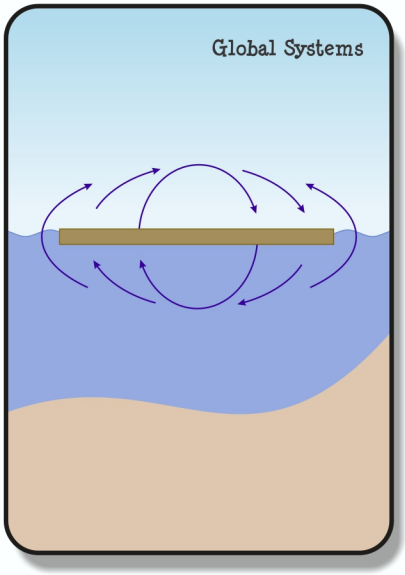
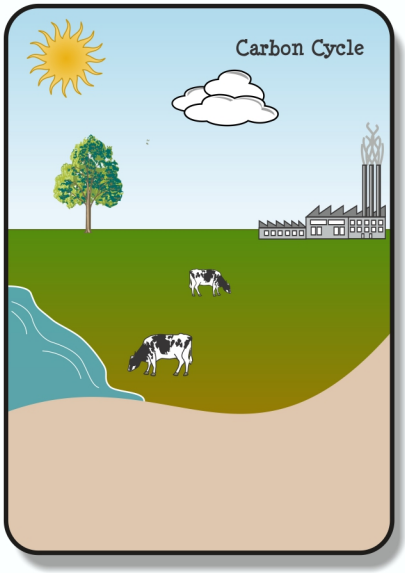
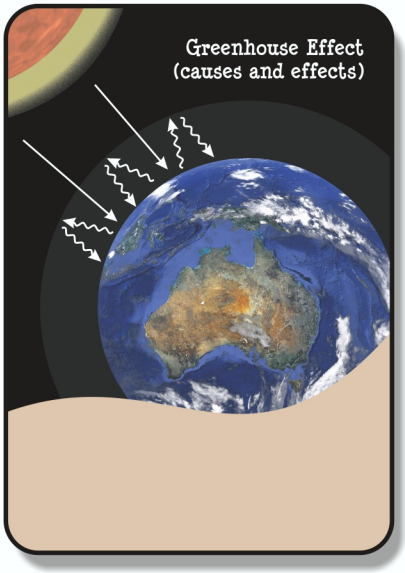


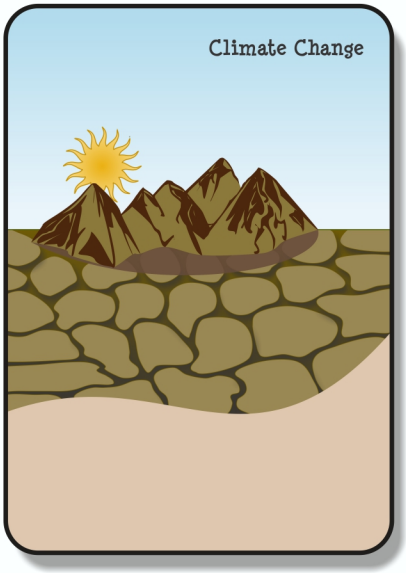
WASP
Woodside Australian Science Project

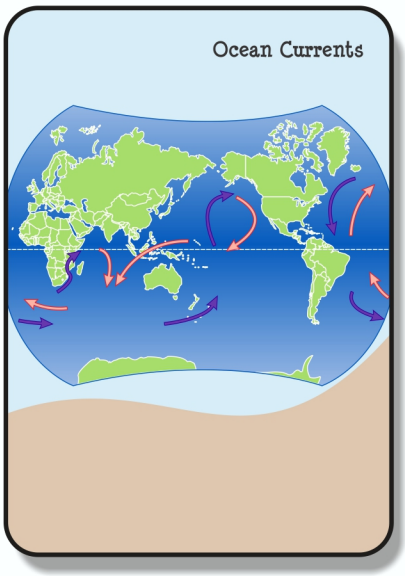
An initiative supported by Woodside and ESWA

Global Systems Package







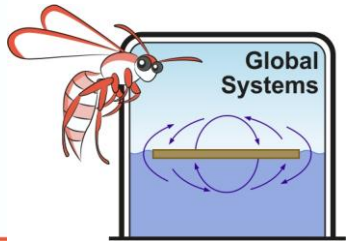


Year 10

Australian Curriculum - Earth Science

EARTH SCIENCE WESTERN AUSTRALIA

woodside



Year 10 WASP - Teacher Introduction

The WASP (Woodside Australian Science Project) is an initiative between Woodside and Earth Science Western Australia (ESWA).
These activities are designed to support the Earth Science part of the Earth & Space Science topic required by the Year 10 Australian Curriculum.

Copies of this and other supporting materials can be obtained from the WASP website http://www.wasp.edu.au or by contacting Julia Ferguson, Julia@wasp.edu.au

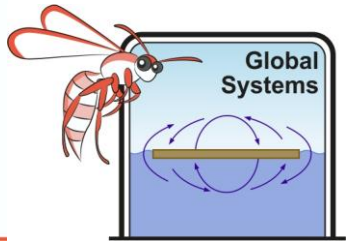
Topic 1	**Global Systems**
Topic 2	**Carbon Cycle**
Topic 3	**Greenhouse Effect (causes and effects)**
Topic 4	**Climate Change**
Topic 5	**Sea Ice and Permafrost**
Topic 6	**Ocean Currents**

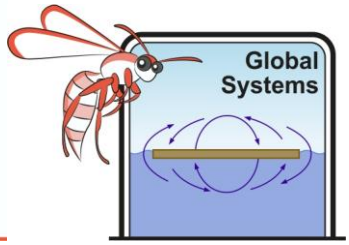
Year 10 Australian Curriculum Science

Earth & Space Science
Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)

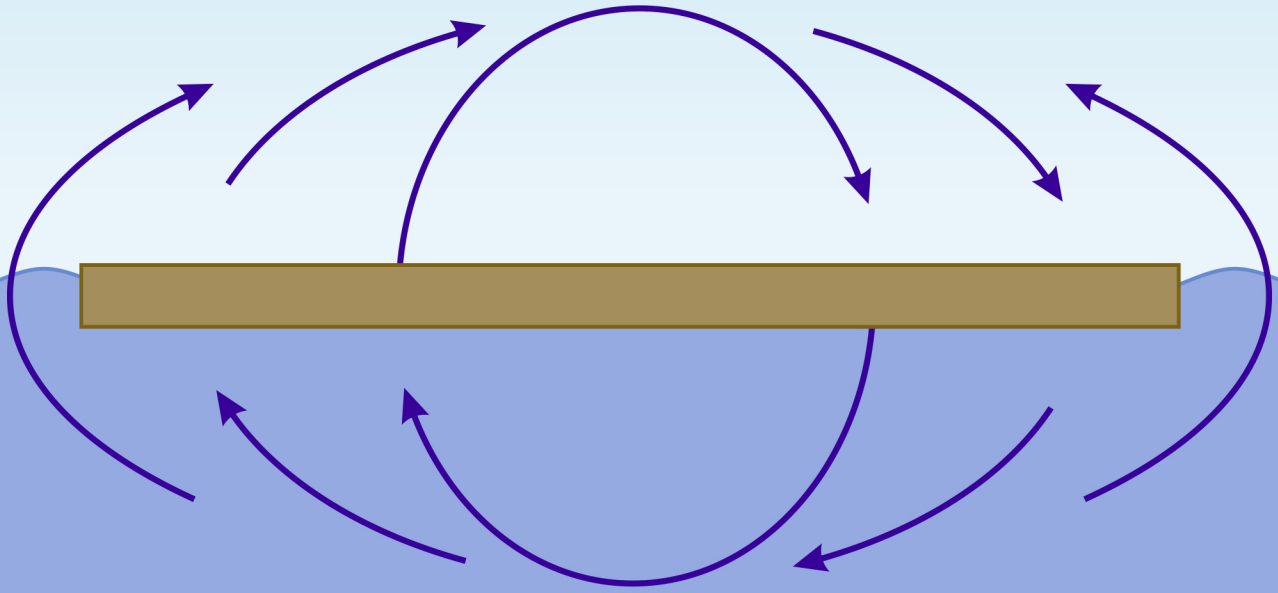
- Investigating how human activity affects global systems
- Modelling a cycle, such as the water, carbon, nitrogen or phosphorous cycle within the biosphere
- Explaining the causes and effects of the greenhouse effect
- Investigating the effect of climate change on sea levels and biodiversity
- Considering the long term effects of loss of biodiversity
- Investigating currently occurring changes to permafrost and sea ice and the impacts of these changes
- Examining the factors that drive deep ocean currents, their role in regulating global climate and their effects on marine life

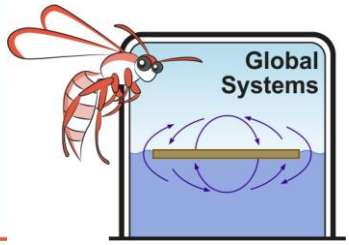
Year 10 WASP - Teacher Introduction





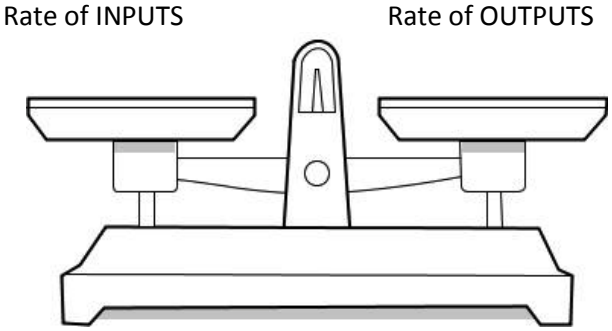
Global Systems





Global Systems - Teacher Background

In order to understand changes in weather over hours or days, seasons over months and climate over tens to thousands of years, we have to treat the Earth as a series of systems which affect each other in the same way as the systems in our bodies react to change to maintain balance (homeostasis). In a variable environment, our body systems have to interact and respond to change through a series of positive and negative feedback loops. Imbalance would result in illness. Similarly our planet at its surface relies on a series of interconnected global systems to maintain its balance. Materials and energy must be moved around these systems in a balanced way.



At a purely human level:
Too much nitrogen in the atmosphere and our breathing would stop. Too little nitrogen and we would catch fire.
Too much carbon dioxide released into our atmosphere will result in heating and desertification. Too little carbon dioxide and it will be too cold for our enzymes to work efficiently and we will die.

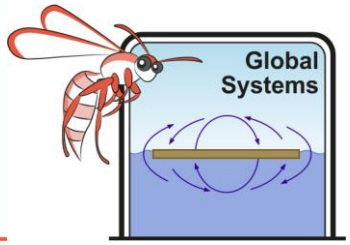
Earths systems:

1. **Atmosphere**: This consists of gases, mostly nitrogen 78.09%, oxygen 20.95% and carbon dioxide 0.039%. Air contains a variable amount of water vapour (average 1%). This zone is one of small molecules of low density bound by weak intermolecular forces.
2. **Lithosphere**: This consists of solid rock. It is the cold, brittle and elastic outermost shell of our planet. It is made of minerals whose atoms are joined with ionic lattices e.g. alumina-silicates.
3. **Hydrosphere**: This is the mass of water lying over, on or under the surface of the Earth as oceans, seas, lakes and rivers. 97.5% is saline and 2.5% is fresh, of which 68.7% is ice. The hydrosphere is mostly small molecules with dissolved ions. The **cryosphere** is that part of the hydrosphere where water is frozen.
4. **Biosphere**: The biosphere is the very thin layer in which all living organisms exist. Life is based on long chain polymers.

There is continual movement between all of these spheres. Elements will be moved through natural and manmade processes from sources to sinks and from sphere to sphere at various speeds. In Nature the balance of input and output should be about the same. When inbalance occurs the whole Earth can be affected.
We can describe the movement of specific materials between systems in cycles such as the carbon cycle or the nitrogen cycle.

We know that the climate of Earth has noticeably changed in the recent past:

- In May 2014, the average temperature over global land and ocean surfaces was the hottest since records began in 1880 according to NOAA (National Oceanic and Atmospheric Administration). “The majority of the world experienced warmer than average monthly



temperatures with record warmth across eastern Kazakhstan, parts of Indonesia and central and northwestern Australia.

- Archaeological evidence demonstrates farmers colonised Greenland during the "Medieval Summer" between 1200AD and 1500AD. They grew wheat and vines until the climate cooled and they had to leave or starve to death.
- Aboriginal people laid fish traps in lakes and swamps near Broken Hill about 20,000 years ago. It is now desert.
- Genetic evidence suggests that our own species was reduced to about 600 breeding pairs during the coldest period of the last Ice Age about 70,000 years ago. Later warming melted the ice and they moved out to colonise most of the land on Earth while mammoths, sabre toothed tigers and cave bears which were suited to severe cold became extinct.

Geological evidence suggests that the Earth has undergone long periods of extreme heating and cooling. Glacial deposits suggest that we have undergone at least three major periods of global glaciation. Desert sands indicate global drought. These extremes of climate have associated evidence of mass extinctions.

On a shorter term, we now have evidence that our planet has undergone a sequence of cycles of warming to an average of 22^{o}C and cooling to 12^{o}C about every 10,000 years. These cycles are named after the Czech scientist Milankovitch who suggested they occur in response to natural variations in the Earth's rotation and tilt and in solar activity. We are presently coming out of a cool period.

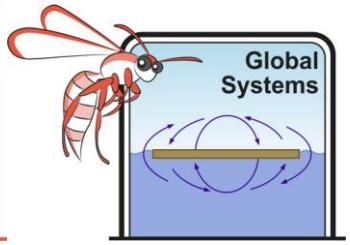
There is no doubt that climate changes over time. The natural rate of change is slow and this permits some plants and animals to change their geographic location or behaviours to suit the changed environment. Those best suited will survive and multiply. However for some specialised organisms change can be lethal. After the largest global mass extinction, between the Permian and Triassic periods, it took 10 million years to recover biodiversity. The forcing factor was volcanic activity and a rise in global temperature due to volcanic carbon dioxide in the atmosphere.

Human activities can affect global systems and the survival of species on our planet. If our behaviours accelerate the tolerable rate of climate change we will cause imbalance in Earth Systems and may be responsible for the loss of many species, perhaps including our own.

What is happening within our global systems needs much scientific investigation and informed debate free of economic and political bias.

An updated version of "The Science of Climate Change" will be released by the Australian Academy of Science in mid 2014. It is an excellence reference source. The following quote is from the earlier 2012 publication.

"We are very confident of several fundamental conclusions about climate change: that human activities since the industrial revolution have sharply increased greenhouse gas concentrations; that these added gasses have a warming effect: that the Earth's surface has indeed warmed since the Industrial Revolution. Therefore, we are very confident that human-induced global warming is a real phenomenon."



Global Systems - Teacher Vocabulary

We can consider that materials are moved or recycled through the Earth through several interconnected natural systems by natural processes. For example, an atom of oxygen will move through the biosphere through the processes of photosynthesis and respiration but will also enter the hydrosphere through transpiration. Processes change materials from one physical or chemical state to another

The spheres are:

1. **Atmosphere**: This consists of gases, mostly nitrogen 78.09%, oxygen 20.95% and carbon dioxide 0.039%. Air contains a variable amount of water vapour (average 1%). This zone is one of small molecules of low density bound by weak intermolecular forces.
2. **Lithosphere**: This consists of rock. It is the cold, brittle and elastic outermost shell of our planet. It is made of minerals whose atoms are joined with ionic lattices e.g. alumina-silicates.
3. **Hydrosphere**: This is the mass of water lying over, on or under the surface of the Earth as oceans, seas, lakes and rivers. 97.5% is saline and 2.5% is fresh, of which 68.7% is ice. The hydrosphere is mostly small molecules with dissolved ions. The **cryosphere** is that part of the hydrosphere where water is frozen.
4. **Biosphere**: The biosphere is the very thin layer in which all living organisms exist. Life is based on long chain carbon based polymers.

Activity: To remember the components of four Earth spheres

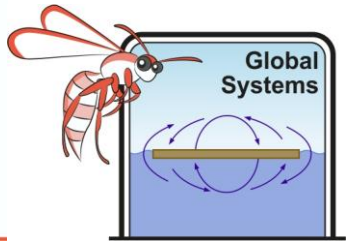
Materials per student

- Compass, ruler and pencil (or use base of beaker or Petri dish for circle sizes)
- This worksheet

Method

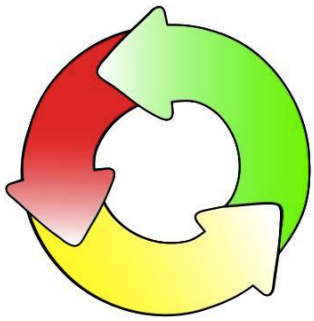
1. Draw four overlapping circles 10 cm in diameter on the reverse of this worksheet.
2. Label each circle after one of the spheres listed above.
3. Draw a smaller 5cm circle within the hydrosphere for the cryosphere.
4. Place the following words into the appropriate Earth System.
5. ***Beware!*** Some words can be found in more than one sphere!

Animal, basalt, carbon, carbon dioxide, clouds, continent, coral, decomposition, deposition, dew, erosion, evaporation, glacier, granite, groundwater, hydrogen, ice, ice cap, lake, mist, mountain, nitrogen, ocean, oxygen, penguin, photosynthesis, plant, rain, respiration, river, rocks, sand, sea, sea ice (pack ice), seagull, silicon, soil, water, water table, water vapour, weathering.

