MACMILLAN WALL CHARTS

AGES 10+

Climate Change

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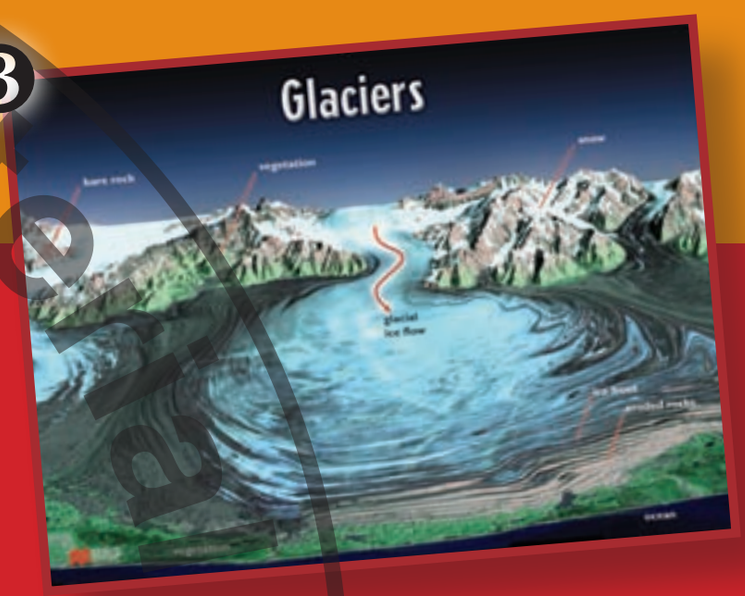

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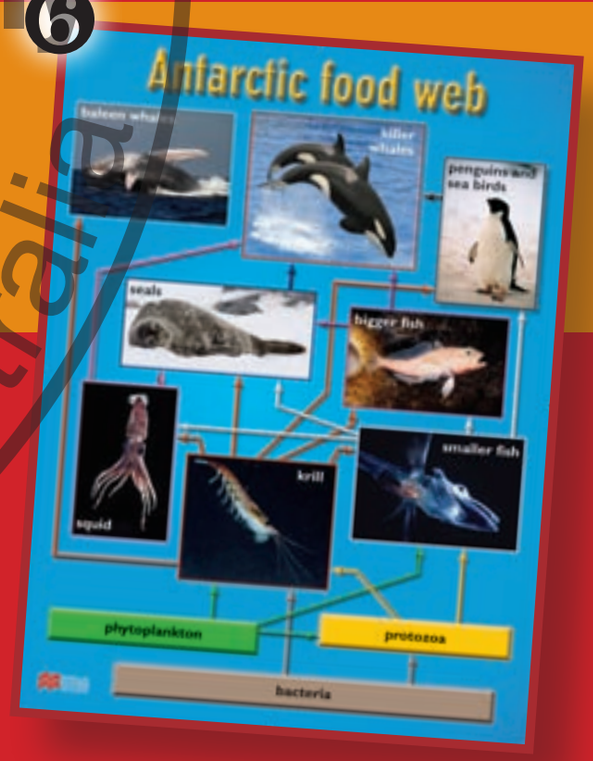

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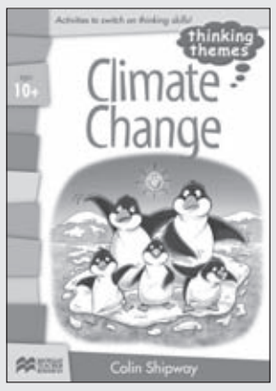

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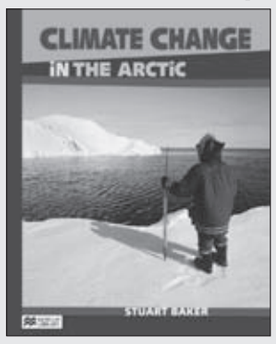

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Hints for using *Macmillan Wall Charts: Climate Change* in the classroom

The purpose of this wall chart series is to support teaching and learning about climate change. The charts can be used:

- to provide information about climate change topics
- to stimulate discussion and thinking
- to stimulate further investigation
- to illustrate particular concepts regarding climate change
- to demonstrate ways that factual information can be presented in forms such as food chains and maps
- with pairs of students, groups of students, or the class as a whole
- as a permanent display in the classroom or for student reference when appropriate.

Teaching Ideas

Teachers can use the charts to introduce a climate change topic or concept.

Display each chart and read the background information to students. Discuss the concepts represented then use the questions included on the back of each chart to stimulate discussion. This will assist you in finding out what students already know and understand about the concepts covered.

The questions provided could also be allocated to pairs or groups of students for further research. Students can report their findings back to the class and can create their own written and spoken text types:

