



Australian Curriculum: Science Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority

Content elaborations and teacher
background information for Years 7-10



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Introduction

This document showcases the 95 new content elaborations for the Australian Curriculum: Science (Foundation to Year 10) that address the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority. It also provides the accompanying teacher background information for each of the elaborations from Years 7 -10 to support secondary teachers in planning and teaching the science curriculum.

The Australian Curriculum has a three-dimensional structure encompassing disciplinary knowledge, skills and understandings; general capabilities; and cross-curriculum priorities. It is designed to meet the needs of students by delivering a relevant, contemporary and engaging curriculum that builds on the educational goals of the Melbourne Declaration. The Melbourne Declaration identifies Aboriginal and Torres Strait Islander cultures as a key area to be addressed for the benefit of both individuals and Australia as a whole. As such, Aboriginal and Torres Strait Islander histories and cultures have been included as a cross-curriculum priority in the Australian Curriculum and are intended to enrich the curriculum through the development of considered and focused content that fits naturally within learning areas. This cross-curriculum priority enables teachers to deliver the learning area content at the same time as students develop knowledge, understandings and skills relating to Aboriginal and Torres Strait Islander histories and cultures.

ACARA has developed 95 new elaborations for the Australian Curriculum: Science (F-10) that demonstrate the connections between Aboriginal and Torres Strait Islander histories and cultures and core science concepts in the Australian Curriculum. The elaborations acknowledge that Aboriginal Peoples and Torres Strait Islander Peoples have worked scientifically for millennia and continue to contribute to contemporary science. These elaborations have the potential to make learning more relevant for Aboriginal and Torres Strait Islander students and, as a result, help increase their participation in STEM subjects. They also provide the opportunity to embed a uniquely Australian perspective into the Science curriculum.

Each of the new elaborations is supported by teacher background information that is intended to assist teachers in preparing culturally appropriate and scientifically rigorous classroom materials. The teacher background information includes a list of published works that were consulted in the preparation of the information.

Background

The Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority recognises two distinct needs in the Australian Curriculum:

- *Aboriginal and Torres Strait Islander students can see themselves, their identities and their cultures reflected in the curriculum of each of the learning areas, can fully participate in the curriculum and can build their self-esteem.*
- *The Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority is designed for all students to engage in reconciliation, respect and recognition of the world's oldest continuous living cultures.¹*

Since the publication of the Australian Curriculum, ACARA has received and collated feedback regarding this cross curriculum priority from stakeholders, including Aboriginal and Torres Strait Islander communities and educators in schools. This feedback suggested the desire for more opportunities to incorporate Aboriginal and Torres Strait Islander histories and cultures in the Australian Curriculum and the need for more coherent alignment between the learning areas and the cross curriculum priority to support implementation.

ACARA's Aboriginal and Torres Strait Islander Advisory Group reflected on this feedback and provided advice to ACARA and its Board, resulting in the project to develop the new content elaborations and teacher background information for the Australian Curriculum: Science provided in this document.



¹ Sourced from the 'Cross-curriculum priorities' section of the Australian Curriculum website:
<https://www.australiancurriculum.edu.au/f-10-curriculum/cross-curriculum-priorities/aboriginal-and-torres-strait-islander-histories-and-cultures/>

Process for developing the elaborations

The process to develop new elaborations and supporting information for the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority in the Australian Curriculum: Science ensured both cultural and scientific integrity. It involved the following steps:

1. Appointment of a writing team consisting of an Aboriginal and Torres Strait Islander science education expert from the Queensland Department of Education and ACARA curriculum specialists, supported by a reference group comprised of nationally recognised Aboriginal and Torres Strait Islander education experts.
2. Researching of Aboriginal and Torres Strait Islander histories and cultures, sourced from materials published by recognised research institutions, universities, museums, government and Aboriginal and Torres Strait Islander community organisations and media publications.
3. External editing of all materials to ensure the materials' cultural integrity.
4. Ongoing consultation with, and endorsement by, ACARA's Aboriginal and Torres Strait Islander Advisory Group.





How the elaborations strengthen the Australian Curriculum: Science

The Australian Curriculum: Science (F-10) contains content descriptions that define what is to be taught and what students are expected to learn. The content descriptions of the three Science strands – Science understanding (SU), Science as a human endeavour (SHE) and Science inquiry skills (SIS) – are accompanied by content elaborations. These elaborations are non-mandatory components of the curriculum, provided to suggest contexts through which to explore the core science content in both depth and breadth.

The new elaborations promote an integrated approach to teaching the three interrelated strands of the Australian Curriculum: Science.

- Elaborations within the Science understanding and Science as a human endeavour strands are organised into topics and embedded in a progression of learning. Some topics are included in several year levels to accommodate increasingly sophisticated aspects or understandings.
- Elaborations within the Science inquiry skills strand provide contexts for the inquiry process and include reference to skills required to engage with Aboriginal and Torres Strait Islander histories and cultures, in particular:
 - acknowledging the scientific knowledge and skills of Aboriginal and Torres Strait Islander Peoples
 - consulting with Aboriginal and Torres Strait Islander communities in the planning or evaluation of scientific investigations
 - collaborating with Aboriginal and Torres Strait Islander communities in mutually beneficial scientific research.
- Wherever possible, the focus of each elaboration has been chosen to facilitate the integration of closely related content from two or more strands at the same year level or two-year band. Such opportunities are referred to as ‘cross-strand linkages’ and are provided in the teacher background information.
- All elaborations reference the appropriate Organising Ideas of the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority framework.
- Many elaborations offer opportunities for students to also develop the general capabilities of the Australian Curriculum, such as Personal and Social Capability, Critical and Creative Thinking, Ethical Understanding and Intercultural Understanding.

Through the cross-curriculum priority dimension of the Australian Curriculum, carefully selected aspects of Aboriginal and Torres Strait Islander histories and cultures relevant to the core science content are woven into the F–10 Science curriculum. These aspects, ranging from times before European colonisation to modern-day society, broadly pertain to Aboriginal and Torres Strait Islander knowledges, technologies, processes, contributions to science and ethical considerations that overlap the content of the F-10 Science curriculum. They provide non-mandatory contexts that can be used to engage the learning of core science concepts, for example:

- **Knowledges** relating to chemistry, physics, geology, botany, zoology, physiology, genetics, meteorology, astronomy, nutrition, hydrology, ecology are covered.
- **Technologies** such as the development of machines, specialised tools, weaponry, architecture, clothing, blankets, torches, nets, traps and domestic utensils (baskets, knives, chisels, sieves) are explored.
- **Processes**, both physical and chemical, are investigated. These include; lithic heat treatment, detoxification, stone knapping, skin tanning, use of acids and alkalis, use of poisons, production of medicines, medicine delivery, cooking methods, production of pigments and dyes, production of adhesives, fire lighting methods, fibre, string and rope production.
- **Contributions** to medicine, mining, ecology, archaeology, anthropology, exploration, zoology, botany, agriculture, bio-security, nutrition, fire management, ecological restoration, water management, sustainability, reduction of atmospheric pollution and bio-geography are revealed.
- **Ethical considerations** regarding the treatment of cultural heritage sites and the respect of intellectual property rights are investigated as they relate to 21st century scientists.

The elaborations are generic in nature and aim to assist educators in opening a dialogue with local communities that could engage and collaborate in the teaching of these curriculum aspects. If a local community does not have the capacity in this space, the elaborations still provide a rich example of how the curriculum content is relevant to Aboriginal and/or Torres Strait Islander Peoples.



The Australian Curriculum: Science content elaborations linked to the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority

The following tables list all of the elaborations linked to the Aboriginal and Torres Strait Islander Histories and Cultures cross-curriculum priority by year level, including the Science strand – Science Understanding (SU), Science as a Human Endeavour (SHE), or Science Inquiry Skills (SIS) – the relevant sub-strand, and the content description from the F–10 Australian Curriculum: Science. The 95 new elaborations are highlighted in blue font.




Foundation

In Foundation Science, students observe and describe the behaviours and properties of everyday objects, materials and living things. They explore change in the world around them, including changes that impact on them, such as the weather, and changes they can affect, such as making things move or change shape. They learn that seeking answers to questions they pose and making observations are a core part of science and use their senses to gather different types of information.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Living things have basic needs, including food and water (ACSSU002)	<ul style="list-style-type: none"> recognising how Aboriginal and Torres Strait Islander Peoples care for living things
SU Physical sciences	The way objects move depends on a variety of factors, including their size and shape (ACSSU005)	<ul style="list-style-type: none"> exploring how the size and shape of traditional instructive toys used by Aboriginal and Torres Strait Islander Peoples influence their movement
SU Earth and space sciences	Daily and seasonal changes in our environment affect everyday life (ACSSU004)	<ul style="list-style-type: none"> learning how Aboriginal and Torres Strait Islander Peoples' concepts of time and weather patterns explain how things happen in the world around them
SHE Nature and development of science	Science involves observing, asking questions about, and describing changes in, objects and events (ACSHE013)	<ul style="list-style-type: none"> recognising how Aboriginal and Torres Strait Islander Peoples gain knowledge about the land and its vital resources, such as water and food, through observation





Year 1

In Year 1 Science, students infer simple cause-and-effect relationships from their observations and experiences, and begin to link events and phenomena with observable effects and to ask questions. They observe changes that can be large or small and happen quickly or slowly. They explore the properties of familiar objects and phenomena, identifying similarities and differences. Students begin to value counting as a means of comparing observations, and are introduced to ways of organising their observations.


STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Living things have a variety of external features (ACSSU017)	<ul style="list-style-type: none"> exploring how Aboriginal and Torres Strait Islander Peoples' observations of the external features of living things are mimicked and replicated in traditional dance
SU Chemical sciences	Everyday materials can be physically changed in a variety of ways (ACSSU018)	<ul style="list-style-type: none"> exploring how Aboriginal and Torres Strait Islander Peoples apply physical changes to natural materials to render them useful for particular purposes
SU Earth and space sciences	Observable changes occur in the sky and landscape (ACSSU019)	<ul style="list-style-type: none"> recognising the extensive knowledge of daily and seasonal changes in weather patterns and landscape held by Aboriginal and Torres Strait Islander Peoples
SU Physical sciences	Light and sound are produced by a range of sources and can be sensed (ACSSU020)	<ul style="list-style-type: none"> exploring how traditional musical instruments used by Aboriginal and Torres Strait Islander Peoples produce their characteristic sounds
SHE Nature and development of science	Science involves observing, asking questions about, and describing changes in, objects and events (ACSHE021)	<ul style="list-style-type: none"> recognising how Aboriginal and Torres Strait Islander Peoples use changes in the landscape and the sky to answer questions about when to gather certain resources
SHE Use and influence of science	People use science in their daily lives, including when caring for their environment and living things (ACSHE022)	<ul style="list-style-type: none"> considering that technologies used by Aboriginal and Torres Strait Islander Peoples require an understanding of how materials can be sustainably sourced to make tools and weapons, musical instruments, clothing, cosmetics and artworks
SIS Communicating	Represent and communicate observations and ideas in a variety of ways (AC SIS029)	<ul style="list-style-type: none"> acknowledging and learning about Aboriginal and Torres Strait Islander Peoples' ways of representing and sharing observations
SIS Evaluating	Compare observations with those of others (AC SIS213)	<ul style="list-style-type: none"> consulting with Aboriginal and Torres Strait Islander Peoples to compare observations and evaluate identifications of animal tracks

Year 2

In Year 2 Science, students describe the components of simple systems, such as stationary objects subjected to pushes or pulls, or combinations of materials, and show how objects and materials interact through direct manipulation. They observe patterns of growth and change in living things, and describe patterns and make predictions. They explore the use of resources from the earth and are introduced to the idea of the flow of matter when considering how water is used. They use counting and informal measurements to make and compare observations and begin to recognise that organising these observations in tables makes it easier to show patterns.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Chemical sciences	Different materials can be combined for a particular purpose (ACSSU031)	<ul style="list-style-type: none"> investigating the ways in which Aboriginal and Torres Strait Islander Peoples combine different materials to produce utensils (hafting, weaving, sewing and glueing)
SU Earth and space sciences	Earth’s resources are used in a variety of ways (ACSSU032)	<ul style="list-style-type: none"> considering how Aboriginal and Torres Strait Islander Peoples live in regions with scarce resources or in sensitive environments
SU Physical sciences	A push or a pull affects how an object moves or changes shape (ACSSU033)	<ul style="list-style-type: none"> investigating the push and pull movements of traditional Aboriginal and Torres Strait Islander children’s instructive toys
SHE Nature and development of science	Science involves observing, asking questions about, and describing changes in, objects and events (ACSHE034)	<ul style="list-style-type: none"> recognising how Aboriginal and Torres Strait Islander Peoples observe and describe developmental changes in living organisms and answer questions about when to harvest certain resources
SHE Use and influence of science	People use science in their daily lives, including when caring for their environment and living things (ACSHE035)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples use science to meet their needs, such as food supply






Year 3

In Year 3 Science, students observe heat and its effects on solids and liquids and begin to develop an understanding of energy flows through simple systems. In observing day and night, they develop an appreciation of regular and predictable cycles. Students order their observations by grouping and classifying; in classifying things as living or non-living they begin to recognise that classifications are not always easy to define or apply. They begin to quantify their observations to enable comparison, and learn more sophisticated ways of identifying and representing relationships, including the use of tables and graphs to identify trends. They use their understanding of relationships between components of simple systems to make predictions.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Living things can be grouped on the basis of observable features and can be distinguished from non-living things (ACSSU044)	<ul style="list-style-type: none"> investigating Aboriginal and Torres Strait Islander Peoples' systems of classifying living things and how these systems differ from those used by contemporary science
SU Biological sciences	Living things can be grouped on the basis of observable features and can be distinguished from non-living things (ACSSU044)	<ul style="list-style-type: none"> recognising Aboriginal and Torres Strait Islander Peoples' use of observable features to group living things
SU Chemical sciences	A change of state between solid and liquid can be caused by adding or removing heat (ACSSU046)	<ul style="list-style-type: none"> investigating how changes of state in materials used by Aboriginal and Torres Strait Islander Peoples, such as beeswax or resins, are important for their use
SU Earth and space sciences	Earth's rotation on its axis causes regular changes, including night and day (ACSSU048)	<ul style="list-style-type: none"> exploring how cultural stories of Aboriginal and Torres Strait Islander Peoples explain the cyclic phenomena involving sun, moon and stars and how those explanations differ from contemporary science understanding
SU Physical sciences	Heat can be produced in many ways and can move from one object to another (ACSSU049)	<ul style="list-style-type: none"> investigating the production and transfer of heat in Aboriginal and Torres Strait Islander Peoples' methods of cooking, such as the use of ground ovens
SHE Nature and development of science	Science involves making predictions and describing patterns and relationships (ACSHE050)	<ul style="list-style-type: none"> researching how knowledge of astronomy has been used by some Aboriginal and Torres Strait Islander Peoples
SHE Use and influence of science	Science knowledge helps people to understand the effect of their actions (ACSHE051)	<ul style="list-style-type: none"> researching Aboriginal and Torres Strait Islander Peoples' knowledge of the local natural environment, such as the characteristics of plants and animals
SIS Communicating	Represent and communicate observations, ideas and findings using formal and informal representations (ACSIS060)	<ul style="list-style-type: none"> consulting Aboriginal and Torres Strait Islander Peoples' representations of living things as evidenced and communicated through formal and informal sharing of information
SIS Communicating	Represent and communicate observations, ideas and findings using formal and informal representations (ACSIS060)	<ul style="list-style-type: none"> acknowledging and exploring Aboriginal and Torres Strait Islander Peoples' ways of communicating information about anatomical features of organisms
SIS Planning and conducting	With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment (ACSIS054)	<ul style="list-style-type: none"> consulting with Aboriginal and Torres Strait Islander Peoples to guide the planning of scientific investigations, including safety considerations for field investigations
SIS Questioning and predicting	With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge (ACSIS053)	<ul style="list-style-type: none"> consulting with and using existing knowledge held by Aboriginal and Torres Strait Islander Peoples to guide the formulation of investigable questions regarding invasive species



Year 4

In Year 4 Science, students broaden their understanding of classification and form and function through an exploration of the properties of natural and processed materials. They learn that forces include non-contact forces and begin to appreciate that some interactions result from phenomena that can't be seen with the naked eye. They begin to appreciate that current systems, such as Earth's surface, have characteristics that have resulted from past changes and that living things form part of systems. They understand that some systems change in predictable ways, such as through cycles. They apply their knowledge to make predictions based on interactions within systems, including those involving the actions of humans.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Living things have life cycles (ACSSU072)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples understand and utilise the lifecycles of certain species
SU Biological sciences	Living things depend on each other and the environment to survive (ACSSU073)	<ul style="list-style-type: none"> recognising how Aboriginal and Torres Strait Islander Peoples perceive themselves as being an integral part of the environment
SU Chemical sciences	Natural and processed materials have a range of physical properties that can influence their use (ACSSU074)	<ul style="list-style-type: none"> considering how Aboriginal and Torres Strait Islander Peoples use natural and processed materials for different purposes, such as tools, clothing and shelter, based on their properties
SU Chemical sciences	Natural and processed materials have a range of physical properties that can influence their use (ACSSU074)	<ul style="list-style-type: none"> considering how Aboriginal and Torres Strait Islander Peoples' knowledge of natural and processed materials informs the preparation of effective, vibrant and long-lasting paints
SU Earth and space sciences	Earth's surface changes over time as a result of natural processes and human activity (ACSSU075)	<ul style="list-style-type: none"> considering how Aboriginal and Torres Strait Islander Peoples' fire management practices over tens of thousands of years have changed the distribution of flora and fauna in most regions of Australia
SU Physical sciences	Forces can be exerted by one object on another through direct contact or from a distance (ACSSU076)	<ul style="list-style-type: none"> investigating the effect of contact and non-contact forces on the movement of objects in traditional Aboriginal and Torres Strait Islander children's instructive toys and games
SHE Nature and development of science	Science involves making predictions and describing patterns and relationships (ACSHE061)	<ul style="list-style-type: none"> considering how scientific practices such as sorting, classification and estimation are used by Aboriginal and Torres Strait Islander Peoples in everyday life
SIS Questioning and predicting	With guidance, identify questions in familiar contexts that can be investigated scientifically and make predictions based on prior knowledge (ACSIS064)	<ul style="list-style-type: none"> acknowledging and using information from Aboriginal and Torres Strait Islander Peoples to guide the formulation of investigable questions regarding life cycles



Year 5

In Year 5 Science, students are introduced to cause and effect relationships through an exploration of adaptations of living things and how this links to form and function. They explore observable phenomena associated with light and begin to appreciate that phenomena have sets of characteristic behaviours. They broaden their classification of matter to include gases and begin to see how matter structures the world around them. Students consider Earth as a component within a solar system and use models for investigating systems at astronomical scales. Students begin to identify stable and dynamic aspects of systems, and learn how to look for patterns and relationships between components of systems. They develop explanations for the patterns they observe.


STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Living things have structural features and adaptations that help them to survive in their environment (ACSSU043)	<ul style="list-style-type: none"> investigating Aboriginal and Torres Strait Islander Peoples' knowledge of the adaptations of certain species and how those adaptations can be exploited
SU Chemical sciences	Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077)	<ul style="list-style-type: none"> recognising Aboriginal and Torres Strait Islander Peoples' knowledge and understanding of evaporation and how the effect of evaporation can be reduced to conserve water, such as by covering surfaces
SU Chemical sciences	Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077)	<ul style="list-style-type: none"> recognising Aboriginal and Torres Strait Islander Peoples' knowledge and understanding of solids, liquids and gases
SU Earth and space sciences	The Earth is part of a system of planets orbiting around a star (the sun) (ACSSU078)	<ul style="list-style-type: none"> researching Aboriginal and Torres Strait Islander Peoples' understanding of the night sky and its use for timekeeping purposes as evidenced in oral cultural records, petroglyphs, paintings and stone arrangements
SU Physical sciences	Light from a source forms shadows and can be absorbed, reflected and refracted (ACSSU080)	<ul style="list-style-type: none"> recognising Aboriginal and Torres Strait Islander Peoples' understanding of refraction as experienced in spear fishing and in shimmering body paint, and of absorption and reflection as evidenced by material selected for construction of housing
SHE Use and influence of science	Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples' traditional ecological and zoological knowledge informs sustainable harvesting practices of certain species, such as dugongs and turtles
SHE Use and influence of science	Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)	<ul style="list-style-type: none"> investigating how Torres Strait Islander Peoples and Aboriginal Peoples of arid regions of Australia use scientific knowledge to manage precious water resources
SHE Nature and development of science	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE081)	<ul style="list-style-type: none"> learning how Aboriginal and Torres Strait Islander Peoples use observation of the night sky to assist with navigation
SIS Planning and conducting	Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (AC SIS086)	<ul style="list-style-type: none"> consulting with Aboriginal and Torres Strait Islander Peoples to guide the planning of scientific investigations, considering potential risks for field investigations
SIS Communicating	Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (AC SIS093)	<ul style="list-style-type: none"> acknowledging and exploring Aboriginal and Torres Strait Islander Peoples' ways of representing and communicating information about anatomical features, including structural adaptations
SIS Questioning and predicting	With guidance, pose clarifying questions and make predictions about scientific investigations (AC SIS231)	<ul style="list-style-type: none"> acknowledging and using information from Aboriginal and Torres Strait Islander Peoples to guide the formulation of investigable questions about adaptations



Year 6

In Year 6 Science, students explore how changes can be classified in different ways. They learn about transfer and transformations of electricity, and continue to develop an understanding of energy flows through systems. They link their experiences of electric circuits as a system at one scale to generation of electricity from a variety of sources at another scale and begin to see links between these systems. They develop a view of Earth as a dynamic system, in which changes in one aspect of the system impact on other aspects; similarly, they see that the growth and survival of living things are dependent on matter and energy flows within a larger system. Students begin to see the role of variables in measuring changes and the value of accuracy in these measurements. They learn how to look for patterns and to use these to identify and explain relationships by drawing on evidence.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	The growth and survival of living things are affected by physical conditions of their environment (ACSSU094)	<ul style="list-style-type: none"> investigating Aboriginal and Torres Strait Islander Peoples' knowledge and understanding of the physical conditions necessary for the survival of certain plants and animals in the environment
SU Chemical sciences	Changes to materials can be reversible or irreversible (ACSSU095)	<ul style="list-style-type: none"> investigating Aboriginal and Torres Strait Islander Peoples' knowledge of reversible processes, such as the application of adhesives, and of irreversible processes, such as the use of fuels for torches
SU Earth and space sciences	Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)	<ul style="list-style-type: none"> researching Aboriginal and Torres Strait Islander Peoples' cultural stories that provide evidence of geological events
SHE Nature and development of science	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples test predictions and gather data in the development of technologies and processes
SHE Use and influence of science	Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)	<ul style="list-style-type: none"> discussing how modern approaches to fire ecology in Australia are being informed by Aboriginal and Torres Strait Islander Peoples' traditional ecological knowledge and fire management practices
SHE Nature and development of science	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)	<ul style="list-style-type: none"> learning how Aboriginal and Torres Strait Islander Peoples' knowledge, such as the medicinal and nutritional properties of Australian plants, is being used as part of the evidence base for scientific advances
SIS Questioning and predicting	With guidance, pose clarifying questions and make predictions about scientific investigations (AC SIS232)	<ul style="list-style-type: none"> consulting with Aboriginal and Torres Strait Islander Peoples to clarify investigable questions based upon their traditional ecological knowledge, such as predictions regarding the impact of invasive species



Year 7

In Year 7 Science, students explore the diversity of life on Earth and continue to develop their understanding of the role of classification in ordering and organising information. They use and develop models such as food chains, food webs and the water cycle to represent and analyse the flow of energy and matter through ecosystems and explore the impact of changing components within these systems. They consider the interaction between multiple forces when explaining changes in an object's motion. They explore the notion of renewable and non-renewable resources and consider how this classification depends on the timescale considered. They investigate relationships in the Earth-sun-moon system and use models to predict and explain events. Students make accurate measurements and control variables to analyse relationships between system components. They explore and explain these relationships through appropriate representations and consider the role of science in decision making processes.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Classification helps organise the diverse group of organisms (ACSSU111)	<ul style="list-style-type: none"> investigating classification systems used by Aboriginal and Torres Strait Islander Peoples and how they differ with respect to approach and purpose from those used by contemporary science
SU Biological sciences	Interactions between organisms, including the effects of human activities can be represented by food chains and food webs (ACSSU112)	<ul style="list-style-type: none"> investigating Aboriginal and Torres Strait Islander Peoples' responses to the disruptive interactions of invasive species and their effect on important food webs that many communities are a part of, and depend on, for produce and medicine
SU Chemical sciences	Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)	<ul style="list-style-type: none"> investigating separation techniques used by Aboriginal and Torres Strait Islander Peoples, such as hand picking, sieving, winnowing, yandying, filtering, cold pressing and steam distilling
SU Earth and space sciences	Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)	<ul style="list-style-type: none"> researching Aboriginal and Torres Strait Islander Peoples' oral traditions and cultural recordings of solar and lunar eclipses and investigating similarities and differences with contemporary understandings of such phenomena
SU Earth and space sciences	Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)	<ul style="list-style-type: none"> researching knowledges held by Aboriginal and Torres Strait Islander Peoples regarding the phases of the moon and the connection between the lunar cycle and ocean tides
SU Earth and space sciences	Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)	<ul style="list-style-type: none"> investigating Aboriginal and Torres Strait Islander Peoples' calendars and how they are used to predict seasonal changes
SU Earth and space sciences	Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)	<ul style="list-style-type: none"> exploring Aboriginal and Torres Strait Islander Peoples' connections with, and valuing of, water and water resource management
SU Physical sciences	Change to an object's motion is caused by unbalanced forces, including Earth's gravitational attraction, acting on the object (ACSSU117)	<ul style="list-style-type: none"> investigating the effect of forces through the application of simple machines, such as the bow and arrows used by Torres Strait Islander Peoples or the spear throwers used by Aboriginal Peoples


STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SHE Nature and development of science	Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119)	<ul style="list-style-type: none"> investigating the contributions of Aboriginal and Torres Strait Islander Peoples' knowledge in the identification of medicinal and endemic plants
SHE Use and influence of science	Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)	<ul style="list-style-type: none"> researching the development of commercial products that are founded on the traditional knowledge and practices of Aboriginal and Torres Strait Islander Peoples and discussing related ethical considerations associated with bio-piracy and intellectual property rights
SHE Nature and development of science	Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE223)	<ul style="list-style-type: none"> investigating how land management practices of Aboriginal and Torres Strait Islander Peoples informs contemporary management of the environment to protect biodiversity
SHE Use and influence of science	People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE121)	<ul style="list-style-type: none"> investigating how the knowledge and experience of Aboriginal and Torres Strait Islander Peoples are being used to inform scientific decisions, such as the care of Country/Place
SIS Planning and conducting	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)	<ul style="list-style-type: none"> collaborating with Aboriginal and Torres Strait Islander Peoples in planning scientific investigations, and seeking guidance regarding culturally sensitive locations during fieldwork
SIS Planning and conducting	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)	<ul style="list-style-type: none"> consulting with Aboriginal and Torres Strait Islander land councils in planning scientific investigations, and seeking guidance regarding land access rights
SIS Planning and conducting	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)	<ul style="list-style-type: none"> collaborating with Aboriginal and Torres Strait Islander communities and organisations to conduct research investigations about ecosystems, ensuring mutually beneficial outcomes
SIS Processing and analysing data and information	Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)	<ul style="list-style-type: none"> acknowledging, analysing and interpreting data and information from Aboriginal and Torres Strait Islander Peoples' understandings of Earth's systems and cycles
SIS Processing and analysing data and information	Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)	<ul style="list-style-type: none"> collaborating with Aboriginal and Torres Strait Islander Peoples in the production of calendars that demonstrate seasonal patterns and relationships using digital technologies



Year 8

In Year 8 Science, students are introduced to cells as microscopic structures that explain macroscopic properties of living systems. They link form and function at a cellular level and explore the organisation of body systems in terms of flows of matter between interdependent organs. Similarly, they explore changes in matter at a particle level, and distinguish between chemical and physical change. They begin to classify different forms of energy, and describe the role of energy in causing change in systems, including the role of heat and kinetic energy in the rock cycle. Students use experimentation to isolate relationships between components in systems and explain these relationships through increasingly complex representations. They make predictions and propose explanations, drawing on evidence to support their views while considering other points of view.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Chemical sciences	Chemical change involves substances reacting to form new substances (ACSSU225)	<ul style="list-style-type: none"> investigating chemical reactions employed by Aboriginal and Torres Strait Islander Peoples in the production of substances such as quicklime, plaster, pigments, acids, salts and ethanol
SU Earth and space sciences	Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)	<ul style="list-style-type: none"> exploring the traditional geological knowledge of Aboriginal and Torres Strait Islander Peoples that is used in the selection of different rock types for different purposes
SU Physical sciences	Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems (ACSSU155)	<ul style="list-style-type: none"> investigating traditional fire-starting methods used by Aboriginal and Torres Strait Islander Peoples and their understanding of the transformation of energy
SHE Nature and development of science	Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples connect knowledge from the disciplines of physics, chemistry, biology and geology in the development of material culture
SHE Nature and development of science	Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples employ knowledge from the disciplines of chemistry, biology, physics and geology in their development of pigments and dyes
SHE Use and influence of science	Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)	<ul style="list-style-type: none"> investigating use of sustainable technologies to deliver basic services in remote Aboriginal and Torres Strait Islander communities and considering ethical implications of these
SHE Use and influence of science	People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples used scientific understandings of complex ecological relationships to develop specific fire-based agricultural practices
SIS Planning and conducting	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (AC SIS140)	<ul style="list-style-type: none"> collaborating with Aboriginal and Torres Strait Islander Peoples in the planning of scientific investigations, including considerations of heritage sites and artefacts



Year 9

In Year 9 Science, students consider the operation of systems at a range of scales. They explore ways in which the human body as a system responds to its external environment and the interdependencies between biotic and abiotic components of ecosystems. They are introduced to the notion of the atom as a system of protons, electrons and neutrons, and how this system can change through nuclear decay. They learn that matter can be rearranged through chemical change and that these changes play an important role in many systems. They are introduced to the concept of the conservation of matter and begin to develop a more sophisticated view of energy transfer. They begin to apply their understanding of energy and forces to global systems such as continental movement.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)	<ul style="list-style-type: none"> investigating the interdependence of communities and the role of Aboriginal and Torres Strait Islander Peoples in maintaining their environment
SU Chemical sciences	All matter is made of atoms that are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms (ACSSU177)	<ul style="list-style-type: none"> investigating how radiocarbon and other dating methods have been used to establish that Aboriginal Peoples have been present on the Australian continent for more than 60,000 years
SU Chemical sciences	Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer (ACSSU179)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples use fire-mediated chemical reactions to facilitate energy and nutrient transfer in ecosystems through the practice of firestick farming
SU Physical sciences	Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)	<ul style="list-style-type: none"> investigating the impact of material selection on the transfer of sound energy in Aboriginal and Torres Strait Islander Peoples' traditional musical, hunting and communication instruments
SU Physical sciences	Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)	<ul style="list-style-type: none"> investigating aspects of heat transfer and conservation in the design of Aboriginal and Torres Strait Islander Peoples' bedding and clothing in the various climatic regions of Australia
SHE Nature and development of science	Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)	<ul style="list-style-type: none"> investigating how fire research has evaluated the effects of traditional Aboriginal and Torres Strait Islander Peoples fire regimes and how these findings have influenced fire management policy throughout Australia
SHE Nature and development of science	Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158)	<ul style="list-style-type: none"> researching how technological advances in monitoring greenhouse gas emissions and other environmental factors have contributed to the reinstatement of traditional fire management practices as a strategy to reduce atmospheric pollution
SHE Use and influence of science	People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)	<ul style="list-style-type: none"> considering how the traditional ecological knowledge of Aboriginal and Torres Strait Islander Peoples is being reaffirmed by modern science and how this is generating new career opportunities in the field of restorative ecology



STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SHE Use and influence of science	Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)	<ul style="list-style-type: none"> researching how Torres Strait Islander Peoples are at the forefront of the development of scientific measures to prevent the transfer of certain infectious diseases and pests to the Australian continent
SIS Processing and analysing data and information	Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)	<ul style="list-style-type: none"> consulting Aboriginal and Torres Strait Islander Peoples' histories and cultures that reveal scientific information about the past
SIS Communicating	Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)	<ul style="list-style-type: none"> acknowledging and exploring Aboriginal and Torres Strait Islander Peoples' ways of communicating their understanding of the internal systems of organisms
SIS Planning and conducting	Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)	<ul style="list-style-type: none"> acknowledging cultural heritage protection Acts as they relate to Aboriginal and Torres Strait Islander Peoples in planning field investigations
SIS Processing and analysing data and information	Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)	<ul style="list-style-type: none"> acknowledging and identifying the relationship between First Peoples' knowledges and contemporary science and the co-contributions in arriving at shared understanding when working "both-ways"
SIS Questioning and predicting	Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)	<ul style="list-style-type: none"> acknowledging and using information from Aboriginal and Torres Strait Islander Peoples to hypothesise about fauna or flora distributions
SIS Questioning and predicting	Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)	<ul style="list-style-type: none"> collaborating with Aboriginal and Torres Strait Islander Peoples to formulate questions and hypotheses that can be investigated scientifically regarding disrupted ecosystems



Year 10

In Year 10 Science, students explore systems at different scales and connect microscopic and macroscopic properties to explain phenomena. Students explore the biological, chemical, geological and physical evidence for different theories, such as the theories of natural selection and the Big Bang. Students develop their understanding of atomic theory to understand relationships within the periodic table. They understand that motion and forces are related by applying physical laws. They learn about the relationships between aspects of the living, physical and chemical world that are applied to systems on a local and global scale and this enables them to predict how changes will affect equilibrium within these systems.

