Unit outline for teachers

WithOnePlanet

> Module 1:
> Carbon

> Level:
> Years 9 to 10

> Section:
> Climate change. Creating critical thinkers … not sceptics!

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Years 9 to 10

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INQuIRY

WithOnePlanet
Open education
An xpand Foundation initiative

Australian Curriculum covered in this unit:

INQuIRY

Learning area		General capabilities		Cross-curriculum priorities	
	English	✓	Literacy		Aboriginal and Torres Strait Islander histories and cultures
	Mathematics	✓	Numeracy	✓	Asia and Australia's engagement with Asia
✓	Science	✓	Information and communication technology (ITC) competence	✓	Sustainability
	History	✓	Critical and creative thinking		
	Geography	✓	Social and personal competence		
		✓	Ethical behaviour		
		✓	Intercultural understanding		

Climate change. Creating critical thinkers … not sceptics!

A unit for Years 9 to 10

Unit outline for teachers

Introduction

Climate change – once it was just part of the science domain. But today, it is a political juggernaut! You can't use the term without someone feeling uncomfortable and changing the subject. But why? What is it about climate change that makes it a political hot potato? The ***Climate change – creating critical thinkers … not sceptics!*** unit is an ideal way to investigate the science of climate change and improve the scientific literacy of students in the classroom. It provides opportunities for students to investigate their misconception of climate change as both a scientific concept and a political issue, and, through discussion and debate, arrive at their own considered opinion about where they stand on this millennium's most contentious and pressing issue.

*'The **Climate change – creating critical thinkers … not sceptics!** unit is an ideal way to investigate the science of climate change and improve the scientific literacy of students in the classroom.'*

Units at a glance – INQuIRY teaching and learning model

The WithOnePlanet **INQuIRY** teaching and learning model provides problem-and challenge-based activities, designed to build sequential and experiential learning, practical skills and actions, critical thinking, knowledge and awareness about the impacts of climate change on plants, people and place in our region.

Inquiry model	Lesson sequence	At a glance
INQuIRY Introduce	Lesson 1 Carbon – a reactive element Students contribute their knowledge about common chemical reactions involving carbon.	To capture students' interest and find out what they think they know about common chemical reactions and processes involving carbon, the different molecular forms it can take, and the different global spheres it occupies (including the biosphere, hydrosphere, lithosphere and atmosphere).
INQuIRY Question	Lesson 2 A burning question about carbon Students develop an essential question about carbon.	To elicit students' questions about chemical reactions and processes involving carbon. To develop an essential question about carbon that students can investigate.
INQuIRY Investigate	Lesson 3 O carbon, carbon! wherefore art thou carbon? Activity: *Carbon – capture it, transport it, sequester it.* Students investigate carbon capture and storage (CCS) including ways to capture, transport and store carbon in underground geological locations. Activity: *Trees are carbon sinks.* Students investigate how trees perform as natural living carbon sinks. Activity: *CCS – the cutting edge of carbon.* Students investigate cutting edge CCS techniques and technologies.	To investigate ways to reduce the concentration of atmospheric carbon, including storage and sequestration.
	Lesson 4 Tip-toe through the greenhouse Students develop an understanding of ecological tipping points and how they work.	To investigate the nature and effects of ecological tipping points and the consequences of tipping points for climate change.

(continued)

