National Curriculum Board

Shape of the Australian Curriculum: Science

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1. PURPOSE

1.1 The *Shape of the Australian Curriculum: Science* will guide the writing of the Australian science curriculum K–12.

1.2 This paper has been prepared following analysis of extensive consultation feedback to the National Science Curriculum Framing Paper and decisions taken by the National Curriculum Board.

1.3 The paper should be read in conjunction with *The Shape of the Australian Curriculum*.

2. INTRODUCTION

2.1 The national science curriculum will be the basis of planning, teaching and assessment of school science and be useful for and useable by experienced and less experienced teachers of K–12 science.

2.2 The framing paper draws on important recent science education research, in particular the Australian *School Science Education National Action Plan* 2008–2012 (Goodrum & Rennie 2007; Rennie & Goodrum 2007) and *Re-imagining Science Education: Engaging students in science for Australia's future* (Tytler 2007). These two reports provide an up-to-date synthesis of national and international research on school science education and bring together the perspectives of a range of science education interest groups with a focus on improving school science learning.

2.3 The imperative to create a futures-oriented curriculum is a major opportunity to lead improved teaching and learning. A futures orientation will include consideration that society will be increasingly complex, with Australians interacting in a global environment needing to know how to learn, adapt, create, communicate, and how to interpret and use information critically.

2.4 Science is a dynamic, forward-looking, collaborative human endeavour arising from our curiosity and interest. It provides a distinctive way of thinking about and explaining events and phenomena. The body of science knowledge, understanding, theories and explanations has been built from observations and evidence gathered in finding answers to the questions we ask. The body of science knowledge and understanding is rapidly increasing.

2.5 For Australia's citizens to be sufficiently well-educated for the development of society and to ensure international competitiveness the Australian science curriculum must meet the needs of those students: who, as citizens in a global world, need to make personal decisions on the basis of a scientific view of the world; who will become the future research scientists and engineers; and who will become analysts and entrepreneurs in the diverse fields of business, technology and economics.

2.6 Learning about science is a cumulative process that begins in early childhood and continues throughout schooling. The kinds of teaching and learning strategies that best assist students to learn will vary according to their different needs and interests. This has implications for the way science is taught.

2.7 The process of building science knowledge is as important as the knowledge itself. Young children and adolescents frequently pose questions to gain a sense of themselves and the world about them. The intrinsic curiosity and simple wonder that is involved in such inquiry is the quality that drives learning and understanding. Passion, excitement, frustrations, uncertainty and enlightenment are experienced in the quest for science understanding and a scientific view of the world.

2.8 The Australian science curriculum will provide the basis for learning science that will engage students in meaningful ways and, with the support of teachers, help them to develop their science understanding so that they can function effectively in a scientifically and technologically advanced society. Students should value science for its rationality, the tentative but trustworthy nature of its knowledge and its objectivity, its shared character, its transcendence of local factors, its openness, and its communicability. These make science such a powerful human endeavour.

2.9 As well as preparing students to use science for life and active citizenship, school science should also provide a foundation for specific learning pathways leading to science and engineering courses at university and technical and vocational education and training. Senior secondary science opens up a wide range of careers in engineering, technology, medical and health professions, as well as careers in science and education.

3. AIMS OF THE SCIENCE CURRICULUM

3.1 The aim of the Australian science curriculum is to provide students with a solid foundation in science knowledge, understanding, skills and values on which further learning and adult life can be built.

3.2 In particular, the science curriculum should foster an interest in science and a curiosity and willingness to speculate about and explore the world. Students should be able to engage in communication of and about science, value evidence and scepticism, and question scientific claims made by others. They should be able to identify and investigate scientific questions, draw evidence-based conclusions and make informed decisions about their own health and wellbeing. Science is a human endeavour that students should learn to appreciate and apply to daily life.

4. KEY TERMS

4.1 Contemporary science

Contemporary science involves new and emerging science research and issues of current relevance such as energy resources and technology, climate change and adaptation, mining and minerals, biodiversity and ecological sustainability, materials science and engineering, health and prevention and treatment of disease.