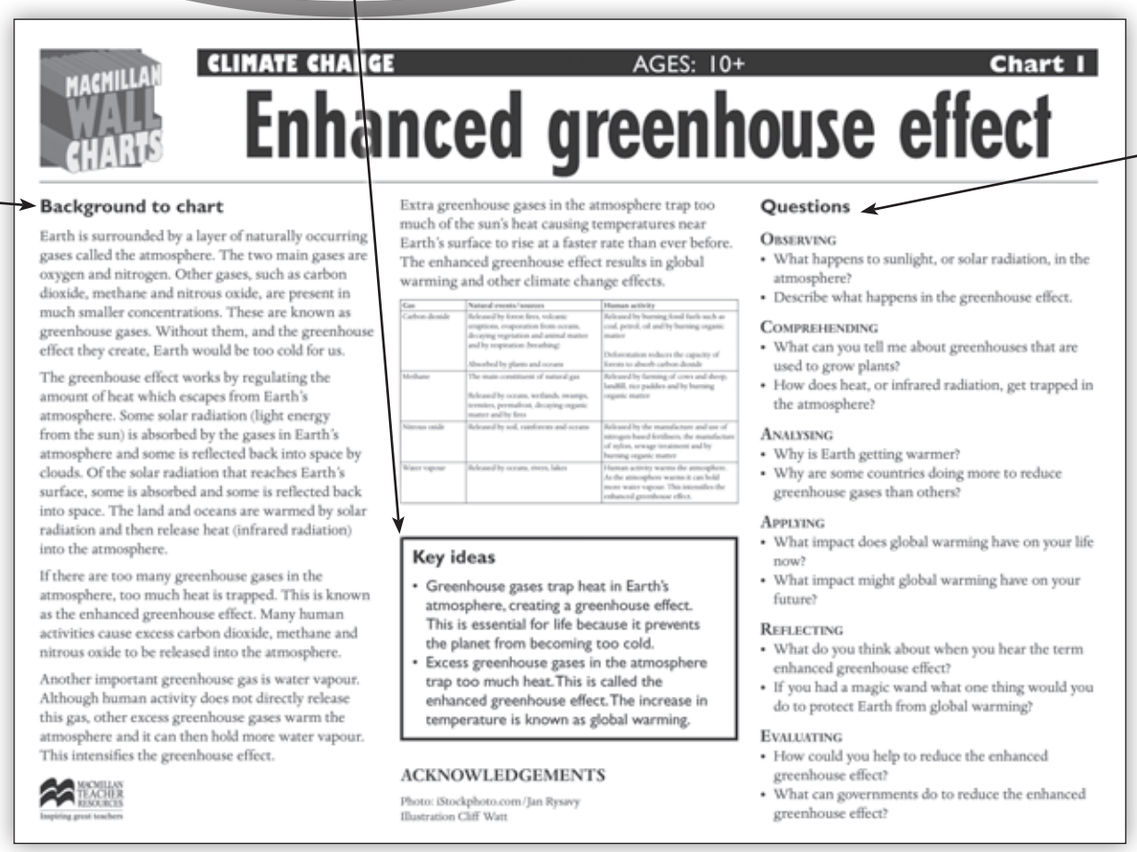
Written

- factual reports
- scientific reports
- explanations
- newspaper articles
- newspaper editorials, advertising, letters to the editor
- procedures (rules, directions, instructions)

Spoken

- role play and dramatisations
- speeches
- campaigns and advertisements
- debates
- lectures
- PowerPoint presentations
- discussions
- explanations

After further research revisit the charts for additional discussion which should now demonstrate a greater depth of understanding and reflection.



Key ideas—provides a few brief statements that sum up the key ideas covered by the images.

Background to chart—gives a brief description of each image on the Wall Chart, plus any relevant information.

Questions—lists questions for you to ask students. The questions are designed to support and facilitate the following thinking skills:

- Observing
- Comprehending
- Analysing
- Applying
- Reflecting
- Evaluating.

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Teaching notes by Colin Shipway
Publisher: Sharon Dalgleish
Project Editor: Claire Linsdell
Design: Cliff Watt

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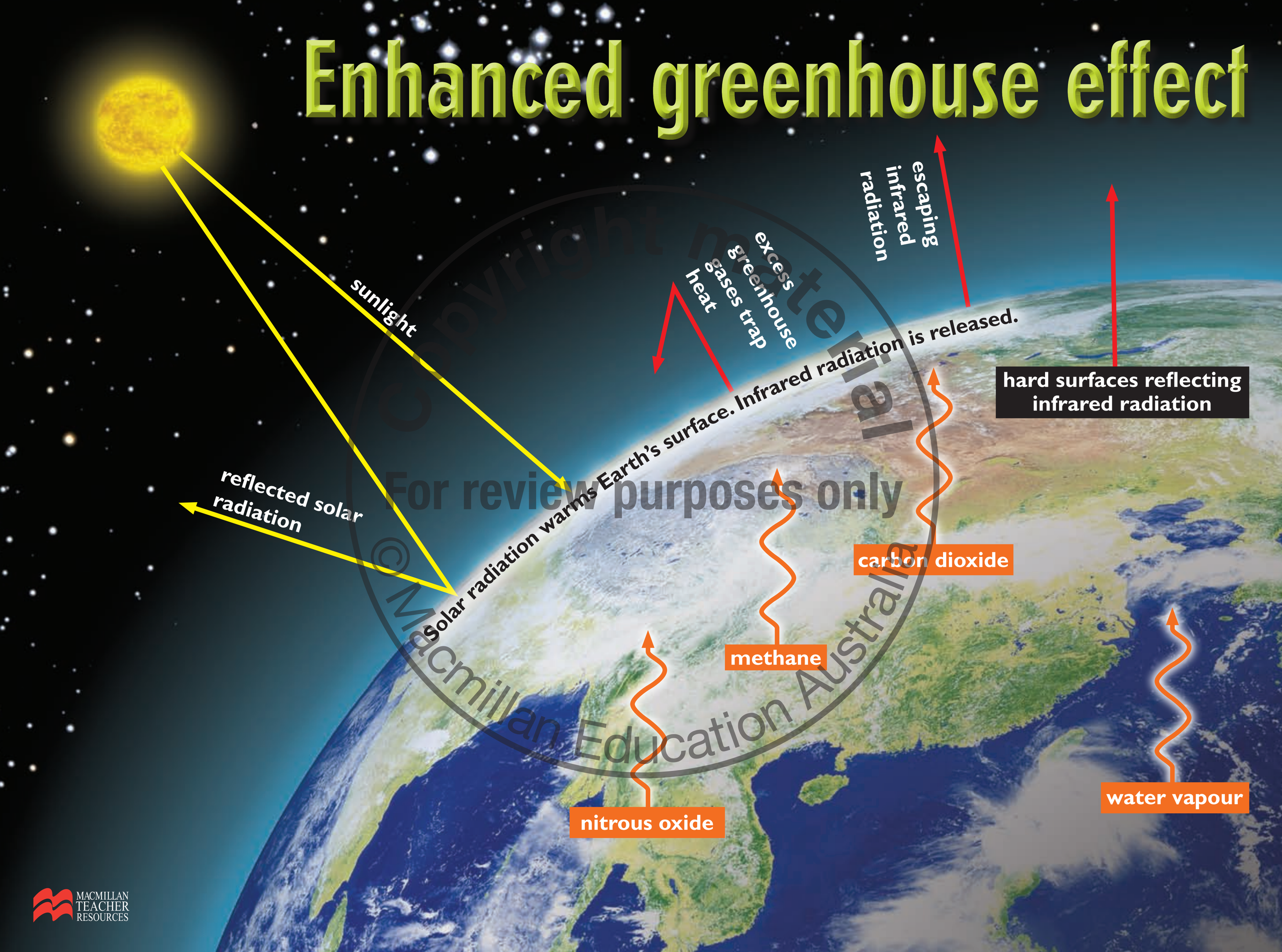
Enhanced greenhouse effect