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SU Biological sciences	Transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184)	<ul style="list-style-type: none"> investigating Aboriginal and Torres Strait Islander Peoples' knowledge of heredity as evidenced by the strict adherence to kinship and family structures, especially marriage laws
SU Biological sciences	The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (ACSSU185)	<ul style="list-style-type: none"> investigating some of the structural and physiological adaptations of Aboriginal and Torres Strait Islander Peoples to the Australian environment
SU Chemical sciences	Different types of chemical reactions are used to produce a range of products and can occur at different rates (ACSSU187)	<ul style="list-style-type: none"> investigating some of the chemical reactions and methods employed by Aboriginal and Torres Strait Islander Peoples to convert toxic plants into edible food products
SU Earth and space sciences	The universe contains features including galaxies, stars and solar systems, and the Big Bang theory can be used to explain the origin of the universe (ACSSU188)	<ul style="list-style-type: none"> researching Aboriginal and Torres Strait Islander Peoples' knowledge of celestial bodies and explanations of the origin of the universe
SU Earth and space sciences	Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples are reducing Australia's greenhouse gas emissions through the reinstatement of traditional fire management regimes
SU Physical sciences	The motion of objects can be described and predicted using the laws of physics (ACSSU229)	<ul style="list-style-type: none"> investigating how Aboriginal and Torres Strait Islander Peoples achieve an increase in velocity and subsequent impact force through the use of spear throwers and bows
SHE Use and influence of science	Values and needs of contemporary society can influence the focus of scientific research (ACSHE230)	<ul style="list-style-type: none"> researching how the values of 19th and early 20th century Australian society, combined with scientific misconceptions about heredity and evolution, influenced policies and attitudes towards Aboriginal and Torres Strait Islander Peoples
SHE Nature and development of science	Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE191)	<ul style="list-style-type: none"> investigating how prior to germ theory Aboriginal and Torres Strait Islander Peoples used their scientific observations to develop traditional medicines to treat wounds and infections of the skin



Year 10

STRAND – SUB-STRAND	CONTENT DESCRIPTION	CROSS-CURRICULUM PRIORITY ELABORATION (NEW ELABORATIONS IN BLUE)
SHE Nature and development of science	Advances in scientific understanding often rely on technological advances and are often linked to scientific discoveries (ACSHE192)	<ul style="list-style-type: none"> researching how technological advances in dating methods of Aboriginal Peoples' material culture are contributing to our understanding of the changing climatic conditions and human interaction with Australian megafauna
SHE Use and influence of science	People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE194)	<ul style="list-style-type: none"> considering how ecological sciences are recognising the efficacy of traditional ecological practices of Aboriginal and Torres Strait Islander Peoples and how restorative programs based on these practices are generating new career opportunities
SHE Use and influence of science	Values and needs of contemporary society can influence the focus of scientific research (ACSHE230)	<ul style="list-style-type: none"> investigating how disease outbreaks and the emergence of drug-resistant infections have focused scientific research into Aboriginal and Torres Strait Islander Peoples' traditional medicines to identify effective therapeutic compounds for the use in pharmaceuticals
SIS Planning and conducting	Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199)	<ul style="list-style-type: none"> collaborating with Aboriginal and Torres Strait Islander Peoples to explore the development of a commercial product based upon traditional ecological knowledge while addressing ethical issues
SIS Evaluating	Critically analyse the validity of information in primary and secondary sources, and evaluate the approaches used to solve problems (ACSIS206)	<ul style="list-style-type: none"> acknowledging the need to critically analyse scientific literature for potential cultural bias towards Aboriginal and Torres Strait Islander Peoples

**Years
7 - 10**



TEACHER BACKGROUND INFORMATION FOR YEARS 7 - 10

Teacher background information

The teacher background information is provided to assist teachers in preparing culturally appropriate and scientifically rigorous classroom materials relevant to the topics suggested in the elaborations.

There is a teacher background information document for each elaboration. Each document contains a short paragraph that explains how the topic suggested by the elaboration connects to the curriculum content and how it emphasises the cross-curriculum priority. The subsequent section describes in detail the cultural significance of the topic and outlines the scientific concepts addressed in it. Each document finishes with a brief paragraph that summarises what students gain from studying the core science content using the context suggested by the elaboration. Each teacher background information also contains a list of consulted works that provides valuable additional information and deeper insights for the educator. Please note that some historical sources listed in the consulted works may contain language that is culturally offensive or inappropriate. These sources are not suitable to be used as classroom resources.

It should be emphasised that all the topics explored in the teacher background information documents focus only on those aspects of Aboriginal and Torres Strait Islander histories and cultures that overlap with the content of the Australian Curriculum: Science. As such, the given information is not meant to provide a complete review of the historical and cultural context of the topic investigated and may only be referring to one component or concept of a highly complex topic. A more complete understanding of the topic may be found through community consultation and further research.

The following section contains the teacher background information documents for Year 7 - 10.



Year 7

Teacher background information



ACSSU111	First Nations classifications
ACSSU112	First Nations food web/food chain restoration
ACSSU113	Traditional separation techniques
ACSSU115	Solar and lunar eclipses
ACSSU115	Lunar cycles and tides
ACSSU115	Seasons and cycles
ACSSU116	Water values and management of finite resources
ACSSU117	Indigenous ballistics
ACSHE119	First Nations contributions to medicine
ACSHE120	Protecting Aboriginal and Torres Strait Islander knowledge in the commercialisation of plants and animals
ACSHE223	Traditional fire regimes protect biodiversity
ACSHE121	Traditional practices used for effective land management
AC SIS125	Collaborating to ensure research is conducted in appropriate locales
AC SIS125	Consulting local knowledge – where can I go?
AC SIS125	Collaborating to establish reciprocal research partnerships
AC SIS130	Acknowledging knowledge as sources of scientific data
AC SIS129	Collaborating through digital technologies

ACSSU111

First Nations classifications

CONTENT DESCRIPTION

Classification helps organise the diverse group of organisms.

CONTENT ELABORATION FOR CCP (01.3, 01.5)

- ▶ investigating classification systems used by Aboriginal and Torres Strait Islander Peoples and how they differ with respect to approach and purpose from those used by contemporary science



Barramundi – classified as fish based on the presence of fins

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with the opportunity to examine a variety of classification systems used to organise organisms and to reflect on the functions these classification systems serve. First Nations Australians' classification systems are used to group together and distinguish organisms from each other in a variety of categories. These categories often differ from, or at times parallel, the Western Linnaean system introduced in the 1700s.

The status of organisms within Aboriginal and Torres Strait Islander worldviews combines cultural, scientific and practical considerations. Practical knowledge of these organisms is essential. At their most basic, classification systems need to reflect broad categories, such as venomous and non-venomous or edible versus inedible. However, in many First Nations' classification systems, categories and names for a given organism can vary depending on age, gender and stage in its breeding cycle. As this knowledge overlaps with cultural systems and obligations, the language used for these classifications can also vary depending on a person's status and level of knowledge.

DETAIL

In science, classification (taxonomy) is the practice of defining and naming groups of living and non-living things on the basis of shared characteristics. In the western tradition of the biological sciences, the Swedish scientist Carl Linnaeus was most influential in formalising a hierarchical system for organising and naming species of living organisms in the early 18th century that, in slightly modified form, is still in use today. In Linnaean taxonomy, organisms are grouped together into taxa that form a ranked hierarchy, starting with either domains or kingdoms. Domains are divided into kingdoms, kingdoms into phyla (or divisions), which in turn are divided into classes, then orders, families, genera and species. Linnaeus originally based his scheme only on the structural similarities of different organisms. Modern biological taxonomy also uses genetic information of living organisms to reflect the evolutionary relationships between different species.

The classification systems of First Nations' Australians are diverse and complex and differ in many respects from Linnaean taxonomy. A common feature of many Aboriginal and Torres Strait Islander classification systems for living things is the inclusion of criteria that pertain to the organism's use, age, stage in life cycle, sex, social status and totemic association. In their simplest forms, these systems use binary classifications, for example, by categorising plants and animals as being edible or inedible, or as being totemic or non-totemic. Similar to Linnaean taxonomy, many Aboriginal and Torres Strait Islander classification systems of edible plants and animals are hierarchical with organisms being grouped in levels with each of the higher levels encompassing the ones below it.

Many living things are grouped by First Nations' Australians based on their use. A vast knowledge exists around the use of living things when alive, such as fresh plant sap for medicines. However, equally important is the knowledge of what once living things can be used for. For example, many

plants are grouped together based on their use when they are no longer living: spear trees, string trees, shield trees, canoe trees, resin trees and many other use-based categories. Living things are at times put into groups based on features such as form and function. These groupings are not always based on relatedness as used in the Linnaean classification system. For example, some First Nations' Australians classify turtles, barramundi and dugong into the same group of organisms, based on the observation that they are all aquatic and have fins or flippers. In contrast, the Linnaean classification system categorises turtles as reptiles, barramundi as fish and dugong as mammals.

First Nations' classifications and groupings can also undergo categorical shifts in that a particular organism can move from one category to another depending on context or usage. For example, Yanyuwa peoples in the Northern Territory have two broad categories which distinguish biological organisms as being either coastal and marine, or inland. Certain animals and plants can move between these two broad categories depending on circumstance. The Yanyuwa language has one term that refers to all dugong and sea turtles, *walya*, but this category further breaks down to at least 16 names to distinguish dugong. These names include variations depending on age, size, gender, and even a dugong's status within its herd. Similarly, in the Meriam language of the Torres Strait, there is one word that names a green turtle but various other words are used at different stages of a green turtle's development and when it is fully grown.

As is the case in many First Nations' taxonomies, these classifications indicate the importance of a particular plant or animal to a cultural group. They reflect First Nations peoples' deep knowledge of different stages in an organism's lifecycle, its interactions and relationships with other animals or plants, its status in learning, cultural stories and totemic systems, and its uses as food, medicine, tools, clothing or other resources with which it may be associated.

It is also worth noting that Aboriginal and Torres Strait Islander peoples' detailed botanical and zoological classificatory knowledge of Australian native plants and animals has been instrumental to scientists applying western classification systems. This existing knowledge was often ignored by early European naturalists, at times resulting in fatal or near-fatal encounters. There are many examples of scientists believing they have discovered a 'new' species only to be informed that Aboriginal or Torres Strait Islander peoples already have names, cultural stories and detailed understandings of the 'new discovery'.

As Europeans colonised Australia, there was an immediate desire to explore and classify the biota of the continent in the framework of the Western classification system. This resulted in many scientific expeditions throughout Australia, the success of which largely relied upon the contributions made by Aboriginal expedition members. For example, the first inclusion of Bennett's tree kangaroo into the Linnaean taxonomy was made possible through the astute observations and contribution of an integral Aboriginal member of the 1872 'Northern Expedition' to southern Cape York Peninsula.

By exploring this elaboration, students gain an awareness that Aboriginal and Torres Strait Islander peoples have complex and sophisticated classification systems. Students can develop an

understanding that all classification systems serve a purpose of relevance and importance to the user, and that these systems can also reflect knowledge, values, behaviours and worldviews of the peoples who construct them.

CONSULTED WORKS

In the construction of this teacher background information, a list of consulted works has been generated. The consulted works are provided as evidence of the research undertaken to inform the development of the teacher background information.

Please note that some of the sources listed in the consulted works may contain material that is considered culturally offensive or inappropriate. The consulted works are not provided or recommended as classroom resources.

The following sources were consulted in the construction of this teacher background information. They are provided as evidence of the research undertaken to inform the development of the teacher background information. It is important that educators recognise that despite written records being incredibly useful, they can also be problematic as they are often based on non-Indigenous interpretations of observations and records of First Nations Peoples' behaviours, actions, comments and traditions. Such interpretations privilege western paradigms of non-First Nations authors and include, at times, attitudes and language of the past. These sources often lack the viewpoints of the people they discuss and can contain ideas based on outdated scientific theories. Furthermore, although the sources are in the public domain, they may contain cultural breaches and cause offence to the Peoples concerned. With careful selection, evaluation and community consultation, the consulted works may provide teachers with further support and reference materials that could be culturally audited, refined and adapted to construct culturally appropriate teaching and learning materials. The ability to select and evaluate appropriate resources is an essential cultural capability skill for educators.

Bradley, J., & Yanyuwa Families. (2007). *Barni-Wardimantha Awara Yanyuwa Sea Country Plan*. Retrieved from <https://www.environment.gov.au/indigenous/publications/pubs/yanyuwa.pdf>

Covacevich, J. (1994). Dandarabilla and Gunjiwuru The discovery of the taipans: The world's most dangerous snakes. In J. Pearn (Ed.), *Some milestones of Australian medicine: A centenary book for the Queensland branch of the Australian Medical Association* (pp. 167-174). Herston: Amphion Press.

Covacevich, J. (2002). First formal Australian record of a tree kangaroo: Aboriginal, not European. *Aboriginal History*, 26, 220-222.

Davis, S., Ganambarr, M., & Traynor, S. (1982). *Aboriginal science teacher's handbook: incorporating the Milingimbi case study*. Darwin: Northern Territory Department of Education.

Goodfellow, D. (2011). The Aboriginal classification of animals. Retrieved from http://www.earthfoot.org/lit_zone/aniclass.htm

Michie, M. (2005, July). *Engaging with Australian Indigenous science*. Workshop presented at CONASTA 54, the annual conference of the Australian Science Teachers Association, Melbourne, VIC. Retrieved from <http://members.ozemail.com.au/~mmichie/engaging.htm>

NSW Education Standards Authority. (2008, 3 Sept). Cultural background: Aboriginal classification and taxonomy. *Aboriginal Educational Contexts*. Retrieved from <http://ab-ed.boardofstudies.nsw.edu.au/go/7-10/science/units/story-1/cultural-background>

Ray, S. H. (1907). *Reports of the Cambridge Anthropological Expedition to Torres Straits. Volume III, Linguistics*. London: Cambridge University Press.

ACSSU112

First Nations food web/food chain restoration

CONTENT DESCRIPTION

Interactions between organisms, including the effects of human activities can be represented by food chains and food webs.

CONTENT ELABORATION FOR CCP (OI.2, OI.5, OI.6)

- ▶ investigating Aboriginal and Torres Strait Islander Peoples' responses to the disruptive interactions of invasive species and their effect on important food webs that many communities are a part of, and depend on, for produce and medicine



Invasive species such as cane toads disrupt important food webs

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration allows students to examine the impact of invasive species that have been imported through human activity such as agriculture. Students learn about how this is impacting upon important food webs of local ecosystems, which subsequently impact Aboriginal and Torres Strait Islander communities who depend on these ecosystems for cultural continuance, food and medicine.

This elaboration also provides students with opportunities to deepen their understanding of food chains and food webs as a way to represent interactions between organisms in ecosystems.

DETAIL

European colonisation has resulted in the introduction of numerous foreign plants and animals which continue to have significant impacts on traditional Aboriginal and Torres Strait Islander peoples' resource access and cultural practices. Invasive species are those that are introduced to a specific location to which they are not native, and which have multiplied to the point where they cause significant interruptions to the environment. These introduced species tend to spread rapidly and cause widespread damage. This has implications for environmental, agricultural, cultural and other social resources. Two critical examples of nationally significant invasive species that were introduced to Australia for European agricultural reasons are the cane toad (*Rhinella marina*) and gamba grass (*Andropogon gayanus*).

Native to South and Central America, the cane toad was introduced to Australia in 1935 to control pest scarab beetles in Queensland's sugarcane crops. The cane toad population quickly established itself as a pest, spread throughout Australia's northern regions and is currently moving westward at an estimated 40 to 60 km per year.

The introduction of cane toads has severely interrupted the food chains and food webs of the ecosystems they have invaded. As toxic and prolific invaders, cane toads have impacted on the populations of native species groups such as quolls, monitor lizards, snakes, fish, turtles, crocodiles, birds and invertebrates. Some examples of species that have been impacted by cane toads are the flood-plain goanna, barramundi, black bream and catfish, long and short-necked turtles, freshwater and salt-water crocodiles, some aquatic invertebrates and even some bird species, such as pelicans and herons.

Research suggests that cane toads are having a significant cascading effect on trophic levels. For instance, it has recently been discovered that cane toads have a negative impact on the population of a grain-eating bird despite these two species not being directly linked in the food web. The populations of many predator species have also been adversely affected by cane toads.

Being part of the food web themselves, this also has a subsequent effect on Aboriginal communities that are partially or solely dependent on the availability of these species as a source of food and other

resources. For example, the yellow-spotted monitor or floodplain goanna is an important source of meat for Aboriginal people living in remote communities in northern Australia where access to butchers or an affordable meat supply is limited. The population of floodplain goannas has been severely impacted by cane toads, and in some areas localised extinctions have been recorded. This is having a serious impact on the availability of meat resources in these communities.

First Nations' organisations such as the Yugul Mangi Aboriginal Ranger group are working with government departments to identify long-term cane toad management strategies. Some approaches include increasing awareness of the impact of cane toads, exploring control management options with various stakeholders and working on a feral animal plan for the South eastern Arnhem Land Indigenous Protected Area.

Originally from the tropical and sub-tropical savannas of Africa, gamba grass was introduced into Australia in the 1930s as pasture for cattle. In the 1990s gamba grass was identified as an invasive species, with potentially devastating impacts on native biota. Considered one of the fastest spreading invasive species in the world, its spread in the Northern Territory and North Queensland is having a significant impact on various ecosystems.

Weeds such as the gamba grass can have a range of impacts on natural habitats including competing with native plants for resources, altering soil-nutrient cycles and intensifying bushfires by carrying higher fuel loads. In addition, gamba grass can also create a monoculture by directly competing with and replacing native plant species and by indirectly increasing fire intensities. Gamba grass grows prolifically once established as it grows taller than native grasses and forms dense clusters, inhibiting the growth of native grasses and replacing native species. This species is having devastating impacts on the food chains and food webs of the ecosystems it is invading and is directly reducing culturally significant food sources for many Aboriginal communities. The abundance of gamba grass has also restricted access to sites of cultural and spiritual significance for some Aboriginal and Torres Strait Islander communities.

As a tussock grass, gamba grass can produce a biomass up to 10 times that of native plants and tends to increase fire intensities by a factor of 3-8. When gamba grass burns, it creates a more intense and hotter fire than native grasses resulting in fires that are more difficult to control or extinguish. When native plants and their seed banks are destroyed in these intense fires, soil erosion can occur. This can inhibit the natural regeneration processes of native species due to an increase in waterway sediment. Gamba grass also impacts the food web of its surrounding ecosystems by altering the structure of native vegetation and having the potential to transform woodlands into treeless grasslands. Moreover, it has been known to reduce the diversity and abundance of reptilian species in eucalypt woodlands.

The Australian Government recognised the threat posed by gamba grass in 2009 when it listed 'Ecosystem degradation, habitat loss and species decline due to invasion of northern Australia by

introduced gamba grass, para grass, olive hymenachne, mission grass and annual mission grass' as a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). In 2012 it was classified as a Weed of National Significance (WoNS). This weed has such profound impact that the world heritage-listed Kakadu National Park is also at significant risk.

Local Traditional Owners such as those in the Rum Jungle mine site in northern Australia are working in collaboration with government agencies to mitigate seed dispersal by means of seed eradication and foliage spraying. This is not only an attempt to control the spread of gamba grass but to reduce impacts on vulnerable ecosystems.

The national response to these introduced species has resulted in the need to include and collaborate with Aboriginal and Torres Strait Islander peoples to address the threats and mitigate the environmental impacts. The extensive knowledge and expertise held by Aboriginal and Torres Strait Islander peoples regarding the delicate and complex interrelationships of food chains and food webs within those ecosystems places them as critical experts and partners in governmental efforts to restore environments damaged by introduced species.

Students will gain an understanding of how interactions between organisms can be represented by food chains and webs, as well as the extent to which these can be affected by human activity. Additionally, they will have opportunities to learn about how invasive species have impacted on food webs which many Aboriginal and Torres Strait Islander communities rely on for food and other resources such as medicine. Students can also investigate how Aboriginal and Torres Strait Islander peoples have responded to these impacts in an effort to restore traditional ecosystems.

CONSULTED WORKS

In the construction of this teacher background information, a list of consulted works has been generated. The consulted works are provided as evidence of the research undertaken to inform the development of the teacher background information.

Please note that some of the sources listed in the consulted works may contain material that is considered culturally offensive or inappropriate. The consulted works are not provided or recommended as classroom resources.

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ACSSU113

Traditional separation techniques

CONTENT DESCRIPTION

Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques.

CONTENT ELABORATION FOR CCP (O1.5)

- ▶ investigating separation techniques used by Aboriginal and Torres Strait Islander Peoples, such as hand picking, sieving, winnowing, yandying, filtering, cold pressing and steam distilling



Winnowing is used to separate a mixture of grains

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration allows students the opportunity to explore a range of separation techniques developed and utilised by Aboriginal and Torres Strait Islander peoples across Australia for a variety of purposes. Students have opportunities to investigate the scientific principles underlying these techniques, and explore examples of specific separation methods developed by First Nations' Australians that enable the procurement and processing of resources necessary for everyday life and for survival in times of food and water shortages.

DETAIL

Aboriginal and Torres Strait Islander societies have long been adept at using numerous separation techniques, both wet and dry, to isolate and extract components of mixtures, including hand-picking, winnowing, yandying, sieving, filtering, straining, cold-pressing and steam distillation.

These techniques are essential for processes such as preparing foods, purifying water for drinking and creating medicines. These practices and technologies utilise readily available local resources and require a complex understanding of the components making up particular mixtures and the most effective techniques for their separation.

Hand-picking is the separation by hand of desired particles from a mixture containing undesired particles. It is based on the principle that particles can be easily distinguished by visual characteristics, such as size, shape or colour. The desired particles may be a food source, medicine, mineral or other valued resource or commodity. Alyawarre, Anmatyerre, Warlpiri and Pitjantjatjara Aboriginal peoples in the central desert regions of Australia frequently use this technique, for example, in the collection of desert raisins (*Solanum centrale*). The stalks and bad fruit are separated and discarded and the ripe fruits are separated from unripe ones.

Winnowing is a separation method that is designed to remove lighter particles while maintaining heavier ones. It is commonly used in separating seeds from their outer shells or coatings (husks). The mixture of seeds and husks is placed in a specifically designed container, such as a koolamon. The word koolamon (or coolamon) is derived from the language of the Kamilaroi people of northern New South Wales and southern Queensland and is now in the Australian vernacular. The mixture is then thrown lightly into the air allowing the wind to remove the lighter husk particles while the heavier seeds fall safely back into the container.

Aboriginal peoples, including the Alyawarre Aboriginal peoples of the Sandover River region in the Northern Territory harvest at least 36 different seed types as resources for food. Seed pods are collected and beaten with sticks to release the seeds within. The resultant mixture composed of seeds, pod fragments and debris from the ground (sticks, dirt, stones etc) is then winnowed to leave just the seeds behind.

Yandying is akin to the process of gold panning, and like winnowing is used to separate less dense particles from denser, desirable ones. A common purpose for yandying would be to separate sand, dirt or ash from seeds. In this technique, a mixture is placed in a wooden container called a yandy, a word used by the Yindjibarni people of the Pilbara region in Western Australia to describe a shallow dish similar to a koolamon, as well as the process of separation for which it is primarily used. The yandy is held in the hand, raised in one corner, and then gently shaken back and forth forcing the smaller and denser particles to collect at the bottom while the larger and less dense particles remain higher up.

Traditionally, Yankunytjatjara Aboriginal peoples in north-western South Australia relied heavily on mulga seeds as a food source. To prepare seeds for consumption they would undergo a double yandying process. The seeds would initially be separated from their pods through threshing and rubbing and then yandied to separate them from the pod fragments. The seeds would then be baked in hot sand and ashes, requiring an additional yandying process to remove sand and ashes. Finally, the seeds would be ground and moistened into a paste for consumption.

Sieving, filtering and straining are methods that allow for the separation of solid particles of different sizes or for the separation of liquid from solid matter using a porous device, mesh or a perforated container. A mixture is sieved, filtered or strained to allow the smaller particles, or liquids, to pass through while keeping the larger particles or solids in place. If the purpose is to separate the liquid for further use it can be collected in a container placed underneath the separation device. The effectiveness of these techniques depends on the size of the holes in relation to the size of the particles to be separated.

A practical example of filtering can be found in southwest Victoria, where in traditional times, Gunditjmara Aboriginal peoples used flowering honeysuckle cones (banksias) to filter water from muddy pools when clean drinking water was unavailable. The cone would be placed in the mouth and used like a filtration straw, separating impurities to provide clean drinking water.

Cold-pressing is a technique that uses pressure to extract the most medicinally rich oils from plant matter without heating the organic matter. The plant matter is ground to a pulp prior to pressing; the pressing process then extracts the water content producing a juice. Macadamias and coconuts are two examples of plants that were traditionally processed widely for their oil using the cold-pressing separation technique.

An example of cold-pressing used by Aboriginal peoples is in the medicinal use of *Eremophila alternifolia*, a shrub that is endemic in areas between the far west of New South Wales, the far south of the Northern Territory and the southern half of Western Australia. Its leaves are finely chopped and then mashed into an oily paste which is then used as a rubbing medicine or tied around the head with grasses as a poultice.

Distillation is a process that separates a mixture of liquids based on their differences in boiling points. A related technique, steam distillation, is often used to extract aromatic oils and other substances from plant matter. In contemporary practice, the plant material containing the often medically-active substance is immersed in water and boiled. The increased temperatures achieved by boiling rupture the plant cells, releasing the oils within. The water vapour carries small amounts of the vaporised aromatic compounds into the gas phase, where they may be used directly by inhaling or wafting over afflicted body parts. Depending on the type and quantity of oil present in the plant material, the oil may accumulate in liquid form at the water surface and can be collected by decanting. Traditionally, the extraction process was achieved by placing large amounts of fresh wet plant matter over cool fires to steam the leaves, releasing the medicinal vapours. Treated individuals were placed over the fire exposing them directly to the medically active components in a kind of 'steam bath'. Eucalyptus and tea tree leaves are now used by people around the world and inhaled as treatments for coughs using the same vapour delivery method.

The main purposes of the above separation methods were for purifying water, processing foods and extracting medicinal components. At the time of colonisation, Aboriginal and Torres Strait Islander peoples' separation methods were keenly noted by Europeans. The skills of Aboriginal and Torres Strait Islander peoples such as in yandying, were quickly recognised and adapted for mining, and often allowed First Nations' Australians to generate an income in times where no or limited employment opportunities existed. An example of this is in North Queensland where Aboriginal peoples owned and operated tin mines utilising traditional and modern methods to extract and separate minerals.

By exploring the range of separation techniques employed by Aboriginal and Torres Strait Islander peoples in different environments for different purposes, students deepen their understanding of the scientific principles underlying these techniques. Students also gain an appreciation of the importance of separation techniques in traditional and modern societies.

CONSULTED WORKS

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ACSSU115

Solar and lunar eclipses

CONTENT DESCRIPTION

Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon.

CONTENT ELABORATION FOR CCP (OI.3, OI.5)

- ▶ researching Aboriginal and Torres Strait Islander Peoples' oral traditions and cultural recordings of solar and lunar eclipses and investigating similarities and differences with contemporary understandings of such phenomena



Petroglyphs, significant to Punnilerpanner, Pallitorre, Noeteeler and Plairhekillerplue Peoples, Tasmania

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration will enable students to gain knowledge and awareness of Aboriginal and Torres Strait Islander understandings of and perspectives on the phases of the moon and the relationship between the lunar cycle and ocean tides.

The traditional astronomical knowledge of Australia's First Nations' communities includes an intricate understanding of the relationship between the moon and tides. This knowledge was acquired through empirical observation of how ocean tides are related to the positioning of the moon and sun relative to the Earth. Some Aboriginal and Torres Strait Islander groups' astronomical awareness of the relationship between the moon and tides was more accurate than early European scientific understandings.

DETAIL

With the full benefit of contemporary astronomical understandings revealed by modern technology, scientists now agree that the Earth's tides are a result of gravitational interactions between the moon, sun and Earth. Tides consist of what appears to be a rising and falling of oceans namely, high tides and low tides. Despite the fact that the sun has an overall greater gravitational pull than the moon, it does not have as significant an impact on ocean tides. This is mainly due to the close proximity of the moon to the Earth.