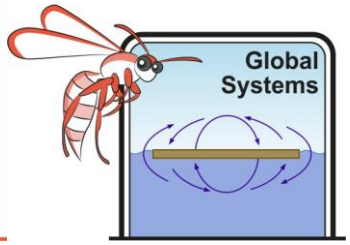


Global Systems - Teacher Vocabulary

animal	**Biosphere**
basalt	**Lithosphere**
carbon	**All spheres**
carbon dioxide	**Atmosphere, biosphere & hydrosphere**
clouds	**Atmosphere**
continent	**Lithosphere**
coral	**Biosphere**
decomposition	**Biosphere**
deposition	**Lithosphere**
dew	**Hydrosphere**
erosion	**Lithosphere**
evaporation	**Hydrosphere**
glacier	**Hydrosphere (cryosphere)**
granite	**Lithosphere**
groundwater	**Hydrosphere**
hydrogen	**All spheres**
ice	**Hydrosphere (cryosphere)**
ice cap	**Hydrosphere (cryosphere)**
lake	**Hydrosphere**
mist	**Hydrosphere & atmosphere**
mountain	**Lithosphere**
nitrogen	**All spheres**
ocean	**Hydrosphere**
oxygen	**All spheres**
penguin	**Biosphere**
photosynthesis	**Biosphere**
plant	**Biosphere**
rain	**Atmosphere and Hydrosphere**
respiration	**Biosphere**
river	**Hydrosphere**
rocks	**Lithosphere**
sand	**Lithosphere**
sea	**Hydrosphere**
sea ice (pack ice)	**Hydrosphere (cryosphere)**
seagull	**Biosphere**
silicon	**All spheres**
soil	**Lithosphere & biosphere**
water	**Hydrosphere**
water table	**Hydrosphere & lithosphere**
water vapour	**Hydrosphere and atmosphere**
weathering	**Lithosphere**



Which of the above describe ***processes?*** (Something which causes a physical or chemical change). **Decomposition, deposition, erosion, evaporation, photosynthesis, respiration & weathering.**



Global Systems - Vocabulary Worksheet

We can consider that materials are moved or recycled through the Earth through several interconnected natural systems by natural processes. For example, an atom of oxygen will move through the biosphere through the processes of photosynthesis and respiration but will also enter the hydrosphere through transpiration. Processes change materials from one physical or chemical state to another.

The spheres are:

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Materials per student

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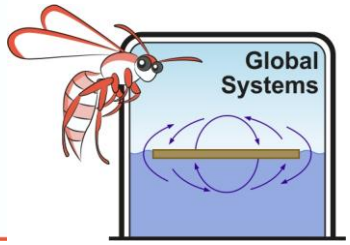

Which of the above describe ***processes?*** (Something that causes a physical or chemical change).

_____

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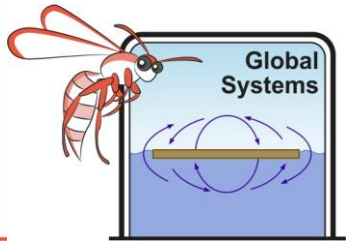
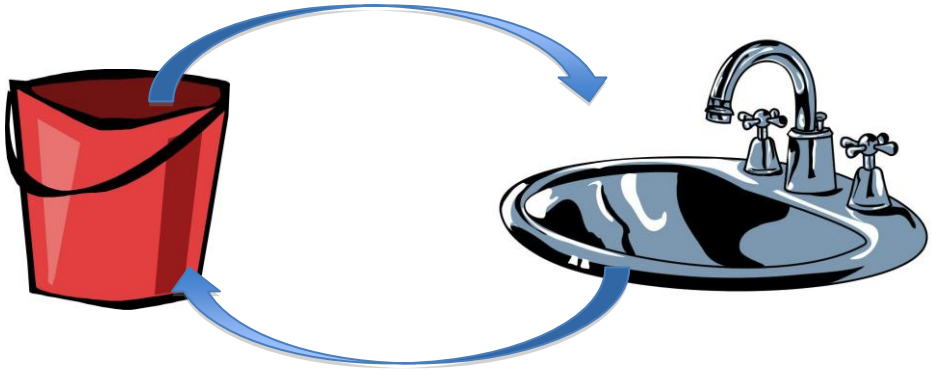
Source to Sink – Teacher Notes





Since our planet formed from a cloud of stellar dust about 4.5 billion years ago, little matter has been added or lost. Perhaps a little hydrogen has escaped from our upper atmosphere and materials from meteors have been added but most of the original atoms are still here. They have however travelled around a bit! In Year 9 Earth Science students learned how heat and gravity have moved materials within the planet to form the core, mantle, crust and atmosphere. Initial planetary differentiation took about 100 million years. Although movement still occurs within the planet, it is on a geologically slow scale.

At the surface of Earth materials move from one location to another at a much faster rate. These locations can be described as four intersecting spheres or zones:

- A ***biosphere*** where life occurs
- A ***hydrosphere*** where water is found
- A ***lithosphere*** of rocks and soils at the surface of the planet
- An ***atmosphere*** of gasses surrounding the planet

Materials can move within spheres and between spheres.

Materials per student

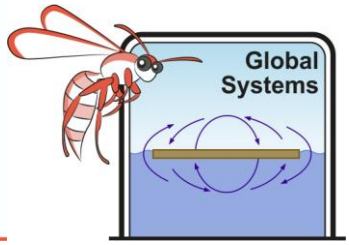
- A pair of compasses or a circular object such as the base of a beaker.
- A pencil

Draw a concept diagram of the four intersecting "spheres "and label each sphere.
Students may prefer drawing four jigsaw pieces. This will help them realise that we are referring to zones or "spheres of influence" rather than perfect spherical volumes.

In reality, do the spheres look like this? Explain your answer No. On Earth water does not lay within one enormous ball shape. The atmosphere lies above the solid Earth in a hollow flattened ball shape. Water can be found distributed through the atmosphere as water vapour, on the lithosphere's surface as an ocean and within the lithosphere as ground water.

Why do you think scientists use the word "sphere"? Sphere or zone of influence

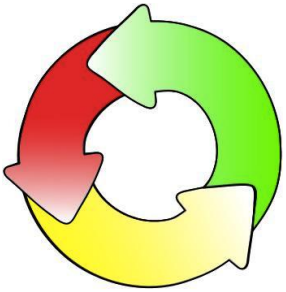
In which sphere do living things exist? Living things exist in the biosphere but depend on materials from the other three for survival.



Source to Sink – Teacher Notes

When discussing matter moving from place to place in global systems, we use the terms:

Source	The original location of the material.
Reservoir or sink	The location to which the material is transferred and stored for an indefinite period of time.
Releasing agent	The process or activity which releases the material from the sink.
Forcing factor	The process that causes materials to be released at a faster rate.
Cycle	Balanced movement from sources to sinks. Over geological time inputs should equal outputs.



Of course during any cycle a sink in time will become a source when the material moves on to another sink. There must always be an overall balance between the rate of output from the source and the rate of input to the sink.

Example: Carbon dioxide

1. A jarrah tree takes in carbon dioxide from the atmosphere during photosynthesis. It can live for 140 years. When it dies and decomposes it releases carbon dioxide back into the atmosphere over 140 years. Name the sources, releasing agents and sinks.

Sources	Atmosphere and jarrah tree
Releasing agents	Photosynthesis, respiration & decomposition
Sinks	Jarrah tree and atmosphere
Time taken	140 years for each movement

Is this a balanced cycle of inputs and outputs? Yes

Name the sources, releasing agents and sinks for carbon dioxide involved if humans burn down 40 years old jarrah trees to clear land for building houses.

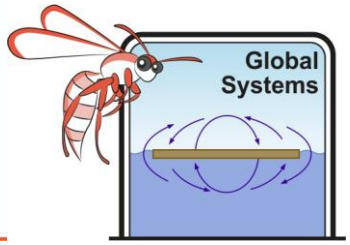
Sources	Atmosphere and jarrah tree
Releasing agents	Photosynthesis, respiration & fire/combustion
Sinks	Jarrah tree and atmosphere
Forcing factor	Human action
Time taken	40 years for absorption from atmosphere but 40 years for return

Is this a balanced cycle of inputs and outputs? Explain your answer No. The carbon dioxide was forced from the tree 100 years too soon. There would now be more carbon dioxide in the atmosphere than there was before.

Imbalance can be the result of natural occurrences. Iceland is an island in the middle of the North Atlantic Ocean. It lies over a mid-oceanic ridge. Massive volcanic eruptions from fissures on the sides of "Laki" volcano between June 1783 and February 1784 poured out lavas and released poisonous gasses, sulphur dioxide, fluoride and carbon dioxide that instantly killed a quarter of the island's human population and most of the agricultural plants and animals. Many more died of starvation and fluoride poisoning over the following months.

NOTE Fluoride in small amounts strengthens borne and tooth enamel. Large amounts produce aberrant behaviour and bone deformities including some cases of gigantism.

The effects of the "Laki fires" were also felt all over Western Europe and even in North America. Dust obscured sunlight and there was a longer colder winter in the following year. The Mississippi river froze, there were terrible floods and crops died and rotted in the fields. Increased CO_2 in the atmosphere caused two years of increased temperatures and drought. Fluorine from volcanic ash c

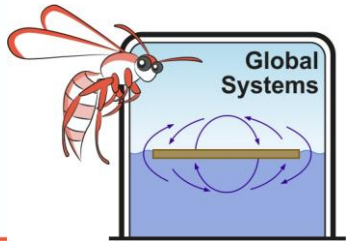


contaminated crops. People starved and the old and young died in increased numbers. It has even been suggested that this helped trigger the French Revolution. Dust from this eruption is even reported to have affected the monsoons in Burma.

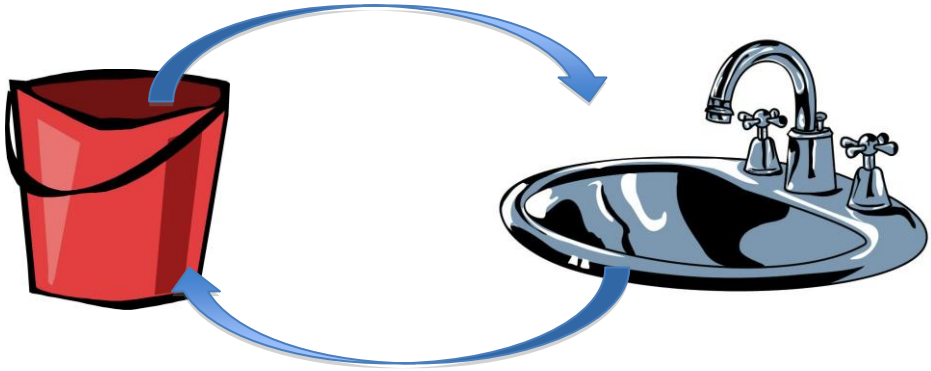
What was the source in this case? Magma in the rocks feeding Laki volcano
What was the sink in this case? The atmosphere
What was the forcing factor in this case? A volcanic eruption rapidly increasing the amount of dust and carbon dioxide in the atmosphere
Give two instances of the negative impact from this imbalance one in the immediate area and another at a distance. Instant death of plants and animals on Iceland and subsequent starvation of humans there. Failure of crops and starvation in Northern Europe and North America. Changed monsoons in Burma

Interesting information

Bhutan is a small kingdom nestled in the Himalayan Mountain Range.
It is the only country in the World that is a carbon sink.
In its constitution it insists that at least 60% of its land must remain forest.
It exports hydro electricity.
The Gross National Happiness Commission is charged with reviewing government policies and allocation of resources.
Dance is the national sport.



Source to Sink – Student Activity



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Materials can move within spheres and between spheres.

Materials per student

- A pair of compasses or a circular object such as the base of a beaker.
- A pencil

Draw a concept diagram of the four intersecting "spheres "and label each sphere.

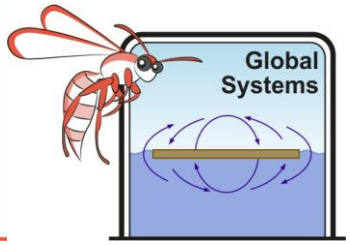
In reality, do these spheres look like this? Explain your answer _____

_____

Why do you think scientists use the word "sphere"? _____

_____

In which sphere do living things exist? _____



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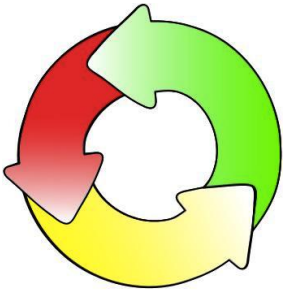
Forcing factor	The process that causes materials to be released at a faster rate.
Cycle	Balanced movement from sources to sinks. Over geological time inputs should equal outputs.



Of course during any cycle a sink in time will become a source when the material moves on to another sink. There must always be an overall balance between the rate of output from the source and the rate of input to the sink.

Example: Carbon dioxide

1. A jarrah tree takes in carbon dioxide from the atmosphere during photosynthesis. It can live for 140 years. When it dies and decomposes it releases carbon dioxide back into the atmosphere over 140 years. Name the sources, releasing agents and sinks.

Sources _____

Releasing agents _____

Sinks _____

Time taken _____

Is this a balanced cycle of inputs and outputs? _____

Name the sources, releasing agents and sinks for carbon dioxide involved if humans burn down 40 year old jarrah trees to clear land for building houses.

Sources _____

Releasing agents _____

Sinks _____

Forcing factor _____

Time taken _____

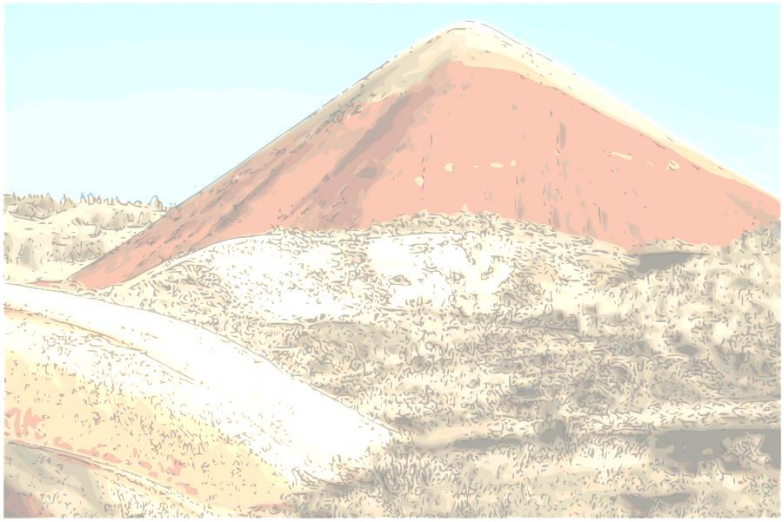
_____

Is this a balanced cycle of inputs and outputs? Explain your answer _____

_____

_____

Source to Sink – Student Activity



Imbalance can be the result of natural occurrences. Iceland is an island in the middle of the North Atlantic Ocean. It lies over a mid-oceanic ridge. Massive volcanic eruptions from fissures on the sides of "Laki" volcano between June 1783 and February 1784 poured out 14km^3 of lava and released poisonous gasses, sulphur dioxide, fluoride and carbon dioxide that instantly killed a quarter of the island's human population and most of the agricultural plants and animals. Many more died of starvation in the following months.
The effects of the "Laki fires" were felt all over Western Europe and even in North America. Dust obscured sunlight and there was a longer colder winter in the following year. The Mississippi river froze, there were terrible floods and crops died and rotted in the fields. Increased CO_2 in the atmosphere caused two years of increased temperatures and drought. Fluorine from volcanic ash contaminated crops. People starved and the old and young died in increased numbers. It has even been suggested that this helped trigger the French Revolution. Dust from this eruption is even reported to have affected the monsoons in Burma.

What was the source in this case? _____

What was the sink in this case? _____

What was the forcing factor in this case? _____

Give two instances of the negative impact from this imbalance, one in the immediate area and another at a distance.

_____

_____

_____

_____

The greatest extinction on Earth (the Great Dying) at the end of the Permian period 251mya was also related to massive outpourings of volcanic lavas in Siberia. 95% of all organisms on Earth became extinct. It took 10 million years for the Earth to recover its biosphere.

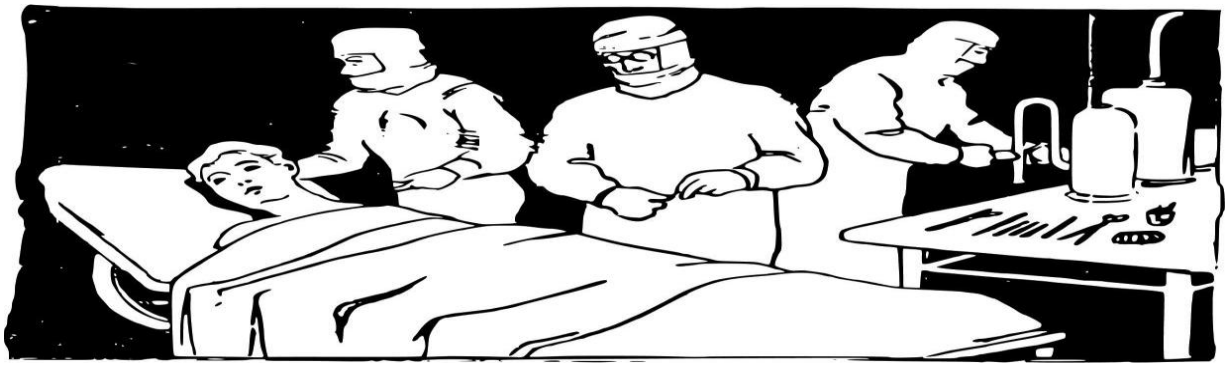
Interesting information

Bhutan is a small kingdom nestled in the Himalayan Mountain Range.
It is the only country in the World that is a carbon sink.
In its constitution it insists that at least 60% of its land must remain forest.
It exports hydro electricity.
The Gross National Happiness Commission is charged with reviewing government policies and allocation of resources.
Dance is the national sport.

Human Activity – Teacher Notes

A fictional fun extension

In Douglas Adams' famous science fiction book "The Hitchhiker's Guide to the Universe"; he describes the fabulously beautiful planet Bethselamin. "It is now so worried about the cumulative erosion by ten billion visiting tourists a year that any imbalance between the amount you eat and the amount you excrete whilst on the planet is surgically removed from your bodyweight when you leave; so every time you go to the lavatory there it is vitally important to get a receipt".
Should this technique be used for visitors into our National Parks? Write a reasoned scientific response below.