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Enhanced greenhouse effect

Background to chart

Earth is surrounded by a layer of naturally occurring gases called the atmosphere. The two main gases are oxygen and nitrogen. Other gases, such as carbon dioxide, methane and nitrous oxide, are present in much smaller concentrations. These are known as greenhouse gases. Without them, and the greenhouse effect they create, Earth would be too cold for us.

The greenhouse effect works by regulating the amount of heat which escapes from Earth's atmosphere. Some solar radiation (light energy from the sun) is absorbed by the gases in Earth's atmosphere and some is reflected back into space by clouds. Of the solar radiation that reaches Earth's surface, some is absorbed and some is reflected back into space. The land and oceans are warmed by solar radiation and then release heat (infrared radiation) into the atmosphere.

If there are too many greenhouse gases in the atmosphere, too much heat is trapped. This is known as the enhanced greenhouse effect. Many human activities cause excess carbon dioxide, methane and nitrous oxide to be released into the atmosphere.

Another important greenhouse gas is water vapour. Although human activity does not directly release this gas, other excess greenhouse gases warm the atmosphere and it can then hold more water vapour. This intensifies the greenhouse effect.

Extra greenhouse gases in the atmosphere trap too much of the sun's heat causing temperatures near Earth's surface to rise at a faster rate than ever before. The enhanced greenhouse effect results in global warming and other climate change effects.

Gas	Natural events/sources	Human activity
Carbon dioxide	Released by forest fires, volcanic eruptions, evaporation from oceans, decaying vegetation and animal matter and by respiration (breathing) Absorbed by plants and oceans	Released by burning fossil fuels such as coal, petrol, oil and by burning organic matter Deforestation reduces the capacity of forests to absorb carbon dioxide
Methane	The main constituent of natural gas Released by oceans, wetlands, swamps, termites, permafrost, decaying organic matter and by fires	Released by farming of cows and sheep, landfill, rice paddies and by burning organic matter
Nitrous oxide	Released by soil, rainforests and oceans	Released by the manufacture and use of nitrogen-based fertilisers, the manufacture of nylon, sewage treatment and by burning organic matter
Water vapour	Released by oceans, rivers, lakes	Human activity warms the atmosphere. As the atmosphere warms it can hold more water vapour. This intensifies the enhanced greenhouse effect.

Key ideas

- Greenhouse gases trap heat in Earth's atmosphere, creating a greenhouse effect. This is essential for life because it prevents the planet from becoming too cold.
- Excess greenhouse gases in the atmosphere trap too much heat. This is called the enhanced greenhouse effect. The increase in temperature is known as global warming.

ACKNOWLEDGEMENTS

Photo: iStockphoto.com/Jan Rysavy
Illustration Cliff Watt

Questions

Observing
- What happens to sunlight, or solar radiation, in the atmosphere?
- Describe what happens in the greenhouse effect.

Comprehending
- What can you tell me about greenhouses that are used to grow plants?
- How does heat, or infrared radiation, get trapped in the atmosphere?

Analysing
- Why is Earth getting warmer?
- Why are some countries doing more to reduce greenhouse gases than others?

Applying
- What impact does global warming have on your life now?
- What impact might global warming have on your future?

Reflecting
- What do you think about when you hear the term enhanced greenhouse effect?
- If you had a magic wand what one thing would you do to protect Earth from global warming?

Evaluating
- How could you help to reduce the enhanced greenhouse effect?
- What can governments do to reduce the enhanced greenhouse effect?

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Future energy

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Future energy

Background to chart

This chart shows a chimney from a coal-fired power station. (Most electricity used today is created in similar stations.) It also shows sources of energy for the future: solar panels, wind turbines, sugar cane and biofuel.

Fossil fuels are found within the top layer of Earth's crust. They include coal, natural gas and oil (petrol). Fossil fuels have formed over millions of years from the remains of dead plants and animals which have been subjected to heat and pressure in Earth's crust. Once used, fossil fuel cannot be replaced for hundreds of millions of years. For this reason it is called a non-renewable resource. Burning fossil fuel releases huge amounts of carbon dioxide into the atmosphere. This contributes to global warming.

Energy supplied by natural resources such as the wind, rain, sunlight and geothermal heat is called renewable energy. Wind and hydro-electric turbines harness the energy of the wind and falling water without releasing greenhouse gases. Solar panels convert the energy of sunlight into electrical energy. This is called the photovoltaic effect, a word derived from the Greek *phos* meaning light, and the name of the Italian physicist Alessandro Volta.

Another source of energy for business and households is biofuel. This renewable energy can be created from agricultural, human and livestock waste, from garden and household waste, and from plants. It can be stored and controlled and it releases less carbon dioxide than fossil fuels. Biofuel can be used to make electricity, and biofuel made from sugar cane or corn can be used to power motor vehicles.

Key ideas

- Energy is either renewable (for example, solar, wind, biofuel) or non-renewable (the fossil fuels: coal, oil and natural gas).
- Energy can be clean (solar, wind) or can produce greenhouse gases (biofuel, fossil fuels).
- Biofuel is a renewable energy which releases less carbon dioxide than fossil fuels.

Questions

Observing

- Name the types or sources of energy you use in or around your home.
- What energy sources does the school use and what is it used for?