The phases of the moon provide an indication of the combined gravitational strength of the moon and sun, which influence the tides on Earth. When the moon is full or new, high tides become very high and the low tides very low; this is referred to as spring tides. During this time the gravitational pull of both the sun and moon contributes to the tides. Contrarily neap tides occur when the moon is in its quarter phases and result in tides becoming exceptionally weak. These tides occur when the moon and sun are perpendicular to each other in relation to the Earth.

The knowledge and awareness of neap tides and their subsequent reduction of currents are well-known to Torres Strait Islander peoples. The understanding of how lunar cycles are related to the occurrence of neap tides allows Torres Strait Islander peoples to predict the safest periods to be diving on reefs for lobsters.

First Peoples across mainland Australia and Torres Strait Islander peoples have many different explanations for the apparent movement of celestial bodies, including the moon. This traditional knowledge extends beyond symbolic representation and includes awareness of every observable object in the sky, and the relationships between their movements and natural occurrences on Earth.

Aboriginal peoples, for example, the Yolngu of the Northern Territory, have detailed stories that explain the phases of the moon and also accurately link the moon with the changing tides. Since the Yolngu people rely on the sea for many resources, they have developed an in-depth knowledge

of tides, including abilities to interpret the phases of the moon in ways that allow the prediction of ocean phenomena, such as the time and height of the next tide. In contrast, the 17th century Italian astronomer Galileo did not believe that the moon was in any way connected to tidal phenomena.

Aboriginal peoples of the Kimberley region of Western Australia, such as the Bardi people, also have comprehensive knowledge of both the moon and the tides and have traditionally been able to effectively utilise this knowledge to predict the best times for the collection of highly prized trochus shells, the best currents for fishing, and the safest times for the use of water-craft.

Traditionally, Aboriginal and Torres Strait Islander peoples did not quantify the attractive force of the moon's gravity. However, they did have an understanding that there was a causal relationship between the lunar cycle and tides. This observed knowledge reflected cultural and spiritual beliefs and helped not only to make sense of the universe, but also assisted in making accurate predictions important to many aspects of daily life, such as the timing of gathering marine resources by water-craft.

Observations and understandings of astronomical movements and phenomena helped First Nations' peoples shape their view of the universe and their place within it. The ontological knowledge associated with these phenomena reinforced important lessons and spiritual beliefs regarding their existence. Critically however, they also provided epistemological knowledge about the world derived from empirical observations, such as insights into seasonal changes and related behaviours of living things and assistance in navigation. They also provided the basis for making accurate predictions about recurring weather patterns and seasonal cycles. These insights helped develop both intricate and holistic understanding of the relationships between heavenly bodies and natural phenomena on Earth.

By investigating Aboriginal and Torres Strait Islander perspectives and cultural stories, students can gain an awareness of First Nations' knowledge of the relationship between the lunar cycle and ocean tides. Through this perspective, students can also develop an understanding of how tides are determined by the relative positioning and gravitational forces between the moon, Earth and sun.

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ACSSU115

Lunar cycles and tides

CONTENT DESCRIPTION

Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon.

CONTENT ELABORATION FOR CCP (OI.3, OI.9)

- ▶ researching knowledges held by Aboriginal and Torres Strait Islander Peoples regarding the phases of the moon and the connection between the lunar cycle and ocean tides



Stone fish traps rely on the lunar cycle. Photo credit: Phillip Breslin

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration allows students to explore Aboriginal and Torres Strait Islander peoples' knowledge of astronomy and consider how First Nations' understandings about the movement of the sun, Earth and moon were used to observe and make sense of solar and lunar eclipses.

Aboriginal and Torres Strait Islander peoples of Australia have been passing down astronomical knowledge through song, dance and ritual for approximately 60,000 years. This knowledge has also had implications for cultural and ceremonial responsibilities which focused on the significance of these cultural stories and ensured this knowledge was protected and passed on to each subsequent generation.

DETAIL

In many First Nations' cultures of the world, the sun is regarded as female and the moon as male. Some cultural stories refer to either the moon pursuing the sun or vice versa, while other cultures believe that an eclipse is caused by the convergence of the sun and the moon. These cultural stories not only demonstrate traditional understandings of the apparent movements of the sun and the moon in the sky, but also provide detailed observational descriptions of solar and lunar phenomena.

During a lunar eclipse the Earth passes in front of the sun's light, casting a shadow on the moon. While the green to violet portion of the light spectrum is filtered out as sunlight enters the atmosphere, the reddish portion of the light spectrum is the least affected. As this reddish light enters the atmosphere, it is refracted and projected onto the moon, causing it to appear red in colour.

Lunar eclipses can be seen from any location on Earth that is facing the moon and are a much more common phenomenon to observe than solar eclipses. Early European observations record that the reactions of First Nations' peoples to eclipses were varied, with some cultural groups reacting with anxiety while others were unafraid. Although it is uncommon for most Aboriginal and Torres Strait Islander groups to attribute lunar eclipses to the relative positions of the sun and moon, there are instances of this knowledge being apparent. This association demonstrates an in-depth astronomical understanding, especially considering the usually diametrical differences between the sun and the moon.

A solar eclipse occurs when the moon passes in front of the sun's light, casting a shadow on the Earth. While partial solar eclipses in which the moon does not cover the sun completely are quite common, in the Southern Hemisphere a total solar eclipse only occurs once every 540 years. With at least 60,000 years of looking skywards, Aboriginal and Torres Strait Islander peoples' accounts regarding total solar eclipses are understandably common.

Similar to lunar eclipses, solar eclipses were also generally regarded as bad omens, although some Aboriginal groups in Western Australia were unafraid of them.

Solar eclipses commonly occur during the new moon phase where the moon is barely visible. Despite this poor visibility of the moon, many Aboriginal and Torres Strait Islander groups describe a solar eclipse as the moon covering the sun. Other First Nations' groups describe a solar eclipse as something covering the sun, often attributed to a specific object or action but not necessarily referencing the moon. These are examples of the detailed observations that Aboriginal and Torres Strait Islander groups made of celestial events. They also demonstrate an awareness and understanding of the relative positions of the moon, sun and Earth.

Observations and understandings of astronomical movements and phenomena helped First Nations' peoples shape their view of the universe and their place within it. The ontological knowledge associated with these phenomena reinforced important lessons and spiritual beliefs regarding their existence. However, critically, they also provided epistemological knowledge about the world derived from empirical observations, such as insights into seasonal changes and related behaviours of living things, and assistance in navigation. They formed the basis for making accurate predictions about recurring weather patterns and seasonal cycles. These insights helped develop intricate and holistic understanding of the relationships between heavenly bodies and natural phenomena on Earth.

By exploring First Nations peoples' explanations of natural phenomena, such as solar and lunar eclipses, students appreciate the commonality of traditional explanations amongst all cultures (including European) and their understanding of celestial phenomena before the advent of telescopes and other astronomical technology. Students gain insights into Aboriginal and Torres Strait Islander peoples' long-standing observations and records of the sky, including recurring phenomena on Earth and beyond. Students can also gain an understanding of the extent to which explanations of these phenomena reinforce Aboriginal and Torres Strait Islander peoples' worldviews and provide important teachings about life, the environment and the universe.

CONSULTED WORKS

In the construction of this teacher background information, a list of consulted works has been generated. The consulted works are provided as evidence of the research undertaken to inform the development of the teacher background information.

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ACSSU115

Seasons and cycles

CONTENT DESCRIPTION

Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon.

CONTENT ELABORATION FOR CCP (OI.3, OI.5)

- ▶ investigating Aboriginal and Torres Strait Islander Peoples' calendars and how they are used to predict seasonal changes



The flowering of particular plant species indicates seasons and fat cycles of important food sources

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with opportunities to learn about Aboriginal and Torres Strait Islander peoples' understandings of seasons through the investigation of seasonal calendars pertaining to various cultural groups. These calendars reflect Australia's varying climatic conditions, ecological diversity and expansive geographic locations inhabited by Aboriginal and Torres Strait Islander peoples. They include detailed understandings of recurring weather patterns and seasonal cycles. Aboriginal and Torres Strait Islander communities hold knowledge that links events in the natural world to cycles that are used in many facets of everyday life.

DETAIL

Many Aboriginal and Torres Strait Islander groups devised highly intricate and comprehensive seasonal calendars based on thousands of years of detailed observation of the environments of which they form an integral part. The gathering and dissemination of this scientific knowledge continues to enable many First Nations' communities to make accurate predictions about recurring seasonal changes.

While the seasonal calendar used in most Western societies is based on specific dates to mark each season, Aboriginal and Torres Strait Islander peoples observe the position of stars in the sky and follow water, plant and animal cycles as ways of identifying seasonal phenomena.

Seasons vary based on the relative positioning of the Earth and sun. According to the contemporary Western calendar, Australia's summer occurs at the end of the year, because the Southern Hemisphere is tilted towards the sun at that time. Days are longer and hotter during this time, as not only are more daylight hours spent facing the sun, but sunlight is also more direct as opposed to being on an angle. The opposite happens during the winter where the Southern Hemisphere is tilted away from the sun. During the spring and autumn, the Earth is not tilted towards or away from the sun but side-on. Despite this, the expanse of the Australian continent and range of latitudes make Australia's climatic conditions extremely diverse.

The seasonal calendars of discrete Aboriginal and Torres Strait Islander cultural groups demonstrate an understanding of the interdependence and interrelationships amongst living things. These calendars can be used to predict seasonal changes and weather patterns to determine the availability of particular resources or the timing of journeys.

Seasonal calendars are not interchangeable throughout First Nations' communities, but vary according to geographic location, ecological context and cultural interpretation. Specific biotic events, usually referred to as bio-indicators, can occur locally or over vast distances and enable accurate predictions of seasonal changes. For instance, in some Aboriginal and Torres Strait Islander peoples' seasonal calendars the appearance of particular insect species is an indication that the rainy/wet season is approaching, thus marking the correct time to commence the harvesting of yams.

Also forming part of some Aboriginal and Torres Strait Islander seasonal calendars are observations of cyclical animal behavioural patterns. One example can be found in the seasonal calendar of the people of D’harawal Country regarding the cries of tiger quolls in search of mates. When this is heard, it is an indication that the lilly pilly fruit has started to ripen. Once the lilly pillies start to fall, it is a sign for the people of the D’harawal Country to begin their annual journey to the coast in search of other seasonal resources.

Seasonal calendars continue to be used by many First Nations’ groups today. The publication of these calendars has revealed the immense scientific knowledge held by the respective communities and has informed Western scientific understandings across a wide range of disciplines, for example, botany, zoology, ecology, meteorology and many more. The publication of First Nations’ seasonal calendars in collaboration with scientific institutions throughout Australia is a good example of how First Nations’ extensive ecological science knowledge is gaining respect and awareness and has contributed to the dissemination of that knowledge amongst school communities and the general public.

Through the investigation of calendars used by Aboriginal and Torres Strait Islander peoples, students will gain an understanding of how seasonal cycles and weather changes are predicted by many First Nations’ groups. Students can also gain an in-depth awareness of how these Aboriginal and Torres Strait Islander groups interpret and utilise ecological patterns and seasonal phenomena.

CONSULTED WORKS

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ACSSU116

Water values and management of finite resources

CONTENT DESCRIPTION

Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable.

CONTENT ELABORATION FOR CCP (OI.2, OI.3)

- ▶ exploring Aboriginal and Torres Strait Islander Peoples' connections with, and valuing of, water and water resource management



The Nicholson River is culturally important to Gulf Nations Peoples

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

Aboriginal and Torres Strait Islander peoples have long held a deep knowledge and understanding of water as a renewable resource cycling through the environment. However, there are risks to the sustainability of the water supply available for drinking and for environmental and agricultural uses. Some of these risks can be minimised through the application of management practices informed by Aboriginal and Torres Strait Islander peoples' detailed and comprehensive understanding of water flows, and of the impact that water use may have on downstream ecosystems.

DETAIL

Australia's waterways have undergone dramatic changes as result of European colonisation. Rivers have been transformed by land clearing and by damming to divert water for agriculture, industry and human consumption. Schemes such as the Snowy Mountains Hydroelectric Scheme have significantly altered both the flow rate of water through the environment, as well as the amount of water available in different locations. These changes have had a profound long-term effect on the ecology of these riverine and riparian ecosystems. This in turn is of great significance to Aboriginal and Torres Strait Islander peoples as custodians of country, and in terms of the impact on cultural continuity.

Aboriginal and Torres Strait Islander peoples have deep connections to country in its totality, placing significant socio-cultural, economic and environmental values on the land, and also its associated water sources and other water features. These connections extend to the custodial responsibilities in managing the inter-related parts of their traditional estates in a sustainable way.

Australia contains a broad range of ecological environments, including water sheds. Each environment has its own unique hydrological and geological features that determine water cycling. Associated with these particular environments are specific Aboriginal and Torres Strait Islander cultural groups who, over millennia, have developed strategies for sustainably managing water and aquatic resources. These strategies and understandings are specific to the way water cycles through their respective environments.

The deeply held understandings regarding water cycling through the environment were and continue to be essential knowledge that has historically been crucial to the access of potable water. Beyond maintaining essential water supply, water ways are also a crucial source of a vast range of resources, including produce and materials necessary for every-day life.

The pragmatic understandings of the critical nature of water ways and their essential function for providing resources underpinned a system of custodial obligations and commitments, including inter-group agreements that ensured the sustainability of each community and the continued access to healthy water ways.

Healthy water ways contain abundant aquatic resources, such as fish, birds, molluscs and crustaceans. They also contain many important aquatic plants that provide a source of food and raw materials for a range of contemporary purposes.

In order to maintain access to these resources, Aboriginal and Torres Strait Islander peoples have long manipulated and influenced water flows in a number of innovative ways. These included extensively engineered weirs, small dams and fish traps. A well-known example of water-way manipulation is the Brewarrina Stone Fish traps on what is today known as the Barwon River in north-central New South Wales. Some researchers believe that these traps are the oldest extant man-made structure on Earth. Also, channels have been excavated to allow fish to be farmed by moving them on to floodplains or into a system of small artificial ponds. In a similar fashion, fish traps with multiple pens are common in the Torres Strait. However, Aboriginal and Torres Strait Islander peoples recognised that such interventions required careful consideration of water flows, especially of perennial freshwater systems, as they involve not only an obligation to maintain the local ecosystem, but also a responsibility to those living downstream. Such practices are considered recognition of Aboriginal and Torres Strait Islander understandings of hydrological processes, including awareness of how water cycles through an interconnected series of both surface and subterranean flows.

For Aboriginal and Torres Strait Islander peoples living in freshwater-poor regions, traditional knowledge of the water supplies available locally was passed down through generations via oral instruction including, at times, stylised mapping. This knowledge is crucial in ensuring survival. Many Torres Strait Islander communities have, for thousands of years, successfully managed severe freshwater supply issues, carefully collecting rainwater in a variety of ways. In desert areas, where rainfall is sporadic, Aboriginal peoples draw on their knowledge of a variety of water sources to meet their needs. These sources include riverine waterholes, soakage-wells in permeable sediments, flooded rock holes (known as gnammas, a Nyungar word from south-west Western Australia), rainwater accumulated in tree hollows and even water from the body of the water-holding frog (*Cyclorana platycephala*).

Managing water resources in a sustainable way is of paramount importance to First Nations' Australians, and increasingly, more Australians are becoming aware of the need to develop a water-governance framework that is inclusive of First Nations' Australians' perspectives and shaped by customary relationships and traditional knowledge.

Water is an essential aspect of the beliefs, practices and cultures of First Nations' Australians. This is not only demonstrated through the records of hydrological knowledge held and transmitted through paintings, stories and ceremonies, but is also evident in the richness of terms and concepts relating to water in all Aboriginal and Torres Strait Islander languages.

As students investigate Aboriginal and Torres Strait Islander peoples' knowledge of, connections with and values about water and water resource management, they have opportunities to develop

an understanding of the need to build cross-cultural collaborative research and management partnerships in the environmental water sector. They also have the opportunity to improve their understanding of the social and economic significance of water to Aboriginal and Torres Strait Islander peoples.

CONSULTED WORKS

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ACSSU117

Indigenous ballistics

CONTENT DESCRIPTION

Change to an object's motion is caused by unbalanced forces, including Earth's gravitational attraction, acting on the object.

CONTENT ELABORATION FOR CCP (OI.5, OI.7)

- ▶ investigating the effect of forces through the application of simple machines, such as the bow and arrows used by Torres Strait Islander Peoples or the spear throwers used by Aboriginal Peoples



Spear throwers are simple machines that use leverage to alter force

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides an opportunity for students to explore how an understanding of the effects of unbalanced forces acting on an object is the basis for the development of hunting technologies used by Aboriginal and Torres Strait Islander peoples.

DETAIL

Across mainland Australia and islands of the Torres Strait, a range of tools to increase the velocity and accuracy of projectiles was developed or produced by Aboriginal and Torres Strait Islander peoples. On much of the mainland, various styles of spear-throwers were developed and refined. Spear-throwers were effective as they provided an extension to the human thrower's arm. In the Torres Strait and the nearby parts of northern Queensland bows and arrows were used alongside spear-throwers. In this teacher background information, the physics of the spear-thrower, as well as its cultural significance to Australia's First Nations' peoples are explored in detail.

The spear-throwers used by First Nations' Australians were crafted out of hardwood, such as mulga, and ranged in length from approximately 50cm to 100cm. Spear-thrower design, including its dimensions, was carefully refined and optimised for each individual user and carefully matched to the projectile type used. They have a variety of shapes and widths, but typically taper towards the gripping end and have notches coated in resin cut on either side at one end to form a hand grip. The other end is narrow and has a 'peg' that is designed to fit into a socket or notch at the base of the spear, more technically called a dart. The 'peg' can be either integrated into the structure or made from an animal's tooth or claw and attached by sinew and resin. Spears up to three metres in length rest on a spear-thrower and are gripped by the spear-throwing hand. The 'peg' is crucial in transmitting force to the spear allowing it to be propelled at a higher velocity than can be achieved by hand alone. The 'peg' also focuses the propelling force enhancing the accuracy of the throw.

A spear-thrower is an example of a lever, which is one of the six mechanisms classified as simple machines that are designed to alter the size or direction of a force on an object. The others are wheel and axle, pulley, inclined plane, wedge and screw. The lever is basically a rigid bar to which a load force and effort force are applied, and which rotates around a fulcrum or pivot point. There are three orders or classes of levers, differing in the relative positions of their load, effort and fulcrum.

Throwing a spear using a spear-thrower involves a complex interaction and co-ordination of the thrower's skeleton and muscles. Since the spear-throwing process involves a series of levers, defining which class of lever applies is often debated. When viewing the system of spear-thrower and spear in isolation, it can be classified as a second-class lever, where the fulcrum as well as the load are situated at the peg. When including the arm and wrist action, a spear-thrower can be classified as a first-order lever which positions the fulcrum between the effort arm and the load arm. The effort force exerted by the thrower's hand pivots around the wrist, acting as the fulcrum to move the spear positioned at the longer end of the thrower. The distance from the wrist to the shorter (proximal) end

of the spear-thrower is very much smaller than the distance from the wrist to the other (distal) end of the thrower. Consequently, as the farther end of the spear-thrower moves through a much greater distance than the nearer end but in the same amount of time, it moves at a much greater speed. The spear-thrower acts as a speed multiplier, which comes at a cost to the mass of the projectile that can be propelled in this way. Spears thrown with the aid of longer spear-throwers are therefore typically lighter than those that are designed to be thrown by relatively shorter spear-throwers. This also means that spears thrown by spear-throwers need to be lighter than spears thrown by hand. The development of light-weight, balanced projectiles exploited the full potential of the spear-thrower and established a new method of casting spears at greatly increased velocity.

When forces on an object are balanced, the object's motion stays constant. The unbalanced force applied to a spear by the spear-thrower causes it to accelerate from rest. Once launched, the unbalanced forces acting on the spear are air resistance, causing it to slow down, and the Earth's gravitational attraction, causing it to fall.

Many examples of spear-throwers are elaborately decorated indicating their cultural significance. Spear-throwers from central Australia were light-weight and easily portable and designed to be used as a multipurpose tool. The spear-thrower could be useful as a shield, and could also be used as a fire saw, a digging stick, a receptacle for mixing ochre, a carrying dish, or as a percussion device during ceremonies. Some examples from central Australia have a sharp piece of rock embedded in the handle and held in place with spinifex resin. This enabled the spear-thrower to be also used as a tool for cutting, chiselling, shaping, and sharpening.

By studying the physics involved in the use of spear-throwers, students are given an opportunity to appreciate First Nations' peoples' knowledge and exploitation of levers and to develop and consolidate their own understanding of the effects of unbalanced forces acting on an object.

CONSULTED WORKS

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ACSHE119

First Nations contributions to medicine

CONTENT DESCRIPTION

Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available.

CONTENT ELABORATION FOR CCP (OI.9)

- ▶ investigating the contributions of Aboriginal and Torres Strait Islander Peoples' knowledge in the identification of medicinal and endemic plants



Traditional knowledge of plants contributes to contemporary medicine e.g. steroidal hormones

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with opportunities to investigate how Aboriginal and Torres Strait Islander peoples' sophisticated knowledge of the medicinal properties of some endemic Australian plant species contributes to refining scientific understanding of the plants' broader pharmaceutical potential. Students learn about a variety of modern medicines and how they have been sourced from First Nations Australians' pharmacopeia.

DETAIL

Around the world there are myriad examples of modern medicines that are derived from traditional botanical and medicinal knowledge. Morphine and aspirin, artemisinin (an antimalarial medicine), teniposide (an anti-cancer agent) and digoxin (a cardiac medicine) are all examples of medicines that have their origins in traditional knowledges and practices.

Australia has a rich and diverse flora, with as much as 84 percent of the plant species being endemic to Australia. Aboriginal and Torres Strait Islander peoples have long possessed a vast knowledge of the pharmaceutical properties of this flora. This knowledge includes understanding the phytochemical activity as well as delivery methodologies, for example, by ingestion, inhalation or transdermal delivery.

Based upon powerful observation and expert botanical knowledge, Aboriginal and Torres Strait Islander peoples, over millennia, trialled plant and non-plant substances for evidence of their healing values culminating in a large body of medicinal knowledge. To this day, Aboriginal and Torres Strait Islander peoples continue their therapeutic investigations with previously unused phytochemical materials.

Pharmaceutical knowledge remains highly prized by Aboriginal and Torres Strait Islander communities. As in Western medicine today, only certain people are entrusted with responsibility for the knowledge of existing medicines and the exploration of new ones. This traditional knowledge, accumulated and refined over thousands of years, is highly detailed and specialised for the specific areas in which the people live. It targets the common ailments they may suffer from and injuries they are likely to sustain.

Since the beginning of colonisation in Australia, there has been extensive interest in the medicinal properties of native Australian plants and First Nations' peoples' use of them, which has helped create numerous treatments and medicines that are widely used today.

As early as 1788, surgeon Dennis Conisden wrote to Joseph Banks claiming that, "This country produces five or six species of wild myrtle [species of *Melaleuca*, *Kunzea* and *Leptospermum*], some of which I have sent you dried. An infusion of the leaves of one sort is a mild and safe astringent for the dysentery" (Clarke, 2008, p.16).

In the early 1920s, scientific research was conducted into the antimicrobial properties of tea tree oil, based on observations of Aboriginal peoples' uses for this purpose. Its traditional use was reaffirmed when this research quantified its properties and found it to be a highly potent remedy of greater efficacy than many Western antimicrobial agents (such as phenol) existing at the time. Over the past century this has led to a thriving industry based on the production of tea tree oil. The oil is commonly used in the treatment of bacterial and fungal infections.

Aboriginal peoples on the east coast of Australia had long been observed treating stomach pain using a medicine derived from a particular species of tree, now known as *Duboisia myoporoides* or corkwood tree. During the 1940s there was a shortage of a previously widely available Western medicine prompting a large-scale search for a replacement. Scientists were quick to recognise traditional Aboriginal treatments for gastric dysfunctions and began to assess the active chemical constituents of the corkwood tree. This resulted in the successful identification and isolation of the important anti-spasmodic compound hyoscine butylbromide. Today, this drug founded on a traditional Aboriginal medicine remains an important commercially produced pharmaceutical used internationally in the treatment of ailments such as abdominal pain, oesophageal spasms, renal colic and bladder spasms.

Through investigating the context suggested by this elaboration, students have opportunities to develop an understanding of how scientific knowledge about the pharmaceutical potential of endemic Australian plants has been refined through the investigation of the traditional medicinal knowledges of Aboriginal and Torres Strait Islander peoples. Students gain an appreciation of the contributions of First Nations' Australians to the development of modern medicines based on the rich pharmacopeia of Aboriginal and Torres Strait Islander peoples.

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ACSHE120

Protecting Aboriginal and Torres Strait Islander knowledge in the commercialisation of plants and animals

CONTENT DESCRIPTION

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations.

CONTENT ELABORATION FOR CCP (OI.9)

- ▶ researching the development of commercial products that are founded on the traditional knowledge and practices of Aboriginal and Torres Strait Islander Peoples and discussing related ethical considerations associated with bio-piracy and intellectual property rights



Observations of Aboriginal use of Dubosia led to commercial pharmaceuticals

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration allows students to explore emerging ethical and cultural issues regarding the use of traditional knowledges in the development of for-profit solutions to contemporary issues, such as novel pharmaceuticals or agricultural products. In recent decades, multi-national companies have increased their focus on investigating the botanical and zoological knowledges of First Peoples around the world to develop commercial products. The traditional knowledges, especially pharmacopeia, of Australia's First Peoples are at risk of biopiracy.

DETAIL

As society strives to meet the challenges in combatting new diseases and providing food and economic opportunities for a growing population, there is increasing pressure to find new cures and treatments, more productive agricultural products, and other new natural resources. One way of finding solutions to these challenges is to systematically explore the medicinal, agricultural and economic potential of nature's biodiversity by investigating species of plants, animals and fungi for the possible presence of substances that may be used to develop new medicines or other commercial products. This screening process is known as bioprospecting.

Due to their longstanding and intimate knowledges of local ecosystems, Aboriginal and Torres Strait Islander peoples and other First Peoples of the world have an acute awareness of the medicinal and other beneficial values of certain species often unknown to Western science. For this reason, commercial enterprises, including research institutions, are increasingly investigating traditional ecological and medicinal knowledges as a focus of their surveying efforts for commercially promising bioactive compounds. In the past, this has often been done without consideration of the rights of First Peoples of the world to own, control and protect their traditional knowledge.

Traditional knowledge refers to the knowledges, know-how, skills and practices of First Peoples. It includes First Peoples' knowledge and learnings about agriculture, science, flora, fauna, ecology, medicine, health, cosmology and biodiversity developed and passed down between generations over thousands of years.

The *United Nations Declaration on the Rights of Indigenous Peoples* enshrines the rights of First Peoples to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the intellectual property over their heritage, knowledge and expressions.

In relation to bioprospecting, the *United Nations Convention on Biological Diversity*, *Nagoya Protocol* and *Bonn Guidelines* require the free, prior and informed consent of First Peoples when using and innovating traditional knowledge in bioprospecting processes. Use of traditional knowledge in bioprospecting must be subject to an agreement that ensures equitable sharing of benefits with

the holders and traditional owners of that knowledge. This is called an access and benefit sharing agreement.

While these are internationally established legal frameworks and principles on bioprospecting, in Australia there are limitations and gaps in how bioprospecting laws protect traditional knowledge. Bioprospecting laws are state based laws and the Commonwealth lands are covered in the Environment Protection and Biodiversity Act 1999. They focus on a framework for access to genetic resources, but include associated traditional knowledge. Protection largely depends on where the biological resources are found (i.e. the type of land and who owns it) and why the resources are being accessed (i.e. for commercial or non-commercial purposes).

In the past, the benefits resulting from the development of novel pharmaceuticals or other commercial products based on traditional knowledge have often not been shared with First Peoples' communities. This practice is commonly referred to as biopiracy.

There is growing awareness of intellectual property by First Peoples and some Indigenous peoples have been able to use intellectual property laws such as copyright, patents and trademarks to protect their traditional knowledge. However, intellectual property laws exist to protect the expression of ideas or the methodologies of individuals and companies; they are not designed to protect the traditional knowledges of First Peoples. This presents unique challenges for First Peoples' communities. For example, traditional knowledge documented in a journal article can be used as a basis to develop an invention and a patent application without the consent of First People communities who own that knowledge. The Patent Act protects inventions that are new and has an 'inventive step'. It does not protect underlying traditional knowledge used to develop the invention, nor are patent applicants currently required to disclose traditional knowledge used in their application.

From the perspective of First Nations' peoples, there is no distinction between intellectual property rights and cultural property rights. Rather than being owned by an individual or a company, the knowledge is owned by a community. Further, more than just being 'owned' by a community, it is often interwoven into cultural belief systems as well. There are ongoing efforts in Australia to have Indigenous cultural and intellectual property rights recognised in legislation and considered alongside other forms of intellectual property.

Since the 1990s, there have been several high-profile legal cases exploring the rights of First Peoples' cultural property rights world-wide. In Australia, the Kakadu Plum (*Terminalia ferdinandiana*) has been used for thousands of years as a food source and as medicine by the Mirarr People in the Northern Territory. The Kakadu Plum contains high levels of ascorbic acid (vitamin C) and acts as an antioxidant when applied to the skin. Its beneficial properties, including in the application as a skin care product, have long been recognised by the Mirarr People. Despite their documented traditional medicinal knowledge about the plant, the Mirarr People were not consulted or approached for consent to use their knowledge when an American cosmetic company attempted to patent extracts

from the Kakadu plum for use in a commercial cosmetic product. The company eventually withdrew their Australian patent claim in response to community concerns and lobbying against this motion. If granted, this patent could have significantly limited the ability of the Mirarr People to innovate on their knowledge about the Kakadu plum's properties. The Mirarr People would have had to pay royalties to the US patent holding company in any potential commercial developments by the community of Kakadu Plum extracts for dermal cosmetic products. However, there are numerous patents held internationally that include Kakadu Plum.

Today, there is an increasing number of examples of scientific and commercial agencies working in successful collaboration with Aboriginal and Torres Strait Islander communities to explore sustainable economic opportunities based on traditional knowledge about flora and fauna. One such example is found in the Cape York region of Queensland, amongst the traditional homelands of the Kuuku l'yu peoples. Parts of their homelands are recognised as an Indigenous Protected Area. The Chuulangun Aboriginal Corporation which represents the community, is working collaboratively with researchers and academics in innovative ways that comply with cultural protocols and promote interaction based on mutual respect and ethical conduct. The corporation acts under several guiding principles to ensure sustainability for the communities and for the ecosystems therein. It focuses on: (1) the intergenerational transfer of knowledge and language; (2) creating homelands-based community enterprises built on sustainable land management principles; (3) creating culturally linked employment opportunities; and (4) incorporating traditional knowledge with contemporary scientific processes to provide benefits to both natural and cultural resource management. In this way, the benefits shared with the community are both monetary and non-monetary – the development of income sources as well as capacity building and knowledge transfer initiatives.

