Chapter 5: Global systems

Pages 111–138

Teacher notes

Introducing the chapter

The big idea of global systems is the main bridge between the four disciplines of science. Although it is listed under Earth and Space Sciences, it encompasses a wide range of knowledge from chemistry, biology and physics. The main link to the key concept is the idea that the Earth is subject to change and that human influence is a major part of that change. The range of time scales is also important here, linking to aspects of sustainability. The overarching idea of systems reaches possibly its most complex point with this content, which includes the carbon cycle and its obvious links to the science of climate change. This is a culmination of a wide range of ideas applied to a complex system (i.e. the spheres that coexist on or above the surface of the planet).

Teacher notes

5.1 The Earth’s spheres are balanced

Pages 112–115

Teaching tip: prior learning

Class discussion is a good opportunity to establish prior knowledge and any misconceptions. Common misconceptions include the following:

• The Earth is a static ‘complete’ entity and any changes are unusual and unpredictable.

• Rocks stay the same forever and are all the same age.

• The Earth is molten, except for its crust.

• The location of earthquakes is random.

• Continents don’t move.

• The biggest danger/effect of a volcano is the hot lava.

• Once something like water or carbon is used, it disappears/leaves the Earth.

• Weather and climate are the same.

• Ocean currents only affect marine life.

• The actions of humans don’t impact on the environment/Earth.

• Earth and its systems are too big to be affected by human actions.

• Earth is both an endless supply of resources and a limitless sink for the waste products of our society.

• Climate change is not human-induced and doesn’t have significant ramifications.

Teaching tip: visualisation

A significant amount of information is located within this unit and as such it should be treated with a view to make it as relatable as possible with real world examples and visualisation techniques.

Showing videos of world events and using student’s home lives is a good way to get them to understand concepts.

Teaching tip: videos

Videos about the atmosphere and its layers can be found through an Internet search.

Teaching tip: the Biosphere

Introduce students to Biosphere 2. This is a structure in Oracle, Arizona, USA, which was built to be an artificial, materially closed ecological system. It was designed to explore the interactions within life systems in a structure that included five areas based on natural biomes.

Students can conduct research into its design, function and purpose.

Additional activity: model the Earth’s atmosphere

Students can make a model of the four layers of Earth’s atmosphere that represents the characteristics of each layer. They should also describe the four layers of Earth’s atmosphere and the characteristics of each.

Additional activity: comparing atmospheres

Students could research atmospheres from other planets and compare them with Earth’s atmosphere, noting any differences or similarities. Information to include could be gases present, chemical composition of the atmosphere, temperature and density of the atmosphere. This activity could involve graphing or tabulating data, especially the composition of the atmospheres.

Additional activity: the cryosphere

Students could research to find out why the cryosphere is so important and how climate change will affect this sphere.

Additional activity: ICT

Scientists can’t always find answers to big questions by doing experiments. Often the risks are too great or the experimental method is outside the limits of current technology. Answers to problems like this can sometimes be found using computer simulations.

A computer simulation takes an established pattern and extends it to make a prediction about further events. A simulation is a type of model and, just like other models, it isn’t always accurate, but it is the best possible inference or answer to a big question that cannot be tested in any other way. Computer simulations can also be used for experiments that require a lot of repetition that would take a scientist a long time to complete manually, or to infer data about places we can’t go to, like other planets or below the crust of our own planet.

Scientists know that the Earth’s mantle is 2800 km thick and that the temperature near the point where the crust and mantle meet is approximately 500°C. Your job is to find out the temperature of the mantle at its deepest point: 2800 km below the Earth’s surface.

1 Enter the information from Table 3.1 into a spreadsheet program, like Microsoft Excel or similar.

2 Create a scatter graph of this information using the graphing function of the computer program. Make sure that temperature is on the y -axis and depth is on the x -axis.

3 Extend the data in the table until you reach a ‘Depth under mantle’ of 2800 km. Do this by using the ‘fill handle’ tool (select the cells in the Excel worksheet and click and drag the small square that appears in the lower right corner of the selection).