Comprehending

- Name as many renewable energy sources as you can.
- Explain why using renewable energy is a good idea.

Analysing

- What is the difference between the four energy sources shown on the chart?
- Which existing energy source in your life is the most important to you and why?

Applying

- Which renewable energy source could you use at home and how?
- What can you do at home to reduce the release of greenhouse gases?

Reflecting

- How would you feel if you had to live next door to a factory that burned fossil fuel 24 hours a day?
- How might you convince a business to switch from non-renewable energy to renewable energy?

Evaluating

- What might be the advantages and disadvantages of wind turbines?
- What factors do you think stop people and companies from switching to renewable energy?

ACKNOWLEDGEMENTS

Fossil fuel: iStockphoto.com / Manfred Steinbach
Wind turbines: iStockphoto.com / José Luis Gutiérrez
Solar panels: iStockphoto.com / Peter Eckhardt
Sugar cane: iStockphoto.com / Hywit Dimyadi

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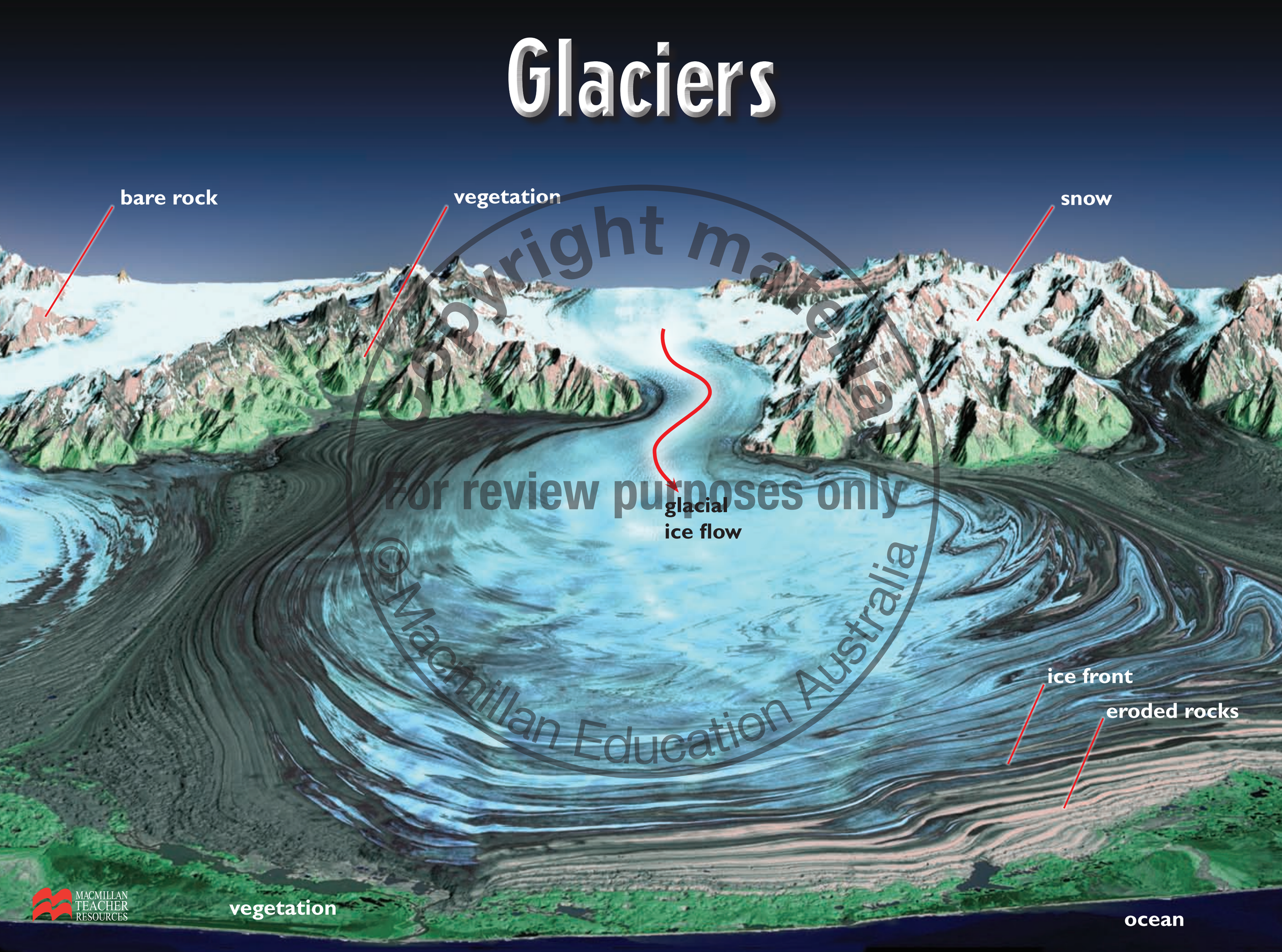
Glaciers



Glaciers

Background to chart

This chart shows the Malaspina Glacier in Southeastern Alaska. The photograph was taken by a NASA Landsat satellite. A glacier is like a frozen river of ice. Glaciers form when snow falls continuously in an area, and over time the snow is compressed into ice. Glaciers cover 10 per cent of Earth's surface. Due to their weight, and the effect of gravity, glaciers move. Usually they move so slowly that it is only noticeable over a long period of time but they can surge quickly at times.

Scientists study glaciers to find evidence of the effects of climate change. Glaciers grow when there is increased snowfall or decreased melting. They retreat or melt when temperatures rise or if there is less snow. NASA Landsat satellite imaging, such as the image on this chart, documents the changes in size of glaciers by comparing images over time. Glaciers have been retreating and melting faster this century than at any other time in history. Most scientists attribute this to the effects of greenhouse gases and global warming.

The surfaces and edges of glaciers melt, and they melt when they meet warmer than usual ocean currents. The surface melt usually runs off the glacier but because of global warming many glaciers have cracks through which the surface melt can seep down to the rock below. This undermines the base of the glacier and speeds up the melting process.