Inquiry model	Lesson sequence	At a glance
INQuIRY **Investigate**	**Lesson 5** **The climate – don't change the subject!** Activity: *I can change your mind about climate.* Students analyse a variety of viewpoints – some scientific, some personal – about the issue of climate change. Activity: *Big feet, small footprints.* Students develop an understanding of what carbon footprints are, how to calculate them and how their own compare with other Asia-Pacific populations.	To provide students with hands-on, shared experiences of climate change as an issue, including the scientific facts, the misconceptions and misinformation surrounding it, and its predicted environmental, economic and social impacts. To provide students with the skills and tools to calculate their own carbon footprints and to take positive actions to reduce them. To support students to represent and explain their understanding of climate change, the issues surrounding it and the actions they can take to reduce their carbon footprints.
	Lesson 6 **Who wants to be a carbon farmer?** Students investigate carbon farming.	To support students to plan and conduct a problem-based learning investigation about the many possible impacts and outcomes of becoming a carbon farmer.
	Lesson 7 **Let's get back to carbon** Students review their progress with their essential question and determine if it has been answered.	To provide students with an opportunity to reflect on their progress with their essential question and determine whether or not it has been fully answered. To support students to conduct additional investigation and research in order to answer their essential question.
INQuIRY **Review**	**Lesson 8** **What's carbon got to do with it?** Students review their understanding of the unit.	To provide opportunities for students to represent what they know about carbon, its role in the carbon cycle and its impacts on the planet, and to reflect on their learning during the unit.
INQuIRY **Your future**	**Lesson 9** **Where to next?** Students decide on where to go next on their own carbon futures learning journey.	To provide opportunities for students to take their learning about carbon futures into a new cycle of inquiry in their own preferred direction.

WithOnePlanet Big questions about big ideas

The WithOnePlanet curriculum seeks to engage students in the big idea of carbon and its effects on their immediate environment and that of their neighbours in the Asia Pacific region. The WithOnePlanet *Carbon* curriculum is based on 5 big questions. These questions can be explored at all levels from Foundation to Year 10, with ever increasing complexity as students move through each unit.

The table below outlines these big questions and provides specific detail about how these ideas can be tackled in Years 9 and 10.

Big Ideas	What is carbon?	What is the carbon cycle?	What is climate change and what role does carbon play in it?	What is my carbon footprint and how can I reduce it?	What can be done to mitigate climate change on a regional scale?
Big ideas	At its core, carbon is a chemical element. Its physical and chemical properties make it the most essential element for life on Earth, and possibly the most versatile.	Carbon is essential for life and can be found in all Earth's spheres. There are many processes that allow carbon to be cycled through these spheres.	Carbon dioxide is a greenhouse gas. When carbon leaves the biosphere and lithosphere and enters the atmosphere and hydrosphere, it enhances the greenhouse effect. This is when the impacts of climate change become visible.	Every living thing is made of carbon and uses carbon in its various forms every day to survive and thrive. But humans have the capacity to determine how much carbon they use and to implement changes to reduce it.	The carbon emissions from everyday activities of Australians not only impact our own carbon footprints, but can have significant effects on others in our local region. Furthermore, as Australians we can not only influence our own carbon footprints, but, through positive actions, we can impact positively on the lives of our neighbours.
Years 9 to 10	Carbon is involved in many types of chemical reactions.	Carbon can be stored and sequestered, which reduces the concentration of atmospheric carbon.	Some of the consequences of climate change involve a tipping point. Once this tipping point is reached, the change is irreversible.	Through communication and interaction with family, friends and others in our local area, our collective carbon footprints can be reduced.	People in different countries in the Asia-Pacific region can collaborate to reduce the carbon footprint of the region.

Alignment with the Australian Curriculum: Science

This *Climate change – creating critical thinkers ... not sceptics!* unit embeds all three strands of the Australian Curriculum: Science. The table below lists sub-strands and their content for Years 9 and 10. This unit is designed to be taught in conjunction with other units at Years 9 and 10 to cover the full range of the Australian Curriculum: Science content.

For ease of assessment the table below outlines the sub-strands and their content aligned to lessons.