Suggest three arguments for and against Douglas Adams' simplistic idea.

Argument for	Argument against
The threat of surgery would be an incentive towards maintaining constant mass of the planet	Expensive in goods and in trained specialists to maintain
Threatening people with surgery would dissuade casual visitors	We excrete water and ions through sweating which is not measured by this method
Tourists might prefer a virtual tour which would be pain free and less expensive	We excrete water when we breathe
An incentive for those who diet during the visit. They can take away souvenirs	People have differing digestive rates and breakdown food at different rates
	Young people need more food to build their bodies and produce energy than older people
	The tourists would breathe in oxygen and breathe out carbon dioxide increasing its percentage in the atmosphere

Human Activity – Student Activity

A fictional fun extension

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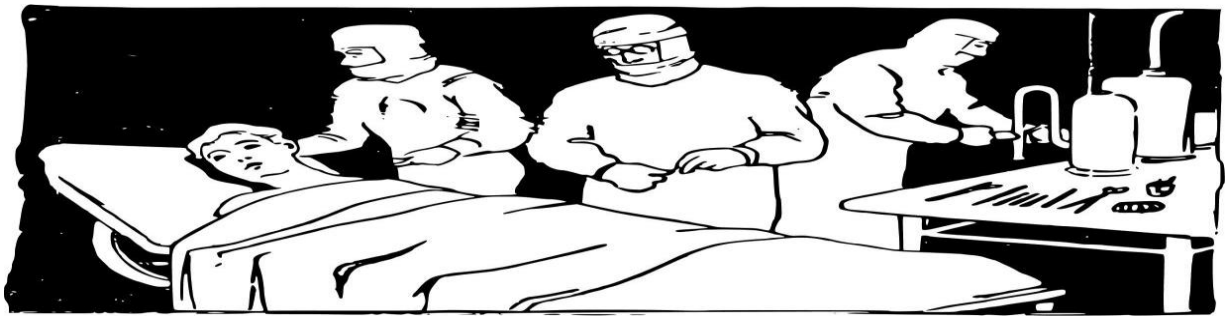

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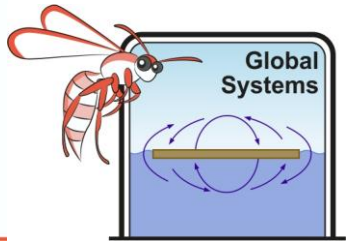
Argument for	Argument against

Global Systems – Teacher Review



M A T E R I A L S L L R D Z E
D R R E S E R V O I R E E C R
K E X E B W E A T H E R P O E
C F C E T L P H C V E U O N H
A S M O C A O A I H G T S D P
B N C Y M S W T P N N A I E S
D A C K P P I S T X A R T N O
E R E H P S O R D Y H E I S M
E T E T O I E S N C C P O A T
F R S P B E E C I Q S M N T A
E P H O T O S Y N T H E S I S
C R Y O S P H E R E I T I O P
M N E V A P O R A T I O N N O
N O I T A R I P S E R C N Y O
F K G N I R E H T A E W S J L

ATMOSPHERE
BIOSPHERE
CHANGE
CONDENSATION
CRYOSPHERE
CYCLE
DECOMPOSITION
DEPOSITION
EVAPORATION
FEEDBACK
HYDROSPHERE
LITHOSPHERE
LOOP
MATERIALS
PHOTOSYNTHESIS
POSITIVE
RESERVOIR
RESPIRATION
SCIENCE
TEMPERATURE
TRANSFER
WATER
WEATHER
WEATHERING

Major concepts covered

1. Name the four major spheres through which global systems cycle materials and energy.

   Atmosphere, Hydrosphere, Lithosphere and Biosphere

2. To which sphere does the cryosphere belong? It is the frozen part of the hydrosphere

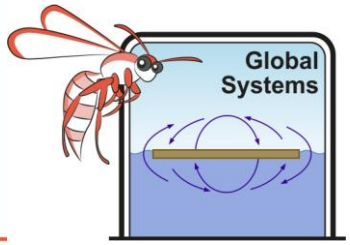
3. What is the name for the long-term storage location from which materials are moved?

   Reservoir or sink

4. To maintain balance, what two things must be balanced in a cycle?

   Inputs must balance outputs

Global Systems – Teacher Review



5. What is the name for a process that may cause materials to be rapidly moved causing imbalance?

   A forcing factor

6. By which process do plants release carbon dioxide into the atmosphere?

Respiration

7. By which process do plants take carbon dioxide from the atmosphere?

Photosynthesis

8. Name a long term and a short term carbon sink.

   Long term Fossil fuel, carbonate rock Short term Atmosphere or a weed

9. What is the difference between climate, weather and seasons?

Weather is measured over hours or days

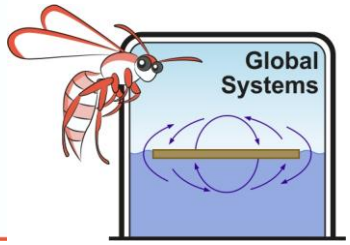
Seasons are measured over months

Climate is measured over tens of years

10. How can understanding the science behind global systems help us make good decisions at this time?

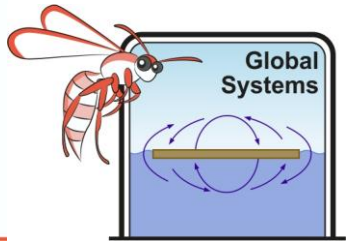
Our climate appears to be changing rapidly. Using science understandings we can make good decisions as to whether it is changing, how it is changing, what things may be the forcing factors and how to deal with these changes.

Global Systems – Student Review



M A T E R I A L S L L R D Z E
D R R E S E R V O I R E E C R
K E X E B W E A T H E R P O E
C F C E T L P H C V E U O N H
A S M O C A O A I H G T S D P
B N C Y M S W T P N N A I E S
D A C K P P I S T X A R T N O
E R E H P S O R D Y H E I S M
E T E T O I E S N C C P O A T
F R S P B E E C I Q S M N T A
E P H O T O S Y N T H E S I S
C R Y O S P H E R E I T I O P
M N E V A P O R A T I O N N O
N O I T A R I P S E R C N Y O
F K G N I R E H T A E W S J L

Find the 24 words used in Global Systems Science above.



Global Systems – Student Review

Major concepts covered

1. Name the four major spheres through which global systems cycle materials and energy.

   _____

   _____

2. To which sphere does the cryosphere belong? _____

3. What is the name for the long-term storage location from which materials are moved?

   _____

4. To maintain balance, what two things must be balanced in a cycle?

   _____

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   _____

6. By which process do plants release carbon dioxide into the atmosphere?

   _____

7. By which process do plants take carbon dioxide from the atmosphere?

   _____

8. Name a long term and a short-term carbon sink.

   Long term_____ Short-term _____

9. What is the difference between climate, weather and seasons?

   _____

   _____

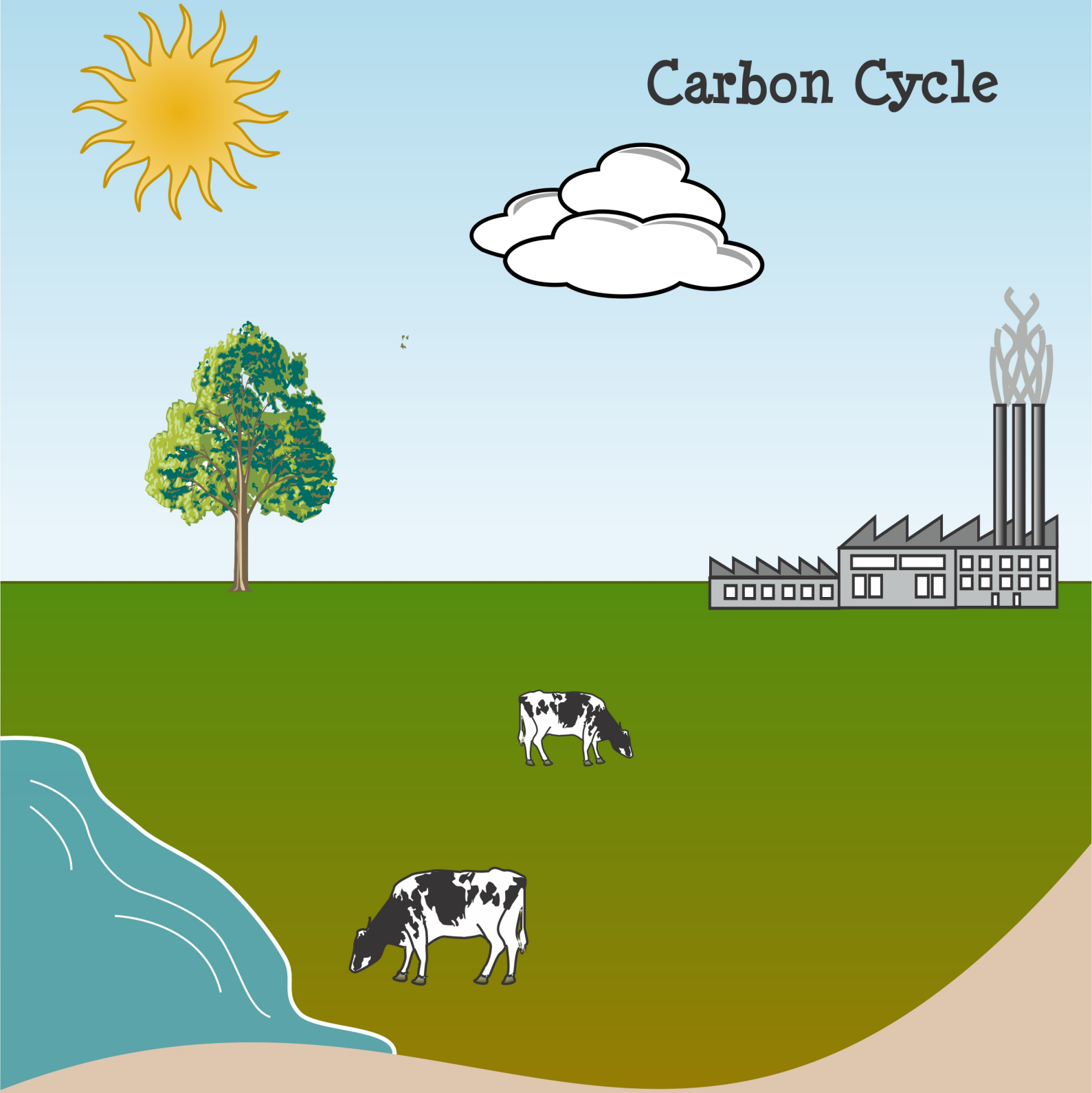
   _____

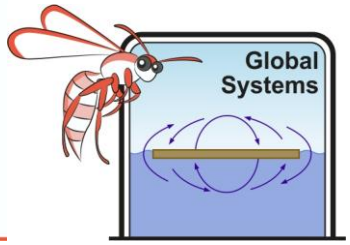
10. How can understanding the science behind global systems help us make good decisions at this time?

_____

_____

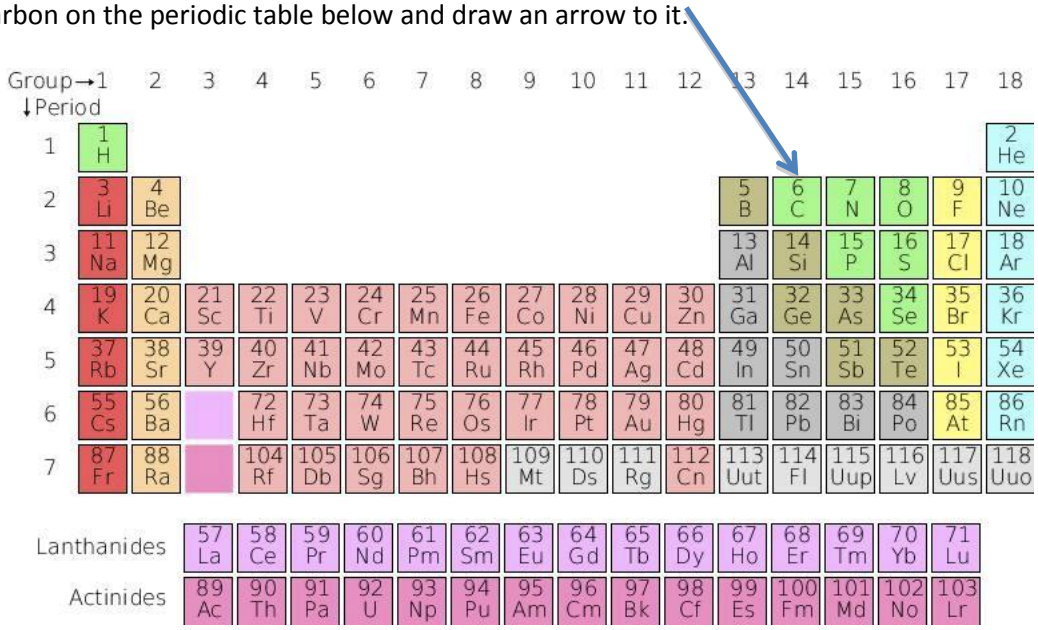
Carbon Cycle





Carbon Chemistry – Teacher Notes

Carbon is the 12th most common element on Earth. To know how it will behave within global systems we need to first understand how its' chemistry is controlled by its atomic structure.
What is an element? An element is a substance made of only one kind of atom, in this case carbon.
What is the symbol for the element carbon? C
Find carbon on the periodic table below and draw an arrow to it.



Using the information from the periodic table provided:
How many protons does carbon have? The atomic number or number of protons lies above the symbol in the periodic table. 6
How many electrons ***must*** a neutral atom of carbon have? 6
If its Atomic Weight is usually 12, how many neutrons ***must*** it have? 6
(This package also includes activities with the isotope carbon-14)

Teacher demonstration **Carbon is found in many materials used by humans.**
Materials
A tray of samples of materials containing carbon can be demonstrated to the students.
Samples could be of: graphite, coal, "lead" pencil, oil, bone, limestone, plastic bags, tissues, paper, petroleum jelly (Vaseline),

Interesting facts

Carbon black or lampblack is pure carbon that is finer than soot having a larger surface area to volume ratio. Medieval monks used it to colour ink. The inscriptions are still clearly legible. Up to Early Victorian times lampblack was used to make the best and longest lasting dark pigment for writing and painting. Anything organic was burned in an oxygen poor environment and the fine black soot-like residue remaining was mixed with water and gum. After Mid-Victorian times coal and crude oil were burned. Children of the poor were employed because fumes from oil combustion and fine carbon particles ruined their lungs within about four years. Like coal miners at that time, they died of "black lung". Carbon black is still being produced though under much healthier conditions. It is commonly used as a filler and colouring agent in car tyres and other artificial rubber products.

Carbon Chemistry – Teacher Notes

The following experiment is usually performed as a teacher demonstration as it involves the production of flames and smelly gas. . If you combust (burn) organic materials either fresh or fossilised into fossil fuel, one of the products will be a black sooty residue which is mostly carbon. The best time to carry out this activity is the last session in the day. When the laboratory can be aired overnight. Most students find destructive testing fascinating.

AIM **To test for the presence of carbon by combustion**

Materials

- Bunsen burner
- Tongs
- Safety Glasses
- Bench protector
- Bowl of water to extinguish flames
- Strips of material to burn (organic and inorganic)
- Fume cupboard or hood if possible

You may choose to use: Thin strips of wood (pop stick) and newspaper, a metal washer, woollen cloth or wool, a rock, a piece of coal, a piece of fruit, aluminium foil (cooking foil),

Method

1. Students should check on safety procedure when using a lit Bunsen burner.
2. Pick up each specimen and place in Bunsen flame for 5 seconds.
3. Remove from Bunsen and extinguish any flames.
4. Write your observations in the table provided.

Observations

Substance	Origin	Before burning	Burned	Is carbon present?
Wood	Tree	Solid, Brown/grey colour - depends.	Solid, black Gas grey	Yes
Paper	Tree	Solid	Solid black Gas grey	Yes
Washer	Iron ore	Solid silvery metallic	Solid. Only slight change of colour	No
Wool	Sheep	Solid white	Black fine dust (solid)	Yes
Rock	Rock	Solid, Depends on rock	Much the same	No
Plastic strip	Fossil fuel	Solid clear/white?	Melted black liquid that became solid. Gas dark and smelly	Yes
Aluminium foil	Aluminium ore/bauxite	Solid, shiny, metallic	Solid melted to liquid then cooled to a solid again. Melted portion less shiny	No

Conclusion

Combustion can be used to test for the presence of carbon

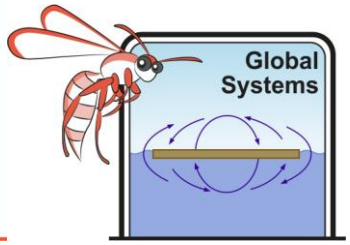
How did you know if carbon was present as a product of combustion (burning)? A fine black sooty residue formed. Soot is mostly carbon

What was common to all the materials that burned to leave black soot? They were all created by living things (organic)

Extension "Flames are the release of past sunlight".

Explain what this statement means

Plants used sunlight to photosynthesise and make materials for their own bodies. This energy is released as light (flames) when wood or peat is burned. If animals eat plants, energy is transferred to them. Fossil fuels are the remains of plants and animals. When they are burned the energy released originally came from photosynthesis within plants.



Carbon Chemistry – Teacher Demonstration

Carbon is the 12th most common element on Earth. To know how it will behave within global systems we need to first understand how its' chemistry is controlled by its atomic structure.

What is an element? _____

What is the symbol for the element carbon? _____
Find carbon on the periodic table below and draw an arrow to it.