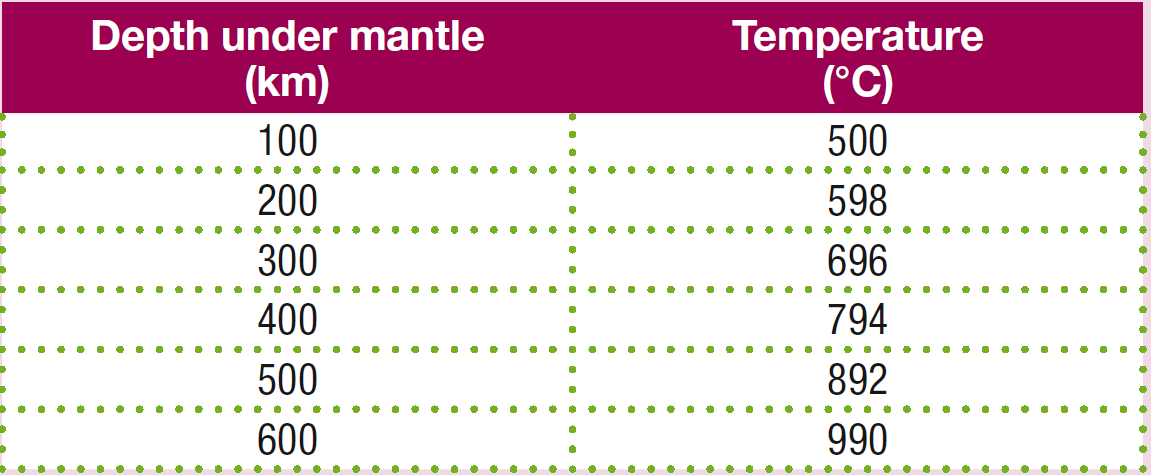
4 Update your graph to represent this new data.

• Does the temperature at a depth of 2800 km match the information you have read on this page? Explain why there is a variance.

• The process you have just followed only works for ‘linear’ data, which is data that increases or decreases at a constant level. Suggest another experiment you have conducted this year that you could have completed using this process.

• Similar modelling is conducted using data about weather and climate. What predictions would scientists want to make with regard to weather and climate? Why would these predictions be useful?

More complex computer simulations are also available to process much more complicated, or non-linear, data.



Students may need a reminder which is the x-axis and which is the y-axis in order to create the graph. A good way to help them remember this is that ‘y’ has a tail that extends down vertically and is, therefore, the vertical axis. Some students may need assistance using a spreadsheet program.

There is likely to be variance in the data because the simulation is using an established pattern to make predictions and assumptions about further events. As such, it isn’t always accurate but is the best inference for data that cannot be tested any other way.

Scientists model the weather and climate to help them predict patterns and changes in the future. For example, scientists have established that there has been a global increase in climate and are predicting this will continue. This has significant effects on conservation efforts and studies.

Going further:

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

Teacher notes

5.2 Matter cycles through the Earth’s spheres

Pages 116–119

Introducing the topic

Matter cycles through all of the Earth’s spheres constantly but at varying speeds depending on the processes involved. This section investigates the oxygen, nitrogen and phosphorus cycles, the key participants and processes within them as well as the impacts upon them.

The natural cycles on Earth are usually referred to as biogeochemical cycles. The term ‘biogeochemical’ implies that biological, geological and chemical factors are involved. Biogeochemical cycles are a pathway in which elements move through the biosphere, lithosphere, atmosphere and hydrosphere, and include the water, carbon, oxygen, nitrogen, and phosphorus cycles. All cycles are critical to sustain life as they essentially recycle the nutrient or element travelling though the cycle.

Additional activity: introduction to cycles on Earth

Ask students what they already know about the nutrients and elements that are cycled on Earth, how the cycles work and why these processes are important. This could be done as a class discussion, or in small groups.

Teaching tip: photosynthesis and cellular respiration

It may be beneficial for students’ understanding of the oxygen cycle to revisit photosynthesis and cellular respiration. The oxygen cycle is interlinked with the carbon cycle through cellular respiration and photosynthesis. Therefore, it is sometimes referred to as the carbon–oxygen cycle.

Photosynthesis is the process by which plants convert light energy (from the Sun) into chemical energy, and is vital for all aerobic life on Earth. In plants, photosynthesis uses carbon dioxide and water, and releases oxygen as a waste product. Photosynthesis helps maintain normal levels of oxygen in the atmosphere, and is the source of energy for almost all life on Earth, either directly through primary production or indirectly as a source of energy in food.