Glaciers contain much of the world's fresh water. Only 2.5 per cent of Earth's water is fresh water. The rest is too salty for drinking. Melting glaciers means loss of habitat for wildlife. If they continue to melt at the current rate, sea levels will rise, flooding many coastal and island communities and leading to shortages of fresh water. Rising sea levels also affect ecosystems such as coral reefs.

Key ideas

- Glaciers are sensitive indicators of climate change.
- Due to global warming, glaciers have been retreating and melting faster this century than at any other time in history.
- Glaciers contain much of the world's fresh water.

Questions

Observing
- Describe what you can see on the wall chart.
- Where would you find a glacier?

Comprehending
- What is a glacier?
- How do the seasons affect glaciers?

Analysing
- How and why do glaciers move?
- How and why do glaciers melt?

Applying
- What happens to the water run-off from glaciers in different regions of the world?
- How would a Pacific Island community at sea level be affected if all of the glaciers in Greenland and the Arctic Zone melted ?

Reflecting
- Why are scientists concerned that glaciers are melting at a faster rate than usual?
- What concerns you the most about melting glaciers?

Evaluating
- What are the links between greenhouse gases and melting glaciers?
- How does what we do in our own homes affect glaciers?

ACKNOWLEDGEMENTS

Photo: Courtesy NASA/JPL/NIMA

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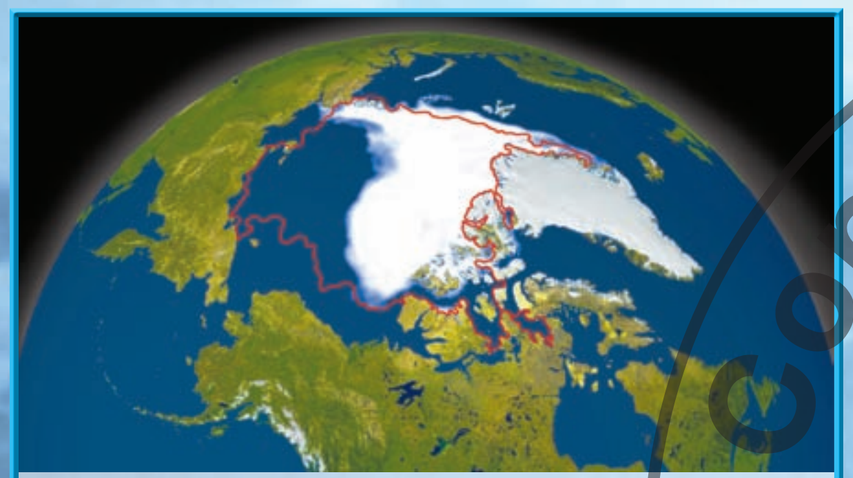
Arctic ice



Satellite view of the Arctic sea ice in September 2007. The red outline shows the ice cap in September 1979.

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Arctic ice

Background to chart

The inset on this wall chart shows a satellite image of summer ice on Greenland and in the Arctic Sea. The extent of the ice is photographed and compared over time to measure the effect of global warming. When measured in September 2007, the extent of the Arctic sea ice was only half what it had been, on average, for the summers 1979 to 2000. In the summer of 2007 a Northwest Passage became navigable to shipping for the first time in thousands of years.

Ice reflects the sun's heat back into the atmosphere while the ocean absorbs the sun's heat. Less ice means that more of the sea is exposed and will warm at a faster rate, further accelerating global warming. Some scientists predict that by 2030 the Arctic could be totally ice-free for part of the year.

The Arctic Zone is the region around the North Pole. The North Pole lies in the middle of the Arctic Ocean. Unlike the South Pole, which is on Antarctica, the North Pole has no land mass but is instead usually covered by drifting sea ice. The Arctic Zone includes parts of Canada, Greenland, Russia, USA, Iceland, Norway, Sweden and Finland. Large areas are covered with land ice or permafrost.

The Arctic Zone includes unique ecosystems. Approximately 60 per cent of the world's polar bears live in Canada, the rest are in Alaska, Russia, Norway and Greenland. Climate change is affecting the polar bears as well as other species and inhabitants of the Arctic Zone. For example, polar bears need the sea ice to hunt for seals. Less sea ice reduces their hunting range and, because the ice is melting sooner than usual, the hunting season is reduced.

Key ideas

- Changes in amounts of sea ice are measured by NASA.
- Arctic summer sea ice has halved over the last 30 years and in 2007 a Northwest Passage became navigable to shipping for the first time in thousands of years.
- Climate change affects polar bears as well as other species and inhabitants of the Arctic Zone.

ACKNOWLEDGEMENTS

Polar bear: iStockphoto.com/David T Gomez
Sea ice satellite photo: NASA Goddard Space Flight Center (nasa.gov)
Red outline: Cliff Watt

Questions

Observing
- What does the wall chart show?
- The borders of which countries lie within the Arctic Zone?

Comprehending
- Explain what is happening to the ice in the Arctic.
- Why is global warming having a faster impact in the Arctic Zone than elsewhere?
- How are polar bears affected by climate change?

Analysing
- What impact would less sea ice have on a polar bear?
- What impact would less land ice have on a country like Greenland?

Applying
- How are shipping and tourism affected by less sea ice?
- How are sea levels affected when land ice melts? How is this different to when sea ice melts?

Reflecting
- What might the polar bear be thinking?
- How might you feel, as an indigenous inhabitant of the Artic region, as you watch the ice and permafrost melt?

Evaluating
- What different opinions might people who live in the Arctic Zone have about the impact of global warming on their lives?
- If the Arctic ice melt continues, what impact will it have on your life?