In another example, the Indjalandji-Dhidhanu People of north-west Queensland are working in collaboration with scientists from the University of Queensland's Australian Institute for Bioengineering and Nanotechnology (AIBN) to develop a commercially viable way of extracting nanocellulose fibres from spinifex grass. These thin yet strong nanofibres with a diameter of less than 10 nanometres can be used as an additive to reinforce flexible materials, such as latex. The University of Queensland and the Dugalunji Aboriginal Corporation have signed a research agreement about the commercialisation of this technology that recognises the Aboriginal traditional owners' knowledge about spinifex, including farming, harvesting, and bioprocessing techniques. This agreement ensures that the Indjalandji-Dhidhanu People will have ongoing rights, equity and involvement as equal partners in the commercialisation of the nanofibre technology. This allows the community to retain control over their traditional knowledge, as well as benefit from the partnership through the development of employment opportunities and sharing of research findings.

By exploring the context suggested in this elaboration, students have an opportunity to learn how Aboriginal and Torres Strait Islander peoples' traditional knowledge about the environment has contributed to finding solutions to contemporary issues through the development of pharmaceuticals, design technology, food and cosmetic products. Students consider the ethical and cultural

implications arising from the use of Aboriginal and Torres Strait Islander peoples' intellectual property by community, external or third-party commercial enterprises, which, in the past, have resulted in little or no benefit flowing back to the community. This elaboration can also allow students to understand the issues and explore potential frameworks, best practices, protocols and international instruments to address these concerns, as well as research contemporary examples of mutually beneficial collaborations that can achieve positive outcomes for Aboriginal and Torres Strait Islander peoples as well as for researchers, companies and consumers.

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ACSHE223

Traditional fire regimes protect biodiversity

CONTENT DESCRIPTION

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures.

CONTENT ELABORATION FOR CCP (OI.5, OI.9)

- ▶ investigating how land management practices of Aboriginal and Torres Strait Islander Peoples informs contemporary management of the environment to protect biodiversity



First Nations Peoples' use of fire is critical for biodiversity

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration allows students to investigate the role of Aboriginal and Torres Strait Islander peoples' fire regimes in protecting biodiversity and how the knowledge that underpins these practices is contributing to scientific understanding and sustainable land-management techniques.

Scientific research has reaffirmed these traditional practices as an effective means of managing a range of ecosystems and has provided the evidence framework for their reintroduction into a number of Australian environments.

DETAIL

The introduction of Western agriculture has had a detrimental impact on the sustainability of a range of Australian environments. Part of this impact is due to the introduction of exotic species, be they livestock, domestic animals, feral animals, crop plants or weeds. The impact has been further compounded in many areas by the removal of Aboriginal and Torres Strait Islander peoples as carers of country and, as a corollary, the disruption of traditional fire regimes.

As a result of this impact over the past two hundred years, there has been significant ecosystem degradation and substantial losses in the biodiversity of many Australian environments, particularly in tropical savanna regions.

To conserve biodiversity, Aboriginal and Torres Strait Islander peoples are working in collaboration with farmers, community groups, government agencies and research scientists from a range of disciplines to restore traditional land management practices across a range of landscapes and environments. One particular practice, the controlled burning of land, has proved to have a long history of positive social, cultural, economic and environmental benefits. By carefully managing fire timing, frequency and intensity, destruction of native plant communities and animal populations can be mitigated, as can negative impacts on soils and water quality. Research into traditional fire management techniques has reaffirmed that Aboriginal and Torres Strait Islander peoples' practices involving cooler, more controlled burning assist in the regeneration and propagation of native flora, thus protecting biodiversity and increasing the availability of key resources.

Furthermore, some scientific research organisations are collaborating with Aboriginal and Torres Strait Islander community groups to use controlled burning as a highly effective tool in managing and/or eradicating infestations of invasive, noxious species, such as rubber vine, *Cryptostegia grandiflora* and *C. madagascarensis*, and non-native hymenachne, *Hymenachne amplexicaulis*.

In the case of hymenachne infestations, the use of fire as an adjunct to other control methods is a cost-effective way of improving the overall result. The control and eradication of rubber vine is best achieved by two successive annual burns. The first fire kills rubber vine plants but also promotes a build-up of fuel load by encouraging grass growth. The second fire is used to kill any rubber vine regrowth that occurs after the first fire.

Without adequate management practices, these plants, each of which has been classified as a 'Weed of National Significance' by the Australian Government, outcompete endemic species and rapidly take over entire ecosystems leading to significant declines in biodiversity.

An example of these two-way modern fire management programs is the Fire and Weed Project. Like other two-way projects, it is founded on the confluence of traditional knowledges and practices and the data-collection and electronic mapping capacities of contemporary science. This project, initiated by the Gangalidda and Garawa People with support from the Carpentaria Land Council Aboriginal Corporation, covers an area of 73,000 km² across Queensland and the Northern Territory. Traditional understandings of when, why and how country is burnt are used in conjunction with scientific data from agencies such as the Bureau of Meteorology to plan strategic burns that target specific weeds such as rubber vine. This plant is listed as a Weed of National Significance due to its ability to spread quickly and to form dense, sometimes impenetrable, thickets. Rubber vine smothers riparian vegetation and prevents access to waterways for many native animals preventing, for example, turtles from nesting on certain beaches.

Modern fire management strategies increasingly recognise the importance of collaborative approaches to protect the environment and conserve biodiversity. These approaches also acknowledge the importance of the cross-generational transfer and documentation of traditional ecological knowledge to ensure that it is not lost, as well as the potential economic development and well-being benefits to Aboriginal and Torres Strait Islander peoples that can ensue from these programs.

By investigating the land-management practices of Aboriginal and Torres Strait Islander peoples and, in particular, traditional fire regimes, students can develop an understanding of how the biodiversity of Australian ecosystems can be protected through reinstating those practices. Students also have opportunities to appreciate how collaboration between Aboriginal and Torres Strait Islander ranger groups and science agencies culminates in the co-generation of strategies to combat weeds of national significance that are directly contributing to a loss of biodiversity.

CONSULTED WORKS

In the construction of this teacher background information, a list of consulted works has been generated. The consulted works are provided as evidence of the research undertaken to inform the development of the teacher background information.

Please note that some of the sources listed in the consulted works may contain material that is considered culturally offensive or inappropriate. The consulted works are not provided or recommended as classroom resources.

The following sources were consulted in the construction of this teacher background information. They are provided as evidence of the research undertaken to inform the development of the teacher background information. It is important that educators recognise that despite written records being incredibly useful, they can also be problematic as they are often based on non-Indigenous interpretations of observations and records of First Nations Peoples' behaviours, actions, comments and traditions. Such interpretations privilege western paradigms of non-First Nations authors and include, at times, attitudes and language of the past. These sources often lack the viewpoints of the people they discuss and can contain ideas based on outdated scientific theories. Furthermore, although the sources are in the public domain, they may contain cultural breaches and cause offence to the Peoples concerned. With careful selection, evaluation and community consultation, the consulted works may provide teachers with further support and reference materials that could be culturally audited, refined and adapted to construct culturally appropriate teaching and learning materials. The ability to select and evaluate appropriate resources is an essential cultural capability skill for educators.

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ACSHE121

Traditional practices used for effective land management

CONTENT DESCRIPTION

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity.

CONTENT ELABORATION FOR CCP (OI.2, OI.9)

- ▶ investigating how the knowledge and experience of Aboriginal and Torres Strait Islander Peoples are being used to inform scientific decisions, such as the care of Country/Place



Traditional ecological knowledge, including using fire, is Caring for Country

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration will give students the opportunity to examine how traditional land management techniques are gaining increasing acceptance by the wider scientific community and how, through collaborative and reciprocal partnerships with researchers and government agencies, these techniques are informing and being incorporated into programs designed to care for country.

DETAIL

Aboriginal and Torres Strait Islander peoples' land management practices effectively sustained Australian landscapes for tens of thousands of years. Many of these practices, built on an in-depth understanding of the needs of each particular ecosystem, have been disrupted over the past two hundred years. This disruption has resulted in the emergence of a range of impacts that threaten the ecological and cultural integrity of these unique environments.

Challenges arising from introduced agricultural practices include the restoration of terrestrial and aquatic ecosystems, conserving biodiversity, protecting the habitats of a diverse range of endangered species, controlling the spread of, and eradicating, invasive species, and managing fire.

Endeavours to re-introduce practices that incorporate aspects of traditional ecological knowledge and acknowledge customary law need to consider a range of issues in order to be successful. This requires the substantial involvement of Aboriginal and Torres Strait Islander land owners in the Caring for Country/Place. To promote this reintroduction of practices, many First Nations' communities have invested considerable time, energy and resources to develop innovative partnerships with scientific researchers, government and industry. These cross-cultural partnerships allow for a two-way approach to share and exchange knowledge and skills from often complementary systems, in order to better understand issues affecting sustainability and to generate new ecological knowledge and responsive strategies to achieve a common purpose.

A two-way, inclusive strategy based on respectful and ethical guidelines and protocols for incorporating First Nations' knowledges into research practice, not only builds scientific knowledge, but also contributes to socio-cultural resilience through the cross-generational transfer and documentation of traditional ecological knowledge. The strategy also provides opportunities for reciprocal training; training for Aboriginal and Torres Strait Islander rangers and businesses in the use of technologies, and hence has the potential to improve economic development and well-being; and training for non-Indigenous researchers in First Nations' land management practices.

Australian Government policies and legislation increasingly recognise the need for a partnership approach and Aboriginal and Torres Strait Islander peoples' engagement in strategies designed to protect the environment and conserve biodiversity.

By exploring how Aboriginal and Torres Strait Islander peoples' knowledge and experience are being used to reshape contemporary Australian land management practices, students have the opportunity

to examine the interactions between First Nations' and Western philosophies and how the scientific knowledge of each can influence the behaviours, philosophies and techniques of both Indigenous and non-Indigenous land management practitioners.

CONSULTED WORKS

In the construction of this teacher background information, a list of consulted works has been generated. The consulted works are provided as evidence of the research undertaken to inform the development of the teacher background information.

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Science Inquiry Skills

New elaborations within the Science Inquiry Skills (SIS) strand provide contexts for the inquiry process and include reference to skills required to engage with Aboriginal and Torres Strait Islander Peoples when working scientifically. These intercultural science inquiry skills are throughout years 7-10 and provide opportunities for students to develop skills relating to:

- acknowledging the scientific knowledge and skills of Aboriginal and Torres Strait Islander Peoples
- consulting with Aboriginal and Torres Strait Islander communities in the planning or evaluation of scientific investigations
- collaborating with Aboriginal and Torres Strait Islander communities in mutually beneficial scientific research.

Unlike the Science Understanding (SU) and Science as a Human Endeavour (SHE) Teacher Background Information (TBI) materials the teacher background information for the new SIS elaborations provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures. Importantly, the Science Inquiry Skills TBI illustrates how concurrent SU and SHE topics can be used to contextualise the ways in which educators may provide skill development opportunities for the development of these skills.



Access to potential research sites requires permission from Traditional Owners

AC SIS125

Collaborating to ensure research is conducted in appropriate locales

CONTENT DESCRIPTION

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed.

CONTENT ELABORATION FOR CCP

- ▶ collaborating with Aboriginal and Torres Strait Islander Peoples in planning scientific investigations, and seeking guidance regarding culturally sensitive locations during fieldwork

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Classification helps organise the diverse group of organisms (ACSSU111)

A potential way to approach this content description is:

Students could plan a field investigation. When planning the field work it is ethically appropriate to consult with the relevant Aboriginal and/or Torres Strait Islander people whose traditional Country/Place they are conducting science on, such as botanical or zoological surveys. These types of collaborations ensure that scientists are not accessing or disturbing culturally sensitive locations, such as burial sites or men's/women's sites.

AC SIS125

Consulting local knowledge – where can I go?

CONTENT DESCRIPTION

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed.

CONTENT ELABORATION FOR CCP

- ▶ consulting with Aboriginal and Torres Strait Islander land councils in planning scientific investigations, and seeking guidance regarding land access rights

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Classification helps organise the diverse group of organisms (ACSSU111)

Interactions between organisms, including the effects of human activities can be represented by food chains and food webs (ACSSU112)

A potential way to approach this content description is:

Students could plan a field investigation. When planning the field work it is ethically appropriate and required to consult with the relevant Aboriginal and Torres Strait Islander people who hold native title or co-manage the land that scientists wish to access. For example, students planning an ecological survey could contact their local land council or equivalent to gain approval to work on or visit Country or Place.

AC SIS125

Collaborating to establish reciprocal research partnerships

CONTENT DESCRIPTION

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed.

CONTENT ELABORATION FOR CCP

- ▶ collaborating with Aboriginal and Torres Strait Islander communities and organisations to conduct research investigations about ecosystems, ensuring mutually beneficial outcomes

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Interactions between organisms, including the effects of human activities, can be represented by food chains and food webs (ACSSU112)

A potential way to approach this content description is:

In collaboration with Aboriginal and/or Torres Strait Islander community members and through consulting their traditional ecological knowledge, students can conduct fieldwork to jointly develop food chains and food webs that highlight the impact of invasive species. These could be published as posters in the school.

AC SIS130

Acknowledging knowledge as sources of scientific data

CONTENT DESCRIPTION

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence.

CONTENT ELABORATION FOR CCP

- ▶ acknowledging, analysing and interpreting data and information from Aboriginal and Torres Strait Islander Peoples' understandings of Earth's systems and cycles

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)

A potential way to approach this content description is:

Students could analyse Aboriginal or Torres Strait Islander peoples' cultural stories, pictorial histories, song, dance, or stone arrangements for astronomical data. This allows students to develop the skill to recognise that data regarding astronomical observations can come from these unique secondary sources and that evidence found therein can be used to draw conclusions.

AC SIS129

Collaborating through digital technologies

CONTENT DESCRIPTION

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate.

CONTENT ELABORATION FOR CCP

- ▶ collaborating with Aboriginal and Torres Strait Islander Peoples in the production of calendars that demonstrate seasonal patterns and relationships using digital technologies

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)

A potential way to approach this content description is:

In collaboration with members of Aboriginal and/or Torres Strait Islander community and consulting traditional ecological knowledge, students can develop seasonal calendars relating to the local environment with the aim of publication as a school/community joint project.

Year 8

Teacher background information



ACSSU225	Chemical reactions employed in the production of new substances
ACSSU153	First Nations geology
ACSSU155	Fire by friction
ACSHE226	Multi-disciplinary scientists in the production of material culture
ACSHE226	Multi-disciplinary scientists in the production of pigments and dyes
ACSHE135	Leaders in embracing of technology
ACSHE136	Fire stick farming agriculture
AC SIS140	Collaborating to ensure geological field work avoids and protects artefacts and heritage sites

ACSSU225

Chemical reactions employed in the production of new substances

CONTENT DESCRIPTION

Chemical change involves substances reacting to form new substances.

CONTENT ELABORATION FOR CCP (01.5)

- ▶ investigating chemical reactions employed by Aboriginal and Torres Strait Islander Peoples in the production of substances such as quicklime, plaster, pigments, acids, salts and ethanol



Many Aboriginal Peoples chemically changed naturally occurring gypsum into plaster

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides a context for students to learn about chemical change and the formation of new substances through exploring the use of chemical reactions by Aboriginal and Torres Strait Islander peoples. Students learn about common everyday chemical reactions such as the organic chemical reactions involved in fermentation, combustion and pyrolysis and inorganic chemical reactions of calcination. Students investigate how Aboriginal and Torres Strait Islander peoples used their organic and inorganic chemistry knowledge to form and utilise new substances, for example, quick lime (calcium oxide), pigments (iron oxide, charcoal), acid (pyroligneous acid), plaster (calcium sulfate), alkali salts (salts of potassium and sodium), beverages (ethanol), charcoal, and by-products such as heat and light.

DETAIL

Chemical change is a fundamental event and is considered by scientists to be the most crucial process in the universe. Chemical reactions are involved in all aspects of life and occur around us every day. Australia's First Nations peoples faced and overcame innumerable challenges in the procurement of essential resources. In many areas, important supplies that could not be readily obtained in the required form or could not be traded, had to be produced in situ. This necessity drove the development of sophisticated and complex chemical science practices that utilised chemical reactions to produce the particular substance or product required. Through astute observation many Aboriginal and Torres Strait Islander groups recognised patterns and key variables associated in the formation of new matter. Building on these observations and through empirical evidence acquired through the testing of various techniques, many successful organic and inorganic chemistry processes that produced new matter (required resources) were developed throughout the continent.

This teacher background information provides information about four documented chemical processes and subsequent products developed and used by Aboriginal and Torres Strait Islander peoples prior to European contact:

1. calcination as used to produce plaster (calcium sulfate) and pigments such as iron oxide
2. pyrolysis used in the production of charcoal, quicklime, pyroligneous acid and salts
3. fermentation in the production of ethanol
4. combustion in the production of heat and light.

Calcination

Calcination is a process of heating a substance to change its physical or chemical composition. It involves dehydration, removal of carbon dioxide and sulphur dioxide, and oxidation of part or all of the substance. Calcination requires the firing of the material and is usually carried out in furnaces and kilns. During the process the material is raked over to ensure even heating and effective production of the desired substance. First Nations Australians understood the requirement of carefully controlling the heating process. For example, when using calcination to produce plaster from gypsum, temperatures that are too high will remove all crystalline water from the mineral, rendering it useless.

Historical accounts record Aboriginal peoples calcining gypsum to produce white pigments for use in paints. In this particular calcination process, calcium sulfate dihydrate (gypsum) was heated in a controlled way until the right amount of the crystalline water was removed to yield a fine white powder to be used as a pigment in paint.

Plaster was produced across Australia by many First Nations' groups for various purposes. In the Lake Eyre region of central Australia, gypsum was collected and then calcined to produce plaster that was used to make balls for various ball rolling and spinning games. In the north-west of Queensland, gypsum was calcined to make plaster for use in body ornamentation.

Pyrolysis

Pyrolysis is a process of high temperature carbonisation of lignocellulosic biomass in the absence of oxygen. Pyrolysis was traditionally used by First Nations peoples to create numerous important ingredients for various applications, for example, quicklime and pyroligneous acid.

In central Australia some Aboriginal groups developed a medicine that assisted people in long, arduous journeys. To increase the effectiveness of the active component within this medicine, quicklime (calcium oxide) was procured in the form of ash through the process of pyrolysis. The source of the quicklime is a particular species of plant that was known to contain high levels of calcium oxide, which could be accessed through pyrolyzing its twigs and leaves. The alkali ash produced was mixed with the desiccated and crushed leaves of the medicinal plant. This mixture could be chewed, held in the mouth, or placed behind the ear for extended periods to release its pharmacologically active content orally or transdermally. The alkali ash (quicklime) has the important effect of raising the pH, facilitating the release of the medicine from the plant source and increasing its absorption into the blood stream.

Pyroligneous acid is a chemical that can be distilled from smoke through the process of pyrolysis. This chemical process was employed by some Palawa women of Tasmania prior to colonisation to procure acid (pyroligneous acid) to use in the removal of periostracum, the thin organic coating of maireener shells, to expose the iridescent nacre. The processed shells were then used in the production of fine necklaces. Commercially available acetic acid (a component of pyroligneous acid

which was once a commercial source of acetic acid) is now used by some Palawa women who continue this important practice.

Another use of pyrolysis by Aboriginal and Torres Strait Islander peoples in the purposeful burning of organic materials is conducted as a means to produce charcoal as an important ingredient in pigments and adhesives.

Charcoal is particularly useful in the production of various pigments and paints. For this purpose, charcoal is collected, ground into powder, and combined with animal fats to make a paint which can then be applied to the surface to be decorated.

Charcoal is also used as an additive to change the mechanical properties of some adhesives made from tree gums and resins. These mixtures can then be used to glue items together, such as axe heads or spear heads to shafts. As these resin mixtures are also water-proof they can be used to patch water containers or water craft.

Charcoal is produced when wood is heated with limited oxygen supply. On heating, water vapour is driven off first. When the temperature increases, the wood carbonises and volatile organic compounds are given off. If this temperature is allowed to rise too high the carbon will also burn and reduce to ash. Charcoal is predominantly carbon with varying amounts of hydrogen and oxygen as well as some minerals, and only forms when the combustion process is incomplete. Careful control of the combustion process is therefore required to produce charcoal as an end-product.

Historical documents show that Tasmanian Aboriginal People used alkali salts in wood ashes as a substitute for sea salt. It has been widely observed that Aboriginal people living far from sources of sea salt gained this important and much desired ingredient through pyrolysing plant matter in order to release the potassium and sodium bound within its organic matrix of plant matter. Without technology such as titration, plants were empirically investigated and those known to be high in alkali salts such as K or Na were chosen. Aboriginal and Torres Strait Islander peoples employed the process of pyrolysis to access these essential dietary components.

Fermentation

Ethanol fermentation, also called alcoholic fermentation, is a biological process in which microorganisms convert sugars such as glucose, fructose and sucrose into cellular energy, producing ethanol and carbon dioxide as by-products.

First Nations peoples have long known how to make alcoholic beverages from nectars and saps prior to the colonisation of Australia. The fermentation processes of First peoples involved the cultivation of unique Australian yeasts and bacteria. A well-known fermentation-derived beverage was developed in Tasmania using the sugar-rich sap of a local Eucalypt known as cider gum. Similarly, Noongar people from south-western Australia exploited certain honey-bearing Banksia species in the production of fermented beverages.

Combustion

Combustion is an exothermic chemical reaction between a fuel and an oxidising agent, usually atmospheric oxygen, and typically accompanied by the generation of heat and light in the form of flame. In combustion reactions, the combination of reactants happens at a high rate, in part because more energy is generated than can be transferred into the surrounding medium resulting in the temperature of the reactants being raised to accelerate the reaction even more.

Aboriginal and Torres Strait Islander peoples also use the combustion of resins and gums derived from a range of trees and shrubs to provide light and to carry fire from campsite to campsite. Various bundles of bark, branches and dried flower heads are smeared with resin or gum and used as torches. These torches assist in navigating at night and are used when burning country. They are also useful for fishing at night, as the fish can be attracted to the light.

By investigating the chemical processes and subsequent products developed and used by Aboriginal and Torres Strait Islander peoples prior to European contact in producing useful new substances, students will have the opportunity to develop a deeper understanding of chemical change and First Nations peoples' knowledge and use of organic and inorganic chemistry beyond combustion reactions used in the generation of heat and light.

CONSULTED WORKS

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ACSSU153

First Nations geology

CONTENT DESCRIPTION

Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales.

CONTENT ELABORATION FOR CCP (OI.2, OI.5)

- ▶ exploring the traditional geological knowledge of Aboriginal and Torres Strait Islander Peoples that is used in the selection of different rock types for different purposes



Rocks containing minerals (quartz/chalcedony) are selected for stone tool manufacture

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

Traditionally, the mineral quartz and fine-grained quartz-rich rocks such as silcrete, chert and quartzite, as well as hard volcanic rocks such as basalt, were important resources for Aboriginal and Torres Strait Islander peoples. Traditional geological knowledge enabled suitable rock types to be identified, quarried or mined, and worked into a variety of sophisticated tools. Respective Aboriginal and Torres Strait Islander groups have their own geological terminology.

DETAIL

This elaboration provides an opportunity for students to explore Aboriginal and Torres Strait Islander peoples' traditional knowledge and use of different rock types. Aboriginal and Torres Strait Islander groups across Australia produced a variety of stone tools. Stone tools, and the debris formed during the production process are collectively classified by archaeologists as stone artefacts. These artefacts are the most common form of archaeological evidence found in Australia and continue to be used to confirm the antiquity of human presence in Australia. Traditionally, stone tools have been of vital importance to Aboriginal and Torres Strait Islander peoples. They have been essential in hunting and gathering food and in its preparation and processing. Stone tools have also been used to make new stone and wooden implements and ceremonial objects.

Aboriginal and Torres Strait Islander peoples have a deep understanding of the properties of various minerals and use different rock types for different applications. Through direct observation and through trial and error, First Nations' Australians recognised that igneous rocks such as basalt or volcanic greenstone, tend to be very hard minerals with high tensile strength which make them ideal materials for stone axes.

More commonly, sedimentary rocks such as sandstone, or metamorphic rocks such as quartzite, were preferred to manufacture grindstones and millstones for other food sources, as they provided a more abrasive surface. However, the Bama people of northern Queensland chose an unlikely stone type, metamorphic slate, as a grindstone in processing toxic cycad kernels for producing an edible source of carbohydrates. As slate has a smooth and generally non-abrasive surface that is not particularly suitable for grinding food, cross-cuts were incised into the stone to achieve the intended effect. It is believed that this rock type was chosen for its mildly hydrophobic properties. The Bama people understood that this property of metamorphic slate prevents the accumulation of toxins in the grinding tool.

Other recorded uses of sedimentary rocks by Aboriginal and Torres Strait Islander peoples include naturally occurring clay earth pigment ochre, which is a mixture of ferric oxide and varying amounts of clay and sand. For thousands of years, in many regions throughout Australia, red ochre has been the most highly prized and important pigment for use in cosmetics, body and artefact decoration and rock painting.

Historically, the distribution and location of valuable rock deposits were well known to Aboriginal and Torres Strait Islander peoples and played a significant role for access and trade between groups. For example, ochre and stone of one sort or another can be found almost anywhere on the Australian continent. However, the ochre and stone deposits that were, and continue to be, exploited by Aboriginal and Torres Strait Islander peoples were of particularly high quality and traded over large distances. In the case of ochre, the most highly valued properties relate to its refractive qualities that create the shimmering effect under fire light, and its low acidity which does not irritate the skin. The optical properties of ochre are still highly sought after in contemporary industries, such as the cosmetic industry, for their exact same use.

After identifying valuable rock types and their locations, Aboriginal and Torres Strait Islander peoples developed sophisticated extraction techniques for these important resources. The two most common of these techniques are quarrying and mining. There are several hundred recorded Aboriginal mineral and rock extraction sites in eastern Australia alone. While many of these sites are open cut, some, such as that at Wilgie Mia in Western Australia, provide examples of extensive and deep underground mining. Wilgie Mia is known as the world's oldest continuous mining operation.

This elaboration will assist students in gaining an understanding of sedimentary, igneous and metamorphic rock types. By learning about Aboriginal and Torres Strait Islander peoples' traditional geological knowledge, students gain an appreciation of the antiquity and sophistication of this knowledge. They also gain a deeper understanding of how Australia's First Nations peoples exploited the useful properties of rock and understood the distribution of valuable rock types and sites. Students gain an insight of how Aboriginal and Torres Strait Islander peoples developed extraction techniques and how First Nations' geological knowledge has contributed to contemporary society, for example, in the production and exportation of iron oxide pigments.

CONSULTED WORKS

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ACSSU155

Fire by friction

CONTENT DESCRIPTION

Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems.

CONTENT ELABORATION FOR CCP (OI.5, OI.7)

- ▶ investigating traditional fire-starting methods used by Aboriginal and Torres Strait Islander Peoples and their understanding of the transformation of energy



A fire plough illustrates conversion of kinetic energy to heat energy

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with a context to strengthen their knowledge and understanding of different forms of energy and the concept of energy transformation. By investigating the various fire-starting techniques developed and used by Aboriginal and Torres Strait Islander peoples, students will also have the potential to develop a deeper understanding and appreciation of the sophisticated fire-starting technologies of First Nations' Australians that rely upon the transformation of energy.

DETAIL

Fire has played a major role in all human communities. From earliest times, humans developed the skills and equipment to make and sustain fire.

Typically, fire occurs when a fuel reacts with oxygen from the air in a rapid exothermic reaction. The reaction forms a range of products and transforms the chemical potential energy of the fuel and oxygen into heat and light. In order for a fire to start, the auto-ignition temperature or kindling point of the fuel/air mixture must be reached. It is at this temperature that there is sufficient heat to provide the activation energy necessary for the combustion reaction to proceed and be self-sustaining. This elaboration discusses common traditional fire-starting technologies that have been ergonomically designed to efficiently transform movement energy into heat energy until the critical auto-ignition temperature is reached.

Prior to the invention of the first chemical friction match in the 1800s, there were four principal methods used for raising tinder material to its ignition temperature. The fire drill, fire saw and fire plough generate the required heat through friction between two pieces of wood. A glowing hot ember is first produced, which is then placed into a tinder bundle and gently blown until a flame is produced. In the fourth method, the percussion method, two stones such as flint and ironstone are struck together to cleave off small shards of ironstone. These shards, having been heated by friction between the two stones, spontaneously ignite as they oxidise in contact with the air, producing high temperature sparks. The sparks are directed onto the tinder to set it alight.

Historically, in many cultures it was common for only one of the methods referred to above to have been used. In Australia, however, there is evidence of the use of all four methods and it is understood that some Aboriginal and Torres Strait Islander peoples had knowledge of at least three. Possessing this knowledge would have enabled fire to be created in a range of conditions, utilising whatever resources were available in a given location and climate. Furthermore, it was common knowledge among Aboriginal and Torres Strait Islander Australians that a pinch of sand would increase the friction between two pieces of wood and hence speed up the formation of a glowing ember.

The fire drill and fire saw are the two most common methods used by Aboriginal and Torres Strait Islander Australians, while the fire plough and percussion methods are less widely utilised.

The fire drill method requires two basic parts; a flat piece of wood as a base or hearth, and a thin elongated stick as the 'drill stick'. The blunter end of the drill stick is pushed down into a small indentation in the hearth and the stick is twirled by vigorously rubbing it between the palms of the hands. The kinetic energy of the moving hands is transferred to the moving stick. The friction between the two sticks transforms the kinetic energy to heat. A side notch in the indentation or socket allows the sawdust resulting from abrasion to collect and form an ember that can ignite tinder material.

The drill stick and the base can be made from the same type of, preferably, softwood. Grass tree, *Xanthorrhoea* species, is one such suitable timber. When two different types of wood are used, the harder wood is used as the drill stick. In some parts of Australia, mulga, an *Acacia* species, is a hardwood that is used for drill sticks. The choice of material to be used as tinder depends on availability and includes dry grass, coconut fibre, dried kangaroo dung, and even the volatile powdered *Eucalyptus* leaves. The fire lighting technologies and their associated materials are always kept protected from moisture.

The fire saw method, as its name implies, uses a sawing motion rather than a drilling motion to generate heat. The base may be a split branch with the slit being held open by thin wedges. Pieces of tinder are placed in or under the slit and a sharp-edged piece of hardwood, which could be a boomerang, woomera, coolamon, or wooden knife, is vigorously 'sawn' in a notch at right angles to the slit until a hot ember ignites the tinder. One of the advantages of this technique is that it incorporates the fire-making apparatus into objects that have a primarily different purpose.

The fire plough method, the use of which was mainly confined to north-western Australia, involves creating embers by rapidly rubbing the dull point of a stick back and forth within a trough or groove cut into the base timber.

Some Aboriginal groups located within modern day South Australia use the percussion method, as described above, to start fires.

By investigating these different fire-making techniques students are given opportunities to gain a deeper understanding of the energy transfers and transformations evident within traditional fire-starting methods of First Nations' peoples, as well as developing an appreciation of the importance of fire to Aboriginal and Torres Strait Islander societies and the ingenious methods used to create and sustain it.

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ACSHE226

Multi-disciplinary scientists in the production of material culture

CONTENT DESCRIPTION

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures.