Group→ / ↓Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
Lanthanides			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
Actinides			89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

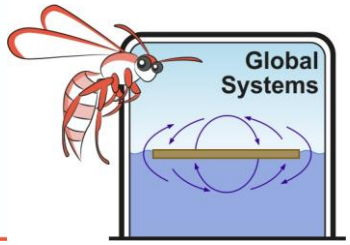
Using the information from the periodic table provided:
How many protons does carbon have? The atomic number or number of protons lies above each element's symbol in the periodic table. _____

How many electrons ***must*** a neutral atom of carbon have? _____

If its Atomic Weight is usually 12, how many neutrons ***must*** it have? _____

Interesting facts

Carbon black or lampblack is pure carbon that is finer than soot having a larger surface area to volume ratio. Medieval monks used it to colour ink. The inscriptions are still clearly legible. Up to Early Victorian times lampblack was used to make the best and longest lasting dark pigment for writing and painting. Anything organic was burned in an oxygen poor environment and the fine black soot-like residue remaining was mixed with water and gum. After Mid-Victorian times coal and crude oil were burned. Children of the poor were employed because fumes from oil combustion and fine carbon particles ruined their lungs within about four years. Like coal miners at that time, they died of "black lung". Carbon black is still being produced though under much healthier conditions. It is commonly used as a filler and colouring agent in car tyres and other artificial rubber products.



Carbon Chemistry – Teacher Demonstration

Teacher demonstration or student activity

AIM **To test for the presence of carbon by combustion**

Materials

- Bunsen burner
- Tongs
- Safety Glasses
- Bench protector
- Bowl of water to extinguish flames
- Strips of material to burn (organic and inorganic)
- Fume cupboard or hood if possible

You may choose to use: Thin strips of wood (pop stick) and newspaper, a metal washer, woollen cloth or wool, a rock, a piece of coal, a piece of fruit, aluminium foil (cooking foil). After combustion, most material containing carbon becomes black.

Method

1. Students should check on safety procedure when using a lit Bunsen burner.
2. Pick up each specimen and place in Bunsen flame for 5 seconds.
3. Remove from Bunsen and extinguish any flames.
4. Write your observations in the table provided.

Observations

Substance	Origin	Before burning	Burned	Is carbon present?
Wood	Tree	Solid, Brown/grey colour -	Solid, black Gas grey	Yes

Conclusion

_____

_____

_____

Discussion

How did you know if carbon was present as a product of combustion (burning)? _____

_____

What was common to all the materials that burned to leave black soot? _____

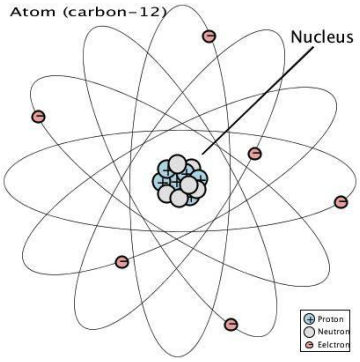
_____

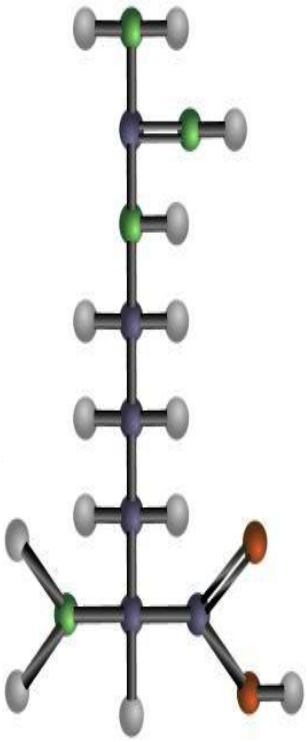
Extension: “Flames are just energy trapped from past sunlight”.

Explain what this statement means

Carbon chains - Teachers' notes

Carbon atoms can form long strong chains





Because carbon has six electrons, two will fill its inner shell allowing the remaining four electrons in the outer shell to be active in forming compounds or more carbon atoms share their 4 outer electrons they can fulfil the "Octet Rule". They can then bond together in long chains creating molecules that are essential in the formation of living things. Carbon chains in our bodies make fats, carbohydrates and proteins. Our DNA is made of a particularly long molecules that if unwound would stretch all the way across the Solar System and back again. The ball and stick model is of a basic amino acid arginine. (Carbon is blue grey, oxygen is red, nitrogen is green and hydrogen is silver)

AIM to create slime and compare its characteristics with those of clay.

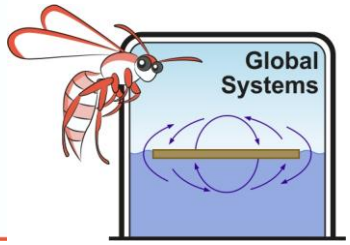
Slime is made from long chain carbon based molecules cross-linked by borax molecules. Clay is an aluminosilicate and does not contain carbon.

Materials

- Safety glasses
- Bench protector
- 2 beakers
- Option – food colouring
- Stirring rod
- Measuring cylinder
- Zip lock sandwich bag and pen
- A small piece of clay or plasticine

For the borax solution

- 240 mL water
- 5mL (one teaspoonful) borax (sodium tetra borate solution) $Na_2BO_4O_2.10H_2O$
- Add a few drops of food colouring if required



Carbon Chains – Teacher Notes

For the PVA (polyvinyl acetate) solution

- 500mL water
- 125 mL PVA glue (about half a cup)
-

Method

Stir borax into water to dissolve.

Which substance is the solute, the solvent and the solution? Solute is borax (solid), solvent is water (liquid) and borax solution forms

Stir PVA into water to dissolve.

Which substance is the solute, solvent and solution? In this case two liquids dissolve into each other to form PVA solution.

Puzzler What is the difference between a solution and a mixture? Mixtures and solutions consist of intermixed materials, but solutions have homogeneity (equal distribution of materials)

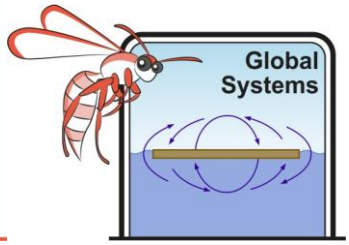
As one student continues to stir the PVA solution another slowly adds the borax solution
As the slime forms, lift it out and knead it in your hands, working it until it is firm and dry.
Pull and twist the slime to discover how flexible and elastic long chains of molecules can be.
Compare this behaviour to clay in your observations.
Place the slime in a Zip lock sandwich to be placed in a cool place until the end of the day.

Observations

The clay can bend a little but breaks easily. It needs to be worked to reform after breakage.
The slime is flexible and reconstitutes easily if broken.

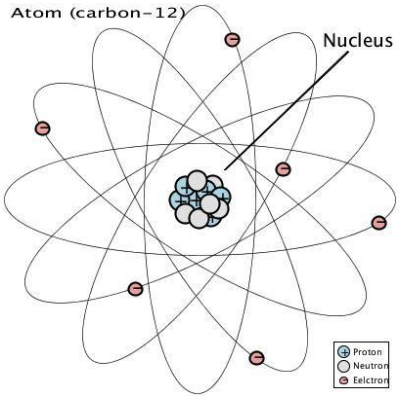
Conclusion

The characteristics of clay and slime are related to their chemistry.



Carbon Chains – Student Activity

Carbon atoms can form long strong chains



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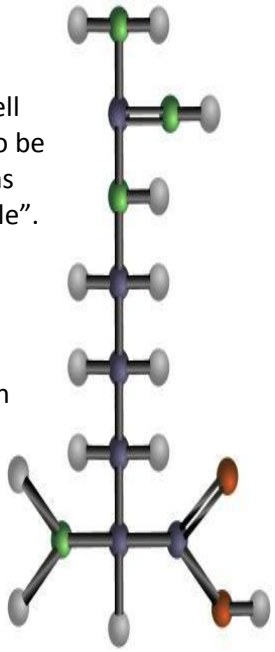

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- A small piece of clay or plasticine

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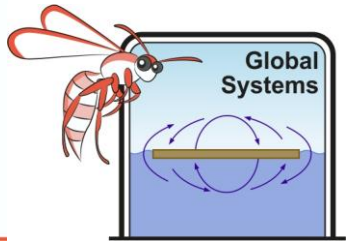
- Add a few drops of food colouring if required

For the PVA (polyvinyl acetate) solution

- 500mL water
- 125 mL PVA glue (about half a cup)

Carbon Chains – Student Activity



Method
Stir borax into water to dissolve.

Which substance is the solute, the solvent and the solution? _____

_____

Stir PVA into water to dissolve.

Which substance is the solute, solvent and solution? _____

_____

Puzzler: What is the difference between a solution and a mixture? _____

_____

_____

_____

As one student continues to stir the PVA solution another slowly adds the borax solution.
As the slime forms, lift it out and knead it in your hands, working it until it is firm and dry.
Pull and twist the slime to discover how flexible and elastic long chains of molecules can be.
Compare this behaviour to clay in your observations.
Place the slime in a Zip lock sandwich to be placed in a cool place until the end of the day.

Observations

_____

_____

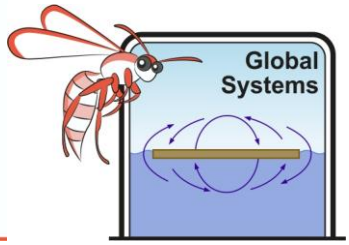
_____

Conclusion

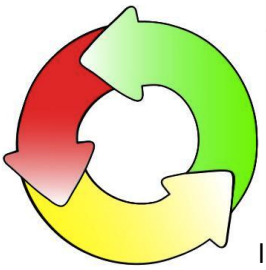
_____

_____

_____



Respiration - Teacher Notes



The carbon cycle is very important when we consider carbon dioxide and methane as forcing factors producing the enhanced Greenhouse Effect. Carbon moves throughout our global systems. It can be found in the atmosphere as carbon dioxide and methane, in the hydrosphere as soluble bicarbonate ions (hydrogen carbonate), carbonic acid and methane clathrate, in the biosphere as insoluble carbonate shells and soluble sugars and in the lithosphere as limestone and marble.

When carbon, as carbon dioxide leaves our atmosphere, it is held in sinks for varying lengths of time. The sea is the largest sink for carbon dioxide. Carbon dioxide resides in the atmosphere for between 2 and 4 years. It resides in deep oceans for up to 500 years, however. Within rocks carbon resides as carbonates and fossil fuels for many million years.

Amount of carbon dioxide in each reservoir (gigatons)

Rocks, soil and sediment	66,000,000 to100,000,000
Fossil fuels	4,000
Ocean	38,000 to 40,000
Terrestrial plants	540 to 610
Atmosphere	766 (CO_2 concentration currently increasing by about 3.2ppm per year).

The processes that cause the carbon to move through the atmosphere and hydrosphere are respiration, photosynthesis, fermentation, combustion, solution and lithification.

Respiration Plants and animals break up simple sugars to create energy for growth, reproduction, movement (for animals) and repair.

Where does respiration occur? In the living cells of plants and animals

Write the word equation for respiration

Sugar + Oxygen = Carbon dioxide + Water + Energy

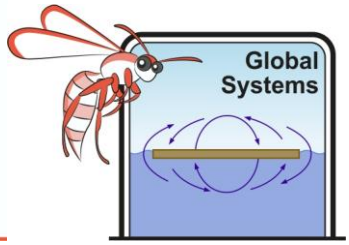
Why does a plant or animal respire? To provide energy for growth, maintenance, repair, reproduction and movement (animals)

What happens initially to the carbon dioxide produced? It is released into the atmosphere

Teacher demonstration: To demonstrate that carbon dioxide is a product of respiration

Materials

- Healthy plant
- Small beaker of limewater $Ca(OH)_2$
- Bell jar or inverted large beaker sealed with plasticine to contain carbon dioxide.
- A cloth or cardboard box.



Respiration - Teacher Notes

Method

1. Place the plant and limewater under the bell jar.
2. Cover with cloth or inverted cardboard box to exclude light
3. Leave for two days and observe changes in limewater

Observations

What did you observe? The clear limewater turned milky. A white precipitate was formed.

Conclusion

What conclusion does this observation lead you to? The plant released carbon dioxide

Discussion

Which substances were the reactants? Limewater and carbon dioxide

Which substances were the products? Calcium carbonate and water

Write the word equation for this reaction

Lime water/calcium hydroxide + carbon dioxide > calcium carbonate + water

$Ca(OH)_2 + CO_2 \quad = \quad CaCO_3 + H_2O$

How could you tell that calcium carbonate is insoluble in water? It precipitated out of solution to form a white solid

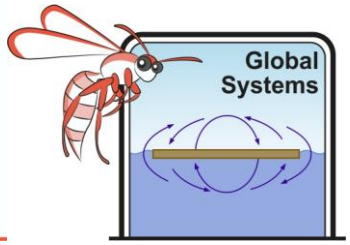
A common misconception amongst students is that plants photosynthesise and do not respire.

Extension respiration activities When humans respire carbon dioxide is also produced (along with water and energy) Students may ***blow gently*** through a straw into limewater to demonstrate this. After a little time the limewater will turn milky. The gas we breathe out is not pure carbon dioxide as tidal air enters and leaves the lungs as well. We breathe out about 200mL of CO_2 every minute.

The air we breathe in contains about 0.04% carbon dioxide. The air we breathe out contains about 4% carbon dioxide (The concentration is increased one hundredfold). Water is also lost during breathing. Exhaled air has a relative humidity of 100%. Both water and carbon dioxide are greenhouse gasses.

Students might enjoy thinking of what measures could be taken to reduce personal CO_2 and H_2O production from respiration. There is none, other than reducing population numbers, as respiration is essential for life.

When we have hiccoughs we can stop them by putting a paper bag over our face and breathing into it. The higher levels of CO_2 stimulate the respiratory centre in the brain and the spasms stop.



Respiration - Teacher Demonstration

The carbon cycle is very important when we consider carbon dioxide and methane as the critical forcing factors producing the enhanced Greenhouse Effect. Carbon moves throughout our global systems.
The processes that cause the carbon to move through the atmosphere and hydrosphere are:
Respiration, Photosynthesis, Fermentation, Combustion, Solution and Lithification.

Respiration

Where does respiration occur? _____

Write the word equation describing respiration.

_____

Teacher demonstration: To demonstrate that carbon dioxide is a product of respiration.

Materials

- Healthy plant
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- A cloth or cardboard box.

Method

1. Place the plant and limewater under the bell jar.
2. Cover with cloth or inverted cardboard box to exclude light
3. Leave for two days and observe changes in limewater

Observations
What did you observe?
_____

_____

Conclusion
What conclusion does this observation lead you to? _____

Discussion
Which substances were the reactants? _____

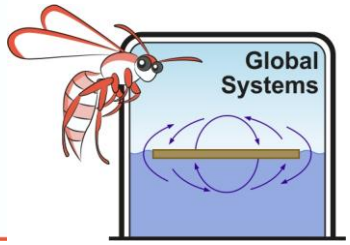
Which substances were the products? _____

Write the equation for this reaction

_____

How could this experiment be improved?

_____



Photosynthesis - Teacher Notes

Photosynthesis: Plants bring together carbon dioxide and water in the presence of light to produce simple sugars. They use these sugars to provide energy for their growth, reproduction and repair. The process also releases oxygen into the atmosphere.

carbon dioxide + water (in sunlight) = sugar + oxygen

Teacher demonstration or student activity

AIM To demonstrate that oxygen is a by-product of photosynthesis

Materials

- A large basin or glass pneumatic trough
- Some water plants
- Water
- A large glass test tube
- A retort stand, and clamp
- A glowing splint or taper. A glowing splint is a pop stick, which has been set on fire .The flames are blown out to leave glowing embers. In the presence of oxygen a glowing splint ignites and bursts into flame.
- Sunshine or a laboratory/microscope lamp

Method

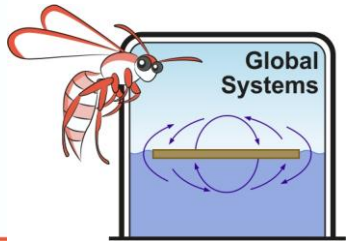
1. Almost fill the basin with water
2. Add the water plants
3. Submerge the test tube then invert it without removing it from the water. The tube should be full of water.
4. Move the tube so that it is above the plant but leave its mouth still under water
5. Adjust the stand and clamps to hold the test tube in this position
6. Place the lamp so that it shines on the plant continuously.
7. Observe
8. When the test tube is almost filled with gas, keep it upside down and remove it from the water.
9. Place the glowing splint at the mouth of the test tube.
10. Observe.

Observation

Bubbles of gas were seen rising from the water plant. This was collected in the upturned test tube by displacement of water. When the glowing splint was placed at the mouth of the test tube it burst into flame.

Conclusion

Oxygen makes a glowing splint burst into flame. The plant in sunshine must have produced oxygen.



Photosynthesis - Student Activity

Photosynthesis: Plants bring together carbon dioxide and water in the presence of sunlight to produce simple sugars. They use these sugars to provide energy for their growth, reproduction and repair. The process also releases oxygen into the atmosphere.

Write the equation for photosynthesis.

_____

AIM **To demonstrate that oxygen is a by-product of photosynthesis**

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Observations

_____

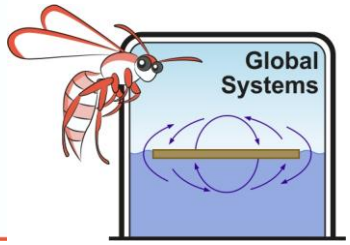
_____

Conclusion

_____

_____

Fermentation - Teacher Notes



Fermentation/decomposition: Carbohydrate in living things decomposes to form methane or alcohol. Fermentation in an animal's stomach produces methane whereas decomposition by bacteria produces alcohol. Methane is also a greenhouse gas.

Teacher Demonstration or student activity

AIM **To demonstrate that decomposition of plant and animal materials produces carbon dioxide and methane.**

This activity mimics the decomposition of lagoonal and marine organisms to produce oil and gas.