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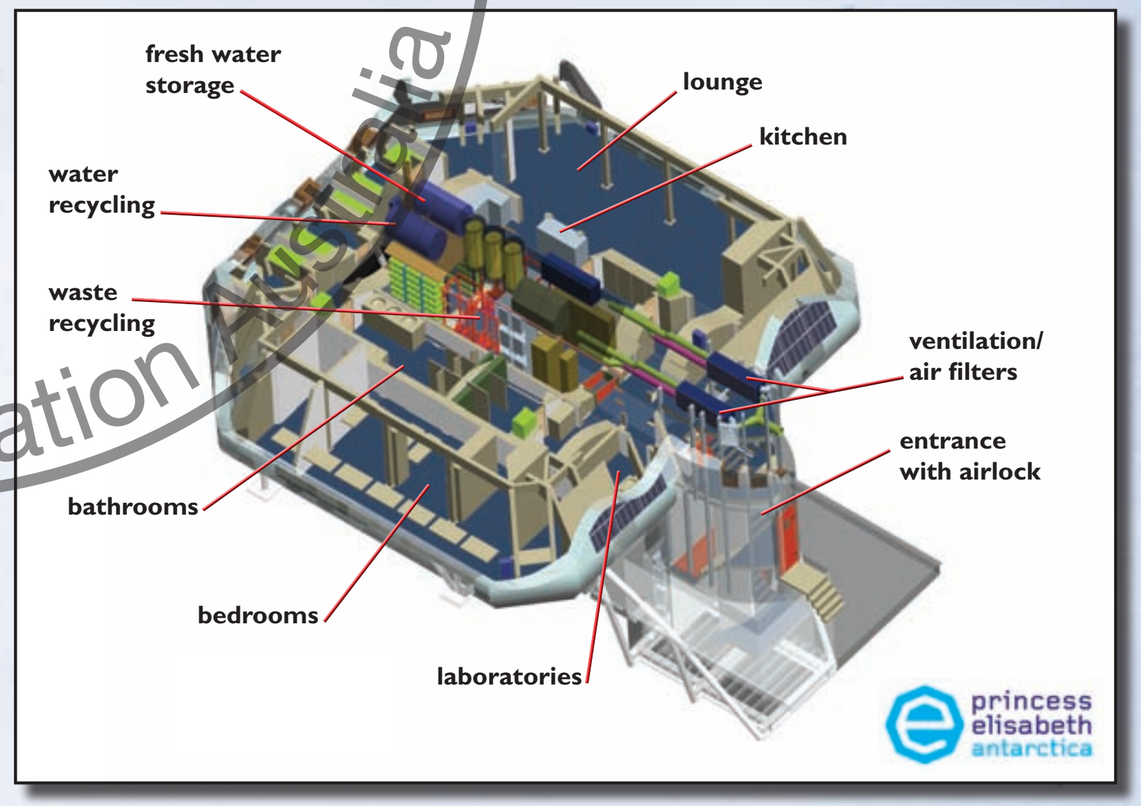
Zero emission



MACMILLAN TEACHER RESOURCES

Zero emission

Background to chart

The Antarctic continent is a land mass and is mostly covered with ice. The only plants found here are very small mosses and lichens. Approximately 30 countries operate summer or year-round research stations on Antarctica. The Australian Antarctic Division maintains four permanent research stations. In the past, waste from Antarctic stations was disposed of in landfill sites like rubbish dumps. Many of these contaminated sites still exist in Antarctica and pose a threat to its environment. Old landfill sites must be cleaned up as part of the Protocol on Environmental Protection to the Antarctic Treaty. Currently most of the power on Antarctica is generated using fossil fuels.

This chart shows the Princess Elisabeth Station. It is Antarctica's first zero emission station. It is located on a granite ridge in east Antarctica at Utsteinen in the Dronning Maud Land (Queen Maud Land). Zero emission means that the station's operations will leave no carbon footprint. It runs entirely on renewable energy provided by the sun and wind, recycles all waste, has its own water treatment system and has been designed to be energy efficient in its construction and daily operation.

It is expected to last a minimum of 30 years. Climate change scientists as well as meteorologists, glaciologists and microbiologists will work there to conduct research. The station was commissioned by the Belgian government and was designed, built and financed by the International Polar Foundation with the help of its public and private sponsors. The station was built during the International Polar Year 2007-2009. The aim of the International Polar Foundation is to educate people around the world about research in the polar regions, on climate change and on sustainable development.

Key ideas

- 30 countries operate summer or year-round research stations on Antarctica.
- The Protocol on Environmental Protection to the Antarctic Treaty now requires research stations to clean up the waste in their Antarctic rubbish dumps.
- Princess Elisabeth Station is Antarctica's first 'zero-emission' station.

Questions

Observing

- Describe what you notice about the exterior of the Princess Elisabeth Station.
- Describe what you notice about the interior.

Comprehending

- What does zero emission mean?
- What does it mean when the station claims to recycle all waste and used water?

Analysing

- What aspects of the design of the station ensure that it is energy efficient?
- Why do you think some Antarctic stations operate all year round while others are seasonal?

Applying

- If you designed a research station for Antarctica how would it be different from Princess Elisabeth Station?
- To maintain their zero emission policy what transport would scientists living at Princess Elisabeth Station use?

Reflecting

- If you were a climatologist what would interest you about living at Princess Elisabeth Station?
- What would it be like to live and work in Antarctica?

Evaluating

- Why is it important for scientists in Antarctica to leave a zero carbon footprint?
- Why do so many countries set up research stations on Antarctica?