Strand	Sub-strand	Year level	Code	Years 9 to 10 content descriptions	Lesson
Science understanding	Biological sciences	9	ACSSU175	Multicellular organisms rely on coordinated and independent internal systems to respond to changes to their environment.	3
			ACSSU176	Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems.	6
		10	ACSSU184	The transmission of heritable characteristics from one generation to the next involves DNA and genes.	
			ACSSU185	The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence.	
	Chemical sciences	9	ACSSU177	All matter is made of atoms that are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms.	1
			ACSSU178	Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction, mass is not created or destroyed.	1, 3
			ACSSU179	Chemical reactions, including combustion and the reaction of acids, are important in both non-living and living systems and involve energy transfer.	3
		10	ACSSU186	The atomic structure and properties of elements are used to organise them in the Periodic Table.	
			ACSSU187	Different types of chemical reactions are used to produce a range of products and can occur at different rates.	1, 3
	Earth and space sciences	9	ACSSU180	The theory of plate tectonics explains global patterns of geological activity and continental movement.	
		10	ACSSU188	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.	
			ACSSU189	Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere.	1, 2, 3
	Physical sciences	9	ACSSU182	Forms of energy can be transferred in a variety of ways through different mediums.	
		10	ACSSU190	Energy conservation in a system can be explained by describing energy transfers and transformations.	

(continued)

Strand	Sub-strand	Year level	Code	Years 9 to 10 content descriptions	Lesson
Science as a human endeavour	Nature and development of science	9 & 10	ACSHE157	Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community.	4, 5
			ACSHE158	Advances in scientific understanding often rely on developments in technology, and technological advances are often linked to scientific discoveries.	3, 6
	Use and influence of science		ACSHE160	People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions.	3, 4, 5
			ACSHE161	Advances in science and emerging sciences and technologies can significantly affect people's livings, including generating new career opportunities.	3, 4, 5
			ACSHE228	The values and needs of contemporary society can influence the focus of scientific research.	3, 5, 6
Science inquiry skills	Questioning and predicting	9 & 10	ACSIS164	Formulate questions or hypotheses that can be investigated scientifically.	1, 2 ,3 ,6
	Planning and conducting		ACSIS165	Plan, select and use appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods.	1, 3, 4, 5, 6
			ACSIS166	Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data.	1, 3
	Processing and analysing data and information		ACSIS169	Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies.	3
			ACSIS170	Use knowledge of scientific concepts to draw conclusions that are consistent with the evidence.	1, 3, 4, 5, 6
	Evaluating		ACSIS171	Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data.	3
			ACSIS172	Critically analyse the validity of information in secondary sources and evaluate the approaches used to solve problems.	3, 4, 5, 6
	Communicating		ACSIS174	Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations.	1, 2, 3, 4, 5, 6

Alignment with Australian Curriculum: Science - Overarching Ideas

Overarching idea	Incorporation in *Climate change – creating critical thinkers ... not sceptics!*
Patterns, order and organisation	Students compare similarities and differences and identify patterns in: > the biosequestration of carbon in trees > carbon footprints from different individuals and cultures > various types of geosequestration > opinions about climate change of various individuals. Students organise their ideas and understanding in: > the analysis of experimental results > developing essential questions about carbon > the contribution of variables to environmental tipping points > planning a carbon farm.
Form and function	Students explore how their senses are used to gather information from their environment. They compare the growth of trees to their ability to store carbon.
Stability and change	Students discuss how: > the needs and desires of people and the planet can be both similar and different to one another at the same time > humanity's desire for constant improvement and progress can affect the stability of different elements of the carbon cycle.
Scale and measurement	Students compare the circumference of tree trunks with their ability to store carbon. Students determine the scale of carbon farming that is most appropriate given a range of variables
Matter and energy	Students investigate the absorption, storage and emission of carbon in different spheres of the carbon cycle, including the role of animals, plants and geological structures in moving carbon and energy through the cycle. Students investigate human manipulation of the carbon cycle to change the amount of matter and energy that is cycled through it.
Systems	Students investigate large-scale Earth systems including the Earth's climate, the carbon cycle. They also identify inputs and outputs necessary for the maintenance of stability in these systems.

Alignment with Australian Curriculum: Science - Curriculum focus

The Australian Curriculum: Science is described by year level, but provides advice across four year groupings on the nature of learners. Each year grouping has a relevant curriculum focus.