4.2 Technology (and design)

Technology involves the designed world, its artefacts and systems, and the infrastructure to maintain them. It has been a powerful force in the development of civilisation. Technology is a complex social enterprise that includes not only research, design, and crafts but also engineering, manufacturing, finance, management, labour, marketing and maintenance. Technology can be used to solve problems about human needs. Science knowledge has often led to applications in society in the form of technologies and their products. In turn, developments in technology have made possible new ways for scientists to explore and further understand the world.

4.3 Unifying ideas

Unifying ideas draw together the concepts and processes of learning in science. They provide students with structures through which they can better understand the world. Unifying ideas include: patterns, systems, order and organisation; exploration, observation, questioning and speculating; cause and effect; evidence, models, explanation and theories; change, constancy and measurement; equilibrium and interdependence; sustainability of systems; form and function; and energy.

5. STRUCTURE OF THE SCIENCE CURRICULUM

5.1 Content strands

5.1.1 The science curriculum will be organised around three interrelated strands: science understanding; science inquiry skills; and science as a human endeavour.

5.1.2 Science understanding: This is evident when a person selects and integrates appropriate science knowledge in ways that explain and predict phenomena, and applies that knowledge to new situations and events. Science knowledge refers to facts, concepts, principles, laws, theories and models that have been established by scientists over time. Science knowledge represents the building blocks of science understanding but it is the dynamic nature of science understanding that will be beneficial to citizens in an ever-changing world.

5.1.3 Science inquiry skills: These involve posing questions, planning, conducting and critiquing investigations, collecting, analysing and interpreting evidence and communicating findings. This strand is concerned with evaluating claims, investigating and making valid conclusions. It also recognises that scientific explanations change as new or different evidence becomes available.

5.1.4 Science as a human endeavour: Science influences society through the posing and responding to social and ethical issues and science research is influenced by societal challenges or social priorities. This strand highlights the need for informed, evidence-based decision making about current and future applications of science. It acknowledges that, in making decisions about science and its practices, moral, ethical and social implications must be taken into account. It also acknowledges that science has advanced through, and is open to, the contributions of many different people from different cultures at different times in history and that science offers rewarding career paths. It identifies the historical aspects of science and is well demonstrated in contemporary science issues and activities.

5.2 Science across K–12

Although the curriculum will be developed year by year, this document provides a guideline across four year groupings:

Years K–2:	typically students from 5 to 8 years of age
Years 3–6:	typically students from 8 to 12 years of age
Years 7*–10:	typically students from 12 to 15 years of age
Years 11–12:	typically students from 15 to 18 years of age

*Specific advice will be provided to writers on the development of the Year 7 curriculum.

The following outline of the curriculum for Kindergarten to Year 10 is organised by the three strands. Unifying ideas which draw together the strands and disciplines of science are provided for each year grouping. The unifying ideas are developmental in nature with subsequent unifying ideas building on those for the previous year grouping. In this way, unifying ideas enable students to accumulate knowledge over time for deeper understanding. For example, order and change are necessary ideas to understand systems. Understanding systems provides the basis for appreciating the nature of equilibrium and interdependence.

5.2.1 Years K–2 (typically from 5 to 8 years of age)

Curriculum focus: awareness of self and the local world

Young children have an intrinsic curiosity about their immediate world and a desire to explore and investigate things around them. Asking questions leads to speculation and the testing of ideas. Exploratory, purposeful play is a central feature of their investigations. Observation, using the senses in dynamic ways, is an important skill to be developed in these years. Observation leads into the idea of order that involves describing, comparing and sorting.

Science understanding	• comparing, sorting and classifying objects and materials • pushes, pulls, position and motion of objects • living and non-living things • needs, structures and growth of organisms • objects in the sky • changes on earth and the effects on living things.
Science inquiry skills	• explore, be curious and wonder • ask questions and begin to investigate • describe what has happened • make and share observations • use evidence to support ideas.
Science as a human endeavour	• recognise aspects of science in everyday life • identify work associated with science in the community • care for the environment.