Further information:
www.antarcticstation.org
www.polarfoundation.org

ACKNOWLEDGEMENTS

International Polar Foundation / Farman Engineering

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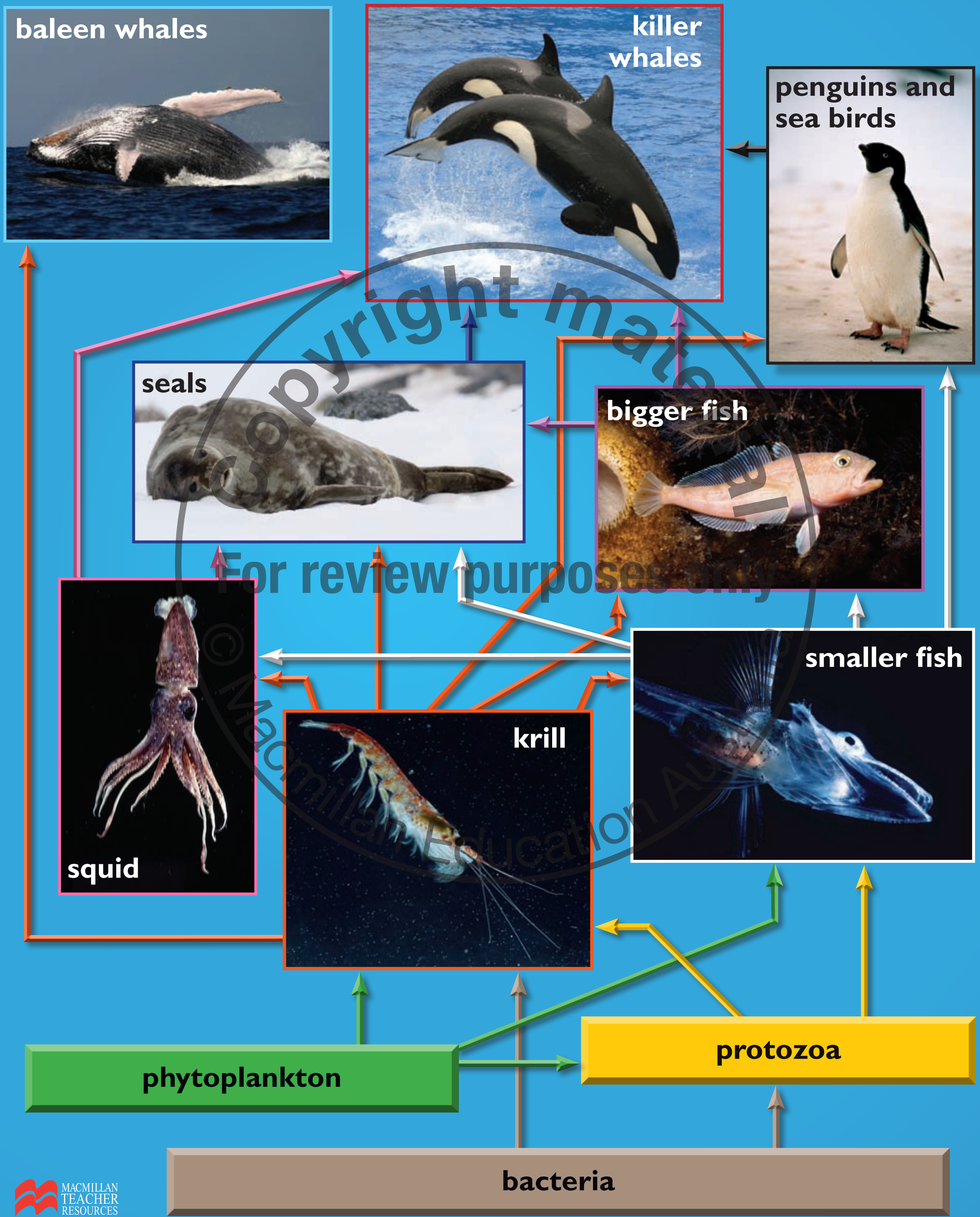
Antarctic food web



Antarctic food web

Background to chart

All of the plants and animals in the Antarctic food web are interconnected and play a vital role in each others' survival. Krill, phytoplankton, bacteria and protozoa, at the base of the food web, are particularly important. Killer whales, at the top of the food web, rely upon a plentiful supply of fish, squid, seals and penguins for their survival.

Bacteria break down waste and other organic matter. This releases the carbon, which then sinks to the ocean floor where it is unable to pollute the atmosphere. In this way bacteria play a role in preventing climate change.

Protozoa are single-celled animals. They feed on bacteria, phytoplankton and other protozoa. Their important role is to manage bacteria numbers.

Phytoplankton are plants, such as algae, which bloom in the spring sunlight. During photosynthesis they absorb carbon dioxide from the ocean, store the carbon, and release the oxygen needed for animal survival. The hole in the ozone layer over Antarctica exposes them to harmful ultraviolet radiation. This causes the phytoplankton to sink deeper into the ocean where there is less sunlight, so the phytoplankton do not grow as quickly. This affects the entire oceanic ecosystem. Less phytoplankton also means less carbon dioxide is absorbed, further accelerating global warming.

Zooplankton, such as krill and jellyfish–like salps, feed upon phytoplankton. Diminishing sea ice, due to climate change, is affecting zooplankton numbers. This is because krill feed on algae growing on the underside of the shrinking sea ice. Warming Antarctic waters have also brought about an explosion of the salp population. These salps then compete with krill for food, further diminishing krill numbers. There has been an 80 per cent decline in krill since the 1970s. Less krill means less food available for all the other animals in the food web, some of which migrate thousands of miles to Antarctica during the Antarctic summer simply to feed upon krill.

Key ideas

- The Antarctic food web is under threat at every level from climate change.

ACKNOWLEDGEMENTS

Krill (*Euphausia superba*): Getty Images/National Geographic/George F. Mobley, Small fish (Emerald notothen *Trematomus bernacchii*):Getty Images/Science Faction/Norbert Wu, Squid (*Histioteuthis sp.*): Photolibrary/Science Photo Library/British Antarctic Survey, Humpback whale (*Megaptera novaeangliae*): iStockphoto.com/Brett Atkins, Weddell seal (*Leptonychotes weddellii*): iStockphoto.com/Brian Lee, Big fish (Antarctic icefish *Champsocephalus gunnari*): Wikipedia/Uwe Kils, Adélie penguin (*Pygoscelis adeliae*): iStockphoto.com/James Richey Killer whale (*Orcinus orca*): iStockphoto.com/Jami Garrison

Questions

Observing
- Describe the different relationships in the Antarctic food web and how they interact.
- Describe the effect of the hole in the ozone layer on Antarctica.