CONTENT ELABORATION FOR CCP (OI.3, OI.5)

- ▶ investigating how Aboriginal and Torres Strait Islander Peoples connect knowledge from the disciplines of physics, chemistry, biology and geology in the development of material culture



Spears illustrate a confluence of science discipline knowledges

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration allows students to explore the stone tool material culture in Australia's First Nations' societies and develop an understanding of how Aboriginal and Torres Strait Islander peoples connected knowledge from a variety of scientific disciplines to develop technologies and processes that enabled the creation of highly specialised tools for a variety of purposes.

Contemporary science disciplines are highly specialised and increasing collaboration across disciplines can be a challenging process for many current scientists. Knowledge within Australia's First Nations' scientists allowed for specialist knowledge and expertise, but was intimately connected through a holistic worldview and a practical need for multidisciplinary knowledge and skills to allow individuals to contribute to the sustainability of communities. This multidisciplinary approach can be understood through the examination of the processes involved in the creation of Australia's First Nations' rich stone tool material culture.

DETAIL

Material culture is a term used by archaeologists, anthropologists and other scientists to refer to the physical aspects of the objects that surround people. It includes the creation and use of objects such as tools, housing and clothing, including the trade of articles, as well as the behaviours, norms and rituals associated with these objects. This elaboration focusses on the scientific knowledge and understanding that were required to create many of the objects of material culture found in Australia's First peoples' societies.

Stone tools provide sophisticated examples of material culture that required the confluence of geological, chemical, biological and physical knowledge. Creating highly efficient stone tools requires knowledge from: the geological sciences in understanding the location, composition and qualities of different types of rocks and stones; the physical sciences in developing and utilising effective stone knapping techniques; the biological sciences in understanding how the tools needed to be crafted for their uses in hunting, skinning, harvesting, peeling and surgical procedures; and the chemical sciences in the treatment of certain types of rocks to transform their physicochemical properties for technical purposes.

Expertly crafted stone tools were, and in some places continue to be, a highly prized commodity. In traditional Aboriginal and Torres Strait Islander societies these were an important part of day to day life. Their production first involved geological expertise in identifying suitable rocks and in the establishment of quarries and processing sites to provide raw materials.

The lithic raw materials (stones) were then reduced by percussion techniques into a variety of tools and blades that could be used either for highly specialised or general purposes. Throughout the lithic reduction process in the production of certain tools, heat treatments were regularly applied at

different stages to improve the flaking qualities. In addition to the chemical and physical knowledge involved in this process, Aboriginal and Torres Strait Islander peoples relied on, and built upon, an expert level of geological knowledge to help identify which rocks formed the necessary conchoidal (Hertzian) fractures for tool making. Conchoidal or Hertzian fracture is a technical term used to describe the way that brittle materials such as obsidian, flint, quartzite, chert and other minerals break or fracture in the absence of any pre-existing fault lines or planes within the material. Some modern-day science disciplines, such as contact mechanics and ballistics, aim to understand the incredibly complex physics of this long-standing process, which involves the analysis of different types of shock waves in the formation of characteristic Hertzian cones.

Percussion flaking, pressure flaking and grinding were the principal methods of creating stone tools.

In percussion flaking, a fine-grained quartz-rich block of rock, known as the 'core' was selected. Suitable raw materials for the core included the mineral, quartz, the metamorphic rock, quartzite, and the sedimentary rocks, chert and silcrete.

The core is struck with a second stone – the 'hammerstone' – the aim being to produce sharp stone fragments called 'flakes'. These flakes are very sharp and can be used as tools. When they become blunt through use, the flakes can be 'retouched', a process that involves applying pressure using a hard, sharp object to detach smaller flakes. In this way a range of hunting weapons, such as spear tips, knives for butchering game and preparing and cleaning animal skins, and tools for shaping objects made of wood, bark and bone, could be fashioned.

Pressure flaking involves the removal of flakes by pressure using a tool often made from wood or bone. It is the process employed for the more delicate flaking procedures required for the finishing and retouching of the tool (see, for example, Kimberly Points). It provides additional leverage so that the body energy can be used with more efficiency, which allows for greater control and precision of the flaking process.

Other tools such as grindstones or millstones and their associated mullers would also undergo lithic reduction before they could be used for crushing, grinding or pounding a range of different food materials. These implements were generally made from highly abrasive rocks such as sandstone or quartzite.

Through interconnected relationships between cultural groups, Aboriginal and Torres Strait Islander peoples shared new discoveries and understandings about rock types and their usages. Each respective cultural group holds detailed geological survey knowledge that identifies and locates valuable rock types. Although most tools were made from readily available local stones, highly specialised tools and blades made from particular lithic materials (for example, volcanic greenstone and natural glass, such as obsidian and tektites) were traded across extensive distances and used only by highly skilled and knowledgeable people.

To this day, no surgical tools have exceeded the efficiency of obsidian blades. There are still some surgeons who use obsidian scalpels as they can cut down to a single micron and leave considerably

less scarring as a result. This demonstrates the value of shaping and treating natural occurring materials when compared to modern day manufactured tools, such as surgical steel.

Despite stone-age tools once being regarded as ‘primitive’, many scientists today understand that they reflect an elegance and simplicity that can only be achieved through complex multidisciplinary understandings.

By investigating traditional tool-making techniques of Aboriginal and Torres Strait Islander peoples, students deepen their understanding of how science knowledge can develop through collaboration across the disciplines of science and also observe how interdisciplinary knowledge is essential in many occupations. Students also gain an appreciation for the highly developed knowledge and skill that are required in the creation of stone tool material culture and for the contribution of this knowledge to contemporary society through the continued use of certain stone tools as high-precision instruments.

CONSULTED WORKS

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ACSHE226

Multi-disciplinary scientists in the production of pigments and dyes

CONTENT DESCRIPTION

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures.

CONTENT ELABORATION FOR CCP (O1.3, O1.5)

- investigating how Aboriginal and Torres Strait Islander Peoples employ knowledge from the disciplines of chemistry, biology, physics and geology in their development of pigments and dyes



Pigments and dyes illustrate a confluence of science discipline knowledges

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students the opportunity to explore the technologies and processes that are involved in the manufacture of pigments and dyes used by Aboriginal and Torres Strait Islander peoples. These technologies and processes require multidisciplinary approaches combining knowledge of geology, biology, chemistry and physics.

DETAIL

First Nations' Australians have been painting in a variety of forms for at least 28,000 years, making Australia the home of the second oldest evidence of painting found to date.

Over this incredible period of time, and through their endeavours to construct enduring, bright, crisp and smudge-free pictorial histories, more recently described as art, Aboriginal people accumulated knowledge of paints, pigments and dyes. The raw materials for these are obtained from a variety of mineral, plant and animal sources and their extraction, refinement and production require knowledge from across a range of science disciplines.

The most commonly used pigments are generally derived from ochre with colours ranging from yellow through brown to red. Ochre is mainly composed of yellowish limonite, itself a mixture of hydrated iron(III) oxide-hydroxides, mixed with clays and sand. Red ochres naturally form in areas with high haematite concentrations. Aboriginal and Torres Strait Islander peoples over thousands of years have developed a comprehensive awareness of the geological distribution of these culturally important mineral resources.

In regions where red pigment was not readily available from a red ochre source, Aboriginal people traditionally used porphyry (or tuff) to produce iron oxide in a form that could be used as a red pigment. In other areas, yellow ochre from limonite was thermally decomposed and converted into haematite, producing a reddish-brown colour. This process is called calcination, a chemical process involving carefully controlled heat treatment of the mineral source, and is still in use today in the production of commercially available pigments.

Black pigment may be obtained from charcoal, while white is principally derived from kaolin, although, historically, calcite and huntite were used where they were locally available. Gypsum was also used to produce a fine white pigment using the process of calcination. In this process, calcium sulfate dihydrate (gypsum) is heated until some of the crystalline water is removed, yielding a fine white powder that can then be used as pigment.

These colouring materials can be applied to surfaces using a variety of techniques. A soft pigment-bearing rock can be used as a drawing implement. Alternatively, the pigment material can be crushed into a fine powder and added to water to form a suspension. Various implements can then be used as brushes to apply the pigment.

The degree to which pigments adhere to a surface depends on the effectiveness and sophistication of the pigment formulation. The development of a particular pigment formula acknowledges a range of factors including the type and nature of the substrate material, the way that the pigment is applied, and the additives, if any, that have been used as binders and fixers in the pigment mixture.

Evidence of effective use of iron oxide-based pigments on different substrate materials by First Nations' Australians may be found across a range of material culture and practices such as shields, boomerangs and bark paintings, and in archaeological remains and rock paintings.

The chemical knowledge and understanding of the properties of suspensions, binders and fixatives were essential for the development of a water-based suspension that could evenly carry the pigment and enable the controlled application of paint. Similarly, knowledge of the properties of available binding agents such as animal fat, egg yolks and blood was critical to ensuring adhesion of the pigment to the substrate.

The final essential chemistry knowledge required to paint successfully was an understanding of the role of fixatives, such as orchid sap, that are applied at each layer/stage and on completion. Fixatives are essential for keeping crisp lines and preventing smudging. Fixatives also play an important role in the protection of the paintings and are partly responsible for the incredible durability of Aboriginal pictorial histories.

Geological knowledge is required in identifying areas and rocks containing the pigment-carrying mineral and knowledge of physics is required to develop quarries and to mine underground. Such activities have been identified as having occurred in many parts of Australia. One mining venture, the Wilgie Mia mine, is believed to be the oldest continuously-mined site in the world. Located east of Geraldton in Western Australia, it was up to 20 metres deep and had a mining face 15 – 30 metres wide. The mining operation at the site included 'stop and pillar' techniques to enhance worker safety and the use of pole scaffolding with wooden platforms to allow extraction to occur simultaneously at different heights. The material from the mine was, and still is, highly prized, especially for use as body decoration, and it is estimated that several thousand tonnes of rock have been extracted from this site. In contemporary times, many Aboriginal mines have been exploited for their valuable iron oxides in the commercial use of paints, stains, inks, plastics, pharmaceuticals and cosmetics.

Biological as well as chemical knowledge are required in dye production for colouring textiles, yarn, baskets, and other materials made from natural fibres. Aboriginal and Torres Strait Islander peoples possess rich botanical knowledge of plants containing coloured substances that can be used to manufacture a variety of colouring agents. Yellow can be obtained from the root of the *Pegonolobos reticulatis* shrub endemic to the Northern Territory and Queensland; purple from the berries of *Haemodorum coccineum*, a flowering plant in the same family as kangaroo paw; green from the core of the leaves of the pandanus palm (*Pandanus spiralis*); black and grey from the leaves of the Quinine tree; and brown from the root of the perennial herb *Haemodorum brevicaulis*. The intensity and shade of the colours vary depending on the soil properties, the part of the plant, and the season of harvesting.

Chemical knowledge is required in extracting the colouring agents from the plant material and in the understanding of how to fix the dye onto the desired fabrics through the use of mordants. These can be organic substances derived from plant materials, such as tannic acid, or inorganic materials containing polyvalent metal ions, such as aluminium, which are derived from salts and ash. Mordants work by forming an insoluble coordination complex with the dye, which then attaches to the fabric.

By studying the required multidisciplinary knowledge in producing pigments and dyes used by Aboriginal and Torres Strait Islander peoples, students deepen their understanding of how science knowledge can develop through the confluence of understandings derived from the various disciplines of science. Students will also gain an appreciation of how Aboriginal and Torres Strait Islander peoples' geological knowledge contributed to the discovery, evaluation and exploitation of commercially important mineral deposits for the production of pigments.

CONSULTED WORKS

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ACSHE135

Leaders in embracing of technology

CONTENT DESCRIPTION

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations.

CONTENT ELABORATION FOR CCP (OI.6)

- ▶ investigating use of sustainable technologies to deliver basic services in remote Aboriginal and Torres Strait Islander communities and considering ethical implications of these



Sustainable energy solutions – wind power on remote Waiben (Thursday Island)

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration focuses on practical, technical and ethical aspects of providing access to basic services in remote communities. These remote Aboriginal and Torres Strait Islander communities are often at the forefront of adopting new and innovative technologies. This elaboration provides opportunities for students to explore a number of innovative and sustainable technologies currently being utilised to address the unique challenges faced by remote communities. It also enables students to examine the numerous benefits to quality of life resulting from the implementation of these sustainable technologies by Aboriginal and Torres Strait Islander peoples living in remote communities.

DETAIL

A great number of Aboriginal and Torres Strait Islander communities remain located, as they have done for thousands of years, in remote areas of Australia. Upon European contact many groups were forced to abandon aspects of their traditional lifestyles and adhere to the assimilation pressures of the new dominant culture. This had a profound effect on Australia's First Nations' cultures and ways of life. However, some groups of Aboriginal and Torres Strait Islander peoples, despite the cultural shift, still live on their land and in some cases live a semi-traditional lifestyle incorporating an amalgamation of both cultures.

The issues faced by many Aboriginal and Torres Strait Islander communities as a result of their remoteness are multi-faceted. They involve the logistical, environmental and ethical considerations of providing infrastructure and access to basic services that people living in larger cities and regional centres perceive as their right as Australian citizens.

For example, access to a reliable, secure electricity supply is deemed an essential for modern life. However, Australia's complex network of transmission and distribution infrastructure principally services the needs of people living in a broad arc stretching along the coast from approximately Cairns to Adelaide, and in the south-west corner of Western Australia. In contrast, those Australians living in areas of low population density are 'off-the-grid' and have historically been dependent on less effective and non-sustainable methods, such as large, noisy and non-environmentally friendly diesel generators, for their electricity.

It has been argued that providing and maintaining essential services, whether they be adequate water supplies, electricity, housing or telecommunications infrastructure to remote communities are too great a cost burden on taxpayers. Further, it has been suggested that many remote Aboriginal and Torres Strait Islander communities are not viable in the long term and that they should be abandoned, with the occupants relocated to areas that do not require basic utility assistance.

In order to maintain their culture and remain on country, while simultaneously meeting their needs, many Aboriginal and Torres Strait Islander communities are now at the forefront of developing and embracing innovative technological solutions to living in remote parts of Australia.

One example is the increasing utilisation of renewable energy technologies, such as the use of solar thermal collectors for hot water, or photovoltaic cell arrays (solar panels) in combination with long-lasting and low-maintenance battery banks to ensure an uninterrupted electrical power supply system. The use of these technologies, supported by careful analysis of demand requirements and effective energy conservation practices, has led to increasing self-sufficiency and sustainability of many remote communities. The adoption of these technologies by numerous Aboriginal and Torres Strait Islander communities has resulted in better access to basic services and more reliable and cost-effective energy supplies, as well as reductions in carbon emissions and noise pollution.

Another contemporary challenge being faced by remote communities is access to mobile telephone reception and internet services. Such services are not only essential for personal communication and access to information, but are also critical for educational purposes and the implementation of telehealth solutions, enabling patients in remote communities to connect with online healthcare professionals. Typically, mobile phone towers provide coverage within a 10-15-kilometre radius, the distance being dependent on terrain and obstructions in the line of sight path between the tower and the phone. By installing an unpowered passive parabolic dish antenna directed at the most suitable tower, mobile phone coverage can be boosted well beyond the existing footprint. Parabolic antennas use a curved surface made of sheet metal or wire grill with the cross-sectional shape of a parabola to direct the radio waves into a single focal point, thus achieving high signal gains. This technology is being used in a number of outdoor situations where the provision of electricity and the costs associated with securely housing and maintaining a powered antenna would be prohibitive. This makes the passive parabolic dish antenna an ideal solution for some smaller remote settlements, roadside stops and remote tourism locations.

By engaging with this elaboration, students can explore how the range of technological solutions being adopted by Aboriginal and Torres Strait Islander communities has a markedly positive impact on quality of life, provides cost savings and makes remote communities more viable in the longer term. Students can also examine how adopting these technological solutions can be of further benefit to Aboriginal and Torres Strait Islander peoples by providing training and employment opportunities to community members and enhancing economic sustainability through tourism.

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ACSHE136

Fire stick farming agriculture

CONTENT DESCRIPTION

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity.

CONTENT ELABORATION FOR CCP (OI.2, OI.3, OI.5)

- ▶ investigating how Aboriginal and Torres Strait Islander Peoples used scientific understandings of complex ecological relationships to develop specific fire-based agricultural practices



Cycads of northern Australia have been cultivated for increased productivity

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides a context for students to investigate how the practice of fire-stick farming, the oldest known farming practice in the world, grew out of the sophisticated knowledge and science understanding of biotic and abiotic relationships and interdependencies of plant and animal communities within ecosystems possessed by Aboriginal and Torres Strait Islander peoples.

DETAIL

Early anthropologists who witnessed fire stick-farming often concluded that it was simply a hunting method used by Indigenous peoples. Although it did serve this purpose, it was also a significant factor in agriculture and in the sustainable ecological management of country. For example, in addition to the agricultural practices of tilling, replanting, transplanting and weeding, Aboriginal people of northern Australia used controlled fires to promote the growth of yams. The use of fire is essential for the successful cultivation of this crop, as without the application of well-timed and cool-burning fires, other species such as grasses and bracken would overgrow and smother its plantations.

Carefully controlled fires are also used to promote the growth and distribution of cycads, resulting in dense groves and improving the quality and yield of crops. In the cultivation of cycads, an important source of carbohydrates, fire has also been shown to be an important trigger in the timing and production of fruit. Through cultivating discrete groves of cycads and through the understanding of how to control fruit production, some Aboriginal communities were able to plan for and produce enough resources to meet peak demands, including for large gatherings. There is scientific evidence that has quantified the increase in productivity per area of this crop as a result of this agricultural practice. Interestingly, the productivity per acre is comparable to that of well-known contemporary commercial crops.

Many Australian ecosystems rely on fire to promote new growth and distribution of plant life. Many plants in these ecosystems have evolved to become highly pyrophilic, like the cycads mentioned above. This means they not only have become fire tolerant, but some species also rely on fire for propagation. Some Australian native plants, including species of *Acacia* and *Banksia*, require the heat from a fire to crack their hard, outer shell. Moisture is then able to reach the embryo inside, enabling germination to occur. The germination of these and other genera of Australian plants has also been found to be responsive to molecules in bushfire smoke. Furthermore, low intensity fires replenish the soil with nutrients locked in dead plant material, allowing them to become available to foster the growth of seedlings and fresh grasses.

First Nations peoples also understood that fire could alter the landscape by changing the structure and mix of vegetation. In particular, fire can be manipulated to provide small clumps of favourable habitat for game species and it can be used to remove the smothering effects of a canopy,

conferring an advantage to understorey species of important staples such as grasses and yam species. The rejuvenated perennial grasses and yams are also sources of carbohydrate for people, with the grass grains being used to make a form of damper.

In-depth knowledge of seasonal change allowed Aboriginal people to select the best times of the year to utilise fire for specific purposes. This knowledge of seasonal change was based on detailed observations of patterns in the physiological responses of flora and fauna and in meteorological and astronomical changes. Which flowers were blooming, which insects were appearing or aestivating, which animals were entering their mating seasons, and the positions of stars and constellations all contributed to accurately predicting conditions in the ecosystem which could be exploited.

By investigating the topic suggested in this elaboration, students learn about the diverse farming practices employed by First Nations' Australians, such as burning, tilling, planting, transplanting, watering, irrigating, weeding, thinning, cropping, storing and trading. Students also have opportunities to appreciate how the detailed knowledge and deep understanding of the relationships that exist within an ecosystem integrate scientific knowledge from a range of disciplines, and are used to inform the development of practices in areas of human activity.

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Science Inquiry Skills

New elaborations within the Science Inquiry Skills (SIS) strand provide contexts for the inquiry process and include reference to skills required to engage with Aboriginal and Torres Strait Islander Peoples when working scientifically. These intercultural science inquiry skills are throughout years 7-10 and provide opportunities for students to develop skills relating to:

- acknowledging the scientific knowledge and skills of Aboriginal and Torres Strait Islander Peoples
- consulting with Aboriginal and Torres Strait Islander communities in the planning or evaluation of scientific investigations
- collaborating with Aboriginal and Torres Strait Islander communities in mutually beneficial scientific research.

Unlike the Science Understanding (SU) and Science as a Human Endeavour (SHE) Teacher Background Information (TBI) materials the teacher background information for the new SIS elaborations provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures. Importantly, the Science Inquiry Skills TBI illustrates how concurrent SU and SHE topics can be used to contextualise the ways in which educators may provide skill development opportunities for the development of these skills.



Scientists must ensure that research does not destroy heritage sites

AC SIS140

Collaborating to ensure geological field work avoids and protects artefacts and heritage sites

CONTENT DESCRIPTION

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed.

CONTENT ELABORATION FOR CCP

- ▶ collaborating with Aboriginal and Torres Strait Islander Peoples in the planning of scientific investigations, including considerations of heritage sites and artefacts

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)

A potential way to approach this content description is:

Students could plan a field investigation. When planning the field work it is ethically appropriate to consult with the relevant Aboriginal and/or Torres Strait Islander people whose traditional Country/Place they are conducting science on, such as geological surveys. These types of collaborations ensure that scientists are not accessing or disturbing heritage sites and artefacts.

Year 9

Teacher background information



ACSSU176	Holistic world view
ACSSU177	First Nations antiquity
ACSSU179	Fire facilitated nutrient flow
ACSSU182	Traditional sound knowledges and practices
ACSSU182	Traditional clothing and blankets
ACSHE157	Fire: an ecological must informing policy
ACSHE158	Modern science validates Indigenous solutions to atmospheric pollution
ACSHE160	Traditional ecological knowledge and practices create carbon farming careers
ACSHE228	Torres Strait Islander frontline defenders
AC SIS170	Consulting Aboriginal and Torres Strait Islander knowledge – not just art!
AC SIS174	Acknowledging understanding and communication of internal systems
AC SIS165	Acknowledging cultural heritage acts and obligations of scientists
AC SIS170	Acknowledging two-way science can lead to new solutions and knowledge
AC SIS164	Acknowledging cultural records of the past
AC SIS164	Collaborating to understand damaged ecosystems

ACSSU176

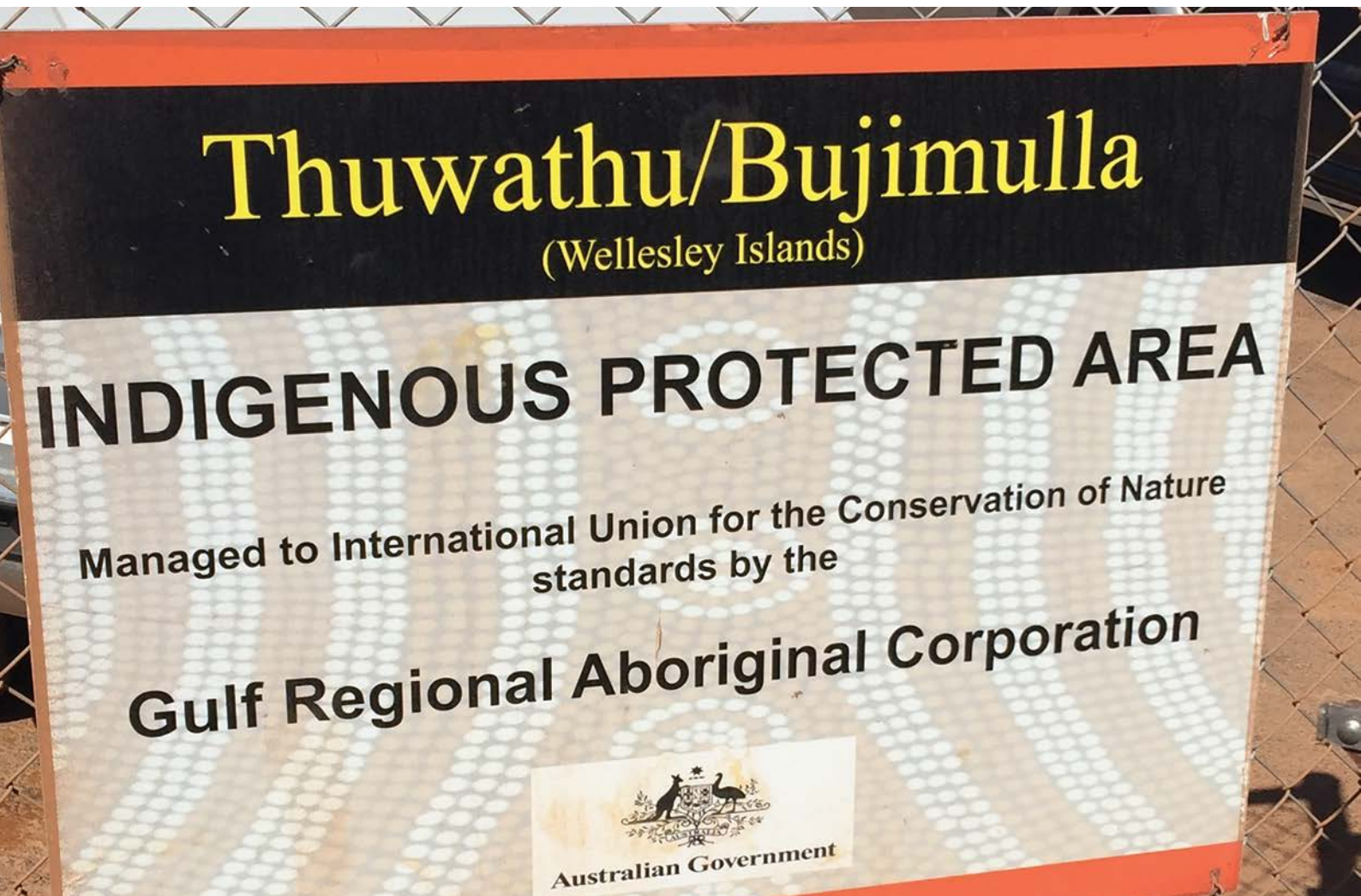
Holistic world view

CONTENT DESCRIPTION

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems.

CONTENT ELABORATION FOR CCP (OI.2, OI.5)

- ▶ investigating the interdependence of communities and the role of Aboriginal and Torres Strait Islander Peoples in maintaining their environment



Many areas of Australia are maintained by Traditional Owners

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides an opportunity for students to learn about First Nations peoples' ecocentric perspectives. It allows students to investigate how this worldview, based on and encompassing an intimate knowledge of the complex inter-relationships that exist within ecosystems, aims to protect and sustain the natural environment and ensures sustainable harvesting practices.

DETAIL

First Nations peoples of Australia possess some of the oldest and most in-depth traditional ecological knowledge in the world. This knowledge, having been amassed and refined over tens of thousands of years, is the culmination of the direct observation of the patterns and relationships that exist within individual ecosystems. First Nations Australians' ecological perspective places humans as an integral part of an interdependent ecosystem, rather than being above or separate from it. This view incorporates a deep appreciation of, and respect for, the environment and embodies a responsibility for maintaining ecosystems and utilising them in a sustainable way; that is for Caring for Country.

This perspective, which sees resource management as a two-way interaction between people and country, may be contrasted to the western notion of 'managing land', which has been perceived as a linear, one-way process in which people take specific actions to affect the environment. For example, since colonisation farmers have been clearing land, modifying soil structure and nutrients, and using ground water for irrigation to cultivate crop species that are not endemic to Australia. Often, these actions have resulted in significant damaging impacts to ecosystems.

Caring for Country involves deep understandings of the local environment and the interdependence of its flora and fauna. It also relies on highly detailed knowledge of cyclic biological events and the seasonal movement of faunal species. This knowledge allows for the sustainable harvesting of plants and animals, ensuring the continuous availability of food and other resources, while simultaneously minimising negative impacts.

A well-known example of this practice is the longstanding sustainable harvesting of turtles and dugongs. Archaeological evidence confirms that Aboriginal and Torres Strait Islander peoples have been consuming large quantities of dugongs and turtles for thousands of years. Only recently have the populations of these species declined considerably in many areas. Saltwater Aboriginal and Torres Strait Islander peoples in the north of Australia are, and have been, essential components within their marine ecosystems. As such, they are acutely aware of their interdependence and reliance upon the marine environment. Important food resources, such as dugong and turtle, are essential to these communities. To ensure their continued access to dugong and turtle, sophisticated and complex protocols regarding who, where and how they are hunted, including how the animal is killed, butchered and shared among the community have been developed. For example, young male dugongs are preferred whilst pregnant females and females with calf are avoided.

There are many other examples of hunting and harvesting practices that do not disrupt the breeding cycles and reproductive events of essential inter-dependent flora and fauna. By investigating an ecosystem, possibly in collaboration and consultation with local Aboriginal or Torres Strait Islander people, students can gain an appreciation of the intricacies and complexities of the inter-relationships that exist between the biotic and abiotic factors within the ecosystem and the role Indigenous people have and are playing in maintaining the ecosystem. They will also have opportunities to learn how contemporary scientific research can be advanced by incorporating, with appropriate permissions, traditional ecological knowledge into project methodologies and land management and restoration practices.

CONSULTED WORKS

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ACSSU177

First Nations antiquity

CONTENT DESCRIPTION

All matter is made of atoms that are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms.

CONTENT ELABORATION FOR CCP (OI.6)

- ▶ investigating how radiocarbon and other dating methods have been used to establish that Aboriginal Peoples have been present on the Australian continent for more than 60,000 years



Radiocarbon dating of midden sites informs Aboriginal antiquity

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with a context for consolidating their understanding of the structure of atoms, and how natural changes in the nuclei of atoms of some elements allow materials to be dated. Students learn how methods based on the phenomenon of radioactivity, in conjunction with other, more recently developed dating methods, have allowed archaeologists to confirm what First Peoples have long held to be true: that Aboriginal people have been present on the Australian continent for more than 60,000 years.

DETAIL

Elements are made up of atoms. Atoms are made up of smaller particles called protons, neutrons and electrons. The atoms of each element contain the same number of protons in their nuclei. The number of neutrons in these atoms may, however, vary. Atoms of the same element, but with different numbers of neutrons are called isotopes. The element carbon, for example, exists naturally as three different isotopes: carbon-12, carbon-13 and carbon-14, generally denoted in the form of their chemical symbols ^{12}C , ^{13}C and ^{14}C . All of these atoms contain 6 protons – this is what makes them carbon atoms. The number of neutrons in each of these isotopes is 6, 7 and 8 respectively. Some isotopes, such as ^{14}C , are unstable. In a process called radioactive decay, the composition of their nuclei changes to become more stable nuclei. The rate at which this decay occurs differs for each particular radio-isotope. In the case of ^{14}C , the rate of decay is such that half of the ^{14}C nuclei in any given sample will decay in 5,730 years. This duration is called the half-life of ^{14}C .

Carbon-14 atoms are formed in the Earth's upper atmosphere by the interaction of cosmic ray neutrons with nitrogen-14 atoms (^{14}N). The ^{14}C atoms combine with oxygen to form carbon dioxide which then enters the biosphere primarily via photosynthesis. While an organism is alive the ratio of $^{14}\text{C} : ^{12}\text{C}$ isotopes in its body is similar to that in the atmosphere and remains relatively constant. When the organism dies, there is no further uptake of ^{14}C , so the ratio of $^{14}\text{C} : ^{12}\text{C}$ changes as the ^{14}C atoms radioactively decay to form ^{14}N again. Therefore, by measuring the $^{14}\text{C} : ^{12}\text{C}$ ratio in biological artefacts, it is possible to calculate the amount of time that has passed since the organism died. Since the half-life of ^{14}C is 5,730 years, this method can be used to measure dates up to about 40,000 years in the past with reasonable accuracy.