Cellular respiration occurs in all breathing organisms and is the process by which cells metabolise and process biochemical energy from nutrients and release waste products.

Additional activity: cycling nitrogen

In Australia, the use of nitrogen-based fertilisers has affected the productive capacity of Australian soils. Students could investigate why nitrogen-based fertilisers are used in agriculture and how this has altered soils and the nitrogen cycle in these areas.

Additional activity: cycling phosphorus

Phosphorus enters ecosystems mainly through the slow weathering of rocks and is dissolved in the soil, then absorbed by plants through their roots. Phosphorus passes through the food chain, eventually returning to the soil through the decomposition of dead matter and through the weathering of rocks. It forms part of nucleic acids and other molecules that control the flow of energy in cells, and is a component of cell membranes, bones and teeth. Because phosphorus exists mostly on land and in rock and soil minerals, it does not enter the atmosphere.

Human input into the phosphorus cycle comes mainly from the use of synthetic fertilisers, manure and outflows from sewage treatment plants. As plants cannot always use all the phosphorus added to the environment, much of it is lost through runoff and erosion, entering the waterways.

Students could investigate why phosphorus is so readily stored in rocks and why it takes a long time to erode/ weather these rocks. Alternatively they could suggest a solution to this time problems and propose ways that phosphorus could become more readily available and the disadvantages of doing this.

Going further:

A useful weblink animation is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

Teacher notes

5.3 The water cycle is a global cycle

Pages 120–123

Introducing the topic

The water cycle is essential to both plant and human life but is readily impacted upon due to sea ice melting, pollution increasing global temperatures causing severe weather patterns.

The sun powers the water cycle, with approximately 80% of global evaporation coming from the oceans. This reduces the ocean temperature, which, in turn, keeps the planet cooler. Water can change states (solid, liquid, gas) through the cycle; however, more water is ‘in storage’ for long periods of time than is actually moving through the cycle. The major storage basins for water are the oceans, and approximately 95% of water is estimated to be in these basins. Water is also a key component in the cycling of other biogeochemical cycles. For example, runoff is responsible for the transport of nutrients such as phosphorus and carbon.

Human activities can dramatically alter the water cycle through agriculture, deforestation, urbanisation, construction of dams, changes to the chemical composition of the atmosphere and industry.

Teaching tip: prior learning

Students have investigated the water cycle and the states of matter in Year 7 and 8 Science. As such they should have a good grasp of this concept and a pre-test should be conducted to ensure students do not become disinterested.

Additional activity: water providers and websites

Most water providers, such as Melbourne Water, have education programs, teacher resources and online/downloadable activities.

Additional activity: water cycle model: NASA precipitation education

A water cycle model experiment can be found on: <https://pmm.pps.eosdis.nasa.gov/education/videos/tour-water-cycle>. This website also includes background information, assessment ideas and observation questions.

Additional activity: water in my state

Have students undertake research to find the current water storage level of dams in their state. What does this mean? How do dams work? Have the water storage levels changed recently? Why/why not? Are there any water restrictions in place? Why/why not?

Additional activity: weather vs climate

It is important that students understand the difference between weather and climate. They need to understand that weather is the day-to-day changes in conditions, whereas climate is the average weather pattern. Discuss recent weather events in Australia (heatwaves, floods, cyclones), or around the world, including physical impacts, effects, responses, causes and aftermath.

Students should complete a visual representation of weather and one of climate and then complete a compare and contrast analysis.

Additional activity: making clouds

Materials

• a large jar or wide-necked bottle

• a large round balloon

• rubber bands

• water

• matches

Method

1 Cut the balloon to make a piece to fit over the top of the jar.

2 Pour 2 cm of water into the bottom of the jar and cover with the balloon.

3 Light a match and, while it burns, ask a partner to uncover the jar.

4 Flick out the match and, while it is still smoking, lower it into the jar. Quickly cover the jar so that some smoke is trapped inside.

5 Fasten the balloon covering with rubber bands. Press down on the balloon cover, holding it for approximately five seconds then pull it up fast and hard. Droplets should form inside the jar. (The droplets can better be seen in a darkened room with torchlight.)

Discussion

Can you explain how the cloud forms? What happens when you depress the balloon cover? What is the significance of the smoke?