Comprehending
- Explain how a food web works.
- Explain how phytoplankton gets its energy to grow.

Analysing
- Explain three ways in which global warming affects penguins.
- Describe the relationship between phytoplankton and seals.

Applying
- How would declining krill numbers affect a seal or a humpback whale?
- Explain how phytoplankton help to prevent global warming.
- Explain how bacteria help to prevent global warming.

Reflecting
- What should be done about overfishing of krill in Antarctica?
- What can you do in your daily life to support the Antarctic food web?

Evaluating
- Which species in the food web is most important, in your opinion, and why?
- Why is commercial krill fishing important?

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Habitat loss

desert

coral reef

savannah

rainforest

MACMILLAN TEACHER RESOURCES

Habitat loss

Background to chart

In the Tropical Zone climate change has been linked to four ecosystems:

• Desert
Prolonged drought is causing more land to turn into desert. A third of Earth's land surface is at risk of desertification. Once an area becomes desert, soil erosion takes place. As vast areas become drier, people face extreme water and food shortages and wildlife habitats are destroyed. Farmers have to encroach further into savannahs and cooler rainforest areas in order to grow food to survive.

• Rainforest
In many tropical countries deforestation occurs when farmers clear forests to create farmland. Many areas are cleared by subsistence farmers, although a large percentage of the Amazon has been cleared for cattle farming, and some forests are cleared for timber. Rainforests help to prevent climate change. They absorb carbon dioxide from the air, store the carbon and release oxygen for the survival of all animal life. Clearing rainforests contributes to global warming and destroys wildlife habitats.

• Coral reef
The coral polyp feeds on algae which live on its surface. Algae give the coral its colour. Warmer water is killing the algae and stressing the coral. Rising sea levels also affect algae because less sunlight reaches it to support photosynthesis. Many other marine species, such as marine turtles, which live in or around coral reefs, are also sensitive to changes in water temperature.

• Savannah (grasslands)
Climate change affects rainfall patterns around the world, creating changes in habitat in vulnerable areas. In some areas of savannah, more rainfall is causing more trees to grow where previously there were grasses. In other areas the savannah is at risk of becoming a desert. The Serengeti is a savannah ecosystem in Africa. It is the habitat for 70 mammal species and 500 bird species which all rely on savannah grasses at the base of their food chain.

Key ideas

- A third of Earth's land surface is at risk of desertification.
- Deforestation contributes to global warming.
- Many marine species are sensitive to changes in water temperature caused by climate change.
- Climate change directly affects rainfall patterns and dramatically changes whole ecosystems.

ACKNOWLEDGEMENTS

Desert: Shutterstock.com/Dmytro Korolov
Coral reef: iStockphoto.com/Zeynep Mufti
Savannah: iStockphoto.com/Peter Malsbury
Orangutan: iStockphoto.com/George Clerk

Questions

Observing
- Describe the four major ecosystems in the Tropical Zone.
- Name some of the effects of climate change in the Tropical Zone.

Comprehending
- What is desertification and what causes it?
- What are some of the reasons for cutting down the rainforests?

Analysing
- How are rainforest habitats affected by climate change?
- Explain how coral is affected by global warming.

Applying
- Explain the difference between drought and too much rain on a savannah.
- What can you do to help save rainforests?

Reflecting
- How does climate change affect the weather where you live?
- How can rainforests be saved when people need to eat?

Evaluating
- What is the difference between the terms global warming and climate change?
- Why are rainforests important ecosystems?

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What can you do?

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What can you do?

Background to chart

A carbon footprint is the measurement of how much carbon dioxide pollution is released into the air by individuals, families, businesses, schools and countries.

Every activity can be measured in terms of carbon. Walking is carbon neutral, planting a tree is carbon positive (you gain carbon credit because the growing tree removes carbon dioxide from the air), travelling by car burns fossil fuel and is carbon negative.

Carbon can also be measured in every purchase we make. Items such as computers, clothing and processed foods have a carbon measurement because carbon was emitted during growing or manufacturing, processing, storing and transporting the goods.

Australians have the biggest carbon footprint per person in the world. Americans rank second. In the future all businesses and organisations around the world will be given an allocation that specifies how much carbon they are allowed to emit. If they emit more carbon than permitted they will have to buy carbon credits from companies or governments. These are awarded for being energy efficient, or gained from activities such as establishing national parks or planting forests.

There are many ways in which individuals can reduce their carbon footprint and help prevent climate change. These include:

- **Planting a tree.** Trees absorb carbon dioxide from the air and store it while releasing oxygen.
- **Air-drying clothes.** A clothes dryer can produce 3kg of greenhouse gas per load.
- **Buying locally grown food.** This saves greenhouse gases produced during transport, storage and refrigeration of food.
- **Turning off appliances** at the power point. Each appliance left on standby mode creates 66kg of greenhouse gas emissions a year.
- **Walking, cycling, car pooling, and using public transport** rather than taking individual vehicles, saves energy and reduces greenhouse gas emissions.
- **Recycling**. This reduces the emissions generated when raw resources are mined.

Key ideas

- A carbon footprint measures the carbon dioxide pollution released by people.
- There are many ways in which individuals can reduce their carbon footprint.

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Questions

Observing
- Describe how you could reduce your carbon footprint at school and at home.
- Explain why it is better for the environment if you buy locally grown fruit.

Comprehending
- Explain the meaning of the term carbon footprint.
- How could your school gain carbon credits?

Analysing
- Why are Australia and the USA such big greenhouse gas emitters, per person?
- Why would a country such as Vietnam produce less carbon emissions than Australia, per person?

Applying
- Why is it better to be carbon positive than carbon neutral?
- How can you motivate people to be more active on climate change?

Reflecting
- Explain which of the activities shown on the wall chart you currently do at home and which ones you will start to do.
- Why is it so difficult for many people to reduce their greenhouse gas emissions?

Evaluating
- What can Australia do to reduce its carbon footprint?
- The developed nations have created climate change. Is it their responsibility to fix it?

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