Radiocarbon dating procedures have been used by archaeologists to study the migration patterns of early humans and the antiquity of the habitation of the Australian continent by Aboriginal Australians. While people of European descent have been living in Australia for a little over 200 years, in the first half of the 20th century it was generally accepted by the scientific community that Aboriginal peoples have been living in Australia continuously for about 20,000 years. The discovery of human remains at Lake Mungo in western New South Wales, however, lengthened this timeline. These remains, informally referred to as 'Mungo Lady' and 'Mungo Man', were unearthed in 1969 and 1974

respectively. The original radiocarbon dating of Mungo Lady's remains revealed that they may have been as old as 26,500 years. Mungo Man's remains were estimated, using stratigraphic comparison with Mungo Lady, to being between 28,000 and 32,000 years old. In 2003, a panel of experts using a range of more refined dating techniques agreed that the Lake Mungo remains are probably about 40,000 years old.

Based on recent archaeological evidence, it is now clear that the Australian Aboriginal peoples have occupied the Australian continent for even longer than the Lake Mungo calculations suggested.

Analysis of excavations at the Madjedebe or Malakunanja II rock shelter in Arnhem Land using a combination of radiocarbon dating and other methods based on thermal and optical luminescence has revealed evidence of continuous habitation of Australia by Aboriginal peoples for at least 65,000 years.

This elaboration provides opportunities for students to investigate the advantages and disadvantages of a range of dating techniques, in particular, the complications associated with radiocarbon dating. Investigation could take into account the fact that the $^{14}\text{C} : ^{12}\text{C}$ ratio in the atmosphere has not always been constant, or the impact of contamination by 'younger' carbon on the age determination, and the methods scientists are using to minimise these limitations.

Furthermore, students will have an opportunity to investigate competing viewpoints about the spread of people to Australia and gain an appreciation of the vast timescale of Aboriginal habitation on the Australian continent.

When exploring this elaboration, it is crucial to keep the following points in mind:

- interfering with the ancestral remains discovered at Lake Mungo is a sensitive issue for the Ngiyampaa, the Mutthi Mutthi and the Paakantji Aboriginal people who are descendants of Mungo Lady and Mungo Man and custodians of the remains
- in many cases, Aboriginal peoples' view on how long they have lived in Australia, embodied in the Dreaming and Aboriginal Law, is that they have always lived in Australia.

CONSULTED WORKS

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ACSSU179

Fire facilitated nutrient flow

CONTENT DESCRIPTION

Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer.

CONTENT ELABORATION FOR CCP (O1.2, O1.5)

- ▶ investigating how Aboriginal and Torres Strait Islander Peoples use fire-mediated chemical reactions to facilitate energy and nutrient transfer in ecosystems through the practice of firestick farming



Low intensity fire facilitates rapid regrowth of many grasses

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

Many chemical reactions require the input of energy to initiate them. In cases, such as combustion, the exothermic nature of the reactions themselves provides sufficient energy to sustain the ongoing reaction. Fire, the result of a combustion reaction, is important in ecosystems, such as the tropical savanna regions of northern Australia, as it promotes the recycling of nutrients. This process is well-known by Aboriginal and Torres Strait Islander peoples and as such, fire has been used for millennia to control the transfer of matter and energy through the ecosystem in a practice known as firestick farming.

DETAIL

The Sun's energy is captured and trapped in plant material through the process of photosynthesis. This energy is primarily utilised through the process of respiration and as it is transferred through food webs it sustains all life in an ecosystem. During fires, the energy stored in biomass is released through the process of combustion. The process of burning biomass releases a wide range of products, some of which can act as nutrients or contribute to the cycling of nutrients in the environment. Others, such as methane and dioxins, are harmful to the environment. Which products are produced, and in what quantities, can be significantly affected by the temperature at which the biomass is burnt. Studies have found that the temperature of the fire also has an impact on the physical, chemical and biological properties of soils.

Over millennia, Aboriginal and Torres Strait Islander peoples have amassed knowledge about the variables that affect the control and intensity of fires. This knowledge is applied to regulate the frequency and timing of fires in order to ensure the efficient recycling of nutrients, thus creating and shaping a patchwork of resources at different stages of regrowth in a convenient and predictable manner. Fires that are burning too hot result in a greater loss of volatile nutrients from the ecosystem and have detrimental effects on the soil. Aboriginal and Torres Strait Islander peoples understand this fact well. Hence, burns are conducted in the early dry season, whilst plant matter still contains moisture, resulting in smaller scale and cooler fires. This method of harnessing fire in strictly controlled fire regimes is known as firestick farming and is the oldest known farming practice in the world.

The successful transfer of nutrients is highly dependent on fire temperature. An essential factor in controlling fire temperature is the time when these fires occur. In recognition of this, Aboriginal and Torres Strait Islander communities in the tropical savanna areas of northern Australia purposefully light fires in the early dry season (March-April) to prevent the occurrence of hotter burning fires in the late dry season (October-November). These low-intensity fires recycle nutrients from the biomass into new growth, allow for the selective distribution of fire-tolerant and fire-sensitive plants, foster the regrowth of crop plant species, and encourage the migration of target game species to the new regrowth zones of the recently burnt areas. At the same time, the mosaic nature of burnt and unburnt areas provides a balanced environment for game species to find food and shelter.

Students could research the chemical reactions of photosynthesis, respiration, the complete combustion of simple hydrocarbons in an ample supply of oxygen and the incomplete combustion of simple hydrocarbons. They could compare the products of these combustion reactions with those produced in the combustion of the more complex compounds involved in biomass fuels, and the effect of high temperature fires on the production of greenhouse gases such as methane and nitrogen oxides.

In investigating the context suggested in this elaboration students will gain a deeper understanding of the role combustion reactions play in the accessibility and recycling of nutrients through the ecosystem and how these reactions have been employed and controlled by Aboriginal and Torres Strait Islander peoples in the agricultural practice of firestick farming.

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ACSSU182

Traditional sound knowledges and practices

CONTENT DESCRIPTION

Energy transfer through different mediums can be explained using wave and particle models.

CONTENT ELABORATION FOR CCP (01.5)

- ▶ investigating the impact of material selection on the transfer of sound energy in Aboriginal and Torres Strait Islander Peoples' traditional musical, hunting and communication instruments



Didgeridoo are designed to amplify and modulate sound waves. Photo credit: Phillip Breslin

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with opportunities to consolidate their knowledge and understanding of how sound is generated and how sound energy is transferred through different mediums, such as air and water. As in all cultures, Aboriginal and Torres Strait Islander peoples have many diverse technologies, knowledges and processes that involve the transfer of sound energy. Students will have opportunities to develop an appreciation of how Aboriginal and Torres Strait Islander peoples' knowledge of sound propagation through different mediums influences the design of technologies including sound instruments, herding and signalling devices.

DETAIL

When people consider the transfer of sound energy, they commonly think of sound transfer through air. However, there are less well-known examples of Aboriginal and Torres Strait Islander understandings of how sound travels through the medium of water. This understanding was exploited to develop fish herding technologies and practices. For example, the traditional practice of clapping stones together under water to frighten fish closer to the surface for easier hunting has been documented throughout Australia. An interesting practice that provides evidence of this understanding is the driving of spears into sand under water by Quandamooka peoples on Minjerribah (North Stradbroke Island) to generate a specific signal for dolphins to assist in the mutual herding and hunting of mullet. These practices could be investigated to demonstrate to students the transfer of sound through liquid.

Musical instruments developed by Australia's First Nations peoples can be used to illustrate the propagation of sound waves through solids and air. First Nations Australians constructed and played a range of different musical instruments; their selection and use being influenced by available resources, cultural practices and spiritual beliefs. The most iconic and widely recognised of these instruments is, arguably, the didgeridu. Its name is not a traditional language word but is believed to have been coined as an onomatopoeic description of the sound it makes, introduced after colonisation.

Traditionally, the didgeridu was played only in the northern parts of Australia, and was an object afforded the utmost cultural and spiritual significance. Laws and protocols governed who could play it, when and where, and specified the ceremonies at which it could be played. The didgeridu is depicted in rock paintings dated at more than 1500 years old, making the didgeridu at least this age but possibly much older. It is therefore a likely contender for the title of the world's oldest wind instrument. Today however, the didgeridu is regularly played across Australia, and also in other parts of the world.

A didgeridu is basically a hollow tube approximately 1 to 3 metres in length. The tube can be made from bamboo, tree trunks or branches that have been hollowed out by termites. It may be cylindrical

or flared at one end to create a more conical shape. Once a suitable trunk or branch has been identified, it is further manufactured by: stripping its bark, usually with a stone axe; cleaning out any termite residue; and applying bees wax to one end to form a better fitting mouth piece, helping to create a seal for the player.

As the basic shape and hollowing of each didjeridu are principally the result of natural processes, each didjeridu is unique, and its acoustic behaviour is determined by the length and shape of its bore. The diameter of the bore also affects the amplitude, or loudness of the sound that is generated. Other factors that contribute to the complex nature of the didjeridu's unique sound are the frequency of the vibration created by the player's lips, the shape of the player's vocal tract and the force of the air flow travelling through the instrument.

Two general rules apply to the sound created by woodwind instruments. First, the greater the length of the instrument, the lower is its pitch. Longer didjeridus have lower fundamental frequencies than shorter instruments. Second, flared instruments play a slightly higher pitch than unflared instruments of the same length.

The fundamental frequency is the lowest natural frequency for which a standing wave is produced, and thus at which an instrument resonates. That is, the standing wave produced has a node at the closed, mouth end and an antinode at, or near, the open end. The wavelength of this fundamental standing wave is four times the length of the instrument. Therefore, its frequency is given by the equation:

$$\text{Frequency } (f_1) = \frac{\text{speed of sound in air } (v)}{4 \times \text{instrument length } (L)} \quad \text{that is, } f_1 = v/4L$$

Taking the speed of sound in air as $340 \text{ m}\cdot\text{s}^{-1}$ means a didjeridu that has a length of one metre has a fundamental frequency of approximately 85 Hz.

The other natural frequencies for a pipe closed at one end are the odd harmonics; that is, the third, fifth, seventh, etc. harmonics. Their frequencies are given by:

$$\text{Frequency of 3rd harmonic } f_3 = 3v/4L$$

$$\text{Frequency of 5th harmonic } f_5 = 5v/4L$$

$$\text{Frequency of 7th harmonic } f_7 = 7v/4L$$

In playing the didjeridu, the initial sound wave is created by the player's lips. The wave travels in every available direction, both forwards into the instrument but also backwards into the vocal tract of the player. The vocal tract acts as a resonator amplifying certain frequencies while suppressing others. Thus, skilled players manipulate not only the force of the air from the lungs and the vibrations of their lips, but also the shapes of their mouths and their tongue articulations. In so doing they alter the frequency, wavelength and amplitude of the sound wave as it reflects through the lips, pushed by

the movement of air from the lungs, and through into the bore of the instrument. This produces the distinct and unique sounds for which the didgeridu is renowned.

By using the didgeridu as an example, students have an opportunity to investigate some of the fundamental principles of acoustics and develop a deeper understanding of how sounds are generated and propagated through different mediums.

CONSULTED WORKS

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ACSSU182

Traditional clothing and blankets

CONTENT DESCRIPTION

Energy transfer through different mediums can be explained using wave and particle models.

CONTENT ELABORATION FOR CCP (01.5, 01.7)

- ▶ investigating aspects of heat transfer and conservation in the design of Aboriginal and Torres Strait Islander Peoples' bedding and clothing in the various climatic regions of Australia



Animal fur, used for insulation and preventing heat loss (transfer)

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides a context for students to consolidate their understanding of thermal energy transfer mechanisms. It provides opportunities for students to investigate particle and wave models of heat transfer in the context of the effective clothing technologies developed by Aboriginal peoples living in cool and temperate climatic regions of Australia. It also provides opportunities to investigate and compare the thermal conductivity of various materials, as well as factors that affect the rate at which energy is transferred as heat between bodies.

DETAIL

Australia is often characterised as a hot and dry continent and the stereotypical image of Aboriginal peoples is often that of desert people with minimal clothing. Similarly, it is easy to think that Torres Strait Islander peoples, living so close to the equator, perhaps may not have had the need to develop effective bedding and clothing. Australia has a large variety of climatic regions and First Nations' peoples have thrived successfully in all its climates, including the cool temperate and oceanic climates of southern Australia, Tasmania and the Alpine regions.

In order to control heat loss, Aboriginal peoples developed technologies that enabled them to live and thrive in these cooler south-eastern parts of Australia. The most lauded of these technologies are cloaks made from the hides of animals such as possums, kangaroos and wallabies.

For warmth, the traditional skin cloaks were typically worn with the fur lining next to the body, trapping a layer of air. During rainy weather, the cloaks could be worn with the fur on the outside. The oily, water-repellent hairs provided a waterproof protection for the wearer. The cloaks were also rubbed with fat to further improve their insulating properties. The cloaks were large and could also be used to sleep on at night, acting as both mattress and blanket.

Possum skin cloaks are of great cultural significance to some Aboriginal peoples. Often, the inner surface of each cloak was incised and painted with ochre to depict themes from nature or stories of identity, kinship, family group and Country. Prior to 1830 almost every person had his or her own possum skin cloak. They were worn from a young age, with additional skins added to the cloak as the individual grew. Possum fur cloaks were also greatly admired and sought after by European colonists for their functionality as well as for their aesthetic value. However, in the mid-1800s, due to the loss of access to their traditional lands and its resources, many Aboriginal people began using government-issued wool blankets that were less effective in keeping the wearer warm and dry and offered little protection in winter. During this time, many Aboriginal people became ill and died from common European colds and influenza viruses.

The heat-conserving properties of cloaks made from animal furs involve three principal modes of heat transfer: thermal conduction, convection and radiation.

An object contains thermal (heat) energy because of the movement of the particles in the object. The faster the particles move, the greater the amount of thermal energy the object possesses.

Temperature is a measure, on a defined scale, of the average kinetic energy of molecular motion in an object. It is a measure of an object's ability to transfer thermal energy to another object.

Temperature and heat are closely related concepts, but they are not the same. Heat is a form of energy; temperature is a measure of it. For example, 200 mL of water at 30 °C contains more thermal energy than 100 mL of water at the same temperature.

Thermal energy will flow from a high temperature substance to a lower temperature substance until they reach thermal equilibrium. This transfer can occur by particles transferring their kinetic energy to nearby particles (conduction) or by the bulk movement of particles in fluids (convection). Transfer of heat energy can also occur as electromagnetic radiation.

The primary purpose of clothing is to regulate these processes. Traditional possum fur cloaks not only act as an insulator by providing a barrier of trapped air that slows thermal conduction, it has also been shown that fur hairs play an important role in reflecting infrared radiation, thus leading to a significant enhancement of a hide's insulating power.

Students could choose to investigate the situations for which the equation for the rate of heat transfer, in watts, through flat surfaces is applicable:

$$\text{rate} = \frac{kA (T_1 - T_2)}{d}$$

Where k = thermal conductivity in $\text{W m}^{-1} \text{ }^\circ\text{C}^{-1}$

A = surface area in m^2

T_1 = the temperature on one side of the wall in $^\circ\text{C}$

T_2 = the temperature on the other side of the wall in $^\circ\text{C}$

d = the thickness of the wall in m.

By studying energy transfer through different mediums in the context of traditional clothing, students can gain an appreciation of the technologies and culturally important methods used by Aboriginal peoples to survive in cold wet climates. There are also opportunities for students to consolidate their understanding about heat and temperature, to become more familiar with the models we use to explain thermal energy transfer, and to deepen their understanding of the differences between thermal conductors and thermal insulators.

CONSULTED WORKS

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AC SHE157

Fire: an ecological must informing policy

CONTENT DESCRIPTION

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community.

CONTENT ELABORATION FOR CCP (OI.2, OI.5, OI.9)

- ▶ investigating how fire research has evaluated the effects of traditional Aboriginal and Torres Strait Islander Peoples fire regimes and how these findings have influenced fire management policy throughout Australia

Antipodean Fire: The Australian Strategy

If litter concentrations could be permanently reduced, the Australian bush fire problem would be largely solved. This forms the basis of a revolutionary policy of fire protection, which has recently been implemented particularly in Western Australia.

—DR. R. G. VINES,
CSIRO Division
of Applied Chemistry (1968)

Even when the programme of fuel modification burning becomes fully operative throughout Australia—and I must be quite honest on this, no matter what opposition there is to this programme, it will be operative and you will have to accept it as part and parcel of the way of Australian life, because this is the only way we can provide adequate fire protection.

—A. G. MCARTHUR,
Symposium Comments (1966)

Controlled burning to reduce fuel loads reinstated through fire policy

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with a context in which to investigate the way scientific understanding of the natural world is built and modified as new evidence emerges. In particular, it is an opportunity for students to learn how understanding has been refined about the role of anthropogenic fire in shaping the interactions between organisms and their environment. Students learn about the beneficial effects associated with the re-introduction of traditional fire regimes of Aboriginal and Torres Strait Islander peoples as a land management and fire risk mitigation strategy, and can expand their investigations to develop their understanding of traditional purposes and contemporary benefits of reinstating these practices.

DETAIL

Prior to the arrival of European colonisers, First Australians had for millennia conducted controlled and purposeful burning of the landscape, a practice that can be described as a planned and precise local caring of country.

Burning occurred over most of Australia every 1-5 years. Aboriginal and Torres Strait Islander communities carefully determined the timing, frequency and location of the burns depending on local flora and local abiotic features, as well as purpose. Cool fires were burnt in spring or in the early dry season to minimise the build-up of fuel load, thus preventing the occurrence of uncontrollable and much more damaging wildfires later. These cool fires also ensured effective cycling of soil nutrients which encouraged the growth of staple foods, such as yams and cycads. The subsequent regeneration of plants could also encourage the migration of target game species by providing the feed and shelter they preferred. Hotter fires were lit in early summer to open hard seeds and pods or germinate legumes.

The development of such strategic burning regimes was based on sophisticated knowledge in multiple scientific fields such as: meteorological knowledge for timing season and moisture conditions; botanical knowledge to understand how certain plant species respond to or even depend on fire and how tolerant they are of fire intensity; and zoological knowledge to choose the correct timing to encourage game species to the area.

The typical European perspective of fire was that it was dangerous and destructive. Until the middle of the 20th century, fire management practices in Australia were generally aimed at prevention of any fires occurring and suppression of fires wherever possible. According to the legislations of most States and Territories at the time, Aboriginal and Torres Strait Islander communities faced imprisonment and fines for burning landscapes according to their traditions.

Therefore, with the incursion into Australia of Europeans, many with little or no experience of bushfires, traditional land management practices were disrupted, the result being sudden and extensive ecological change. The extent of these changes is evident by comparing the descriptions

of landscapes seen by naturalists such as Leichhardt with the landscapes as they currently exist. For example, in many places where there were park-like grasslands, there are now dense undergrowth and forest with their associated increased fuel loads and altered landscapes.

When scientific research of bushfires began in Australia in the 1930s it was heavily influenced by, and modelled on, North-American and European research with its prime focus on bushfire protection and suppression. The beneficial effects of bushfires on Australian ecosystems and biodiversity were not yet understood by Western science. Following a series of catastrophic bushfires in the 1950s and 1960s, researchers became increasingly aware of the necessity of fuel load reduction to prevent the occurrence of massive out-of-control wildfires. Western researchers increasingly looked towards indigenous solutions to fire management and, although heavily debated at the time, controlled burnings were eventually introduced to mitigate the risk of large-scale fires. Bushfire scientists also started to investigate the long-term effects of traditional Aboriginal and Torres Strait Islander fire regimes on forest health and on the distribution of plant and animal communities.

It is now understood that anthropogenic fire has been an integral part of Australia's ecosystem for thousands of years and has favourably shaped the distribution and diversity of flora and fauna on the Australian continent. It is widely accepted among ecologists today that the disruption of traditional burning practices has led to substantial declines in biodiversity in many areas, particularly in the tropical savanna regions of northern Australia. Numerous studies have shown that by utilising traditional ecological knowledge and re-adopting traditional burning practices of Aboriginal and Torres Strait Islander peoples, the risk of catastrophic fire events, as well as the total area burnt by hot wildfires, is significantly reduced. This also leads to environmentally beneficial outcomes, such as fewer greenhouse gas emissions and reduced long-term damage to ecosystems. See elaboration for ACSSU179 for a more detailed discussion of the beneficial ecological effects of traditional fire management practices.

By exploring recent studies into various fire-management regimes, students learn how the traditional fire management practices of Aboriginal and Torres Strait Islander peoples have informed and shaped Australian bushfire policies and subsequently reduced the occurrence of catastrophic fire events. Students also have opportunities to develop their appreciation that science understanding of the natural world is dynamic and continues to be refined over time.

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ACSHE158

Modern science validates Indigenous solutions to atmospheric pollution

CONTENT DESCRIPTION

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries.

CONTENT ELABORATION FOR CCP (OI.2, OI.5, OI.9)

- ▶ researching how technological advances in monitoring greenhouse gas emissions and other environmental factors have contributed to the reinstatement of traditional fire management practices as a strategy to reduce atmospheric pollution



Uncontrolled wildfire is a significant contributor to greenhouse gas emissions

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with a context in which to investigate the part that technological developments can play in providing new information that extends our scientific understanding of the natural world. It is an opportunity for students to learn about remote-sensing technologies and their role in providing data with which to monitor and validate greenhouse gas emissions. Students also learn about First Nations' traditional fire-management practices in northern Australia's savanna regions, and how, now that their effects can be quantified, these practices have been recognised for their role in the reduction of greenhouse gas emissions.

DETAIL

Currently too many fires in Australia's savanna regions are large, intense wildfires burning during the late dry season (approximately October – November). Dried grasses and other vegetation devoid of moisture provide ample fuel for these highly-destructive, hot fires. They may burn for months, destroying tree canopies and significantly damaging vast areas. These fires produce nearly half of the Northern Territory's total greenhouse gas emissions.

In comparison, the traditional Aboriginal fire management practice of early dry-season burning (approximately March – April) has been shown to be less damaging. These fires are 'cooler' burning as the fuel is not as dry, and dewy night-time conditions tend to extinguish the fires. A patchwork of carefully burnt areas also creates fire-breaks in the landscape, reducing the risk of late dry season wildfires spreading. As the area and fuel load burnt each year are reduced under this practice, there is a corresponding reduction in the emission of the potent greenhouse gases methane and nitrous oxide. There is also a corresponding increase in the amount of carbon being sequestered in dead organic matter.

Government authorities are now advocating the re-introduction of these traditional fire-management regimes in northern Australia's savanna regions. The Carbon Farming Initiative allows carbon credits to be earned by storing carbon or reducing greenhouse gas emissions. Aboriginal ranger groups, land councils, traditional owners, local communities and other organisations participating in the scheme use vegetation maps and satellite fire maps to determine the level of emission abatement achieved by the re-instated fire-management regime. (See elaboration for ACSHE160 for more detail on the economic benefits of this initiative.)

The ability to quantify greenhouse gas emissions from wildfires has only been made possible by advances in technology. NASA's Earth Observing System (EOS) Terra (EOS AM-1) and Aqua (EOS PM-1) satellites carry the MODIS (MODerate Resolution Imaging Spectroradiometer) equipment that detects thermal anomalies, fires and biomass burning. This information can be used to monitor changes in the distribution, frequency and relative strength of fires.

Satellites, such as GOSAT, and OCO-2, carry instruments that measure carbon dioxide concentrations in the atmosphere. The newer GOSAT-2 satellite can obtain atmospheric

concentrations of methane, water vapour and carbon monoxide, in addition to carbon dioxide. The molecules of these compounds absorb light at different specific wavelengths. Spectrometers on board the satellites measure the amount of light absorbed by the atmosphere at these specific wavelengths. These data can then be used to determine the local atmospheric concentration of each of these greenhouse gases. Scientists have also developed cost-effective mobile land-based instruments that can be deployed to quantify local and regional greenhouse gas sources and sinks.

While the principal aim of the Carbon Farming Initiative is carbon abatement, there are other environmental benefits, such as the effective recycling of soil nutrients and the maintenance of biodiversity-rich habitats by minimising the invasion of weeds and feral animals. The projects also provide an enduring economy for Aboriginal peoples as well as opportunities to maintain and strengthen connection with, and caring for, country.

Students studying this elaboration will have opportunities to research how technologies for measuring greenhouse gas emissions have led to a better understanding of the positive impact that reapplying traditional ecological knowledge of fire regimes can have on the atmosphere and on savanna environments. Students will also develop a greater appreciation of how improvements to our ability to quantify natural and anthropogenic processes can promote scientific understanding of underlying phenomena and result in innovative solutions to contemporary issues.

CONSULTED WORKS

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ACSHE160

Traditional ecological knowledge and practices create carbon farming careers

CONTENT DESCRIPTION

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities.

CONTENT ELABORATION FOR CCP (01.2, 01.5, 01.9)

- ▶ considering how the traditional ecological knowledge of Aboriginal and Torres Strait Islander Peoples is being reaffirmed by modern science and how this is generating new career opportunities in the field of restorative ecology



Indigenous ranger groups play significant roles in Caring for Country

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides students with opportunities to learn about how knowledge and experience in traditional fire management practices are creating employment and business opportunities for Aboriginal communities and providing significant benefit to the environment and to all Australians.

Modern science recognises traditional fire management techniques as a means of reducing risk from bushfires as well as minimising greenhouse gas emissions into the atmosphere.

DETAIL

Since modern scientific understanding of fire ecology has recognised the effectiveness of traditional Aboriginal and Torres Strait Islander fire management practices in mitigating bushfire risk and fostering biodiversity (see elaboration for ACSHE157), government authorities are now advocating the re-introduction of traditional fire-management regimes in northern Australia's savanna regions. In addition to the ecological benefits, this approach has also created new economic opportunities for Aboriginal communities in northern Australia. As recent advances in remote-sensing technologies have made it possible to monitor greenhouse gas emissions from space (see elaboration for ACSHE158), carbon credit schemes have been initiated and provide an economic incentive to reapply land management practices that are informed by traditional ecological knowledge.

The Carbon Farming Initiative (2011-2014, incorporated into the Emissions Reduction Fund from 2015) allows carbon credits to be earned by storing carbon or reducing greenhouse gas emissions. These carbon credits are measured in Australian carbon credit units (ACCU) with each unit representing one tonne of carbon dioxide equivalent (tCO₂-e) stored or avoided by a project. To be eligible for the credits, Aboriginal and Torres Strait Islander ranger groups, land councils, traditional owners, local communities and other organisations participating in the scheme must first develop a vegetation map of their proposed area. The vegetation map is important because different types of vegetation generate different amounts of greenhouse gases. Participants must then determine a 10-year fire history of their area. From these data participants are able to calculate the area's historical average baseline of greenhouse gas emissions. Project participants can then use vegetation maps and satellite fire maps to determine the emissions abatement achieved by the reinstated fire-management regime. Many of these projects, such as the WALFA project in Western Arnhem Land or the Fish River Fire Project southwest of Darwin, are undertaken in close collaboration with traditional owner groups and local Aboriginal and Torres Strait Islander communities, and rely heavily on the knowledge and expertise of Aboriginal and Torres Strait Islander ranger groups.

The carbon credits earned through these projects are on-sold to companies to offset the amount of greenhouse gas pollution they are emitting into the atmosphere. The monetary returns from these carbon trading schemes are reinvested locally to expand existing projects or found new initiatives, thus creating a demand for workers with experience in traditional ecological knowledge as well as in

modern science and technology. This creates career opportunities for park rangers and field officers in Aboriginal and Torres Strait Islander ranger groups, as well as ecologists, zoologists, botanists and similar science-related professions. It also provides opportunities for Aboriginal and Torres Strait Islander peoples to maintain and strengthen connection with country and place.

By investigating the application of traditional fire management practices in the context of carbon abatement schemes to reduce and offset greenhouse gas emissions, students have opportunities to appreciate how traditional ecological knowledge, combined with contemporary science and technology, is creating new career opportunities in Indigenous communities of Northern Australia.

CONSULTED WORKS

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ACSHE228

Torres Strait Islander frontline defenders

CONTENT DESCRIPTION

Values and needs of contemporary society can influence the focus of scientific research.

CONTENT ELABORATION FOR CCP (01.9)

- ▶ researching how Torres Strait Islander Peoples are at the forefront of the development of scientific measures to prevent the transfer of certain infectious diseases and pests to the Australian continent



Torres Strait Islander Peoples play important roles in customs and quarantine

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides opportunities to learn about the role of Torres Strait Islander communities in protecting Australia from introduced pests, weeds and diseases. Given the geographical position of the Torres Strait Islands to the north of Australia, and their proximity to other nations, it is a crucial zone in which to identify and address potential threats to Australia's biosecurity. Students learn how Torres Strait Islander communities work collaboratively with research organisations and government agencies to conduct scientific investigations about the ecology of various pests, diseases and weeds, possible arrival pathways and methods of spreading, and how they conduct surveillance, quarantine and monitoring activities designed to minimise these potential threats.

DETAIL

Northern Australia is vast and remote, and with more than 10,000 km of coastline, inlets and islands, it is at serious risk of pest, weed and disease incursions from countries to the north. The proximity of the Torres Strait Islands to Australia's near northern neighbours, such as Papua New Guinea, is one of the region's primary biosecurity concerns. Just under 5 km separates the Torres Strait's northernmost island, Saibai, from the Papua New Guinea coastline.

There are numerous ways in which pests, weeds, and diseases can reach the mainland via the Torres Strait, including natural pathways, such as wind and tide movements and animal migrations, as well as human-assisted ship and aircraft pathways and their associated passenger and cargo movements.

Since European colonisation more than two hundred years ago, Australia has experienced a significant increase in introduced pests, weeds and diseases that were previously unknown to the continent, and many of these have had devastating impacts on the environment and its ecosystems, including human populations.

Rabbits, cane toads and lantana are among the better-known species that have been introduced into Australia. Diseases like smallpox have largely been eradicated, while others continue to provide significant challenges to scientists and communities working to eliminate them. One such disease is Japanese Encephalitis (JE), which is carried by mosquitoes, and was identified on Badu Island in the Torres Strait in 1995. A serological study conducted during the outbreak established the distribution of virus infection and identified domestic pigs as a contributing risk factor to human infection. In response to this threat, local communities now utilise sentinel pigs (a potential amplification host) to monitor for the emergence of the JE virus. Other exotic pests and diseases of major concern to Australia include the screw worm fly, Asian tiger mosquito, papaya fruit fly, Zika virus disease, malaria, hand-foot-mouth, rabies and swine fever.

Since 1989, the Northern Australia Quarantine Strategy (NAQS) has worked in collaboration with State and Federal Governments, local Aboriginal and Torres Strait Islander communities, and other

relevant stakeholders, to provide an early warning system for exotic pest, weed and disease detection across northern Australia and to help address the unique biosecurity risks facing the region. These activities rely heavily on local Aboriginal and Torres Strait Islander people working with scientists and government agencies, and have created several key employment opportunities for local communities and individuals. Given the traditional ongoing movements among the Torres Strait Islands, other areas of Queensland and also Papua New Guinea, it is essential that these programs work closely within Aboriginal and Torres Strait Islander communities to monitor and detect potential threats.

