic structures are represented in the way the periodic table has been constructed. They use the periodic table to write electronic configurations for a range of elements representative of the major groups and periods in the periodic table. They use atomic symbols and balanced chemical equations to summarise chemical reactions, including neutralisation, precipitation and combustion. They identify and classify the sources of wastes generated, and describe their management, within the community and in industry. They use a specific example to explain the sustainable management of a resource.

Students explain change in terms of energy in a range of biological, chemical and physical contexts. They demonstrate the link between natural selection and evolution. They explain the role of DNA and genes in cell division and genetic inheritance. They explain how the coordination and regulatory functions within plants and animals assist them to survive in their environments. They explain how the action of micro-organisms can be both beneficial and detrimental to society. Students apply concepts of geological time to elaborate their explanations of both natural selection and evolution, and the origin and evolution of the Universe. They give both qualitative and quantitative explanations of the relationships between force, mass and movement.

Science at work

At Level 6, students describe the science base of science-related occupations in their local community. They use the relevant science concepts and relationships as one dimension of debating contentious and/or ethically based science-related issues of broad community concern. They demonstrate an awareness of the ways in which scientific vocabulary is used incorrectly in the mass media, distinguishing between the intended meaning of such terms and their meaning in non-scientific contexts. They provide two examples of the work of scientists that demonstrate different approaches to developing scientific knowledge or solving a scientific problem.

Students formulate their own hypotheses and plan and conduct investigations in order to prove or disprove them. They use chemicals (including biomaterials), equipment, electronic components and instruments responsibly and safely. They select appropriate equipment and measurement procedures that will ensure a high degree of reliability in data collected and enable valid conclusions to be drawn. They construct working models and visual aids that demonstrate scientific ideas. They present experimental results using appropriate data presentation formats, and comment on the nature of experimental errors. They use Material Safety Data Sheets (MSDS) and risk assessment to evaluate the safety of their investigations. They evaluate the appropriateness of the experimental design and methodology used to investigate their predictions.

Glossary

Australian scientists

For information regarding what is happening (and what has happened) in Australian science, contact the Australian Academy of Science at <www.science.org.au/aashome.htm>

Classification system for living things

Scientists have found and described approximately 1.75 million species on Earth. In addition, new species are being discovered every day. Classification is one way to make sense of the diversity of life. There are many classification systems, but the one most commonly used by scientists is the *Linnaean system of classification*. In this binomial (two-name) system of classification, scientists name animals and plants by naming the genus and species of the organism. The first word is the *genus* and the second is the *species*. The first word is capitalised and the second is not. Humans are scientifically named *Homo sapiens*. An abbreviation of this name as *H. sapiens*, where the genus is only represented by the first letter, may also appear in scientific literature.

Earth's atmosphere

The atmosphere is the thin layer of gases that surrounds the Earth and is retained by Earth's gravity. It contains about four-fifths nitrogen and one-fifth oxygen, with trace amounts of other gases. The atmosphere protects life on Earth by absorbing solar radiation and reducing temperature extremes between day and night. The layers of the atmosphere are the troposphere, stratosphere, mesosphere, thermosphere, ionosphere and exosphere. The atmosphere has no abrupt cut-off. It slowly becomes thinner and fades away into space. The *Karman line*, at 100 kilometres above the Earth's surface, is frequently used as the boundary between Earth's atmosphere and space.

Ecological footprint

An ecological footprint (or eco-footprint) is a measure of our ecological performance. It tracks the quantity of resources individuals (or organisations, cities, regions, nations or the global population) consume and compares this amount to the resources nature can provide. It indicates how much biologically productive land and water area a given population occupies in order to produce the resources it consumes and to absorb its waste, using prevailing technology.

Emerging sciences

Traditional science discipline boundaries are being revised as new knowledge in science creates broader and novel applications of science. The emerging sciences include:

- **Nanotechnology**
Further information can be found at <www.nano.gov>
- **Biotechnology**
Further information can be found at <www.gtac.edu.au> and <www.biotechnology.vic.gov.au>
- **Green chemistry**
Further information can be found at <www.chem.monash.edu.au/green-chem>
- **Synchrotron science**
Further information can be found at <www.synchrotron.vic.gov.au>

Energy

Energy is defined as the amount of work required to change the state of a physical system. Energy may be classified as *potential* (stored) energy or *kinetic* (moving) energy. Forms of energy include thermal, mechanical, electrical, gravitational, elastic, chemical, heat, light and sound. Energy may be transformed from one form into another. The presence of energy is revealed only when a change takes place. Animals obtain their energy from food. Toasters and washing machines use electricity as their energy supply.

Energy transfer

This refers to the ways in which energy can be moved, for example heat transfer by *convection*, *conduction* and *radiation*.

Energy transformation

This refers to energy conversions from one form to another. Energy can be readily transformed from one form into another. Potential energy (stored energy, for example chemical, gravitational and elastic) may be converted to kinetic energy (moving energy, for example electrical, mechanical) and from kinetic energy to heat, light or sound energy. For example, using a battery to power an electrical heater converts chemical energy into electrical energy, which is then converted into thermal energy. Allowing elevated water to move down a hill transforms stored potential energy into the kinetic energy of moving water and turbines, which in turn may be transformed into electrical energy by a generator.

Geological processes

Geological processes have shaped and continue to shape the Earth. These processes can occur at the Earth's surface; for example, physical and chemical weathering, removal by gravity such as landslides and mudflows, erosion, and the building up and breaking down effects of running water, groundwater, waves, currents, tides, tsunamis, wind and glaciers). They can be caused by events inside the Earth; for example, continental drift, folding, faulting and vulcanism. They can also be caused by events away from the Earth; for example, meteorites. The activities of living things, including humans, also impact significantly on geological processes.