Materials

- 2L cool drink bottle or washed wine bottle
- 1 long glass rod
- 1 rubber glove or balloon (Note The methane molecule is small enough to penetrate latex and some will be lost)
- Strong sealing tape
- 1tbs tinned or fresh fish and 5 shredded lettuce or spinach leaves
- Sand or soil
- A funnel
- 1.5L pond water, muddy puddle water or the water from under plant pots

Method

1. Using the funnel, drop 3 or 4cm soil into the bottle
2. Add layers of animal and vegetable shreds
3. Place the glass rod into the bottle
4. Pour the pond water down the rod to prevent splashing
5. Remove the rod
6. Fit the empty glove or balloon over the end of the bottle and seal well
7. Leave in a warm spot to rot

Safety notes

Label the bottle "DO NOT OPEN" and add a biohazard symbol.
Do not expose the experiment to open flame, as methane is combustible
Dispose of carefully after use

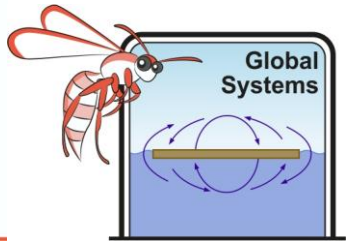
Observation

The balloon filled with a gas that is lighter than air.

Conclusion

This gas is likely methane.

Fermentation - Teacher Demonstration



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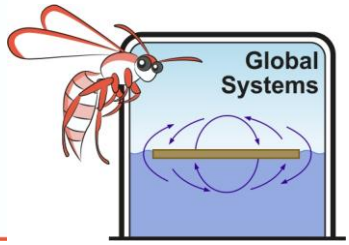
_____

Conclusion

_____

_____



Solution - Teacher Notes

Solution

Solubility of carbon dioxide in cold water
Our oceans absorb 40% of all the carbon dioxide we release. Increased carbon dioxide results in increased ocean acidification (OA)

> ***Ocean acidification, or "OA" for short, is the term given to the chemical changes in the ocean as a result of carbon dioxide emissions.***

Carbon dioxide is soluble in water. Two selected students or teams of selected students may easily demonstrate this by bubbling expired air through water that has been coloured with two drops of Universal Indicator. Green (neutral pH7) water will turn red (acid) in about two minutes indicating that water has become carbonic acid. (Over excitable students can create a colourful wet mess.)

Carbon dioxide + Water → Carbonic acid
$CO_2 + H_2O \rightarrow H_2CO_3$

Carbonic acid dissociates in water to form ions.
$H_2CO_3 \rightarrow H^+$ and $HCO3^-$

Carbon dissolved in sea water is found as a bicarbonate or hydrogen-carbonate ion.

AIM To test the solubility of carbon dioxide in water

Materials

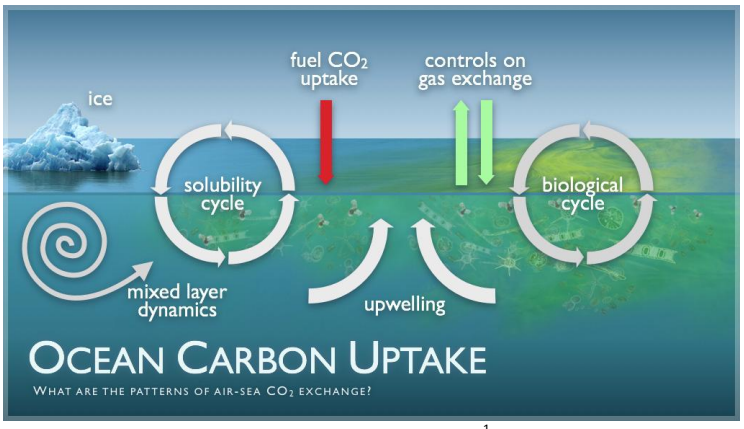
- 2 test tubes half filled with water
- Universal indicator
- 2 straws (plastic are best)

Method

1. Place two drops of Universal Indicator Solution or a strip of indicator paper in each tube
2. Each student blows gently into the test tube. If teams are used each student may blow for 10 seconds before retaining their straw and passing on the test tube to another in their team
3. Blowing stops when a colour change is observed.

Observation
What change occurred? The liquid changed from green to red.

Conclusion
What does this change of colour lead you to conclude? Neutral water (green) became acidic (red) Carbon dioxide is soluble in water.



Produced courtesy of NOAA[1]

Solution - Teacher Notes

The sea is a large sink (reservoir) of carbon dioxide. Carbon dioxide moves between the atmosphere where it is in a mixture with other gasses and the ocean (hydrosphere) until a balance is reached (CO_2 partial pressures are equivalent). An increase in atmospheric CO_2 due to burning fossil fuels or land volcanism will force more into the sea until a balance is reached. The increased concentration moves to mix very slowly as it is driven by slow moving deep ocean currents. Plumes of ocean rich in bicarbonate can be found near industrial areas of the Northern Hemisphere.

Conversely, undersea volcanism outgassing CO_2 or ocean heated because of the enhanced Greenhouse Effect will release CO_2 back into the atmosphere.

The solubility of carbon dioxide in warm water

AIM To demonstrate the effect of heat on the solubility of carbon dioxide in water

Materials

- Some carbonated water (cool drink or soda water)
- Two small glasses or beakers
- A hot water bath (larger beaker with a little hot water)

Students may need to be told that the “fizz” in soft drink is carbon dioxide gas held in flavoured water under pressure. When the cap is removed pressure decreases and the gas comes out of solution. As cold deep water rises through upwelling ocean currents it becomes warmer and outgasses carbon dioxide into the atmosphere. Similarly atmospheric warming due to the enhanced Greenhouse Effect will release more carbon dioxide producing a positive feedback loop.

Plants and animals in the ocean absorb the soluble bicarbonate ions and turn them into insoluble carbonates with which to build shells and skeletons. Coral reefs are carbonate sinks and are made from the skeletons of coral. Carbonates are also deposited as ooze in warm tropical oceans. Soluble bicarbonates often form the cement that turns sediment into sedimentary rock during the process of lithification.

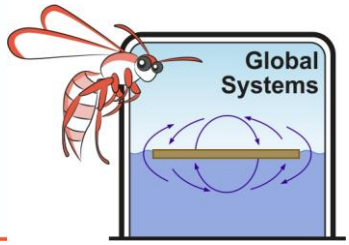
Solution - Teacher Notes

Note: Combustion Carbon in living organisms or their fossilised remains (fossil fuels such as coal, oil and gas) can be burned with oxygen to produce energy, water and carbon dioxide. In third world countries land is often cleared for agriculture by setting fire to vegetation. Fire removes the vegetation and provides some fertiliser from ash. Fire is also used to remove weeds and straw after harvest. In both cases most of the carbon stored in the biosphere is removed to the atmosphere.

Combustion activities are found in the "Carbon Chemistry" section.

References

[1] Ocean Carbon Uptake, National Oceanic and Atmospheric Adminstration, accessed at http://www.pmel.noaa.gov/co2/story/Ocean+Carbon+Uptake, accessed on May 6th, 2014



Solution - Student Activity

Solution

AIM To test the solubility of carbon dioxide in cold water

Our oceans absorb 40% of all the carbon dioxide we release. Increased carbon dioxide results in increased ocean acidification (OA)

Materials

- 2 test tubes half filled with water
- Universal indicator
- 2 straws (plastic are best)

Method

1. Place two drops of Universal Indicator Solution or a strip of indicator paper in each tube
2. Each student blows gently into the test tube.
3. Blowing stops when a colour change is observed.

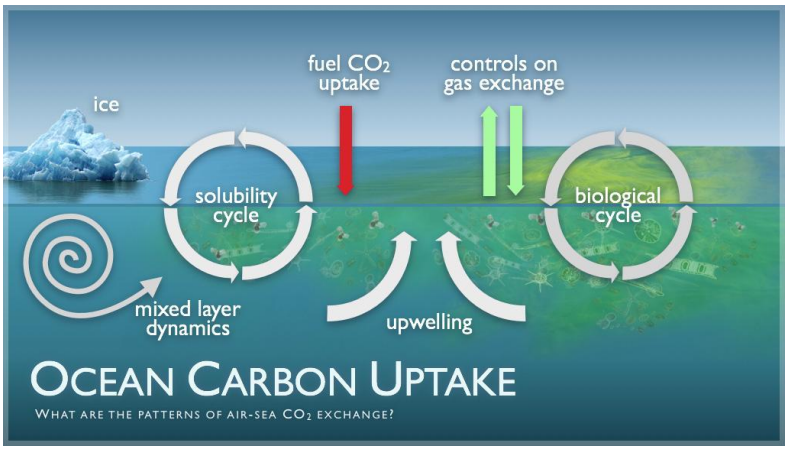
Observation

What change occurred? _____

Conclusion

What does this change of colour lead you to conclude? _____

_____



Produced courtesy of NOAA

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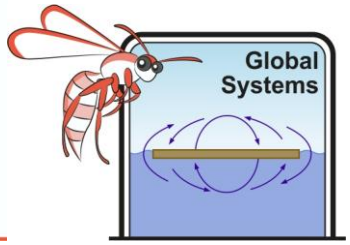
AIM To test the solubility of carbon dioxide in warm water

Materials

- Some carbonated water (cool drink or soda water)
- Two small glasses or beakers
- A hot water bath (larger beaker with a little hot water)



Solution - Student Activity

Method

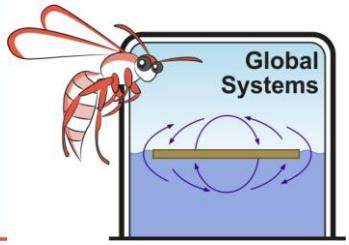
1. Fill two small containers with carbonated water
2. Place one container in a warm water bath
3. Observe

Observation

_____

_____

_____



Lithification - Teacher Notes

Lithification

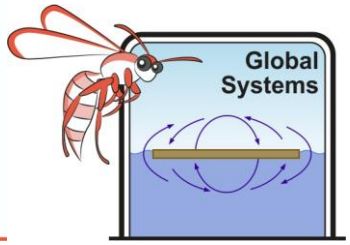
The process of lithification turns loosely compacted and poorly cemented sediments into rock
Most of Earth's carbon is bound up in rocks, sediments and soils. They can be very long lasting sinks.
If the rocks contain high amounts of fossilised material they can become fossil fuel reservoirs.
We burn North West Shelf oil and gas from rock to create power for industry and domestic use.

Students will need access to reference books or the Internet to answer these questions.

1. Approximately how long has carbon from our North West oil and gas fields been stored in the rocks before it is released into the atmosphere by combustion?
   About 130million years – Lower Cretaceous

2. We burn Perth Basin gas for domestic use. Approximately how long has its carbon been stored in the rocks before it is released into the atmosphere by combustion?
   About 270 million years (Mostly Jurassic but some Cretaceous near Gingin)

3. We we burn Collie coal for electricity production. Approximately how long has its carbon been stored in the rocks before it is released into the atmosphere by combustion?
   About 280 million years (Permian)



Lithification - Student Activity

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_____

_____

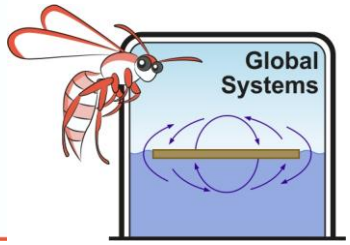
_____

3. We burn Collie coal for electricity production. Approximately how long has its carbon been stored in the rocks before it is released into the atmosphere by combustion?

_____

_____

_____

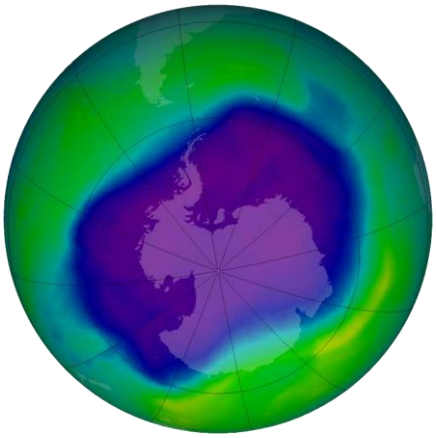


Carbon Cycle Poster - Student Activity

Bringing the carbon cycle together

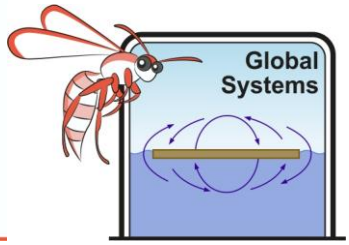
You are asked to assemble a poster of the carbon cycle describing the inter-relationship between the processes of:

- Photosynthesis
- Respiration
- Fermentation and decomposition
- Solution
- Combustion
- Lithification



Method

1. Work silently, using your own notes to draft a description of these six processes
2. Submit your draft for feedback
3. Use the feedback given to fill any gaps (using reputable sources of information).
4. Create your own poster



Radiocarbon – Teacher Notes

Dealing with data

Researchers need to collect data that is both accurate and precise. However, as Clifford Stroll famously said:

"Data is not information
Information is not understanding
Understanding is not wisdom" ***Garbage in = Garbage out***

Researchers into climate change cannot directly use temperature measurements before three hundred years ago. Daniel Gabriel Fahrenheit only built the first accurate thermometer in 1709. It used a standard scale named after him. Prior to that instruments could only indicate if substances were cooler than or hotter than others.
To assess if changes in temperature are atypical or lie within the normal range of variation, researchers need information that stretches beyond a few hundreds of years. They need information that ranges over geological time. Milankovic cycles are variations in Earth's average temperature from 12°C to 22°C. Data suggest that they repeat over 100,000 year cycles.

Scientific data must be observable, measurable and repeatable.

Primary data is data collected by a scientist or group of scientists for a specific purpose

Secondary data is data collected by other scientists for another similar purpose but which can be used to support an hypothesis

Proxy data is data that can be used to infer information to support an hypothesis

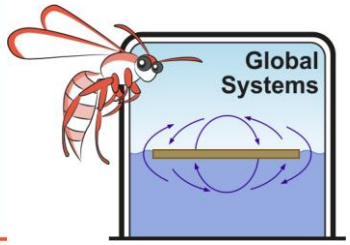
Example
An Australian scientist observes and measures the length of year 10 students left arm. Which kind of data are they collecting? Primary data
The scientist then compares their data with that collected by a Japanese scientist. What kind of data are they using now? Secondary data
To get a word wide perspective, the scientist uses the sleeve length of uniforms given to fifteen years old Swedish maritime students during the 1914 to 1916 period.
What kind of data are they using now? Proxy data

To support the concept of Milankovic Cycles, scientists have drilled deep into the Antarctic Ice Cap. From ice core they have collected air bubbles trapped. From the volume carbon dioxide they can estimate the percentage of carbon dioxide in the atmosphere at that time. By using the carbon-14 to carbon 12 ratio in trapped carbon dioxide they can also estimate the age of the specimen. From this they can infer the ambient global temperature changes over a long period of time. Ice at the base of the cap in East Antarctica is estimated to be 1.5 million years old.

From the paragraphs above:
Give two examples of primary data collected and explain your choices. Temperature readings collected by Fahrenheit. (He collected them himself). Percentage of carbon dioxide in the air bubbles collected by the scientists themselves.
Give two examples of proxy data and explain your choice. Estimations of the temperature based on carbon dioxide levels and estimation of age based on carbon – 12 to carbon – 14 ratios.

Radiocarbon – Teacher Notes

Interesting fact Although the incidence of radiocarbon in the atmosphere has remained fairly constant at 1.2 parts per trillion to carbon-12 over the last few thousand years, above ground atomic bomb testing in the 1950s and 1960s caused a doubling of concentration. This spike was absorbed into tooth enamel and can be used as a marker to accurately estimate a person's age. CSIs can also measure the time of burial of bodies more that 400 years ago. At lesser time the readings can be inaccurate.



Radiocarbon – Student Activity

Dealing with data

Researchers need to collect data that is both accurate and precise. However, as Clifford Stroll famously said:

"***Data is not information***
Information is not understanding
Understanding is not wisdom" ***Garbage in = Garbage out***

Researchers into climate change cannot directly use temperature measurements before three hundred years ago. The first accurate thermometer was only built by Daniel Gabriel Fahrenheit in 1709. It used a standard scale named after him. Prior to that instruments could only indicate if substances were cooler than or hotter than others.
To assess if changes in temperature are atypical or lie within the normal range of variation, researchers need information that stretches beyond a few hundreds of years. They need information that ranges over geological time. Milankovic cycles are variations in Earth's average temperature from 12^{o}C to 22^{o}C. Data suggest that they repeat over 100,000 year cycles.

Data must be o_____able, m_____able and r_____able.

Primary data is data _____

_____

Secondary data is data _____

_____

Proxy data is data _____

_____

Example

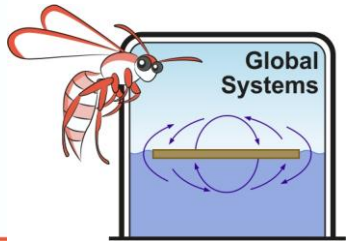
An Australian scientist observes and measures the length of 150 year 10 students' left arms.

Which type of data is being collected? _____

The scientist then compares their data with that collected by a Japanese scientist. What type of data is being used now? _____

To get a long term world wide perspective, the scientist then uses information from an old sewing pattern giving the sleeve lengths of uniforms given to fifteen years old Swedish maritime students during the 1914 to 1916 period.

What kind of data is being used now? _____



Radiocarbon – Student Activity

To support the concept of Milankovic Cycles, scientists have drilled deep into the Antarctic Ice Cap. From ice core they have collected air bubbles trapped. From the volume carbon dioxide they can estimate the percentage of carbon dioxide in the atmosphere at that time using the carbon-14 to carbon 12 ratio in carbon dioxide they can also estimate the age of the specimen. From this they can infer the ambient global temperature changes over a long period of time. Ice at the base of the cap in East Antarctica is estimated to be 1.5 million years old.

From the paragraphs above:

Give two examples of primary data collected and explain your choices.

_____

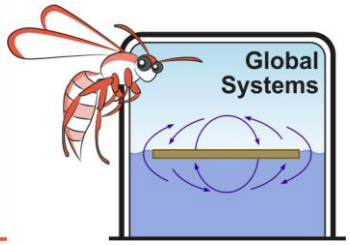
_____

Give two examples of proxy data and explain your choice.