The NAQS engages in a number of targeted initiatives to address the potential threats from pests, weeds and diseases:

- surveillance of animal and plant health, targeting pests, diseases and weeds in coastal areas across northern Australia
- biosecurity operations to address risks associated with movements of people, cargo, aircraft and vessels into and between defined biosecurity zones in the Torres Strait, and from these zones to mainland Australia
- public awareness and education activities
- collaborations with Aboriginal and Torres Strait Islander communities and State and Territory agencies
- surveillance and monitoring activities in neighbouring countries for early signs of targeted pests, diseases and weeds.

By investigating how these threats have prompted scientific research and how they are currently being managed within the Torres Strait Islands, students have an opportunity to understand the important role local Indigenous people play in the development and maintenance of scientific measures to protect the biosecurity of Australia.

CONSULTED WORKS

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Science Inquiry Skills

New elaborations within the Science Inquiry Skills (SIS) strand provide contexts for the inquiry process and include reference to skills required to engage with Aboriginal and Torres Strait Islander Peoples when working scientifically. These intercultural science inquiry skills are throughout years 7-10 and provide opportunities for students to develop skills relating to:

- acknowledging the scientific knowledge and skills of Aboriginal and Torres Strait Islander Peoples
- consulting with Aboriginal and Torres Strait Islander communities in the planning or evaluation of scientific investigations
- collaborating with Aboriginal and Torres Strait Islander communities in mutually beneficial scientific research.

Unlike the Science Understanding (SU) and Science as a Human Endeavour (SHE) Teacher Background Information (TBI) materials the teacher background information for the new SIS elaborations provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures. Importantly, the Science Inquiry Skills TBI illustrates how concurrent SU and SHE topics can be used to contextualise the ways in which educators may provide skill development opportunities for the development of these skills.



*X-ray representations from the Arnhem region communicate important anatomical features.
"Bininj painting Anbangbang walk, Kakadu Northern Territory".*

AC SIS170

Consulting Aboriginal and Torres Strait Islander knowledge – not just art!

CONTENT DESCRIPTION

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence.

CONTENT ELABORATION FOR CCP

- ▶ consulting Aboriginal and Torres Strait Islander Peoples' histories and cultures that reveal scientific information about the past

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

All matter is made of atoms that are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms (ACSSU177)

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

A potential way to approach this content description is:

Important data and information regarding scientific claims and explanations from many fields of science is stored, communicated and accessed in Aboriginal and Torres Strait Islander histories and cultures, for example, in language, songs, pictorial histories and technologies. Ancient petroglyphs and rock paintings record and communicate a wealth of information that provide measurable and rigorous records of the past. Students could consult pictorial histories or rock paintings that depict mega-fauna and the published radiocarbon dating data of these depictions in regard to Australia's First Nations peoples and interactions with mega-fauna.

AC SIS174

Acknowledging understanding and communication of internal systems

CONTENT DESCRIPTION

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations.

CONTENT ELABORATION FOR CCP

- acknowledging and exploring Aboriginal and Torres Strait Islander Peoples' ways of communicating their understanding of the internal systems of organisms

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment (ACSSU175)

A potential way to approach this content description is:

Students could investigate published records that depict Aboriginal and Torres Strait Islander material culture items that communicate information about the internal features of animals, for example, the circulatory, digestive, or reproductive systems as depicted in X-Ray paintings, sculptures, or head dresses. This provides students with the opportunity to learn about the conventions used in scientific drawings and discover parallels in such representations made by Aboriginal and Torres Strait Islander peoples.

AC SIS165

Acknowledging cultural heritage acts and obligations of scientists

CONTENT DESCRIPTION

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods.

CONTENT ELABORATION FOR CCP

- acknowledging cultural heritage protection Acts as they relate to Aboriginal and Torres Strait Islander Peoples in planning field investigations

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

A potential way to approach this content description is:

Students could plan a field investigation researching the impact of an invasive species on a local ecosystem and consider ethical issues regarding access to, and potential discovery of, cultural heritage sites, including obligations under legislated Acts.

AC SIS170

Acknowledging two-way science can lead to new solutions and knowledge

CONTENT DESCRIPTION

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence.

CONTENT ELABORATION FOR CCP

- ▶ acknowledging and identifying the relationship between First Peoples' knowledges and contemporary science and the co-contributions in arriving at shared understanding when working "both-ways"

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

A potential way to approach this content description is:

Students could conduct online research regarding the West Arnhem Land Fire Abatement project and access carbon dioxide emissions data pre and post the reinstatement of traditional fire regimes, provided by data.gov.au.

AC SIS164

Acknowledging cultural records of the past

CONTENT DESCRIPTION

Formulate questions or hypotheses that can be investigated scientifically.

CONTENT ELABORATION FOR CCP

- ▶ acknowledging and using information from Aboriginal and Torres Strait Islander Peoples to hypothesise about fauna or flora distributions

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

A potential way to approach this content description is:

Students could investigate flora and fauna records as depicted in rock paintings and pictorial histories for evidence of species-specific information. For example, using such information students could formulate a research hypothesis and predict the possible distribution of animals that are now extinct on the Australian mainland, such as the Tasmanian Tiger or the Tasmanian Devil.

AC SIS164

Collaborating to understand damaged ecosystems

CONTENT DESCRIPTION

Formulate questions or hypotheses that can be investigated scientifically.

CONTENT ELABORATION FOR CCP

- ▶ collaborating with Aboriginal and Torres Strait Islander Peoples to formulate questions and hypotheses that can be investigated scientifically regarding disrupted ecosystems

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

A potential way to approach this content description is:

With guidance, classes form a scientific collaboration with an Aboriginal and/or Torres Strait Islander community to formulate a research question regarding an observed disruption of an ecosystem that impacts upon the community. Schools that lack the opportunity to collaborate in person with Aboriginal and Torres Strait Islander communities could potentially form collaborations with active Indigenous land management organisations online. Such schools could provide their partnered community with research support.

Year 10

Teacher background information



ACSSU184	Skin groups-marriage laws
ACSSU185	Adaptations of First Nations' Peoples
ACSSU187	Detoxification practices
ACSSU188	Astronomy and origins of the universe
ACSSU189	Greenhouse gas reduction through traditional practice
ACSSU229	Indigenous ballistics
ACSHE230	Science history of segregation
ACSHE191	Wounds and infection treatment understandings beyond miasma theory
ACSHE192	Ancient evidence in cultural relics
ACSHE194	Restorative ecology through traditional ecological knowledge creating diverse career opportunities
ACSHE230	Need for new medicine focuses research on Aboriginal and Torres Strait Islander pharmacopeia
ACSIS199	Collaborating in accordance with United Nations Declaration on the Rights of Indigenous Peoples and intellectual property rights
ACSIS206	Acknowledging Aboriginal and Torres Strait Islander peoples have been misrepresented due to cultural bias

ACSSU184

Skin groups-marriage laws

CONTENT DESCRIPTION

Transmission of heritable characteristics from one generation to the next involves DNA and genes.

CONTENT ELABORATION FOR CCP (01.8)

- ▶ investigating Aboriginal and Torres Strait Islander Peoples' knowledge of heredity as evidenced by the strict adherence to kinship and family structures, especially marriage laws



Knowledge of heredity is interwoven with kinship and family structures

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides the opportunity to learn about the complex societal systems of Aboriginal and Torres Strait Islander peoples that dictate who can marry whom. The development of societal rules that impose regulations on marriages rests on the understanding that unions between individuals that are too closely related can lead to the inheritance of detrimental traits in their offspring. Students learn about the genetic principles that underlie the transmission of heritable characteristics and realise that, while the details of Aboriginal and Torres Strait Islander marriage laws may be different from those determined by the Australian Marriage Act, they share the common understanding of the hereditary benefits in imposing certain restrictions.

DETAIL

One of the many important reasons for marriage systems is the prevention of the transmission of defective genes to subsequent generations. Aboriginal and Torres Strait Islander peoples have long recognised that many characteristics are inherited and often run in family lines. Traditional kinship systems ensure that closely related marriages do not occur. This prevents the potential transfer of hereditary defects that may culminate in abnormalities, diseases or dysfunctions. By studying the inheritance patterns of a genetic defect such as haemophilia, students gain an understanding of the scientific principles that underlie heredity and contemplate their societal implications.

Many Aboriginal and Torres Strait Islander Australians have demonstrated a long-held understanding of traits and inheritance patterns without the assistance of technology that revealed the existence and role of DNA and genes. This understanding is not dissimilar from the famous geneticist Gregor Mendel's early understandings of how certain traits are passed down through generations and family lines. Mendel made his discoveries in the mid-1800s. Thousands of kilometres away from Europe and possibly thousands of years earlier, Aboriginal and Torres Strait Islander peoples had also observed, and knew, that traits and illnesses could appear in the offspring generated from closely related individuals. Many Aboriginal and Torres Strait Islander groups developed a complex system which informed people of who they were (where they fit within their social structure) and with whom they shared blood (DNA and genes). This is known as a kinship system whereby individuals are given skin names that reveal their family lineage.

These longstanding traditional practices and obligations of kinship systems are still in use in many Aboriginal and Torres Strait Islander communities, including urban environments. Kinship systems are central to Aboriginal and Torres Strait Islander society. They are highly sophisticated and complex systems that not only define relationship to others but can also determine a connection to the universe and include responsibilities towards people, land and the use of natural resources.

There are generally three levels of kinship in Australian First Peoples' societies, Moiety, Totem and Skin Names, and they can be based on either matrilineal or patrilineal lines of descent (mother's

or father's lines of descent). Unlike Torres Strait Islander societal structures, skin groups are found across mainland Australia, but different Aboriginal societies have different numbers of skin groups. These groups are not related to skin colour, but rather are a means of identifying relatedness and roles in society. One of the key features of skin group identification is that it defines who one is, and is not, allowed to marry.

By investigating the diverse kinship systems of Aboriginal and Torres Strait Islander peoples, students learn about the complex organisation of Australia's First Nations' societies. Students gain an understanding of the biological principles that govern the transmission of heritable characteristics from one generation to the next and consider how the awareness of these natural laws in different cultures may be reflected in the emergence of different forms of societal organisations and marriage laws.

CONSULTED WORKS

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ACSSU185

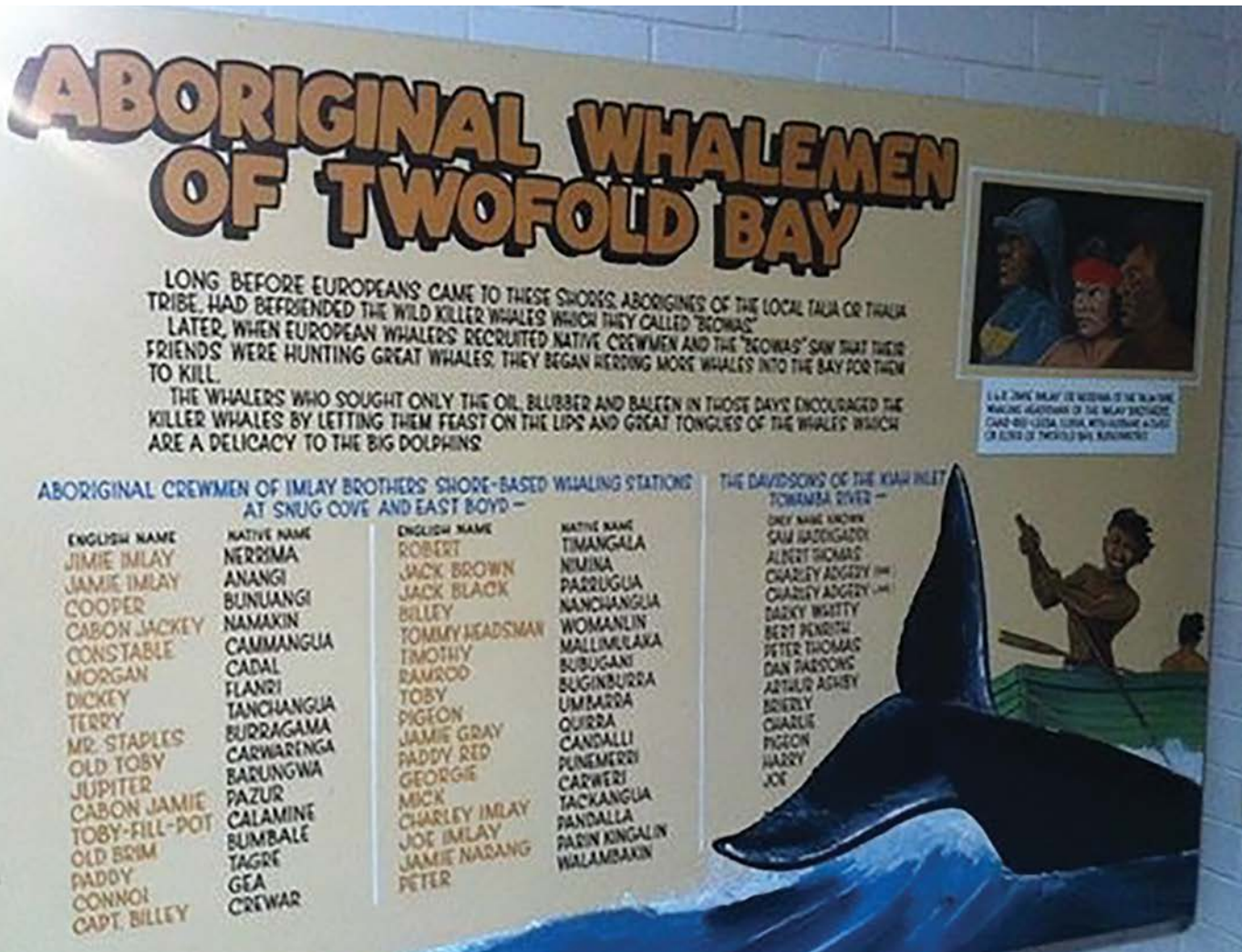
Adaptations of First Nations' Peoples

CONTENT DESCRIPTION

The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence.

CONTENT ELABORATION FOR CCP (01.3, 01.7)

- ▶ investigating some of the structural and physiological adaptations of Aboriginal and Torres Strait Islander Peoples to the Australian environment



Colonists utilised First Nations Peoples superior eyesight for whaling

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides opportunities for students to investigate some of the remarkable physical traits of Aboriginal and Torres Strait Islander peoples and how this is evident by the over representation of First Nations' Australians in some historical as well as contemporary professional fields. By studying the theory of evolution by natural selection in this context students gain an understanding of the mechanism that is responsible for the development of such characteristics. At the same time students learn about and appreciate the important contributions of Aboriginal and Torres Strait Islander Australians to Australian society.

DETAIL

On initial contact with Aboriginal and Torres Strait Islander peoples, European colonisers quickly noted that First Australians were equipped with many abilities and traits superior to their own, such as exceptional eyesight, reflexes, jumping ability, throwing accuracy, spatial awareness, running speed and stamina. This has been well documented in the private journals and official documents of early European colonisers. As a consequence, Aboriginal and Torres Strait Islander Australians were, and still are, highly sought-after in certain professional fields that require such abilities, such as in the whaling and pearling industries in the 1800s or in professional sports today.

It has been recognised that such variations in physical abilities cannot be explained through differences in training and lifestyle alone, but contain a strong genetic component. The theory of evolution by natural selection explains how such diversity appears in populations of organisms including humans. Traits or characteristics that confer a reproductive advantage will over many generations become more frequent throughout the entire population. Aboriginal and Torres Strait Islander peoples' long habitation in the diverse regions of Australia has led to the development of physical characteristics that are favourable to living in those environments. It is likely that the traits held by pre-contact Australians are responsible for remarkable achievements in certain sports. Many scientists believe that this can explain the overrepresentation of First Nations Australians in the highest levels of many sports today.

Investigating the exceptional sprinting and jumping abilities of Aboriginal and Torres Strait Islander football players due to the predominance of type II (fast twitch) muscle fibres, or the acuity of vision and rowing abilities of Aboriginal and Torres Strait Islander whalers employed in the Australian and New Zealand whaling industries in the early 19th century, may set the context in which students can explore the mechanisms that explain how such characteristics evolve.

CONSULTED WORKS

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ACSSU187

Detoxification practices

CONTENT DESCRIPTION

Different types of chemical reactions are used to produce a range of products and can occur at different rates.

CONTENT ELABORATION FOR CCP (O1.5)

- ▶ investigating some of the chemical reactions and methods employed by Aboriginal and Torres Strait Islander Peoples to convert toxic plants into edible food products



Toxic cycads products are chemically changed into edible produce

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration provides the opportunity to learn how Aboriginal Peoples of tropical north Queensland developed complex detoxification processes that allow the exploitation of plentiful food resources that were previously inedible. The various and sophisticated methods to remove toxins from poisonous endemic plants employed by many of Australia's First Nation groups set the context for students to study the chemical reactions that underlie these processes and to investigate some of the factors that affect the rate of chemical reactions. At the same time, the exploration of these methods provides an opportunity to learn about the extensive scientific knowledge and highly developed inquiry skills of Aboriginal peoples in the detoxification of food products.

DETAIL

The development of complex detoxification processes by the rainforest Aboriginal peoples of North Queensland was undoubtedly driven by the food needs of the society at the time. The recognition of patterns in data, gathered from experiments that attempted to remove toxins, allowed this cultural group to modify and perfect the detoxification processes. Since Europeans survived a near-fatal experience after consuming under-processed cycad kernels on the first voyage to Australia by Cook and his party in 1770, many of the detoxification processes of poisonous plant foods employed by Aboriginal peoples throughout Australia have been documented. These detoxification processes provide evidence of Australia's First Nations peoples' extensive scientific knowledge of chemical and physical processes, and an acute ability to draw conclusions that are consistent with evidence.

Students can explore a great variety of methods to remove toxins from poisonous foods as used by many of Australia's First Nations' peoples. A particularly suitable example for student investigation may be the method to detoxify cycad seeds employed by the rainforest Aboriginal people of North Queensland.

Cycads are a rich source of carbohydrates, but they contain a toxic substance called cycasin, which causes not only a range of acute symptoms, such as vomiting, nausea and abdominal pains, but also long-term damage to the nervous system and the liver and has been linked to various types of cancer. Cycasin consists of an innocuous sugar part (glucose) that is chemically bound to the active toxic substance methylazoxymethanol (MMA). In a chemical reaction with water (called hydrolysis), cycasin is broken up into these two parts, thus facilitating the removal of the toxic (and water soluble) MMA. However, this is a slow reaction under normal conditions, which made it necessary for the rainforest Aboriginal peoples of North Queensland to discover and employ a range of measures to speed up the reaction, including increasing both the contact surface with water and the temperature. In contrast, if the untreated cycad kernels are consumed, the same reaction happens at a much greater rate in the body due to the presence of a catalyst (an enzyme called β -glucosidase), thus leading to the rapid onset of acute symptoms.

By investigating the detoxification of cycads, students are given opportunities to gain a deep understanding of the factors that govern the rate of chemical reactions as well as to learn about and appreciate the highly developed science inquiry skills, ingenuity, and scientific knowledge of the rainforest Aboriginal peoples of North Queensland.

CONSULTED WORKS

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ACSSU188

Astronomy and origins of the universe

CONTENT DESCRIPTION

The universe contains features including galaxies, stars and solar systems, and the Big Bang theory can be used to explain the origin of the universe.

CONTENT ELABORATION FOR CCP (OI.3, OI.5)

- ▶ researching Aboriginal and Torres Strait Islander Peoples' knowledge of celestial bodies and explanations of the origin of the universe



Stars are significant celestial bodies to Australia's First Nations Peoples

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration describes opportunities to learn about the rich body of knowledge including stars, planets, galaxies and other features of the universe that forms an integral part of Aboriginal and Torres Strait Islander peoples' cultures. Investigations into the astronomical knowledge of Aboriginal and Torres Strait Islander peoples as evidenced in histories inscribed in bark, rock and sand painting set the context for students to study traditional and modern understandings about the structure and origin of the universe. Students learn about the exceptional observation skills of First Australians, investigate how observations are embedded in histories and handed down through generations, and research how this knowledge was, and is used, to aid navigation and to construct seasonal calendars. Such investigations also provide opportunities for students to consider different perspectives about the nature of astronomical knowledge and the role it plays in traditional and modern societies.

DETAIL

Pre-contact First Australians had a deep understanding of the positions and movements of celestial bodies and are sometimes referred to as the 'world's first astronomers'. It is well-documented that many Aboriginal and Torres Strait Islander peoples not only knew every star visible to the naked eye, but also had intimate knowledge of the precession of the planets, the apparent movement of the stars through the night sky, and the shift that the whole pattern of stars undergoes over the course of a year. This knowledge played, and continues to play an essential role in the prediction and timing of seasonally recurring events, as well as in the highly developed navigational abilities of Aboriginal and Torres Strait Islander peoples.

Many constellations are associated with histories, some of which are strikingly similar to those from European and other cultures. Contrary to many other traditions, in Aboriginal and Torres Strait Islander astronomy, the identity of stars and constellations is not only determined by the brightness and patterns of the observed light, but also takes into account the patterns originating from the dark clouds within the Milky Way and the colour of light emitted by certain stars.

Students may research stories associated with well-known Torres Strait Islander and Aboriginal constellations, such as 'Tagai' and 'Emu in the Sky', while learning how to locate them in the night sky and considering the astronomical features they contain. Through the use of paper-based planispheres or star chart apps, students become familiar with important geometric features inherent in star observation, such as the ecliptic, and contemplate traditional and modern understandings of the nature and origin of stars.

CONSULTED WORKS

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ACSSU189

Greenhouse gas reduction through traditional practice

CONTENT DESCRIPTION

Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere.

CONTENT ELABORATION FOR CCP (OI.5, OI.9)

- ▶ investigating how Aboriginal and Torres Strait Islander Peoples are reducing Australia's greenhouse gas emissions through the reinstatement of traditional fire management regimes



Early dry season burn conducted by Gangalidda Peoples, Queensland Gulf

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration describes opportunities for students to investigate the interactions between the biosphere and the atmosphere in the context of bushfire management. Students will learn how the traditional fire management practices of the Aboriginal and Torres Strait Islander peoples of tropical northern Australia are being recognised for effectively reducing greenhouse gas emissions. Additionally, these practices result in healthier ecosystems compared to former practices in fire management informed by Western science. Students have opportunities to appreciate how the traditional ecological knowledge and experience of Aboriginal and Torres Strait Islander Australians is informing and enriching modern scientific understanding of tropical savanna ecosystems and how the reinstatement of traditional fire management regimes is contributing to more sustainable land management practices and a reduction of atmospheric pollution.

DETAIL

Wildfires form a major component of the global carbon cycle. During this natural phenomenon the carbon stored in the biosphere (in the form of organic matter in plants and animals) is converted into carbon dioxide and released into the atmosphere. Fire also plays an important role in other global system cycles when it returns vital nutrient elements such as nitrogen and phosphorus from the biosphere back to the lithosphere, thus making them available once more for the regrowth of plants and the rejuvenation of the whole ecosystem.

Carbon dioxide is a naturally occurring atmospheric gas, the heat-trapping properties of which play a vital role in the stability of global climate patterns. However, the burning of fossil fuels, such as coal, mineral oil, and natural gas, has led to a dramatic increase of carbon dioxide levels in the atmosphere since the beginning of the Industrial Revolution. This by-product of modern-day (western) lifestyles has been identified as the major cause of an enhanced greenhouse effect. This is leading to a gradual warming of the Earth's systems and an associated change of climate patterns, which has sparked global efforts to reduce the emission of carbon dioxide into the atmosphere.

Over millennia, Aboriginal and Torres Strait Islander peoples living in the tropical savanna woodlands of northern Australia have amassed a wealth of ecological knowledge, and have developed strictly controlled fire regimes. These have been purposefully designed to burn at low intensity in the early dry season and only burn carefully selected patches of bushland. This practice results in a landscape that consists of a 'mosaic' of patches in different stages of regrowth. Recently burned patches act as effective fire breaks against the spread of large-scale and high-intensity fires. Since the beginning of European colonisation, western land management practices have disrupted this carefully designed fire management regime leading to more frequent out-of-control wildfires that are extremely destructive, highly polluting and emitting significantly larger quantities of greenhouse gases.

Students could investigate the West Arnhem Land Fire Abatement (WALFA) project. With support from local communities, the Northern Land Council, and Aboriginal traditional owners and organisations from the West Arnhem Land region, this project has adopted a new fire management regime. Defining factors such as fire timing, frequency and the size and pattern of patches to be burnt, are informed by the experience and knowledge of the Aboriginal peoples of this region. Similarly, the traditional fire management practices of Torres Strait Islander peoples are being recognised and reinstated on the islands of Moa, Badu and Mabuiag. These projects use traditional ecological knowledge, together with modern scientific practices, to better control the timing and intensity of savanna fires and to monitor the effectiveness of the new measures in reducing greenhouse gas emissions.

CROSS-STRAND LINKAGES

Year 10: People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE194)

CONSULTED WORKS

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ACSSU229

Indigenous ballistics

CONTENT DESCRIPTION

The motion of objects can be described and predicted using the laws of physics.

CONTENT ELABORATION FOR CCP (OI.5)

- ▶ investigating how Aboriginal and Torres Strait Islander Peoples achieve an increase in velocity and subsequent impact force through the use of spear throwers and bows



Spear throwers increase velocity and impact force of ballistic missiles

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration describes opportunities for students to learn how the laws of physics can be applied to explain the effectiveness of hunting tools used in Aboriginal and Torres Strait Islander cultures. Students investigate how variables such as mass, dimensions and force influence the acceleration, velocity, reach and impact force of the projectiles used in combination with spear throwers and bows. By studying the design features of traditional hunting tools, students gain an understanding of the laws of physics that govern the motion of objects. At the same time students have the opportunity to learn about and appreciate the highly developed scientific knowledge, inquiry skills and engineering abilities of Aboriginal and Torres Strait Islander peoples.

DETAIL

The development and use of light weight spears and spear throwers in mainland Australia, and bows and arrows in the Torres Strait Islands, many millennia prior to European contact is clear evidence that Australia's First Nations peoples were able to recognise patterns and trends in data and demonstrated a good understanding of the relationship between the mass of the spear (dart/arrow/projectile), the force applied to it, and its velocity, range and impact force.

A spear thrower acts as a lever that extends the throwing arm, causing the wrist rotation to increase the velocity of the spear and allowing a hunter to throw it significantly further and with greater impact force than by hand. A bow and arrow works by a different physical principle, as it makes use of the elastic potential energy that is stored in the bow when drawn. Upon release, this energy enables a greater acceleration of the arrow than could be achieved by hand. It ultimately depends on the distance of the target, and the impact force that needs to be achieved, to determine which of these two methods is more effective. It is well documented that many Aboriginal peoples of mainland Australia find the spear thrower, which enables greater impact force at a shorter range, to be more effective against large marsupials. Torres Strait Islander peoples prefer the bow and arrow, as it is more suited to hunting smaller prey, which requires less penetrating force, and can achieve greater range.

An investigation into the mechanics of the traditional hunting methods of Aboriginal and Torres Strait Islander peoples allows students to deepen their understanding of the physical laws that govern the motion of objects. It not only provides students with an authentic context that requires the application of the laws of physics, but also allows students to learn about the ingenuity and the scientific knowledge of Australia's Aboriginal and Torres Strait Islander peoples.

CONSULTED WORKS

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ACSHE230

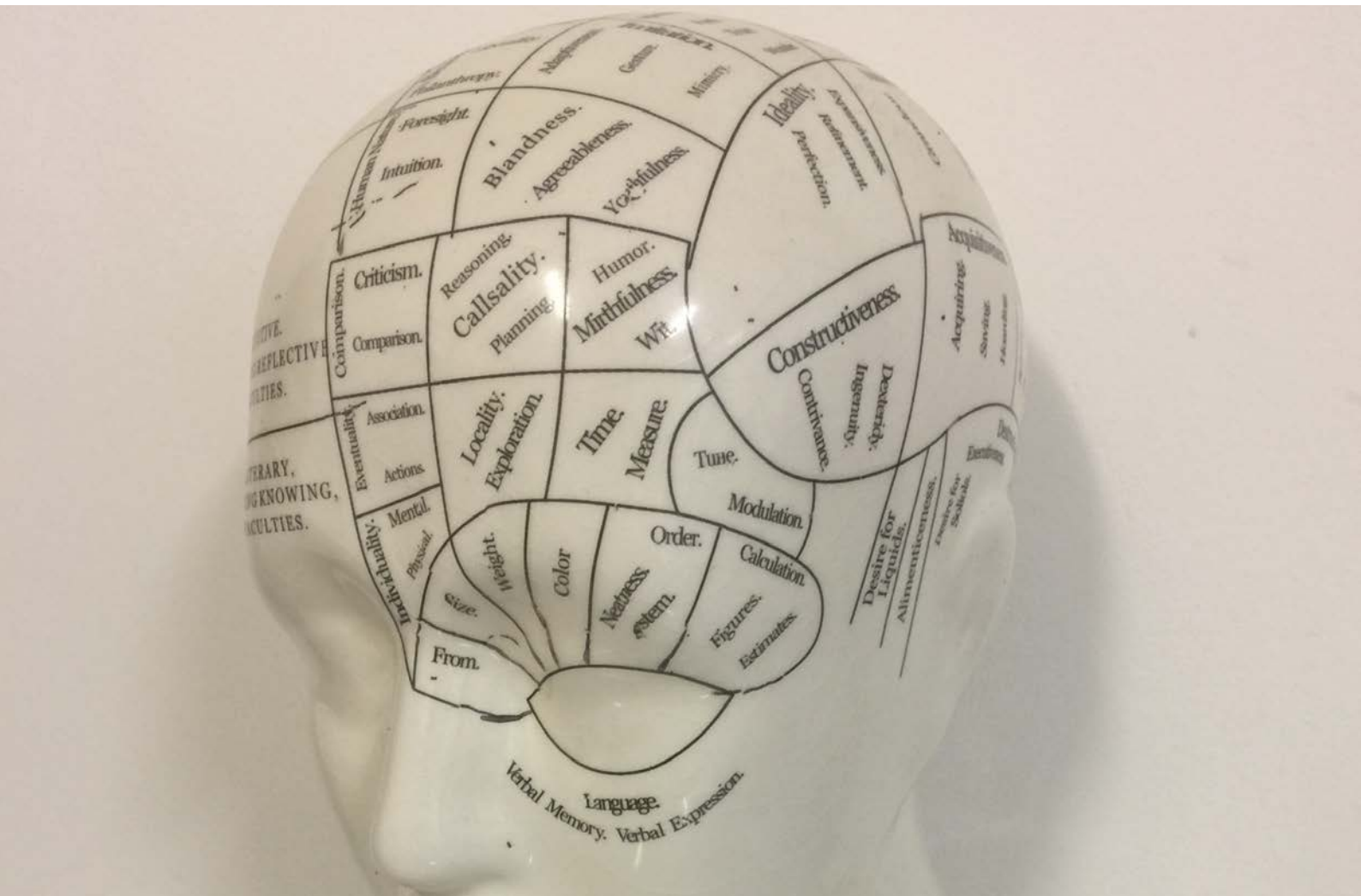
Science history of segregation

CONTENT DESCRIPTION

Values and needs of contemporary society can influence the focus of scientific research.