Curriculum focus Years 9 to 10	Incorporation in *Climate change – creating critical thinkers ... not sceptics!*
Explaining phenomena involving science and its applications.	The contemporary context of climate change is used to develop students' understanding of important scientific concepts such as how the idea of equilibrium is important in dynamic systems and how a change in one component of a system can affect all components of that system. Current research into climate change and its effects on living systems, including human populations, is used to motivate and engage students.

Alignment with Australian Curriculum: Science – Achievement standards

The achievement standards of the Australian Curriculum: Science indicate the quality of learning that students typically demonstrate by a particular point in their schooling, for example, at the end of a year level. These standards will be reviewed regularly by ACARA and are available on the ACARA website.

By the end of this unit, teachers will be able to make evidence-based judgments on whether the students are achieving below, at or above the Australian Curriculum: Science Years 9 and 10 achievement standards.

Alignment with Australian Curriculum: General capabilities

The skills, behaviours and attributes that students need to succeed in life and work in the 21st century have been identified in the Australian Curriculum as General capabilities. There are seven general capabilities and they are embedded throughout the science curriculum.

For further information go to :

ACARA 2012, General Capabilities in the Australian Curriculum, viewed 20 December 2013, <http://www.australiancurriculum.edu.au/GeneralCapabilities/Overview/General-capabilities-in-the-Australian-Curriculum>.

For examples of our unit-specific General capabilities information see the table below.

General capabilities	Australian curriculum description	*Climate change – creating critical thinkers ... not sceptics!* example
Literacy (continued)	By learning the literacy of science, students understand that language varies according to context and they increase their ability to use language flexibly. Scientific vocabulary is often technical and includes specific terms for concepts and features of the world, as well as terms that encapsulate an entire process in a single word, such as 'photosynthesis'. Students learn to understand that much scientific information is presented in the form of diagrams, flow charts, tables and graphs.	The literacy focuses are: > tables > articles in science journals and newspapers > websites > diagrams > maps > graphs > infographics

Numeracy	Many elements of numeracy are evident in the Science Curriculum, particularly in Science inquiry skills. These include practical measurement and the collection, representation and interpretation of data from investigations. Students are introduced to measurement, first using informal units then formal units. Later they consider issues of uncertainty and reliability in measurement. As students progress, they collect both qualitative and quantitative data, which is analysed and represented in graphical forms. Students learn data analysis skills, including identifying trends and patterns from numerical data and graphs. In later years, numeracy demands include the statistical analysis of data, including issues relating to accuracy, and linear mathematical relationships to calculate and predict values.	Students: > collect data in tables > represent and communicate data in tables, diagrams and graphs > interpret data in graphs, tables and diagrams.
Information and communication technology (ICT) competence	Students develop ICT capability when they research science concepts and applications, investigate scientific phenomena, and communicate their scientific understandings. In particular, they employ their ICT capability to access information; collect, analyse and represent data; model and interpret concepts and relationships; and communicate science ideas, processes and information. Digital technology can be used to represent scientific phenomena in ways that improve students' understanding of concepts, ideas and information. Digital aids such as animations and simulations provide opportunities to view phenomena and test predictions that cannot be investigated through practical experiments in the classroom and may enhance students' understanding and engagement with science.	Students: > use digital devices to record their ideas, responses to questions and data > use interactive resource technology to view, record and analyse information.

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Critical and creative thinking	In the science learning area, critical and creative thinking are embedded in the skills of posing questions, making predictions, speculating, solving problems through investigation, making evidence-based decisions, and analysing and evaluating evidence. Students develop understandings of concepts through active inquiry that involves planning and selecting appropriate information, and evaluating sources of information to formulate conclusions. Creative thinking enables the development of ideas that are new to the individual, and this is intrinsic to the development of scientific understanding. Scientific inquiry promotes critical and creative thinking by encouraging flexibility and open-mindedness as students speculate about their observations of the world. Students' conceptual understanding becomes more sophisticated as they actively acquire an increasingly scientific view of their world.	Students: > formulate, pose and respond to questions for inquiry > consider different ways of thinking about contemporary environmental issues > develop evidence-based opinions about environmental issues.
Personal and social competence	Students develop personal and social capability as they engage in science inquiry, learn how scientific knowledge informs and is applied in their daily lives, and explore how scientific debate provides a means of contributing to their communities. This includes developing skills in communication, initiative taking, goal setting, interacting with others and decision-making, and the capacity to work independently and collaboratively. The science learning area enhances personal and social capability by expanding students' capacity to question, solve problems, explore and display curiosity. Students use their scientific knowledge to make informed choices about issues that impact their lives such as health and nutrition and environmental change, and consider the application of science to meet a range of personal and social needs.	Students: > work collaboratively in teams > participate in discussions > follow directions to work safely > follow detailed instructions when completing practical and written tasks.