Additional activity: cyclone/ hurricane investigation

Students could research the number of cyclones/hurricanes that have occurred this year and where they occurred. This could be compared to the same data for 10, 15 and 20 years ago.

Going further:

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

Teacher notes

5.4 Human activity affects the carbon cycle

Pages 124–125

Introducing the topic

This section explores the carbon cycle, its various inputs and outputs and the effect that human beings have on, not only the cycle itself, but the speed at which it occurs.

This cycle is also referred to as the carbon–oxygen cycle. All living things are made of carbon, and the cycle is driven largely by the biota. Carbon exists in the atmosphere primarily as the gas carbon dioxide, and although it is a small percentage of the atmosphere, it plays a vital role in supporting life. It is dependent on the capacity of plants to photosynthesise, thereby absorbing carbon dioxide from the air and incorporating the carbon into glucose, starch and other substances. The carbon moves up the food chain when animals eat the plants and are in turn eaten by other animals. At each stage, some carbon is released back into the cycle as carbon dioxide through respiration.

Students should understand that some parts of the carbon cycle happen in milliseconds whereas others can take millions of years to have an effect.

Teaching tip: prior learning

As with the water cycle, students should be familiar with the various factors which impact upon the carbon cycle, but not necessarily the specifics, speeds or terminology. As such they should have a good grasp of this concept and a pre-test should be conducted to ensure students do not become disinterested.

It may be useful to start by ensuring that students know what carbon is, why it’s important and how it behaves. To help students explore this, ask questions such as ‘How is it that the carbon on this planet has not been completely consumed?’, ‘How do living things use carbon?’ and ‘What are the physical and chemical properties of carbon and some of its compounds both within and outside of living things?’.

Use the photosynthesis and respiration equations to explain the relationship between the two.

Additional activity: role play carbon cycle

Students could role-play the carbon cycle to help them gain a better understanding of the process. This could be done as a whole class activity or in small groups. Students should provide information about their part of the cycle.

Additional activity: information posters

Students can create information posters based on the carbon cycle which outline the ways in which humans are having a negative impact and the changes that can be conducted to reduce this impact.

Additional activity: research

Students can research alternative energy sources to fossil fuels and present a detailed analysis/ comparison which outlines the process involved in creating/manufacturing the alternative energy as well as the process of a selected fossil fuel.

Going further:

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

Teacher notes

5.5 Evidence supports enhanced global warming

Pages 126–129

Introducing the topic

The data that is used to provide evidence for climate change is numerous and very diverse. People often become lost in the amount of data presented and the mis-interpretation of data can lead to serious misconceptions and often inaccurate opinions.

Teaching tip: prior learning

As this topic garners a great deal of media coverage, students will have some familiarity but many misconceptions. Try an introductory activity or set of questions to determine student misconceptions (such as the greenhouse effect is entirely the fault of humans, and so on).

Teaching tip: data interpretation

Assign groups of students a piece of data on climate change and ask them to interpret this and make conclusions which they can present to the class. These can be from the student book or from internet sources.

Additional activity: debate

Split students into two groups and have them argue on the sides of climate change deniers and climate change acceptors. It is best if you do not tell students which side they will argue for until the actual day to ensure students have all the facts, otherwise they will only research one side of the debate.

Additional activity: the cool Australia website

This website has numerous activities based on climate change which can be used as an activity or assessment. All activities come with up-to-date worksheets and are based on real world concerns, issues and data.

Going further:

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

Cool Australia: <http://www.coolaustralia.org/climate-change/>

Teacher notes

5.6 Enhanced global warming has widespread effects

Pages 130–133

Introducing the topic

The effects of global warming are world-wide and becoming more and more obvious. It is essential that students understand why these events occur and that every individual has a role to play in incorporating practices into their live which improves this situation on a global scale.

Additional activity: deep ocean currents and climate control

Thermohaline circulation is the term used to describe large-scale ocean circulation that is driven by the density and temperature of sea water. It is also referred to as the ocean conveyor belt, the great ocean conveyor, or the global conveyor belt.

Students could research thermohaline circulation, ocean currents, the oceans involved and the effect on climate these currents have.

Additional activity: movies

Depending on time constraints within your classroom, there are many movies available which demonstrate the impact of global warming on the globe. Some examples include:

• The Day after Tomorrow: This may start a discussion of the importance of ocean currents in climate control.