_____

_____

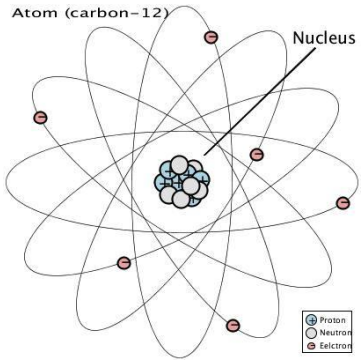
Interesting fact: Although the incidence of radiocarbon in the atmosphere has remained fairly constant at 1.2 parts per trillion to carbon-12 over the last few thousand years, above ground atomic bomb testing in the 1950s and 1960s caused a doubling of concentration in the atmosphere. This "spike" was absorbed into tooth enamel and can be used as a marker to accurately estimate a person's age. CSIs also use radiocarbon to estimate the age of bodies buried over 400 years ago.



Age Graphing – Teacher Notes

If you look at the position of the element carbon in the periodic table, you will be able to find how many protons an atom of carbon has. A neutral atom of carbon must have the same number of protons as electrons.

How many protons does carbon have in its nucleus? 6
If its mass number is 12, how many neutrons does carbon usually have in its nucleus? 6
How many electrons does carbon have in its external electron cloud? 6



Carbon's chemical behaviour depends on the number of electrons it has within its outer shell. It can, and does have different numbers of neutrons in its nucleus. Early chemists realised this when they compared its measured atomic weight with its mass number

The mass number of an element is the sum of protons and neutrons in that atom's nucleus.
What should the mass number of carbon be 12 (6 protons and 6 neutrons)
When the average weight of carbon is estimated we find however that it is not 12 but **12.00096**
The measurement is precise and accurate. What could the scientific explanation for this increased number be? Some atoms of carbon have more than 6 neutrons in their nucleus. They must be few because the deviation from 12 is small. Actually only one trillionth of all carbon atoms are carbon- 14

Carbon isotopes

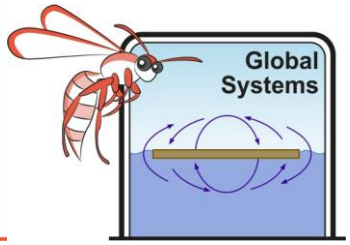
Carbon - 12 or ^{12}C has 6 neutrons	and is 99% of all carbon on Earth
Carbon – 13 or ^{13}C has 7 neutrons	and is less than 1% of all carbon on Earth
Carbon - 14 or ^{14}C has 8 neutrons	and is 1 trillionth of all carbon on Earth

Radioactive carbon is formed in the upper atmosphere when a nitrogen atom is struck by a thermal neutron from the Sun. Write this equation below.

1 neutron + nitrogen-14 = carbon – 14 + 1proton + energy.

$$n + {}^{14}N = {}^{14}C + p + e$$

Draw a diagram of carbon – 14 below. (HINT you can use the diagram of carbon – 12 above to help)
(as above but with 8 neutrons instead of 6 neutrons)



Age Graphing – Teacher Notes

Carbon – 14 will react with oxygen to form carbon monoxide and subsequently carbon dioxide in the atmosphere. It will then be taken up by plants during photosynthesis and enter the food chain.
Write a balanced equation for the first reaction where carbon monoxide is formed.

Carbon + oxygen = carbon monoxide

$2C + O_2 = 2CO$

Write a balanced equation for the second reaction where carbon dioxide is formed.

$2CO + O_2 = 2CO_2$

There may only be a little ^{14}C compared to ^{12}C but it is very useful. Being radioactive its path can be traced as it moves through global cycles. Its natural breakdown to more stable nitrogen occurs at a known rate and can be used to age organic materials.

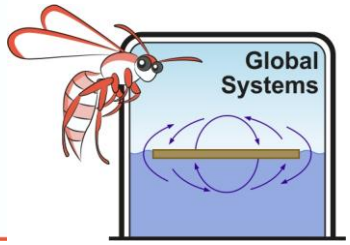
Using carbon -14 to estimate age

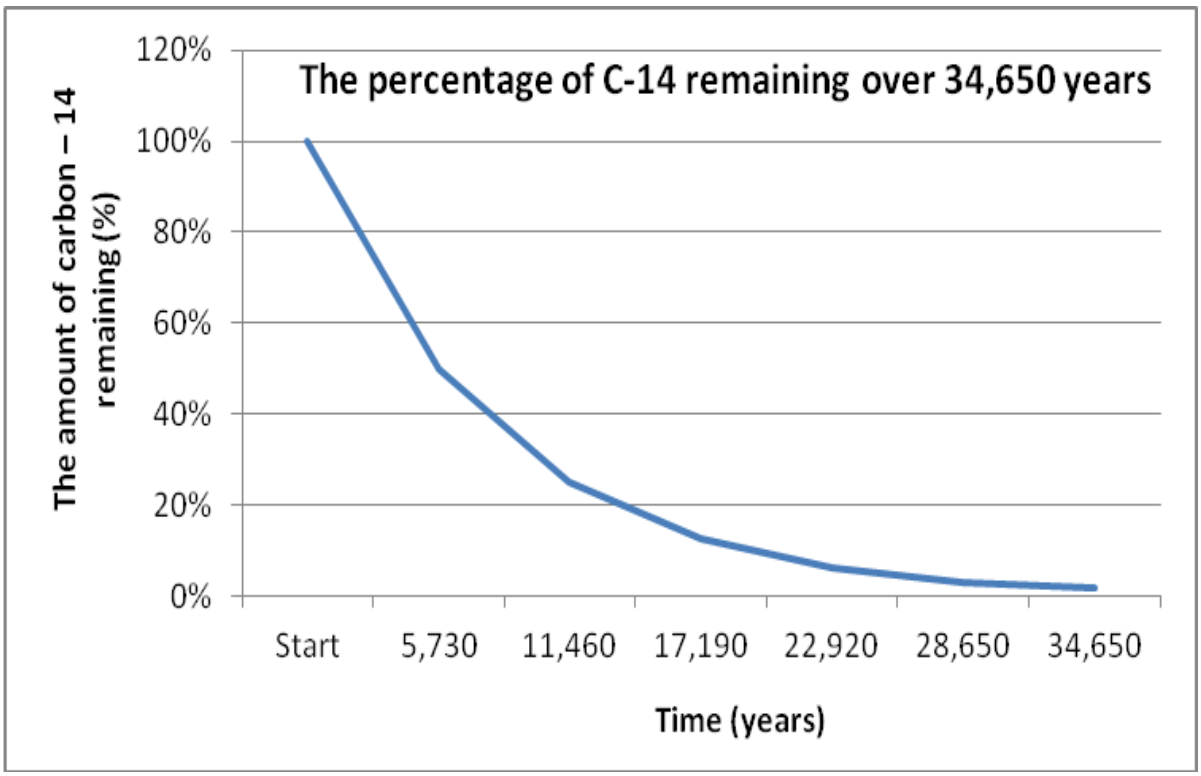
A small percentage of carbon – 14 is continuously being produced in the upper atmosphere. Plants take in carbon dioxide in the process of photosynthesis. One trillionth of this will contain carbon – 14. If an animal eats the plant, it too will have the isotope in its body.
When the plant or animal dies the unstable isotope will start to decay back to nitrogen-14. Decay occurs at a known measured rate.
The time it takes carbon – 14 to lose half of its radioactivity is 5,730 years. This is called its ***"half life".***
It will take another half-life of 5,730 years for half of the remaining carbon – 14 to break down and every 5,730 years the amount of remaining isotope will be halved. By estimating what percentage of the original amount remains we can tell how long ago the organism died.
Use the table below to estimate how much carbon- 14 will remain after the first 7 half lives have passed.

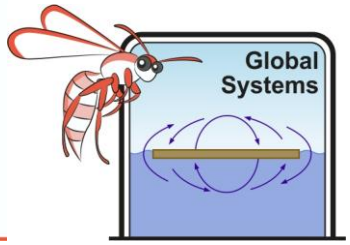
Time	Number of half lives lost	Percentage of C-14 remaining
Start	0	100%
5,730 years	1	50%
11,460 years	2	25%
17,190 years	3	12.5%
22,920 years	4	6.25%
28,650 years	6	3.15%
34,650 years	7	1.58%

Use the graph paper provided to draw up this data.
HINTS
Use a pencil (not 2B), ruler and eraser
The graph should fit over most of the page and be easy to read.
What will the title of your graph be? The percentage of C-14 remaining over 34,650 years
What label should you put on the X axis (horizontal axis) and which units will you use? Time in years
What label will you put on the Y axis (vertical axis) and which units will you use? The amount of carbon – 14 remaining as a percentage of the original amount.
Will this be a line graph or a bar graph? Explain your answer. A line graph as it describes a change in one thing. A bar graph describes differences between different things.
How much carbon – 14 remains after 9,000 years? Approximately 32%

Age Graphing – Teacher Notes







Age Graphing – Student Activity

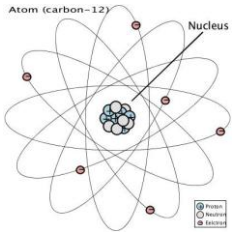
If you look at the position of the element carbon in the periodic table, you will be able to find how many electrons, protons and neutrons make an atom of carbon

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓Period																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
Lanthanides				57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides				89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

How many protons does carbon have in its nucleus? _____

If its mass number is 12, how many neutrons does carbon usually have in its nucleus? _____

How many electrons does carbon usually have in its external electron cloud? _____



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When the average relative weight of carbon is estimated we find however that it is not 12 but **12.00096**
The measurement is precise and accurate. What could the scientific explanation for this increased number be?

_____

Isotopes have the same number of electrons and protons but differing numbers of neutrons

Carbon Isotopes

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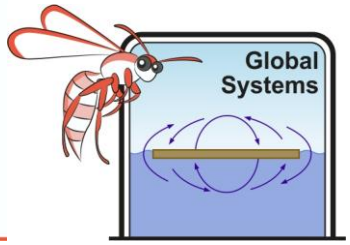

Age Graphing – Student Activity

Radioactive carbon is formed in the upper atmosphere when a nitrogen atom is struck by a thermal neutron from the Sun. Write this equation below.

_____

Draw a diagram of carbon – 14 below. (HINT you can use the diagram of carbon – 12 on the previous page to help)

Carbon – 14 will react with oxygen to form carbon monoxide and subsequently carbon dioxide in the atmosphere. It will then be taken up by plants during photosynthesis and enter the food chain.

Write a balanced equation for the first reaction where carbon monoxide is formed.

_____

Write a balanced equation for the second reaction where carbon dioxide is formed.

_____

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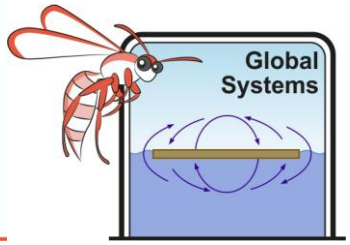
Use the table below to estimate how much carbon- 14 remains after the first 7 half lives have passed.



Age Graphing – Student Activity

Time	Number of half lives lost	Percentage of C-14 remaining
Start	0	100%

Use the graph paper provided on the next page to draw up this data.

HINTS
Use a pencil (not 2B), ruler and eraser.
The graph should fit over most of the page and be easy to read.

What will the title of your graph be? _____

What label should you put on the X axis (horizontal axis) and which units will you use?

_____

What label should you put on the Y axis (vertical axis) and which units will you use?

_____

_____

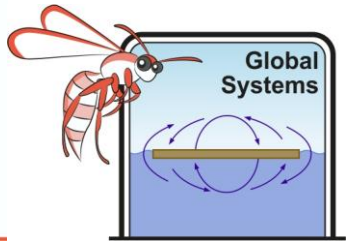
Will this be a line graph or a bar graph? Explain your answer.

_____

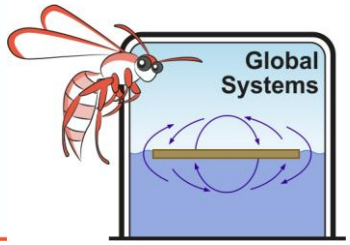
_____

How much carbon – 14 remains after 9,000 years? _____

Age Graphing – Student Activity



Carbon and the Carbon Cycle – Teacher Review



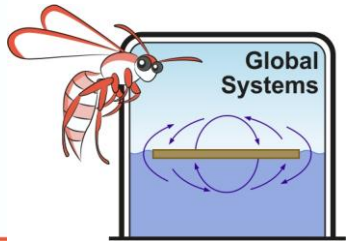
S L R Q B K N N Q C B I L E R
N I M E C N E O O I O S N L A
O S S O S U O M T M C O D B D
I S R E T P B R E O I T I A I
T O I R H U I R T T R O O T O
U F O E S T U R A C C P X C C
L N C T L S N C A A E E I I A
O M I H S E I Y R T F L D D R
S O O E A F M B S U I C E O B
N E R T I I O E E O Y O Z I O
Y P G H A N N L N C T N N R N
R E T A W E M I L T Y O E E V
V I S E D I M E N T K R H P T
L F E R M E N T A T I O N P E
P A R T I A L G S S E C O R P

AGE
ATOM
CARBON
CHAIN
COMBUSTION
CYCLE
DIOXIDE
ELECTRON
ELEMENT
FERMENTATION
FOSSIL
FUEL
ISOTOPE
LIMEWATER
LITHIFICATION
NEUTRON
PARTIAL
PERIODICTABLE
PHOTOSYNTHESIS
PRESSURE
PROCESS
PROTON
RADIOCARBON
RESPIRATION
ROCK
SEDIMENT
SOLUTION

For each process in the carbon cycle give an explanation of what it means and an example of where it occurs

Respiration	The breakdown of sugars to release energy	Animal and plant cells (mitochondria)
Photosynthesis	The bringing together of carbon dioxide & water in the presence of light to create sugars	Plant and bacterial cells (chloroplasts)
Fermentation	The anaerobic breakdown of sugars to form carbon dioxide, water and methane	Bacteria
Solution	Conversion of a solid or gas into a liquid by mixing with a liquid	Sugar dissolves in water to form a sugar solution
Lithification	The change of a sediment to form a rock (compaction & cementation)	Sand becomes sandstone
Combustion	Creation of heat and light from the reaction of a substance with oxygen	Wood burns in air if heated

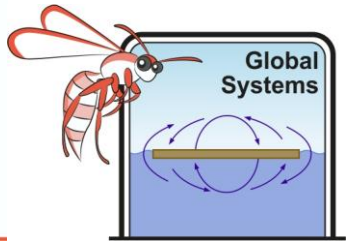
Carbon and the Carbon Cycle – Student Review



S L R Q B K N N Q C B I L E R
N I M E C N E O O I O S N L A
O S S O S U O M T M C O D B D
I S R E T P B R E O I T I A I
T O I R H U I R T T R O O T O
U F O E S T U R A C C P X C C
L N C T L S N C A A E E I I A
O M I H S E I Y R T F L D D R
S O O E A F M B S U I C E O B
N E R T I I O E E O Y O Z I O
Y P G H A N N L N C T N N R N
R E T A W E M I L T Y O E E V
V I S E D I M E N T K R H P T
L F E R M E N T A T I O N P E
P A R T I A L G S S E C O R P

Find 26 words relating to carbon and the carbon cycle in the wordsleuth above and write them below

What words are missing?

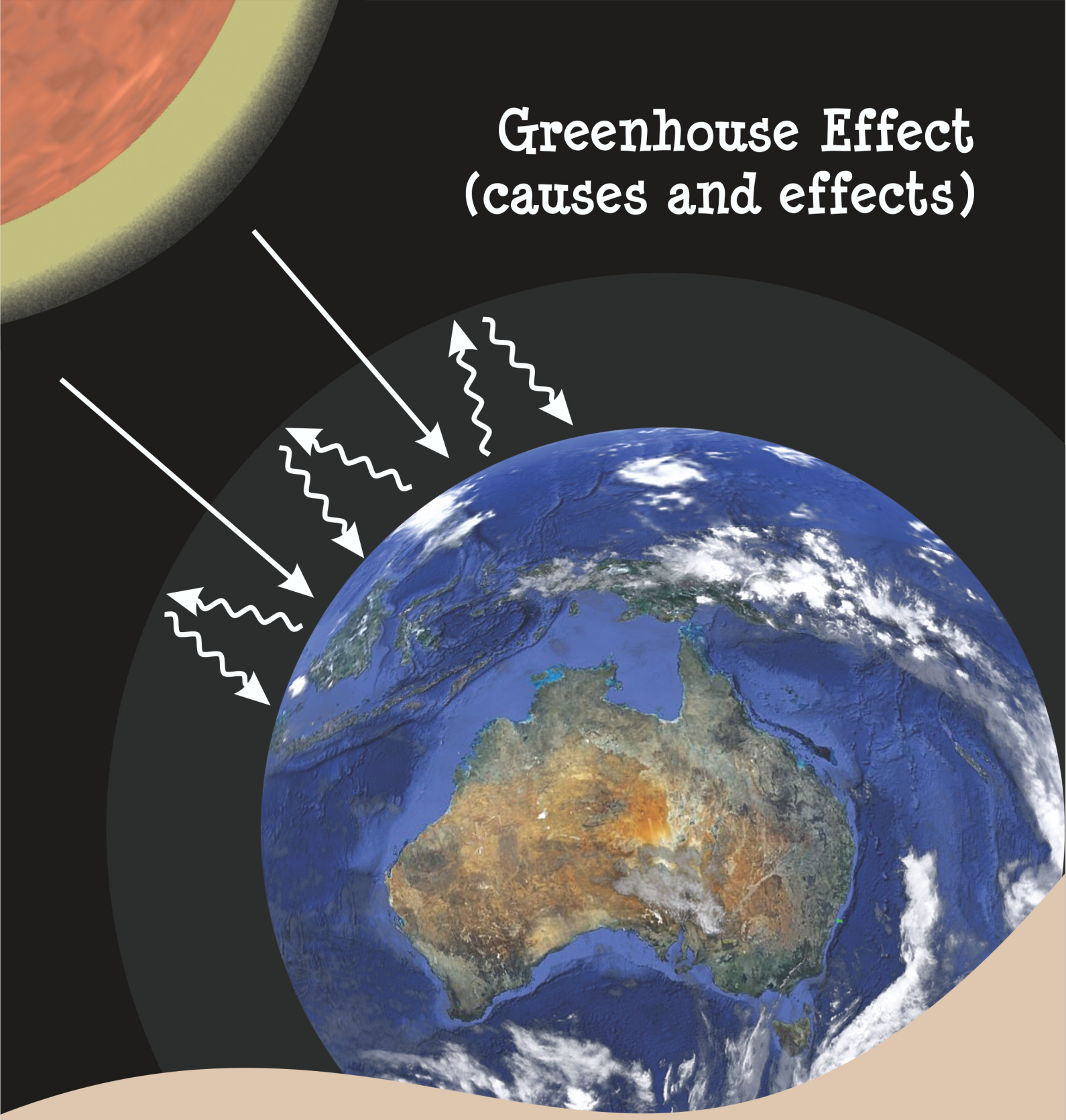


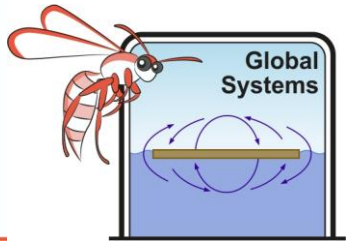
Carbon and the Carbon Cycle – Student Review

For each process in the carbon cycle give an explanation of what it means and an example of where it occurs

Process	Meaning or description	Example
Respiration		
Photosynthesis		
Fermentation		
Solution		
Lithification		
Combustion		

Greenhouse Effect (causes and effects)





Greenhouse Effect – Teacher Notes

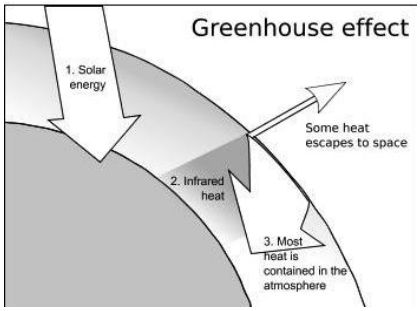
Before our present atmosphere was formed, radiant heat from the Sun was directly reflected from Earth's surface to be lost out into space. The original atmosphere was made up of hydrogen, water vapour, methane and ammonia. Most of this would have been blown away by solar winds.