Ethical behaviour	Students develop the capacity to form and make ethical judgments in relation to experimental science, codes of practice, and the use of scientific information and science applications. They explore what integrity means in science, and explore and apply ethical guidelines in their investigations. They consider the implications of their investigations on others, the environment and living organisms. They use scientific information to evaluate claims and to inform ethical decisions about a range of social, environmental and personal issues, for example, land use or the treatment of animals.nd use or the treatment of animals.	Students: > ask questions respecting each other's points of view > consider their rights and responsibilities as a global citizens and as environmental stewards.
Intercultural understanding	There are opportunities in the science learning area to develop intercultural understanding. Students learn to appreciate the contribution that diverse cultural perspectives have made to the development, breadth and diversity of science knowledge and applications. Students become aware that the raising of some debates within culturally diverse groups requires cultural sensitivity. They recognise that increasingly scientists work in culturally diverse teams and engage with culturally diverse communities to address issues of international importance.	Students are given opportunities to: > compare their livelihoods with others in other cultures > investigate Important contributions made to science by people from a range of cultures > recognise the value of collaboration with peoples of different cultures in identifying and implementing solutions to global issues.

Alignment with Australian Curriculum: Cross-curriculum priorities

There are three cross-curriculum priorities identified by the Australian Curriculum:

> Aboriginal and Torres Strait Islander histories and cultures.
> Asia and Australia's engagement with Asia.
> Sustainability.

For each cross-curriculum priority, a set of organising ideas reflects the essential knowledge, understandings and skills for the priority. The organising ideas are embedded in the content descriptions and elaborations of each learning area as appropriate.

Aboriginal and Torres Strait Islander histories and cultures

Climate change – Creating critical thinkers ... not sceptics! primarily focuses on the Western science way of making evidence-based claims about things required for survival.

Indigenous cultures might have different explanations about the needs for survival, and they might prioritise their relative importance in different ways depending on their culture.

WithOnePlanet recommends working with indigenous community members to access contextualised, relevant indigenous perspectives (see table on next page).

Code	Organising ideas	Incorporation in *Climate change – creating critical thinkers ... not sceptics!*
Country/Place		
011	Australia has two distinct Indigenous groups, Aboriginal Peoples and Torres Strait Islander Peoples.	N/A
012	Aboriginal and Torres Strait Islander communities maintain a special connection to and responsibility for Country/Place throughout all of Australia.	N/A
013	Aboriginal and Torres Strait Islander Peoples have unique belief systems and are spiritually connected to the land, sea, sky and waterways.	N/A
Culture		
014	Aboriginal and Torres Strait Islander societies have many language groups.	N/A
015	Aboriginal and Torres Strait Islander Peoples' ways of life are uniquely expressed through ways of being, knowing, thinking and doing.	N/A
016	Aboriginal and Torres Strait Islander Peoples have lived in Australia for tens of thousands of years and experiences can be viewed through historical, social and political lenses.	N/A
People		
017	The broader Aboriginal and Torres Strait Islander societies encompass a diversity of nations across Australia.	N/A
018	Aboriginal and Torres Strait Islander Peoples have sophisticated family and kinship structures.	N/A
019	Australia acknowledges the significant contributions of Aboriginal and Torres Strait Islander peoples locally and globally.	N/A

Asia and Australia's engagement with Asia

Asia and Australia's engagement with Asia is a key component of the *Carbon* curriculum and is integrated into the curriculum throughout F to10.