• Before The Flood (most recent) – National Geographic and Leonardo DiCaprio: This may start a discussion of the impact that climate change has had on the shape of our Earth as well as the severity of weather patterns.

Additional activity: ‘The Weather Makers’ by Tim Flannery

Have a discussion with your class’s English teacher and determine whether they can put this book in their reading list. It provides a fantastic summary of the history and future impact of climate change and is a great starting point for discussion and debate.

Additional activity: climate change effects poster

Students could create a poster or brochure telling people the effects of climate change, and suggesting ways in which people can reduce their impact on the environment and help reduce climate change.

Additional activity: research increased global temperature

Have students research and pose possible answers to the following questions.

• What effect will this rise in temperature have on the Australian climate and environment?

• How does this affect the people and the land (emotionally, economically and in quality of life)?

Additional activity: the effect of climate change on biodiversity

Students choose an Australian animal whose survival is at jeopardy due to changes in climate/ weather conditions. They can identify why the animal is at risk, where they live, the weather patterns of that location, whether any policies or conservation efforts are in place for the animal, what will happen to the animal if current weather patterns continue and what can be done to help it.

Additional activity: health and disease investigation

Students could look at the World Health Organization data and compare health and disease in a number of different countries. Ask students whether there is a connection between area of the world and statistics. As an extension, students could investigate one of the health/disease concerns they have analysed and prepare a report discussing the disease, any eradication/prevention programs and any relevant data.

Additional activity: decreasing water supplies investigation

Students are likely to understand the importance of water and conservation efforts in Australia; however, a discussion about this is likely to improve understanding. Students could investigate the water levels in their local reservoirs, and those around the country. Is there an area where reservoirs are lower/higher than the rest of the country? Students could also look at what different states are doing to help conserve water – for example, Murray–Darling Basin Authority, policies, restrictions, and campaigns.

Going further:

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

Teacher notes

5.7 Humans can reduce global warming

pages 134–135

Introducing the topic

This is an essential end to the chapter as it ties all of the prior learning of 5.1 – 5.6 and asks students to answer the difficult questions of ‘Where to next?’ and ‘What can I do?’.

Students determine how they can reduce global warming and determine that even the smallest of changes can have a large impact.

Additional activity: brainstorming

Determine what strategies students are currently aware of and incorporate into their own lives as a gauge of prior knowledge. Students should list these strategies and discuss whether they need to occur on a personal, community, city, state, national, government or international scale. They can also discuss whether if these strategies are not being utilised, why aren’t they?

Additional activity: the ‘Rising Giants’ debate

Students should be provided with research time prior to the debate. Split students into two groups and have them argue on the affirmative and negative side of “Carbon trading and ‘avoided deforestation’ have become popular ways to offset carbon emissions and environmental impacts”. It is best if you do not tell students which side they will argue for until the actual day to ensure students have all the facts, otherwise they will only research one side of the debate.

This also gives students experience in persuasive writing and speaking.

Additional activity: movies

Depending on time constraints within your classroom, there are many movies available which demonstrate the impact of global warming on the globe. Some examples include:

• *An Inconvenient Truth* looks at climate change, the science behind it and the importance of considering and reducing the impacts of climate change.

• *Climate of Change* follows everyday people around the world who are making a difference in reducing the impact of global warming.

Additional activity: human impacts on the environment

Ask students to provide other examples of human impacts on the environment. Students should identify what type of impact it is (positive or negative) and how wide-ranging this impact could be (local/global).

Additional activity: research

Students could investigate the types of activities that contribute to carbon dioxide emissions in different countries around the world, and why different countries have significantly different emission levels. Ask students why no data are available for some countries, and have them predict what their emissions may be if we did have data, providing reasons for their answer.

Additional activity: effects of climate change

Ask students to investigate the effects of each of the changes happening to the Earth and its climate (or choose one/a couple). This could include providing examples of current world events that could be attributed to these changes. Some examples could include the flooding in Australia and hurricanes/cyclones/tornadoes (especially in the USA).

Additional activity: graphing exercise

Students could graph the global temperature over the past 13 years, or find a graph that demonstrates that 12 of the past 13 years have been the hottest ever recorded.

Going further:

Many useful weblinks are available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.