Outgassing from volcanic activity with additions from asteroid bombardment produced our second nitrogen and carbon dioxide rich atmosphere to which was slowly added oxygen produced during photosynthesis by very early life forms such as the stromatolite fossils we find in rocks in the Pilbara.

An increase in photosynthetic plants raised our oxygen levels to near our present levels by the Cambrian times. Carbon dioxide levels produced during tectonic movements and related volcanism can be related to periods of heating and cooling during our geological history. The evidence of past climate variation lies in the rocks.

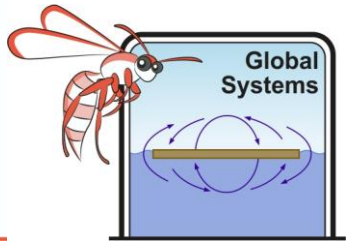
Most of the gas in our atmosphere is nitrogen 78.09% and oxygen 20.95%. These have little effect on retaining heat to maintain plant growth. The gasses, which produce the "Greenhouse Effect", are sometimes termed "aerosol gasses". Solar energy warms the Earth's surface and was originally radiated back out into space. The build up of "Greenhouse" gasses in the atmosphere absorbed this radiated energy and re-radiated it in all directions, including back to the surface of the planet. Life on Earth is sustained by warming due to carbon dioxide and its greenhouse effect. The surface of Earth would be more than 30^{o}C cooler without natural greenhouse gasses

Water vapour is the most important greenhouse gas in terms of volume and heat retention. Having a short residence time of four days in the atmosphere means that it must be constantly replenished by evaporation from the ocean. Although the three other main greenhouse gasses, carbon dioxide, methane and nitrous oxide are less present they remain in the atmosphere for very much longer and therefore have a greater continuous heat trapping effect, residing for thousands of years. The largest source of carbon dioxide is from volcanic activity.



Gas	Percentage of greenhouse gasses	Percentage produced naturally
1. Water vapour H_2O	95.000%	94.99%
2. Carbon dioxide CO_2	3.618%	3.502%
3. Methane CH_4	0.360	0.294%
4. Nitrous oxide N_2O	0.950%	0.903%
5. Others	0.072%	0.025%

How does water vapour enter the atmosphere? Evaporation from oceans and other water bodies, burning fossil fuels, respiration from plants and animals



Greenhouse Effect – Teacher Notes

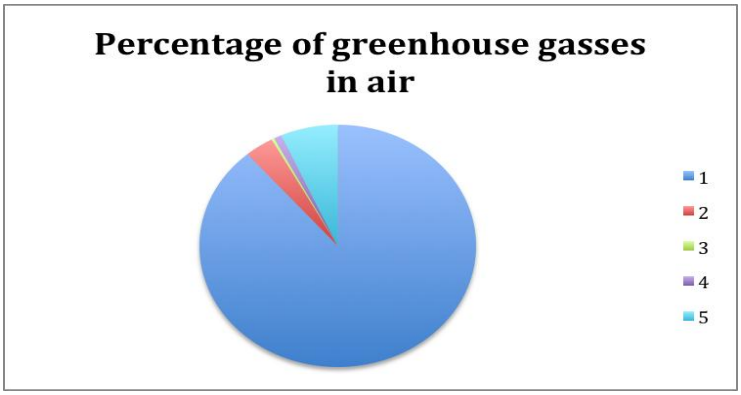
How does carbon dioxide enter the atmosphere? Respiration and decomposition from plants and animals, outgassing from volcanoes and burning fossil fuels.

How does methane enter the atmosphere? Decomposition in wetlands, vegetated soils and the ocean, decomposition in landfill, termite digestion, digestion by-product of ruminants, rice agriculture, burning fossils fuels and industrial processes. It traps 20 times more heat than CO_2

How does nitrous oxide N_2O enter the atmosphere? Natural decomposition in soils and oceans, fertilisers in agriculture, burning fossil fuels, wastewater management and industrial processes. X 300 the effect of CO_2 emitted by humans. Lifetime in atmosphere of about 120 years

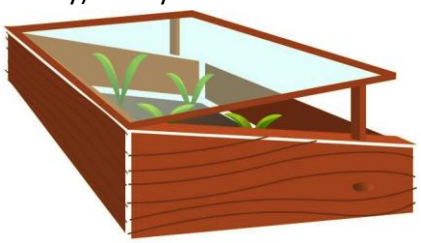
Interesting facts: If carbon dioxide levels rose from the present 0.03% to 1% the surface temperature of Earth would rise to boiling point. The atmosphere of the planet Venus is 98% CO_2 and its surface temperature is 477^{0}C

Which style of graph or chart would best represent the relative percentages of different greenhouse gasses in the atmosphere? Explain your answer. A pie chart would best demonstrate the relative percentages (parts) of the whole.



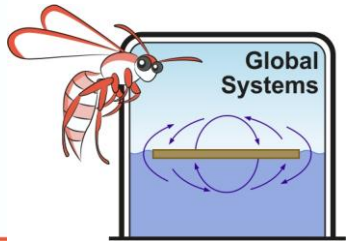
You may wish students to draw or use Excel to create a graph or chart.

Heat affects enzyme efficiency. (See enzyme efficiency and heat activity). Many cold climate gardeners and farmers extend the growing period and productivity of plants by placing seeds in a greenhouse or cold frame or cloche to encourage germination at an earlier date. Glass permits the heating rays of the sun to enter and walls stop wind blowing the heat away. Soil is slower to warm than air but retains heat longer. Seedlings are placed into the earth when ambient temperatures are warmer.



In very cold countries such as Iceland where mid-summer temperatures may stay below 7^{o}C, geothermal power is used to warm greenhouses so that the ground is warm enough to grow vegetables.

Greenhouse Effect – Teacher Notes



AIM **To demonstrate the greenhouse effect.**

Thermometers in greenhouse air, greenhouse soil and in open air

Materials per student or group

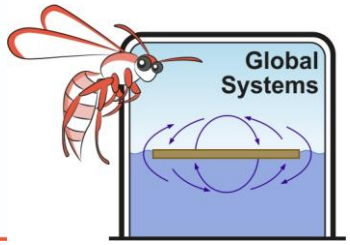
- A clean plastic cool drink bottle cut in half
- Two laboratory thermometers. (The class can share Readings from one "control" thermometer). Thermo-probes may be used to take a digital recording over a longer period.
- A little plasticine or play dough to seal the thermometer holes in the half bottles
- Access to a garden bed or a laboratory tray with soil
- A sunny day will give the fastest results but a warm classroom window (radiant energy) will also give reasonable results

Thermometers are delicate glass tubes and should be treated with respect.
Never hold a thermometer by the bulb as this may affect later readings.
Adjust your position so your eye is level with the top of the liquid in the thermometer to avoid parallax mistakes.

Method

1. Select an area of sunlit soil or fill a laboratory tray with moist soil and place on a sunlit location.
2. Cut a clean clear plastic bottle in half.
3. Make a hole in the bottom half of the bottle. (See below for ideas).
4. Gently push the first thermometer through the hole in the bottom half of the bottle.
5. Set half bottle and thermometer safely upright in soil. The bulb of the thermometer should be in the air above the soil. Seal any gaps with plasticine or dough.
6. Place the second thermometer into the top of the half bottle and set it into the underlying soil. Gently adjust the position of the thermometer so that the bulb lies under the surface of the soil. Seal off the thermometer in the neck of the bottle with plasticine.
7. The control thermometer should be held to read ambient air temperature.
8. Read the temperatures in the air, the air in the bottle and the soil in the bottles.
9. Record your data.

Hypothesise what will happen to the air temperatures inside and outside the flask. You may write this as an "If……. Then ……." statement
If the tray is placed in sunlight then temperatures of air and soil will rise above external temperature.



Greenhouse Effect – Teacher Notes

Results/observations The results below may serve as a guide or be used if it is cloudy or raining

Time minutes	Control air temperature °C	Air temperature in greenhouse °C	Soil temperature in greenhouse °C
0	28	28	28°C
5	28	30	28°C
10	28	32	28°C
15	28	34	30°C
20	28	34	30°C
25	28	34	31°C
30	29	35	32°C
35	29	35	32°C
40	29	35	32°C

Did you observe any other change inside the "greenhouses"? Yes they had condensation on their insides from heated, moist soil.

Conclusions Temperature inside the "greenhouse" is higher than outside. The air heats faster than the soil. Radiant energy is stored within the greenhouse.

The temperature of soil is not directly related to air temperature. Soil heats and cools more slowly than air. Energy transfer and storage can be affected by soil colour and albedo (reflectivity) of mulch. Darker soil and mulch gain and retain heat better than lighter soils

Discussion

Was your hypothesis supported? Answer depends on the stated hypothesis.
Was your hypothesis proven? No. In science nothing is ever proven because data changes as instruments and ideas change.
How could this experiment be improved? Both accuracy and precision would be improved if a more sensitive temperature measuring device was used (difficult to read thermometer with precision) and the activity be repeated many times (to provide an average result).
What effect would the water vapour have on temperature in the greenhouse? Water vapour is a greenhouse gas and would cause further retention of heat.

Recall

1. What is meant by the "Greenhouse effect"? Atmospheric gases help retain Solar heat to support life on Earth. It is a natural process that warms Earth's surface. Solar radiation is reflected back to Earth. This should not be confused with "The enhanced Greenhouse Effect" which is a recent rapid rise in atmospheric temperature caused by increased levels of carbon dioxide, water, methane and nitrous oxide in the atmosphere.

Greenhouse Effect – Teacher Notes

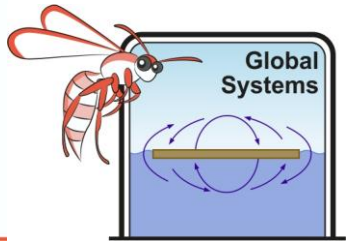
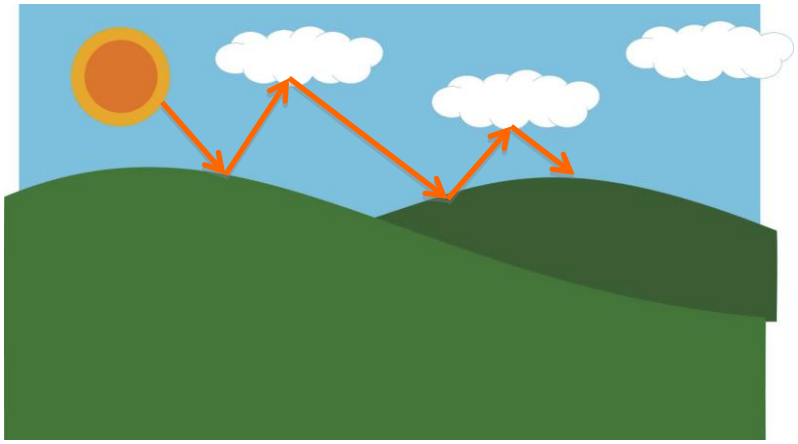


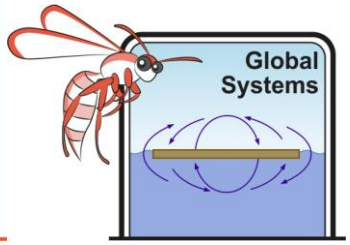
Diagram: Draw the Sun's rays and what happens because of the "greenhouse effect".



2. Why should we be grateful that there are "greenhouse gasses" in our atmosphere? Greenhouse gasses keep the surface of this planet warm enough to support life.

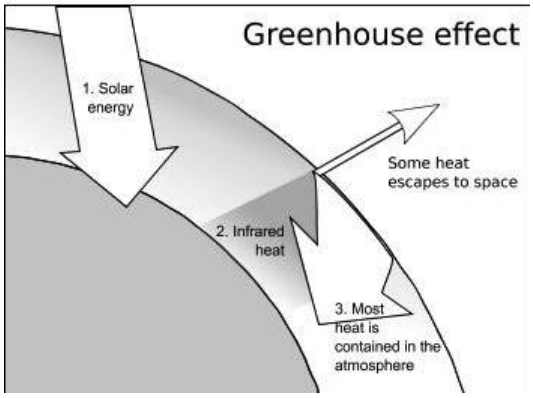
3. List the four main greenhouse gases from most common to least common. Water, carbon dioxide, methane and nitrous oxide

4. The "Enhanced Greenhouse Effect" or recent rapid warming of our atmosphere is the result of human/anthropogenic activities such as burning fossil fuel and industry (a point of some debate).



Greenhouse Effect – Student Activity

Before our present atmosphere was formed, radiant heat from the Sun was directly reflected from Earth's surface to be lost out into space. A slow build up of gasses created an atmosphere where heat was retained and life could exist.



Water vapour is the most important greenhouse gas in terms of volume and heat retention. Having a short residence time of four days in the atmosphere means that it must be constantly replenished by evaporation from the ocean. Although the three other main greenhouse gasses, carbon dioxide, methane and nitrous oxide are less present, they remain in the atmosphere for very much longer and therefore have a greater continuous heat trapping effect.

Gas	% of greenhouse gasses	% Produced naturally
1. Water vapour H_2O	95.000%	94.99%
2. Carbon dioxide CO_2	3.618%	3.502%
3. Methane CH_4	0.360%	0.294%
4. Nitrous oxide N_2O	0.950%	0.903%
5. Others	0.072%	0.025%

How does water enter the atmosphere?_____

_____

How does carbon dioxide enter the atmosphere? _____

_____

How does methane enter the atmosphere? _____

_____

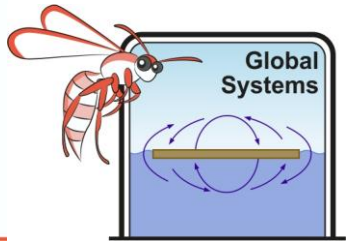
How does nitrous oxide N_2O enter the atmosphere? _____

_____

Which style of graph or chart would best represent the relative percentages of different greenhouse gasses in the atmosphere?

Explain your answer. _____

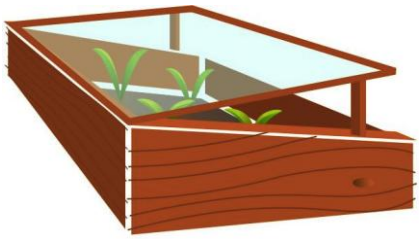
_____



Greenhouse Effect – Student Activity

Interesting fact If atmospheric carbon dioxide levels rose from the present 0.03% to 1%, the surface temperature of Earth would rise to boiling point. The atmosphere of the planet Venus is 98% CO_2 and its surface temperature is 477^{0}C

Heat affects how plants grow. Many cold climate gardeners and farmers extend the growing period and productivity of plants by placing seeds in a greenhouse, cold frame or cloche to encourage germination at an earlier date.
In very cold countries such as Iceland where mid-summer temperatures may stay below 7^{o}C, geothermal power is used to warm greenhouses so that the ground is warm enough to grow vegetables.



AIM To demonstrate the greenhouse effect.

Thermometers in greenhouse air, greenhouse soil and in open air

Materials per student or group

- A clean plastic cool drink bottle cut in half and one hole drilled in each half
- Two laboratory thermometers.
- A little plasticine or playdough to seal the thermometer holes in the half bottles
- Access to a garden bed or a laboratory tray with soil
- A sunny day will give the fastest results but a warm classroom window (radiant energy) will also give reasonable results

Thermometers are delicate glass tubes and should be treated with respect.
Never hold a thermometer by the bulb as this may affect later readings.
Adjust your position so your eye is level with the top of the liquid in the thermometer to avoid parallax mistakes.