The table below outlines the organising ideas for Asia and Australia's engagement with Asia and their content aligned to lessons.

Code	Organising ideas	Incorporation in *Climate change – creating critical thinkers ... not sceptics!*
Asia and its diversity		
011	The peoples and countries of Asia are diverse in ethnic background, traditions, cultures, belief systems and religions.	Students compare their ecological footprints with peoples of other cultures and discuss why they may be similar or different.
012	Interrelationships between humans and the diverse environments in Asia shape the region and have global implications.	Students discuss the differences and similarities in ecological footprints between different Asian environments.

Achievements and contributions of the peoples of Asia		
013	The peoples and countries of Asia have contributed and continue to contribute to world history and human endeavour.	Students investigate different data sets developed and collected by a range of different global scientific institutions.
Asia-Australia engagement		
015	Collaboration and engagement with the peoples of Asia support effective regional and global citizenship.	Students discuss the merits and the value of collaboration and engagement with the peoples of Asia in reducing global and regional greenhouse gas emissions, while improving quality of life, particularly of poorer Asian regions.
016	Australia is part of the Asia region and our histories from ancient times to the present are linked.	Students develop an understanding that the historical and future actions of Australia directly influence the ability of the Asian region to mitigate climate change and improve livelihoods.
017	Australians play a significant role in social, cultural, political and economic developments in the Asia region.	Students develop an understanding that the historical and future actions of Australia directly influence the ability of the Asian region to mitigate climate change and improve livelihoods.
018	Australians of Asian heritage have influenced Australia's history and continue to influence its dynamic culture and society.	Students investigate the impacts of energy-saving advertising campaigns on all Australians, including those that involve Australians of Asian heritage, and design new campaigns for Australians, including those of Asian heritage.

Sustainability

Sustainability is a key component of the *Carbon* curriculum and is integrated into the curriculum throughout F to 10. The table below outlines the organising ideas for Sustainability and their content aligned to lessons.

Code	Organising ideas	Incorporation in *Climate change – creating critial thinkers ... not sceptics!*
Systems		
011	The biosphere is a dynamic system providing conditions that sustain life on Earth.	The biosphere is an integral component of the carbon cycle and changes in the biosphere can directly impact on the movement of matter and energy throughout the carbon cycle.
012	All life forms, including human life, are connected through ecosystems on which they depend for their well-being and survival.	Carbon moves through ecosystems and the nature of this movement can affect the well-being and survival of all life forms.
013	Sustainable patterns of living rely on the interdependence of healthy social, economic and ecological systems.	The global nature of greenhouse gas emissions and climate change both highlights and necessitates the interdependence of social, economic and ecological systems.

World views		
014	World views that recognise the dependence of living things on healthy ecosystems, and value diversity and social justice, are essential for achieving sustainability.	World views on climate change highlight the diversity of opinion that currently exists and the importance of reliable data and evidence-based decision making in the quest for diversity, social justice and sustainability.
015	World views are formed by experiences at personal, local, national and global levels, and are linked to individual and community actions for sustainability.	World views on climate change can result from a range of different experiences and can impact on actions to reduce greenhouse gas emissions and change lifestyles.
Futures		
016	The sustainability of ecological, social and economic systems is achieved through informed individual and community action that values local and global equity and fairness across generations into the future.	Global equity and inequity are both highlighted in the levels of greenhouse gas emissions, their impacts and the actions of different regions in mitigating these impacts.
017	Actions for a more sustainable future reflect values of care, respect and responsibility, and require us to explore and understand environments.	Comparisons of carbon footprints between individuals and regions can be linked to differences and similarities between individual and regional environments. Reduction of carbon footprints and the impacts of climate change on regions are linked to the values mentioned.
018	Designing action for sustainability requires an evaluation of past practices, the assessment of scientific and technological developments, and balanced judgments based on projected future economic, social and environmental impacts.	Students design actions to reduce their personal ecofootprints, as well as mitigate the impacts of climate change on theirs, their school community's and other neighbouring regions.
019	Sustainable futures result from actions designed to preserve and/or restore the quality and uniqueness of environments.	Students design actions to reduce their personal ecofootprints, and the energy use of their school community, and compare the impact of these changes to peoples in neighbouring regions.