Unifying ideas for students in this age range are:

- *Exploration*: Investigation of objects and things around them as a precursor to more directed inquiry in later years.
- *Observation*: Using the senses to observe and gather information about the environment, looking for what is the same and what is different.
- *Order*: Observing similarities and differences and comparing, sorting and classifying to create an order that is more meaningful.
- *Change*: There are many changes that occur in the world. Changes occur in materials, the position of objects, and the growth cycles of plants and animals. Some of these changes are reversible, but many are not. These changes vary in their rate and their scale.
- *Questioning and speculating*: Questions and ideas about the world become increasingly purposeful; explanatory ideas are developed and tested through further exploration.

5.2.2 Years 3–6 (typically from 8 to 12 years of age)

Curriculum focus: recognising questions that can be investigated scientifically and investigating them

During these years students will have the opportunity to develop ideas about science that relate to their life and living. A broad range of science concepts will be explored. Within these, the unifying ideas of patterns, systems, cause and effect, and evidence and explanation will be developed.

In the early years of primary school, students will tend to use a trial-and-error approach to their science investigations. As they progress through these years, the expectation is that they will begin to work in a more systematic way. The notion of a 'fair test' and the idea of variables will be developed, as well as other forms of science inquiry. Understanding the importance of measurement will also be fostered.

Science understanding	• properties and uses of materials • forces and motion • forms, use and transfer of energy • structures and functions of living things • life cycles of organisms • living things and the environment • changes on earth and in space • relationship between earth, moon and sun • earth's resources and their uses.
Science inquiry skills	• identify questions and predictions for testing • plan and conduct simple investigations • observe, describe and measure • collect, record and present data as tables, diagrams or descriptions • analyse data, describe and explain relationships • discuss and compare results with predictions • draw conclusions and communicate ideas and understandings.
Science as a human endeavour	• consider how science is used in work and leisure • become aware of science-related careers • recognise the effect of science and technology on our environment • be aware of the historical nature of science ideas.

Building on the unifying ideas of exploration, observation, order, change, questioning and speculating, the unifying ideas of this age range are:

- *Patterns:* Through observation one can detect similarities among objects, living things and events. These similarities form patterns that underlie the idea of regular repetition. By identifying these patterns in nature, explanations can be developed about the reasons for them.
- *Systems:* The world is complex but can be understood by focusing on its smaller components. Understanding develops by examining these smaller components, or parts, and how they are related. Groups of parts that work together as a whole are commonly described as systems. There are also systems within systems, or subsystems. For example, an animal can be regarded as a system and within the animal there can be subsystems, such as the nervous system. There are many types of systems. Some examples are: a pond, a network, a particular machine, a school, the solar system.
- *Cause and effect:* An important aspect of science investigation is the study of relationships between different factors or variables. Cause and effect is an important kind of relationship. Examples of cause and effect questions are: If a plant dies, what are the factors that caused its death? If a person develops a skin rash, what has caused that rash?
- *Evidence and explanations:* Evidence is the driving force of science knowledge. From the data derived from observation, explanations can be developed and tested. With new evidence, explanations may be refined or may change.

5.2.3 Years 7–10 (typically from 12 to 15 years of age)

Curriculum focus: explaining phenomena involving science and its applications

During these years, students study science concepts associated with each of the disciplines: biology, physics, chemistry and earth science. It is important to include contemporary contexts in which science can be learned and issues and recent research to enhance understanding of science in the world. It is current research and its human uses and implications that motivates and excites students.

In determining what concepts students should learn, it is important to exercise restraint and avoid overcrowding the curriculum, and so provide time to build the knowledge base that underlies science understanding. The unifying ideas of energy, sustainability of systems, equilibrium and interdependence lead to the ideas of form and function that result in a deeper appreciation of evidence, models, explanations and theories.