CONTENT ELABORATION FOR CCP (O1.6)

- ▶ researching how the values of 19th and early 20th century Australian society, combined with scientific misconceptions about heredity and evolution, influenced policies and attitudes towards Aboriginal and Torres Strait Islander Peoples



Science is not static; theories are refuted or accepted over time

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration describes opportunities for students to investigate the role of science and the scientific community in the justification of policies affecting Aboriginal and Torres Strait Islander peoples during the 19th and early 20th century. Students consider how the deeply entrenched beliefs of the time, regarding the moral and intellectual ‘superiority’ of the ‘white race’, led to a skewed focus of western scientific research on classifying human populations based on physical, mental and ‘moral’ traits. Discredited branches of science, such as phrenology and eugenics, as well as poorly understood evolutionary concepts from biology, provided ‘scientific’ arguments that seemingly justified policies of racial segregation in Australia. These policies went as far as denying citizenship rights for Aboriginal and Torres Strait Islander peoples and allowing state officials to take away ‘mixed-race’ children from their parents and families, known as the Stolen Generations.

DETAIL

While notions of racial superiority have deep roots in many human societies, the technological and economic dominance of European nations in the 19th century and the establishment of colonial empires, made such ideas particularly popular in Western societies of the time. With the emergence of scientific interest in questions of heredity and evolution, many researchers attempted to classify human populations into discrete races and sought empirical evidence for the existence of racial differences in intellectual capabilities and moral characteristics. Such traits were often thought to be linked to certain physical traits, such as facial features or the shape of the skull, as articulated in the now disparaged field of phrenology. Results of such research were commonly published in the form of racial hierarchies, with the European or ‘white’ race at the top.

This belief in racial superiority was often accompanied by a fear that intermarriage between races would cause an intellectual and moral decline of Western civilisation through the inheritance of inferior mental traits that were believed to be prevalent in the ‘coloured races’. This fear also rested on the now discounted belief that a human’s mental capabilities and moral character are entirely, or at least primarily, determined by genetics and (virtually) unaffected by social and environmental circumstances. Influenced by Charles Darwin’s hypotheses on evolution, his cousin Francis Galton proposed the idea that human society can be improved through ‘eugenics’, that is the encouragement of ‘good breeding’ based on a rigorous statistical understanding of heredity. Fuelled in part by the fear of racial degeneration through miscegenation, eugenics developed into a well-established academic field by the early 20th century.

Scientists at the time often believed that the ‘primitive’ races represented an earlier, less evolved stage of human development. Seemingly in accordance with Darwin’s ideas about evolution through natural selection and the notion of “survival of the fittest”, as popularised by the sociologist Herbert Spencer, it was commonly assumed that the ‘native peoples’ would eventually become

extinct through contact and competition with the ‘superior European race’. This idea, which in the Australian context is referred to as the “doomed race” theory, was often understood to be an inevitable consequence of ‘natural law’. The outcome of extinction was believed to be inevitable unless the state took measures to segregate and ‘protect’ Aboriginal and Torres Strait Islander peoples. It was intended to minimise contact between races by establishing reservations and by imposing employment and marriage restrictions on Aboriginal and Torres Strait Islander peoples. Policies also included the forcible removal and subsequent institutionalisation of “half-caste” children with the intention of preventing any ‘wild’ influences from their Aboriginal and Torres Strait Islander cultures while educating them for life in ‘civilised’ Western society. The scientific argument was that through controlled marriage policies for mixed-race Australians, any Aboriginal or Torres Strait Islander traits could be ‘bred out’ over the course of a few generations.

In light of contemporary developments in genetics and biotechnology, the central idea of eugenics – the ‘betterment’ of the human species through control of its genepool, be it through old-fashioned breeding programs or modern gene-editing methods – may become a contentious topic again. By investigating the role of science in the development of policies affecting Aboriginal or Torres Strait Islander peoples in the early 20th century, students contemplate how the values and beliefs of a society may influence the direction of scientific research and how, in turn, scientific concepts may have an impact on the governance of that society.

CROSS-STRAND LINKAGES

Year 10: Transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184)

Year 10: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (ACSSU185)

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ACSHE191

Wounds and infection treatment understandings beyond miasma theory

CONTENT DESCRIPTION

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community.

CONTENT ELABORATION FOR CCP (01.5)

- ▶ investigating how prior to germ theory Aboriginal and Torres Strait Islander Peoples used their scientific observations to develop traditional medicines to treat wounds and infections of the skin



Tea tree is well known for its antibacterial properties

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration describes opportunities for students to learn about how our understanding of diseases and their causes has been refined over time. It also provides opportunities for students to learn how the processes of contemporary science can demonstrate the effectiveness of Aboriginal and Torres Strait Islander Peoples' traditional treatments of wound infections. These treatments relied on rich and sophisticated scientific knowledge that predates the development of western science's germ theory.

People have grappled with the causation of diseases for millennia and have typically viewed the causes of illness from three broad perspectives: natural, human and supernatural. Aboriginal and Torres Strait Islander Peoples have diverse and complex beliefs regarding illnesses relating to the human and supernatural categories. These two categories come under the umbrella of secret and sacred knowledges. Aspects associated with these categories may only be shared by the relevant community and persons with authority to do so. Consequently, this elaboration is specifically about illnesses associated with the natural category.

DETAIL

The germ theory of disease states that many diseases and infections are caused by specific micro-organisms (germs) invading the body. Until the acceptance of germ theory in the 1870s, there were two viewpoints prevalent in western thought regarding the origin of infections and diseases. More than two thousand years ago, Greek philosophers had proposed the theory of spontaneous generation which asserted that living organisms could arise from non-living matter. Even though micro-organisms had been observed in the 1670s, it was thought, for example, that wound infections arose spontaneously rather than from contact with infectious material.

The miasma theory held that diseases were caused by inhaling foul-smelling poisonous vapours or gases in the air. These miasmas tended to be prevalent where there was rotting matter such as in swamps or in densely populated urban places which had poor sanitation. Miasmas matched the locations where diseases such as cholera occurred. Improved sanitation led to a reduction in outbreaks of disease, so observations supported the miasma theory.

However, belief in the miasma theory prevented medical practitioners from realising the true nature of infectious diseases for many years. It was only through intense debate and the work of people such as John Snow, Louis Pasteur and Joseph Lister that the miasma theory was finally refuted, and Western science accepted germs as the causative agent of disease and infection. Lister had hypothesised that the infections that killed up to 50% of surgical patients were due to germs entering the wound. He began washing his hands and sterilising his instruments and wound dressings with carbolic acid (now known as phenol) before operating on his patients. In the 1870s his antiseptic surgical methods were shown to work and became common practice.

These practices can be compared with those that European colonists of the late 18th and early 19th centuries observed when Aboriginal and Torres Strait Islander Peoples effectively treated skin

infections and serious physical injuries, such as spear wounds. These traditional practices for treating wounds and infections had been developed and used by Aboriginal and Torres Strait Islander Peoples over millennia – the knowledge being encoded and passed down through generations via example and oral history. For example, it has been recorded that Torres Strait Islander peoples have used coconut oil to treat wound infections. Aboriginal peoples of northern New South Wales were observed using the crushed leaves of the *Melaleuca alternifolia* (tea) tree as a poultice for wounds. The leaves were also brewed into a ‘tea’ for coughs, colds and throat infections.

Such treatments are part of the vast pharmacopeia of Aboriginal and Torres Strait Islander Peoples, and rely on rich and sophisticated scientific knowledge that predates the development of Western science’s germ theory. This knowledge was compiled through acute observation and testing and trialling plant and non-plant-based materials as medicines. The amassed knowledge included information about the location, optimal collection time, and methods for preparing medicinal materials.

It was not until the 1920s that Western science started to make careful analyses of the active components of the Aboriginal pharmacopeia, such as tea tree oil, and their medicinal properties. It was found that tea tree oil was about eleven times as strong as carbolic acid (phenol), the disinfectant of the day. These active components were also found to have antimicrobial, antifungal, antiviral and anti-inflammatory properties. Tea tree oil is now incorporated into many topical formulations to treat skin infections, and there is continued research, in collaboration with Aboriginal communities, into the therapeutic properties of their pharmacopeia. In addition, coconut oil has been found to contain numerous medicinal properties including antibacterial, antifungal, antiviral and antiparasitic activity.

By investigating examples of how Aboriginal and Torres Strait Islander peoples used and continue to use their pharmacopeia to treat wounds and skin infections, students gain a deeper knowledge of, and a greater appreciation for, the richness of the scientific knowledge held by Aboriginal and Torres Strait Islander peoples. The elaboration also provides students with further opportunities to investigate examples of how the broader scientific community is constantly seeking to review and refine scientific understanding.

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AC SHE192

Ancient evidence in cultural relics

CONTENT DESCRIPTION

Advances in scientific understanding often rely on technological advances and are often linked to scientific discoveries.

CONTENT ELABORATION FOR CCP (OI.5, OI.9)

- ▶ researching how technological advances in dating methods of Aboriginal Peoples' material culture are contributing to our understanding of the changing climatic conditions and human interaction with Australian megafauna



Modern dating methods provides evidence of Aboriginal interactions with megafauna

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

This elaboration describes opportunities for students to investigate how technological advances in archaeological dating techniques combined with evidence from the rich cultural heritage of Aboriginal peoples have shaped our understanding of the beginnings of human habitation in Australia and the interactions of First Australians with their environment. The ongoing debate regarding the respective roles of climate change and human agency in the extinction of the Australian megafauna sets the context for students to research some of Australia's most significant archaeological discoveries and the arguments that surround them. Students gain an understanding of some of the scientific principles underlying modern dating techniques. They also learn how cultural histories, petroglyphs and paintings provide evidence of Aboriginal peoples' knowledge of climatic changes and extinct animal species. Students are then able to examine how this evidence can be used to support or refute various points of view.

DETAIL

Some Aboriginal histories tell of a time when inland Australia was much more fertile and inhabited by giant animals. There are also many examples of rock paintings that depict long extinct animal species, such as a giant flightless bird painted on a rock shelter in Arnhem Land. Both histories and rock paintings provide evidence of the age-old knowledge held by Aboriginal peoples and of the long human presence in Australia. They continue to inform modern science of the different fauna and climatic conditions that once existed on the Australian continent.

Most scientists today tend to agree that the spread of early modern humans reached the Australian continent by at least 45,000 years ago. This understanding is based on numerous archaeological finds throughout Australia, arguably the most important one being the site of human remains at Lake Mungo in western New South Wales which has been dated to between 40,000 and 45,000 years using radiocarbon dating. Before the disinterment of human remains at Lake Mungo, most scientists estimated that humans had been living in Australia for perhaps 20,000 years. New discoveries, such as the most recent findings at the Madjedbebe rock shelter in the homelands of the Mirarr People in the Northern Territory, and advances in dating techniques, including refinements of radiocarbon dating and other methods based on radioactive decay, thermal and optical luminescence, and DNA analysis, now suggest even longer habitation of Australia by Aboriginal peoples going back about 65,000 years.

Scientists are also in agreement over the fact that numerous large animal species, including Diprotodon (a 'giant wombat'), Megalania (a giant monitor lizard), Thylacoleo (marsupial lion), Procoptodon (giant kangaroo) and Genyornis (a giant flightless bird), once existed on the Australian continent. However, a lively and ongoing scientific debate has developed over the question whether the disappearance of the megafauna from the archaeological record coincides with the arrival of

humans and, if so, whether there is a causal link between those events. Some scientists hypothesise that the hunting and/or fire-stick farming practices of First Australians may have driven these species to extinction. Others favour the hypothesis that changing climate conditions during this period were the primary cause for their disappearance.

By investigating the cultural, historical and archaeological evidence used in this debate and the various dating methods that underpin this evidence, students gain an insight into exciting and authentic current research. This elaboration provides opportunities for students to learn more about the rich histories and cultures of Aboriginal Peoples. It allows students to recognise how age-old knowledge about Australia's past environment, preserved and passed on through more than a thousand generations, can serve as a valuable source of data that informs contemporary science. Students also learn to appreciate how new scientific discoveries and technological advances shape and confirm understandings of the long histories and cultures of Aboriginal Peoples in Australia.

CROSS-STRAND LINKAGES

Year 10: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (ACSSU185)

Year 9: All matter is made of atoms that are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms (ACSSU177)

CONSULTED WORKS

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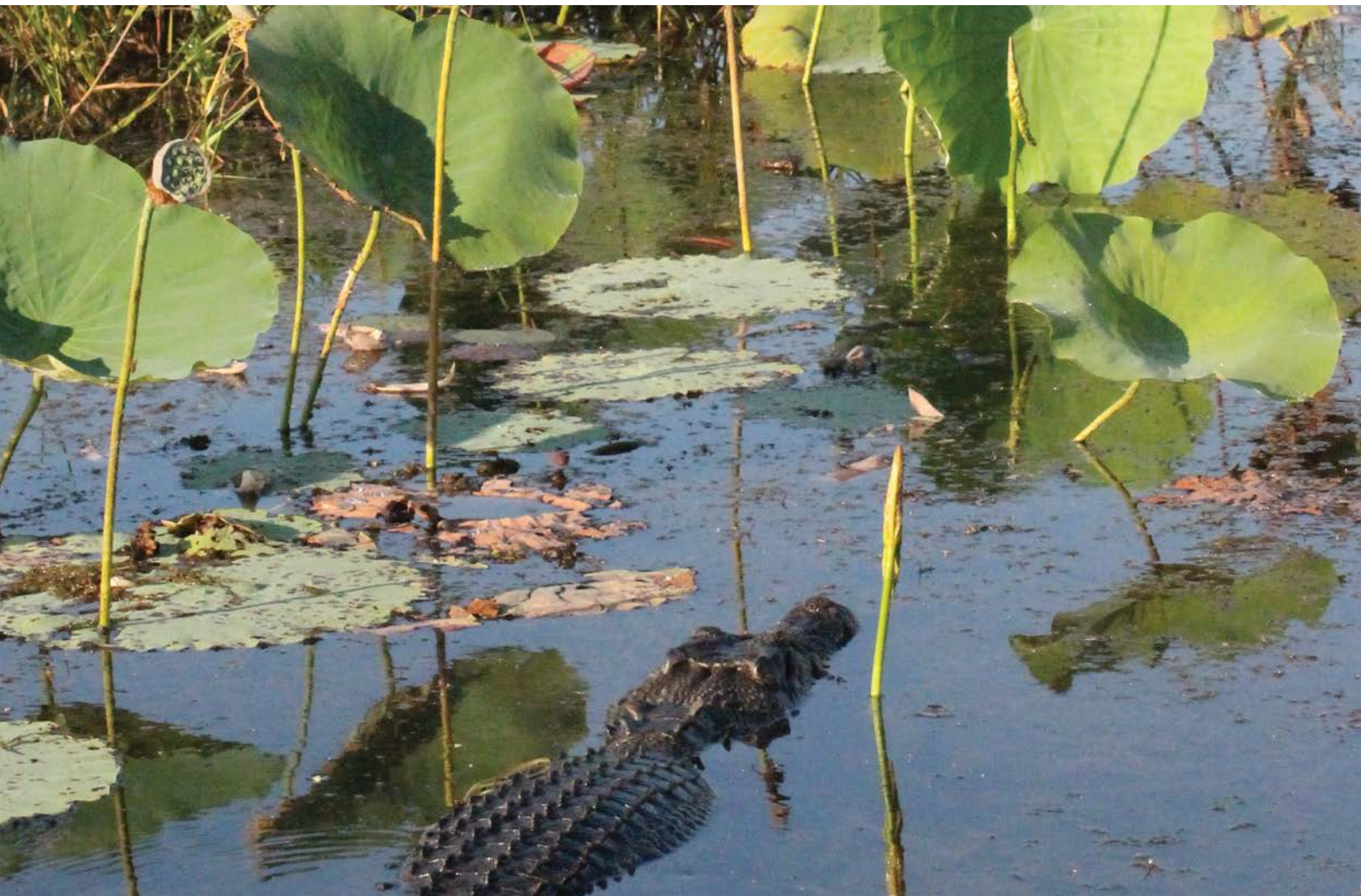
Restorative ecology through traditional ecological knowledge creating diverse career opportunities

CONTENT DESCRIPTION

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities.

CONTENT ELABORATION FOR CCP (OI.2, OI.5)

- ▶ considering how ecological sciences are recognising the efficacy of traditional ecological practices of Aboriginal and Torres Strait Islander Peoples and how restorative programs based on these practices are generating new career opportunities



Indigenous ranger groups use ecological knowledge to restore environments nationally

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

Aboriginal and Torres Strait Islander peoples possess in-depth traditional ecological knowledge (TEK) of Australian ecosystems. Such knowledge of the environment, with its critical relationships and fragility, has allowed Aboriginal and Torres Strait Islander Peoples to develop land-care practices that are conducted with a deep understanding of their impact. As technologies and data-collecting techniques develop, opportunities to demonstrate the efficacy of traditional ecological practices are emerging. For example, new scientific studies are monitoring the impact of traditional fire-management programs on greenhouse gas emissions. Furthermore, many land-care organisations are now utilising TEK in their regional land management programs which has led to new career opportunities for Aboriginal and Torres Strait Islander Peoples.

DETAIL

Over thousands of years Aboriginal and Torres Strait Islander Australian peoples have been living in close connection with their environment and have gained a deep understanding of the interdependence of plant, animal and human communities in these ecosystems. This rich body of traditional ecological knowledge (TEK) is expressed in a large variety of ‘caring for country’ practices, such as ‘firestick farming’ and sustainable harvesting practices. It rests on sophisticated knowledge from multiple scientific fields, such as meteorological knowledge for the timing of seasons and the judgement of moisture conditions; botanical knowledge to understand the life cycles of plants, how certain plant species respond to fire, and how tolerant they are of fire intensity; and, zoological knowledge to understand the population dynamics of certain targeted species and the species-specific knowledge underpinning sustainable harvesting practices.

European colonisation has led to the discontinuation of these traditional ecological practices in many regions of Australia. Combined with the negative environmental impacts of industrial activities and cattle farming, such as increased soil erosion or saltwater ingress into coastal wetland areas and the introduction of invasive plant and animal species, many ecosystems have experienced dramatic deterioration during past decades, usually accompanied by a significant loss of biodiversity.

Global efforts to counteract these negative impacts, which are felt in many sensitive ecosystems around the world, have sparked the emergence of ‘restoration ecology’ in the 1980s as a separate branch of the environmental sciences. TEK has been recognised as an invaluable contributor to scientific knowledge in this field. An ever increasing number of restoration projects in Australia are undertaken in collaboration with local Aboriginal and Torres Strait Islander communities and rely heavily on the knowledge and expertise of Aboriginal and Torres Strait Islander ranger groups. Such restoration projects include rescue efforts for threatened plant and animal species, reintroduction of locally extinct species, prevention of saltwater ingress into coastal wetland areas, eradication of invasive weeds, biological control of feral predators, wildfire management through the reestablishment

of traditional fire management regimes, habitat protection, monitoring of endangered bird populations, and many other environmental protection and restoration efforts.

By investigating restoration projects students gain an understanding of the scientific principles that govern the health of Australia's vital ecosystems and have opportunities to learn about and appreciate the sophisticated ecological knowledge held by Aboriginal and Torres Strait Islander peoples. Students learn how the collaboration of these two important knowledge bases generates new thinking and solutions to environmental challenges. As a result, new career opportunities are emerging in the field of restoration ecology.

CROSS-STRAND LINKAGES

Year 10: Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)

Year 9: Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

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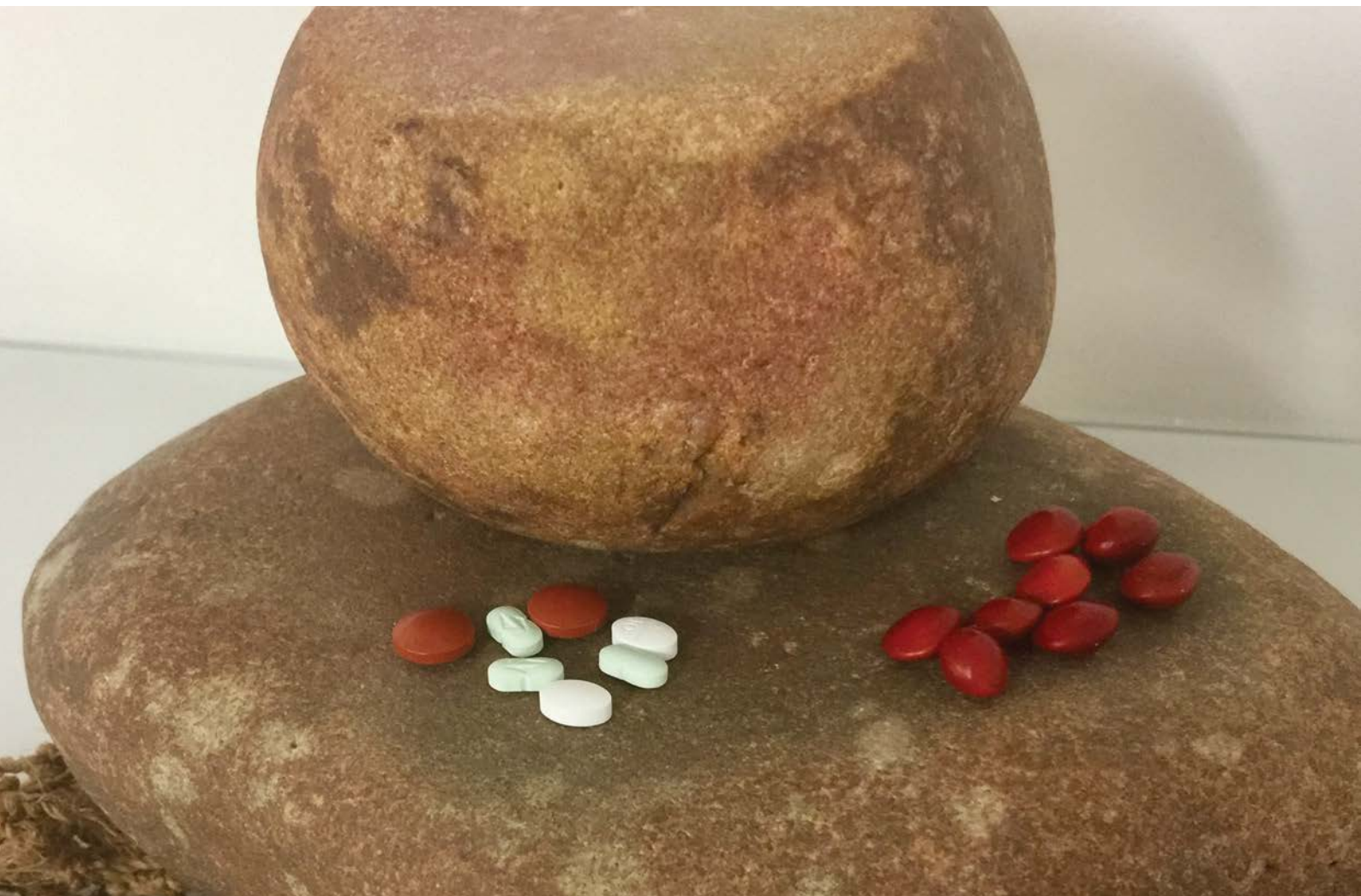
Need for new medicine focuses research on Aboriginal and Torres Strait Islander pharmacopeia

CONTENT DESCRIPTION

Values and needs of contemporary society can influence the focus of scientific research.

CONTENT ELABORATION FOR CCP (OI.5, OI.9)

- ▶ investigating how disease outbreaks and the emergence of drug-resistant infections have focused scientific research into Aboriginal and Torres Strait Islander Peoples' traditional medicines to identify effective therapeutic compounds for the use in pharmaceuticals



Increasing drug resistance focuses scientific research into traditional pharmacopoeia

CONNECTING THE ELABORATION AND CONTENT DESCRIPTION

Since Australia was colonised, Western science has looked to the pharmacopeia of Aboriginal and Torres Strait Islander peoples. The early Australian colonists were isolated far from their own homes and had little or no access to Western medicines or their own folk remedies. Although most colonists disparaged the health and well-being practices of Aboriginal and Torres Strait Islander people, it is widely accepted that many colonists did in fact develop ‘bush medicines’ based on observations of the use of traditional Aboriginal and Torres Strait Islander pharmacopeia. Fast forward to today and we can again see a need to investigate the active compounds in traditional pharmaceuticals.

Students gain awareness of the fact that contemporary society is continually facing outbreaks of increasingly virulent strains of diseases accompanied by the decreased effectiveness of some medicines. These global issues are having a major influence on the focus of scientific research into the development of new, efficacious medicines. Scientists, in collaboration with Aboriginal and Torres Strait Islander communities, continue to investigate the potential of traditional medicines as a source of novel pharmaceuticals for treating modern illnesses.

DETAIL

Evolution pressures and the extensive use of antibiotics by contemporary society have driven the emergence of highly virulent strains of diseases that are resistant to many medicines. Since the discovery of penicillin in 1928, and its subsequent use to treat infections, scientists have been searching for other new treatments and antimicrobial agents. There is now a growing awareness that Aboriginal and Torres Strait Islander peoples’ knowledge of medicinal plants can provide new medicines and/or lead to the discovery of new pharmaceuticals for treating infections.

Aboriginal and Torres Strait Islander people possess a vast amount of knowledge about traditional pharmaceuticals derived from myriad sources. These medicines have been, and continue to be developed over millennia through observation and experimentation and are passed down through generations via histories, songs, and rituals.

Some of this knowledge was incorporated into colonisers’ ‘bush remedies’, such as relieving aching joints by applying a poultice made from the creeper *Clematis microphylla*. Other examples of the early adoption of Aboriginal and Torres Strait Islander healing methods include the inhalation of eucalyptus oil (from *Eucalyptus* spp.) to relieve respiratory problems and throat infections, and the topical application of tea tree (*Melaleuca alternifolia*) for wounds and skin infections.

Prior to the Second World War, some drugs based on alkaloids were manufactured in Germany. One of these was hyoscine hydrobromide which was used as a sedative and to relieve motion sickness. When the war began, alternative sources of this chemical had to be found by the Allies. Australian researchers found it in the leaves of the corkwood tree (*Duboisia myoporoides*), a plant used by

Aboriginal and Torres Strait Islander peoples to relieve stomach pain and to stupefy fish in waterholes. After the war, commercial plantations of *Duboisia* were established to produce the raw materials for a pharmaceutical that is still widely used as a digestive tract muscle relaxant to treat stomach aches and intestinal problems.

The kangaroo apple, *Solanum laciniatum*, produces a fruit that has long been used by Aboriginal peoples, in poultices to treat swollen joints. Scientists have found that the fruit contains the steroid solasodine, which is an important precursor for producing cortisone and other steroids for use in oral contraceptives, and for the treatment of a range of illnesses, including asthma and arthritis.

Other recent studies of the Aboriginal pharmacopeia have found that the seeds of the Moreton Bay chestnut (*Castanospermum australe*) contain castanospermine, a chemical that may be useful in the treatment of cancer and inhibiting HIV. Antiviral activity has been found in the boiled roots of the Pale Flax-Lily (*Dianella longifolia*), used as a medicine to inhibit poliovirus Type 1, and the Crimson Turkey-bush (*Eremophila latrobei*), used for treating colds and the Ross River virus.

Further investigation into traditional medicines may identify other therapeutic compounds with the potential for commercialisation. By investigating the historical and contemporary interest in the rich pharmacopeia of Aboriginal and Torres Strait Islander peoples, students can appreciate the highly-developed medical knowledge held by Australia's First Peoples and their significant contributions to contemporary medical science.

CROSS-STRAND LINKAGES

Year 10: The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (ACSSU185)

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Science Inquiry Skills

New elaborations within the Science Inquiry Skills (SIS) strand provide contexts for the inquiry process and include reference to skills required to engage with Aboriginal and Torres Strait Islander Peoples when working scientifically. These intercultural science inquiry skills are throughout years 7-10 and provide opportunities for students to develop skills relating to:

- acknowledging the scientific knowledge and skills of Aboriginal and Torres Strait Islander Peoples
- consulting with Aboriginal and Torres Strait Islander communities in the planning or evaluation of scientific investigations
- collaborating with Aboriginal and Torres Strait Islander communities in mutually beneficial scientific research.

Unlike the Science Understanding (SU) and Science as a Human Endeavour (SHE) Teacher Background Information (TBI) materials the teacher background information for the new SIS elaborations provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures. Importantly, the Science Inquiry Skills TBI illustrates how concurrent SU and SHE topics can be used to contextualise the ways in which educators may provide skill development opportunities for the development of these skills.



Commercialisation of traditional knowledges is an important Australian ethical issue

AC SIS199

Collaborating in accordance with United Nations Declaration on the Rights of Indigenous Peoples and intellectual property rights

CONTENT DESCRIPTION

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods.

CONTENT ELABORATION FOR CCP

- ▶ collaborating with Aboriginal and Torres Strait Islander Peoples to explore the development of a commercial product based upon traditional ecological knowledge while addressing ethical issues

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Different types of chemical reactions are used to produce a range of products and can occur at different rates (ACSSU187)

A potential way to approach this content description is:

Students could explore the hands-on context of soap manufacturing. Soap is a product of a chemical reaction called saponification.

As part of the planning process of making a soap that contains Aboriginal or Torres Strait Islander pharmacopeia, students could read the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), especially Article 31, and discover Australia is a signatory. Students could plan to develop a commercial product (e.g. soap or anti-bacterial hand wash) based upon traditional medicinal knowledge (e.g. tea-tree oil). They could also establish research collaborations (actual or virtual) with Aboriginal or Torres Strait Islander communities and organisations. This activity provides students with the opportunity to learn about UNDRIP Article 31 and develop cultural capability skills as they relate to collaborating with First Nations peoples in the development of a commercial product.

AC SIS206

Acknowledging Aboriginal and Torres Strait Islander peoples have been misrepresented due to cultural bias

CONTENT DESCRIPTION

Critically analyse the validity of information in primary and secondary sources, and evaluate the approaches used to solve problems

CONTENT ELABORATION FOR CCP

- ▶ acknowledging the need to critically analyse scientific literature for potential cultural bias towards Aboriginal and Torres Strait Islander Peoples

DETAIL

This elaboration provides students with an opportunity to develop this core Science Inquiry Skill whilst addressing intercultural science inquiry skills relevant to Aboriginal and Torres Strait Islander Histories and Cultures within the context of the following content description(s) from the Science Understanding and/or Science as a Human Endeavour strand(s).

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE191)

A potential way to approach this content description is:

Students can review anthropological misinformation regarding Aboriginal and Torres Strait Islander peoples in historical scientific publications. Common theories students may encounter, now invalidated, are polygenism, eugenism and scientific Darwinism.

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