Key lesson outcomes

In the *Climate change – creating critical thinkers ... not sceptics!* unit, students develop more complex understandings of carbon as an element, a molecule (e.g. carbon dioxide), and a reactant in some common chemical reactions and processes. They continue to delve into the movement of carbon within the carbon cycle, identifying the different global spheres it occupies and the specific Earth processes allowing movement of carbon between them. These spheres and processes are understood in the context of both the normal and human-enhanced greenhouse effect, and the impact of increasing atmospheric carbon on life as we know it. Students are given the tools and an opportunity to refine their problem-solving skills in order to examine a climate change-based problem in a variety of contexts, including environmental, social, political and economic – and are challenged to arrive at a solution that ensures the short-term and long-term futures of us, as Australians, and our regional neighbours.

Teacher background information

Carbon chemistry, the carbon cycle and the enhanced greenhouse effect

Carbon, the sixth element on the Periodic Table of elements, has four valence electrons. Carbon can form covalent bonds with other non-metals, reacting to form many molecules, including glucose (a simple sugar) and carbon dioxide (a greenhouse gas).

The many different forms that carbon can take, both in terms of the composition of the covalent compounds it forms and in the range of states of matter that these compounds can occupy on the Earth, allows carbon to occupy all of Earth's spheres - the biosphere (as simple and complex sugars), the lithosphere (as minerals such as limestone, as well as natural resources such as coal and oil), the hydrosphere (dissolved in water to form aqueous hydrogen carbonate or carbonic acid), and the atmosphere (most commonly as carbon dioxide and methane gases).

The natural processes that enable the cycle of carbon through these spheres, such as photosynthesis, erosion and combustion, are subject to the influences of human activity. This can both increase and decrease the volume of carbon stored in the various spheres.

When the concentration of carbon stored in the atmosphere is artificially increased, through the human desire for improved living conditions and convenience, such as the increasing demand for electricity, air travel and household goods, the greenhouse effect becomes enhanced. This is what has become more colloquially known as climate change (or to a lesser extent, global warming).

The lifestyles of Australians are many and varied, often based not only on choice, but on necessity. The circumstances of each Australian, and in part, the choices they make, can influence their carbon footprint. A carbon footprint is one measure of the level of greenhouse gas emissions that an individual is responsible for through their daily practices and decisions. This carbon footprint can be equated to a specific number of planet Earths that would be required if all of Earth's citizens were to live like us. While most people in the Asia-Pacific region have a sustainable carbon footprint (and conversely a reduced life expectancy, among other conditions), the average carbon footprint of an Australian is not environmentally sustainable. Actions can be taken by an individual to reduce their carbon footprint and hence increase the environmental sustainability of their lifestyle. However, this can potentially come at a cost in terms of their economic and social prosperity. These factors need to be carefully considered and prioritised when changes are contemplated.

A vast range of actions can be taken to reduce carbon footprints. They can be more or less disruptive to an individual's habits and lifestyle, and they can have larger or smaller impacts on carbon footprints, and on the lifestyles and footprints of others. Actions can be practical, social, economic and political. An individual must make choices about the level of engagement they have with all these components, which will ultimately be based on their own set of values. Some individuals may choose to interact with others regarding climate change and actions to mitigate it, while others may choose not to.

Students' conceptions

Taking into account students' existing ideas is important in planning effective teaching approaches that help students learn science. Students develop their own ideas during their experiences in everyday life and might hold more than one idea about an event or phenomenon.

Students quickly link carbon with other elements and molecules, such as carbon dioxide, but less often with the stuff of everyday living objects, such as trees, people and geological structures. Many students do not connect elemental or molecular carbon (that is, carbon chemistry) to carbon in living and non-living structures on the Earth (or carbon in the biological and Earth sciences).