Science understanding	*Physics and chemistry* • nature of matter, including particle theory • forms of energy, energy transfer and storage • forces and motion • acids and bases • metals and non-metals • elements, compounds and chemical reactions. *Biology* • cells and living things • the human body • ecosystems • theory of evolution and the diversity of living things. *Earth science* • structure of the earth and geological history • plate tectonics and geological phenomena • stars, galaxies and the universe.
Science inquiry skills	• formulate scientific questions or hypotheses for testing • design and conduct science investigations involving measurement and repeated trials • gather and organise data from a variety of sources • analyse and test models and theories based on the evidence available • explain and summarise patterns in data using science concepts.
Science as a human endeavour	• be aware of contemporary issues such as water and its management, climate change, stem cell research, nanotechnology, gene technology • apply scientific understandings to make responsible, ethical and informed decisions about issues • be aware of the nature of science and research of Australian scientists • appreciate that science provides rewarding careers • appreciate the diversity of people who have contributed to, and shaped the development of, science.

Building on the unifying ideas of exploration, observation, order, change, questioning and speculating, patterns, systems, cause and effect, evidence and explanations, the unifying ideas of this age range are:

- *Energy:* Energy is the basis of all activity. There are different forms of energy and energy is transferred between these forms. A guiding principle is that energy is always conserved. A challenge for humans is to use energy wisely.

- *Sustainability:* The idea of sustainability is central to the nature of dynamic systems. A system has inputs, outputs and a variety of internal functions. The interaction of these inputs, functions and outputs determines the degree to which any system can sustain itself. The inputs include resources that may be renewable or non-renewable.

- *Equilibrium and interdependence:* In a system there are forces and changes that act in opposing directions. For a system to be stable, these factors need to be in a state of balance or equilibrium. This equilibrium is based on the interdependence of all the components within the system. A change in one of the components can affect all components of the system because of the interrelationships between the parts.

- *Form and function:* For objects and organisms, form and function are complementary. Form describes the nature or make-up of an aspect of an object or organism, while function represents the use of that aspect. For example, the form of a particular bone in the human body is specifically suited to its use.

- *Evidence, models, explanations and theories:* Just as evidence provides the basis of explanations, explanations are used and refined to form models and theories. Models and theories are more complex; abstract schemes or structures that provide a more detailed but tentative basis for understanding a range of evidence.

5.2.4. Years 11–12 (typically from 15 to 18 years of age)

Curriculum focus: disciplines of science

There will be courses in physics, chemistry, biology and earth and environmental science in the senior secondary years. These courses will recognise the sequential nature of knowledge in the field and enable the development of depth of understanding of key concepts, processes and contexts without overcrowding the curriculum. These courses will be organised by the three strands.

There will be further advice for writers about the nature of the curriculum in the senior secondary years and key considerations in the development of the curriculum.

6. CONSIDERATIONS

The following considerations have informed the development of the framing paper and will continue to inform the development of the Australian science curriculum.

6.1 Equity and opportunity

6.1.1 The Australian science curriculum will provide flexibility and choice for teachers and students. The factors that influence this choice include school and community contexts, local science learning opportunities, historical perspectives, contemporary and local issues and available learning resources. In managing this choice, a balanced science curriculum should engage every student while catering for a broad cohort of students and a range of delivery contexts.

6.1.2 Equally, the Australian science curriculum will provide a common and consistent base that delivers equity of opportunity, engaging every student and enabling them to make active and informed decisions about whether to pursue further study of science. Ensuring that all students learn the science knowledge, skills and understanding to enable them to participate actively in the broader community will require consideration of how best to engage every student and of the way particular groups may have previously been excluded.

6.1.3 The Australian science curriculum will provide opportunities for students to develop understanding of aspects of Indigenous cultures.

6.2 Connections to other learning areas

6.2.1 The learning acquired by students in science contributes to learning in other areas. The curriculum for each area will identify where there are links or opportunities to build cross curriculum learning.