Investigations

Investigations provide students with the opportunities to frame and pose questions which can be tested scientifically. Students work independently or in small groups or teams. They plan their work and select processes and equipment with attention to safety and draw conclusions from their data. They comment on the accuracy and reliability of the processes used and data collected, and complete a report of their investigation which can be presented in a range of formats.

Mass

Mass and weight are not the same. In science these words have special meanings. Mass is a measure of the amount of matter (material) in an object and is commonly measured in grams (g) or kilograms (kg).

Material Safety Data Sheets (MSDS)

MSDS provide the information needed to allow the safe handling of hazardous substances used at the workplace. Schools are required to comply with these procedures for the management of hazardous substances. An MSDS should provide sufficient information to enable users of the hazardous substances to handle them safely, to understand their potential dangers and to take appropriate action in case of an emergency.

Models

Models are ways of representing complex structures and relationships. They are used to simplify a more complex arrangement; for example, the structure of matter represented through particle and atomic theory.

Scientific method

This involves the principles and empirical processes of discovery and demonstration of considered characteristics of, or necessary for, scientific investigation. Scientific method generally involves

the observation of phenomena, the formulation of a hypothesis concerning the phenomena, experimentation to prove or disprove the hypothesis, and a conclusion that validates or modifies the hypothesis. Science by inquiry or science by discovery is also integral to investigations in science.

Scientific Procedures Premises License (SPPL)

An SPPL is required when animals are used to teach science. For further information contact Schools Animal Welfare Project, Bureau of Animal Welfare, Department of Primary Industries (Victoria) at <www.dpi.vic.gov.au> and/or the Department of Education and Training (Victoria) at <www.sofweb.vic.edu.au>

Scientific vocabulary

This refers to the words used by scientists to accurately describe matter, organisms, processes and systems. These words have an exact meaning or definition, and application. Sometimes these words are used incorrectly or imprecisely when applied in everyday use.

Sustainability

Sustainability is an ecological, economic, social and political concept. A sustainable society is one that meets the needs of the present without compromising the ability of future generations to meet their own needs. In the Science domain, issues which need to be considered for sustainability include: the conservation of biodiversity and ecological integrity; dealing judiciously with risk, uncertainty and irreversibility; ensuring appropriate valuation of environmental assets; integration of environmental and economic goals in government and institutional policies and activities; social equity (both intragenerational and intergenerational); and community participation.

Resources:

- <www.earthcharter.org> for information about The Earth Charter (a United Nations initiative) and listing a number of teaching and learning resources
- <www.unesco.org/education/tlsf> provides access to 'Teaching and Learning for a Sustainable Future', a multimedia teacher education programme published by the United Nations Educational, Scientific and Cultural Organisation (UNESCO). It contains 25 professional development modules for teachers, teacher educators and student teachers, as well as curriculum developers, education policy makers and authors of educational materials. The program may be used in both pre- and in-service teacher education, by individuals or by groups.

- Australian Government Department of the Environment and Heritage, 'Educating for a Sustainable Future', A National Environmental Education Statement for Australian Schools, Curriculum Corporation, Carlton South, Victoria, 2005.

Systems

Systems consist of inputs, processing and outputs for a group of organs (or cells) that work together to provide living things with advantages for survival. Systems can be found in plants and animals (including humans). Systems work alone and with other systems. The human body is an example of a complex system and illustrates the progression from *cells* to *tissues* to *organs* and then *systems*. Maintaining *homeostasis*, or a stable internal environment, enables humans to survive.

The Law of Conservation of Energy

This law (also known as the *First Law of Thermodynamics*) states that energy can be converted from one form to another, but it cannot be created or destroyed.

The Law of Conservation of Mass

This law states that matter changes form, but it cannot be created or destroyed. This means that for any chemical process in a closed system, the mass of the reactants must equal the mass of the products.

Units of measurement

A unit is a particular physical quantity, defined and adopted by convention, with which other particular quantities of the same kind are compared to express their value. The International System of Units (SI) is founded on seven base quantities, assumed to be mutually independent, as shown in the table below:

BASE QUANTITY	SI BASE UNIT	
	NAME	SYMBOL
Amount of substance	mole	mol
electric current	ampere	A
length	metre	m
luminous intensity	candela	cd
mass	kilogram	kg
thermodynamic temperature	kelvin	K
time	second	s

Further information about SI units can be found at the Bureau International des Poids et Mesures website at <www.bipm.org>

Variables

Variables are factors that can and do affect the outcome of experiments. Some variables can be controlled during experiments. These are known as *control variables*. The impact of some variables can be reduced by refining procedures and/or repeating the experiment many times. Only one variable should be included in the design of an experiment.

Weight

Weight and mass are not the same. Weight is a measure of the force of gravity pulling on a mass and is measured in newtons (N). Under ordinary conditions the mass of an object can be said to be constant (the object's mass will be the same at different locations in the Universe). The weight of an object is not constant, since the force of gravity varies from place to place (the object's weight varies depending on its location in the universe). For example, Earth's moon is smaller than Earth and pulls objects towards it less strongly. A given object will therefore have the same mass on Earth and on the moon, but its weight on the moon will be about 16% of the weight as measured on the Earth. A human with a mass of 50 kg on Earth, for example, will weigh 500 N on Earth. On the Moon, this person will still have a mass of 50 kg but will only weigh 80 N.

First published February 2005

Revised Edition published January 2008

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Published by

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

41 St Andrews Place East Melbourne Victoria 3002 Australia

TELEPHONE +61 3 9651 4300 FACSIMILE +61 3 9651 4324

EMAIL vcaa@edumail.vic.gov.au

WEB www.vcaa.vic.edu.au