Students often find the concept of trees growing (adding biomass) by removing carbon from the air as a reactant in the process known as photosynthesis (rather than from the soil as they are wont to say intuitively), a difficult concept to consider and integrate with their existing basic understandings of how a plant grows (using sunlight, water and soil).

Students generally feel comfortable linking the greenhouse effect with climate change and/or global warming. However, it is quite common for students to have embedded misconceptions surrounding these terms. Students can often believe that the greenhouse effect is not necessary for life on Earth, but has only developed as a consequence of human activity. That the greenhouse is, in effect, the reason for life on Earth, and when enhanced, the reason for potential species extinction, is often an unfamiliar concept for students. In addition, it is very common to find that students are unable to distinguish the thinning (or 'hole') in the ozone layer from the greenhouse effect, and therefore it is worthwhile taking some time to clearly outline the similarities and differences between the two global issues of our current times.

When discussing the effects and impacts of climate change, students can mistakenly assume that 'global warming' means that the world will be a hotter place. While true on a general scale, the effects that are both happening now, and forecast for the future, are much more intricate and region-based. It is essential that students grasp the subtlety of this idea. One means to this end is to use the term climate change in preference to global warming.

Students bring a wide variety of attitudes and beliefs to the issue of climate change, its existence, and the role humans play, and should play, in its causes and solutions. Each student may already have a firm opinion on how much they are willing to engage in the science and politics of this issue, as well as how much, or little, they are prepared to do or feel they can do about its mitigation. This can be a very sensitive issue for some students, particularly in secondary school, as they grapple with their place in the family, their friendship groups and society at large. It is important to allow students to find the right path for their particular circumstances, by facilitating a sense of ownership and control over their beliefs and actions, and establishing the idea that all positive action, large or small, has value and potential to create positive change.

Safety

Learning to use materials and equipment safely is central to working scientifically. It is important, however, for teachers to review each lesson before teaching in order to identify and manage safety issues specific to a group of students.

The following guidelines will help minimise risks:

- Be aware of the school's policy on safety in the classroom and for excursions and lessons conducted in the outdoors.
- Check students' health records for allergies or other health issues.
- Be aware of potential dangers by trying out activities before students do them.
- Caution students about potential dangers before they begin an activity.
- Clean up spills immediately as slippery floors are dangerous.
- Instruct students never to taste, smell or eat anything unless they are given permission.
- Discuss and display a list of safe practices for science activities.

Carbon futures program

Out of the classroom and into the bush

Carbon futures is an engaging, inquiry-based program developed by WithOneSeed in association with the Royal Botanic Gardens, Melbourne.

The program is available as a field trip to the Royal Botanic Gardens, Cranbourne and Melbourne, yet most elements of this program can also be completed within a school setting. Specific elements of the *field trip* are embedded within the lessons of this unit.

Carbon futures aims to 'plant' seeds to enable Australian students to better understand their environment, the carbon cycle and their rights and responsibilities as citizens of the Asia-Pacific region.

The *Carbon futures* program takes students out of the classroom and into the bush to gain a practical look at carbon in the environment. Students will learn about how carbon works in different natural systems through ocean acidification experiments and measuring carbon in trees. Students will also discover the many other services a forest has to offer people anywhere on the planet. The program also aims to connect schools in Australia with subsistence school communities in Timor Leste, as part of WithOnePlanet's open education and WithOneSeed's community forestry initiatives.

Teachers can arrange a *Carbon futures field trip* through the Royal Botanic Gardens Education Program.

Primary school bookings: http://www.rbg.vic.gov.au/learn/programs/primary-cranbourne
http://www.rbg.vic.gov.au/learn/programs/primary-melbourne

Secondary schools bookings: http://www.rbg.vic.gov.au/learn/programs/secondary-cranbourne
http://www.rbg.vic.gov.au/learn/programs/secondary-melbourne

Carbon futures program info video – http://vimeo.com/51257037

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Royal Botanic Gardens Melbourne