6.2.2 Learning in science involves the use of knowledge and skills learned in other subjects/ areas, particularly in English, mathematics, technology and design, and history.

6.2.3 There is strong support in schools across Australia for linking learning in science with learning literacy skills. The science tradition places a high priority on accurate communication. The language and literacy demands of the Australian science curriculum will be supported by and in turn will reinforce learning of literacy skills. Students will need to be able to describe objects and interpret descriptions, read and give instructions, explain ideas to others, write reports and participate in group discussions.

6.2.4 The union of science, mathematics and technology and design forms 'the scientific endeavour'. Although each of these areas has an identity of its own, each is dependent on and reinforces the others. Mathematics knowledge and skills are fundamental to learning science. Students will need knowledge and skills in areas such as: graphing, ratio and proportion, converting from one unit to another, scientific notation, an understanding of place in number (significant figures), estimation and calculation.

6.2.5 History provides another avenue to the understanding of how science works. Science and its discoveries are a source of historical facts and artefacts. The strand, Science as human endeavour, is an important link to historical facts and processes. It is important that students come to realise that much of the growth of science and technology has resulted from the gradual accumulation of knowledge over many centuries. Students should learn that all sorts of people, not only great scientists but people like themselves, have done and continue to do science. Historical case studies of science, mathematics and technology and design in the early Egyptian, Greek, Chinese, Arabic and Indigenous Australian cultures extending to modern times, will help students understand the contributions of people from around the world.

6.2.6 The Australian science curriculum will take account of what students have learned in these areas so that their science learning is supported and their learning in other areas enhanced.

6.3 Clarity of the curriculum

6.3.1 The Australian science curriculum needs to be easily read by experienced teachers and a source of clear, succinct information for beginning teachers. To meet these needs the curriculum must be briefer rather than longer, written in simple, plain English and not jargon-ridden, and must allow all readers to know the purpose of learning particular aspects.

6.4 Breadth and depth of study

6.4.1 There is a body of science knowledge and understanding that can be considered fundamental to the learning of science. A challenge for the Australian science curriculum is how to take account of the known fundamental body of knowledge and the rapidly increasing body of knowledge and not simply to add more to what students are expected to know. A curriculum that covers an extensive range of science concepts and knowledge has the potential to treat concepts in a superficial way as teachers attempt to cover what is expected in the curriculum. It will be important to identify key science concepts, focus on developing understanding and skills rather than mere memorisation of a large amount of knowledge, be clear about how much time is allocated to science and, within this time allocation, determine an appropriate range of key concepts and skills for learning in the primary and secondary school years.

6.4.2 The Australian science curriculum will include contexts which are relevant to students. By explicitly encouraging personal interest and social significance in the design of learning experiences, teachers will help students develop the affective aspects of learning science.

6.4.3 The science curriculum will provide opportunities to explore complex issues to enable students to understand that the application of science and technology is often concerned with risk and debate. The inclusion of complex issues should not be avoided on the basis that there is a potential for making science seem difficult. The idea is to use them to promote a more sophisticated understanding of the nature of science and science knowledge. Young people need to understand that decisions concerning science applications involve constraints, consequences and risks. Such decision-making is not value-free. Students will learn about the influence of particular values in attempting to balance the issues of constraints, consequences and risk.

6.4.4 Consideration needs to be given to the expectations of intellectual rigour in the curriculum, the need to avoid overloading the curriculum, and the need to improve engagement of young people in learning science. The curriculum should allow time for teachers to assist students who need more time to learn particular concepts and time for students to be extended in more depth on key concepts.

6.5 The role of digital technologies

While the Australian science curriculum will not mandate particular technologies it will be important to recognise in the curriculum the possibilities that digital technologies provide for helping students understand science. Some of the technologies available include: internet-based inquiry resources, digital images, computer simulations, probeware tools for science investigations and on-line data for scientific analysis. Use of digital technologies can help to engage and maintain the interest of students provided that the context of their use is relevant and interesting.

6.6 The nature of the learner (K–12)

In developing the curriculum (both content and achievement standards) consideration must be given to the unique characteristics of learners across the years of schooling. These characteristics influence curriculum decisions about how and when particular content is best introduced and consolidated.

6.7 General capabilities

Skills and understanding related to numeracy, literacy and ICT need to be further developed and used in all learning areas, as do thinking skills and creativity. In addition, there are other general capabilities like self management, team work, intercultural understandings, ethical awareness, and social competence which will be represented in each learning area in ways appropriate to that area.

6.8 Cross-curriculum perspectives

There are other cross-curriculum matters related to Indigenous education, sustainability and Australia's links with Asia that can be thought of as perspectives rather than capabilities. Each of these perspectives will be represented in learning areas in ways appropriate to that area. The curriculum documents will be explicit on how the perspectives are dealt with in each learning area and how links can be made between learning areas.

7. PEDAGOGY AND ASSESSMENT: SOME BROAD ASSUMPTIONS

7.1 Important for the design of a world-class curriculum is the recognition of the dynamic alignment that exists between curriculum, pedagogy and assessment. While this document focuses on the proposed content of an Australian science curriculum, it is important to consider each of these elements to ensure the development of a flexible and rigorous curriculum that encourages high expectations, with meaningful and rewarding opportunities, catering for the diverse needs of learners.

7.2 To achieve the stated aims of the Australian science curriculum it is proposed that there needs to be less emphasis on a transmission model of pedagogy and more emphasis on a model of student engagement and inquiry. The driving force of the transmission model is teacher explanation whereas the learning engine for inquiry is based on teacher questions and discussion. Teacher explanation is still important but it should be seen as one skill in a broad repertoire of teaching skills.

7.3 A balanced and engaging approach to teaching science will typically involve context, exploration, explanation and application. Wherever appropriate, students should be actively involved in the science concepts being taught. This requires a context or point of relevance by which students can make sense of the ideas to be learnt. The context may vary depending on the students, school or location. Having set the scene, the teacher provides science activities by which students can explore the ideas, using language the students are familiar with. Using this exploration and experience as a basis, the teacher introduces the science concepts and science terms in a way that has meaning to students. With these explanations and science language, the teacher then provides activities through which students can apply the science concepts to new situations.

7.4 In a recent evaluation of science learning in United Kingdom schools, the report by science inspectors concluded that the main factor in the schools with the highest or most rapidly improved science learning was their commitment to science inquiry. In those schools students were given the opportunity to pose questions and design and carry out investigations for themselves. The ability to pose and investigate questions is an important part of science inquiry.

7.5 The importance of assessment in curriculum development is highlighted in the process referred to as 'backward design', in which one works through three stages — from curriculum intent, to assessment expectations, to finally planning learning experiences and instruction. This process reinforces the simple proposition that, for a curriculum to be successfully implemented, there must be a clear and realistic picture of how the curriculum will be assessed.

7.6 Within its many purposes, assessment should serve the purpose of learning. Assessment should encourage longer-term understanding and enable the provision of detailed diagnostic information to support student learning. It should show what students know, understand and can demonstrate. It should also show what they need to do to improve. In particular, some of the important science learning aspects concerning attitudes and skills outlined in this paper will require a variety of assessment approaches.

8. CONCLUSION

8.1 The national science curriculum will provide the basis for learning science that will engage students in meaningful ways and, with the support of teachers, help them to develop their science understanding so that they can function effectively in a scientifically and technologically advanced society. The desired result is that students will be interested in and understand the world about them, be able to communicate scientifically, be sceptical and questioning of the claims of others, and be able to identify and investigate questions and draw evidence-based conclusions.

8.2 By undertaking this curriculum students will be able to choose whether they wish to pursue a career as a scientist or be employed in science-related industries or services or in some other field. Regardless of their choice of career path, students are expected to complete their schooling as people who can make decisions based on science evidence and reasoning about the environment and their own health and wellbeing.