Method

1. Select an area of sunlit soil or fill a laboratory tray with moist soil and place in a sunlit location.
2. Cut a clean clear plastic bottle in half
3. Make a hole in the bottom half of the bottle. (See below for ideas).
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6. Place the second thermometer into the top of the half bottle and set it into the underlying soil. Gently adjust the position of the thermometer so that the bulb lies under the surface of the soil. Seal off the thermometer in the neck of the bottle with plasticine.

Greenhouse Effect – Student Activity

7. The control thermometer should be held to read ambient air temperature.
8. Read the temperatures in the air, the air in the bottle and the soil in the bottles.
9. Record your data.

Hypothesise what will happen to the air temperatures inside and outside the flask. You may write this as an "If……. then ……." statement. An hypothesis is a scientific guess or estimate, which must be tested.

My Hypothesis

If _____ then _____

_____

Results/observations

Time minutes	Control air temperature °C	Air temperature in greenhouse °C	Soil temperature in greenhouse °C
0			
5			
10			
15			
20			
25			
30			
35			
40			

Describe any other change inside the "greenhouses"? _____

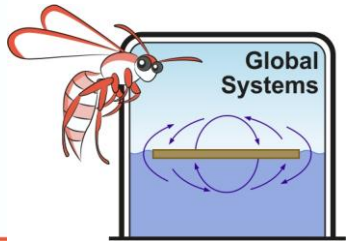
_____

Conclusions

What did this data lead you to conclude? _____

_____

_____



Greenhouse Effect – Student Activity

Discussion

Was your hypothesis supported? _____

Was your hypothesis proven? _____

How could this experiment be improved? _____

_____

_____

What effect would the water vapour produced have on temperature in the greenhouse? _____

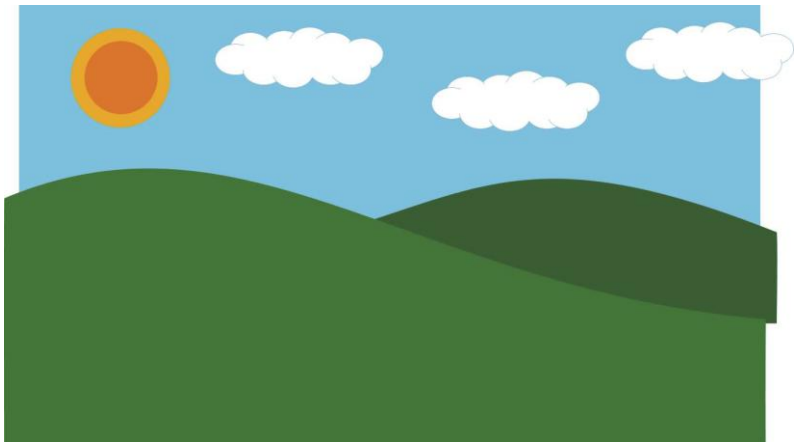
_____

Recall

1. What is meant by the "Greenhouse effect"? _____

_____

Diagram: Draw the Sun's rays and what happens because of the "greenhouse effect".



2. Why should we be grateful that there are "greenhouse gasses" in our atmosphere? _____

_____

_____

3. List the four main greenhouse gases from most common to least common.

_____

4. The "Enhanced Greenhouse Effect" or recent rapid warming of our atmosphere is the result of _____

Animal Enzymes & Cold – Teacher Notes

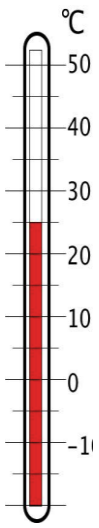
Catalysts called enzymes speed up most metabolic processes in living things. Catalysts affect the rate of chemical activity but do not themselves take part in the reaction. Enzyme activity is most efficient within a narrow range of:

1. Temperature
2. pH (acidity or alkalinity)
3. Concentration

Temperature

Enzyme activity in any species of plant or animal, works most efficiently within a narrow range of temperatures. The Arctic fox has enzymes that are most efficient at lower temperatures than a sidewinder snake that lives in canyons where temperatures often rise above 40°C. Animals can partially control their temperatures by behaviours such as lying in the shade, wearing clothes, moving at night or hibernating in winter. Plants are usually restricted to a specific geographic area by the requirements of their enzymes.

Core temperature in humans usually is about 37°C. Variation from this will cause enzyme dysfunction resulting in illness or death. Core temperature is usually a little higher than oral temperature. Human core temperature rises during the day and varies with women's menstrual cycle.



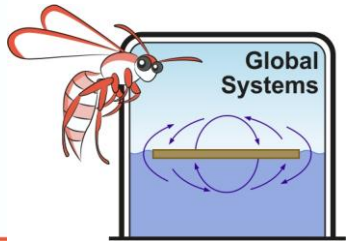
Core Temperature	Result
43°C	Death
42°C	Vomiting delirium
41°C	Fainting, vomiting, headache, confusion, panting, delirium
40°C	Fainting, vomiting, headache, life threatening
39°C	Severe sweating, fast heart rate
38°C	Hot sweating thirsty, onset of hyperthermia
37°C	Normal
36°C	Moderate shivering
35°C	Blue skin, intense shivering, onset of hypothermia
34°C	Severe shivering, loss of movement of fingers
33°C	Confusion, sleepiness, shivering stops
32°C	Extreme sleepiness, delirium, medical emergency
31°C	Comatose, shallow breathing
30°C & less	Some people survived below 30°C for hours. Most do not.

<u>Aim</u> **To demonstrate the effect of cold on the enzymes the activity of a human hand**

Plunging a hand into chilled water slows enzyme activity and results in slowed nerve muscle interaction and a marked loss of writing ability. The signature has to be written almost immediately after removal from iced water.

Materials per group or class

- Large buckets of cold water
- Ice cubes
- Scrap paper
- Ballpoint pens
- Towels or paper towels
- A laboratory thermometer
- Scissors and sticky tape or paste



Animal Enzymes & Cold – Teacher Notes

Method

1. Measure air temperature and add your observation to the table provided. (NOTE: remember to add units to the number!)
2. Add ice to the cold water and measure the temperature of the icy water. Add this observation to the table.
3. Each student quickly writes their signature on the scrap paper using their pen
4. Students immerse their writing hand in icy water for two minutes
5. After 2 minutes rapidly remove hand from water, dry it and write your signature directly underneath the first example.

Results/Observations

Air Temperature _____

Water temperature _____

Stick your two signatures onto the space below

Was there an observable change in your signature? Cold resulted in poor signature

What could have caused that change? Change in temperature decreases efficiency in enzymes controlling nerves & muscles in hand

Conclusion

Temperature affects enzyme efficiency.

How could this experiment be improved?

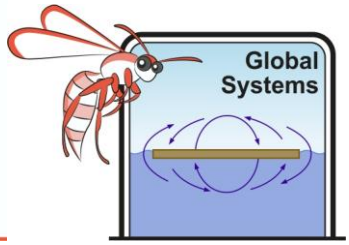
- Repeat
- Control for same sex, age, health etc.
- Select a result that is quantitative (measurable) not qualitative. Throw a dart at a spot and measure deviation?

EXTENSION

Why do most people in Australia suffer indigestion trying to eat a traditional English Christmas dinner in the middle of the day?

Traditional English Xmas dinner was full of fats and eaten during cold weather in the middle of winter. Fat digestion produces energy and necessary heat so the diet was relatively high in animal fat. Fat digesting enzyme production levels were high and digestion was efficient. People would not move around much in the cold weather so blood supply to the stomach was good.

Australians do not eat a lot of fat so their fat digestion enzyme levels are low. Australian Xmas is in summer and high temperatures decreases enzyme efficiency. Blood supply is diverted from the stomach to the skin surface to cool the body by radiation and sweating. Indigestion results!



Animal Enzymes & Cold – Student Activity

Catalysts called enzymes speed up most metabolic processes in living things. Enzyme activity is most efficient within a narrow range of:

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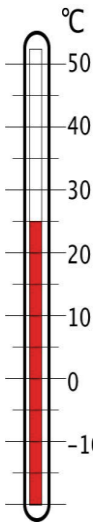
2. pH (acidity or alkalinity)
3. Concentration

Temperature

Core temperature in humans is usually maintained at about 37°C. Variation from this will cause enzyme dysfunction resulting in illness or death.



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35°C	Blue skin, intense shivering, onset of hypothermia
34°C	Severe shivering, loss of movement of fingers
33°C	Confusion, sleepiness, shivering stops
32°C	Extreme sleepiness, delirium, medical emergency
31°C	Comatose, shallow breathing
30°C & less	Some people survive below 30°C for hours. Most do not.

Aim **To demonstrate the effect of cold on the enzymes of a human**

Materials per group or class

- Large buckets of cold water
- Ice cubes
- Scrap paper
- Ballpoint pens
- Towels or paper towels to dry hand
- A laboratory thermometer
- Scissors and sticky tape or glue

Method

1. Measure air temperature and add your observation to the table provided. (NOTE: remember to add units to the number!)
2. Add ice to the cold water and measure the temperature of the icy water. Add this observation to the table.
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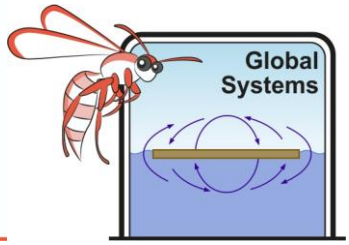


Results/Observations

Air Temperature _____

Water temperature _____

Stick the paper with your two signatures onto the space below

Conclusion

_____

_____

Discussion

Was there an observable change in your signature? _____

What could have caused that change? _____

_____

How could this experiment be improved? _____

_____

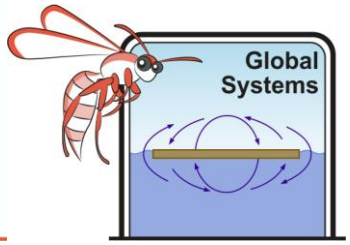
_____

EXTENSION

Why do most people in Australia suffer indigestion trying to eat a traditional English Christmas dinner in the middle of the day?

_____

_____



Plant Enzymes & Heat – Teacher Notes

As discovered with the experiment where a human hand was plunged into freezing water, enzyme activity in organisms is temperature dependant. This explains why the growth of plants is confined to climatic zones. The "Wheat Belts" of Australia are constrained by both temperature and rainfall.

An agricultural scientist was concerned about the effect of possible global warming on wheat crops. They grew groups of 100 seedlings under different temperature conditions and measured the amount of carbon dioxide produced by the group.

Why did they measure carbon dioxide produced? Carbon dioxide is produced from respiration. It is therefore a measure of the amount of cellular activity of wheat.

Why did they measure groups of 100 seedlings? To limit the effects of any outlying results and make the average more reliable.

Graph the data from the experiment below. Remember, graphs require

1. A title.
2. Labelled axes.
3. Units on axes.
4. A scale to fill the paper provided.

Temp. ^{o}C	Vol. CO_2 mL	Temp. ^{o}C	Vol. CO_2 mL	Temp. ^{o}C	Vol. CO_2 mL	Temp. ^{o}C	Vol. CO_2 mL
1	0	11	430	21	532	31	130
2	0	12	500	22	532	32	80
3	0	13	520	23	535	33	55
4	10	14	523	24	505	34	40
5	90	15	528	25	490	35	10
6	175	16	530	26	430	36	5
7	250	17	529	27	370	37	0
8	270	18	532	28	300	38	0
9	345	19	530	29	250	39	0
10	380	20	530	30	190	40	0

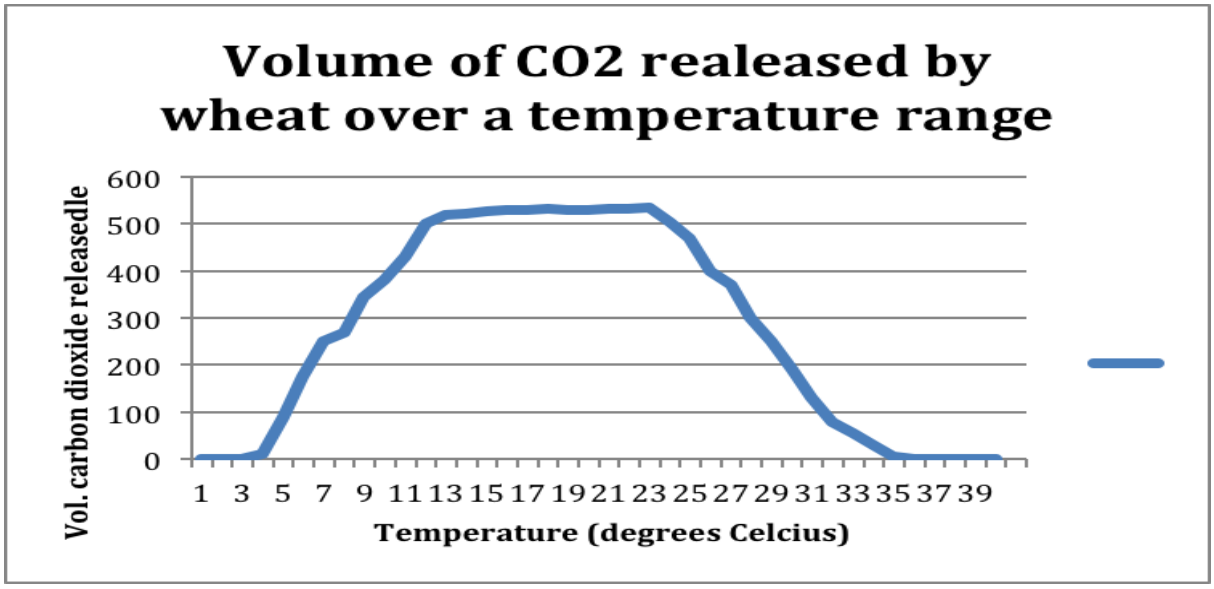
In the experiment, which is the dependent (measured) variable? Volume of carbon dioxide

And which is the independent (experimental) variable? Temperature

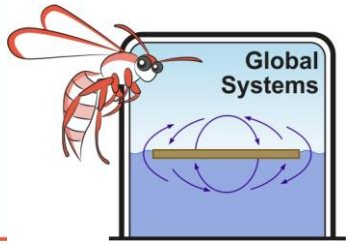
Which variable should be on your horizontal axis (Temperature or volume of CO_2) and explain why.

Temperature should be on the horizontal axis because it is controlled.

Should your graph be a line graph or a bar graph? Explain your answer. It should be line graph as it describes a change of one thing relative to another.



This graph form is typical for the effects of temperature or pH on enzyme activity.



Plant Enzymes & Heat – Student Activity

As discovered with the experiment where a human hand was plunged into freezing water, enzyme activity in organisms is temperature dependant.

An agricultural scientist was concerned about the effect of possible global warming on wheat crops. They grew groups of 100 seedlings under different temperature conditions and measured the amount of carbon dioxide produced by the group.

Why did they measure carbon dioxide produced? _____

_____

_____

Why did they measure groups of 100 seedlings? _____

_____

Graph the data from the experiment below. Remember, graphs require

1. A title
2. Labelled axes
3. Units on axes
4. A scale to fill the paper provided

Temp ^{o}C	Vol. CO_2 mL	Temp ^{o}C	Vol CO_2 mL	Temp ^{o}C	Vol. CO_2 mL	Temp ^{o}C	Vol. CO_2 mL
1	0	11	430	21	532	31	130
2	0	12	500	22	532	32	80
3	0	13	520	23	535	33	55
4	10	14	523	24	505	34	40
5	90	15	528	25	490	35	10
6	175	16	530	26	430	36	5
7	250	17	529	27	370	37	0
8	270	18	532	28	300	38	0
9	345	19	530	29	250	39	0
10	380	20	530	30	190	40	0

In the experiment, which is the dependent (measured) variable? _____

And which is the independent (experimental) variable? _____

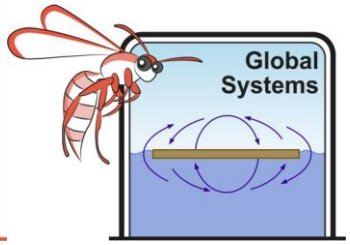
Which variable should be on your horizontal axis (Temperature or volume of CO_2) and explain why.

_____should be on the horizontal axis because _____

Should your graph be a line graph or a bar graph? Explain your answer. _____

_____

This graph is typical for the effects of temperature or pH on enzyme activity.



The Enhanced Greenhouse Effect – Teacher Notes

We need accurate data to scientifically measure changes in the forcing factors, which are responsible for the "Enhanced" Greenhouse Effect or Global Warming. Two government bodies, the Bureau of Meteorology and CSIRO have been collecting data that has been used to produce the State of the climate 2014 report. The questions in italics may need to be answered using other sources if student do not already know the answers.

Materials per student

- Access to reference books and the Internet. Copies of the report can be downloaded and printed if necessary.

When we evaluate research we need to first consider the scientific credentials of the authors of the reports and of the accuracy and the validity of data collected.

1. What is the area of responsibility of the Bureau of Meteorology? It provides weather forecasts, warnings and observations for all states and territories. It also reports on natural disasters such as landslides, earthquakes, volcanoes and tsunamis.

2. Is this a world-renowned scientific organisation that has experts who study climate? Yes

3. What do the letters CSIRO refer to and what is the purpose of this organisation? The "Commonwealth Scientific and Industrial Research Organisation" is Australia's national research agency and is one of the largest and most diverse research agencies in the world.

4. Is this a reputable scientific organisation with a good reputation for scientific research? Yes

5. What is an isotope and what are the three most common isotopes of carbon? *? An atom that has the same number of electrons but differing numbers of neutrons in the nucleus.* ^{12}C, ^{13}C and ^{14}C

Leading scientists from the BoM and CSIRO worked together to produce the "State of the climate 2014" report.

Visit http://www.bom.gov.au/state-of-the-climate/ watch "Behind the science. Our changing atmosphere" and answer the following questions.

6. What did the scientists want to do? They wanted to measure the amount of carbon dioxide in the atmosphere and find where it is coming from.

7. From how many stations is data being collected? 10 to 15 stations around the world

8. Is this primary data, secondary data or proxy data? Explain your answer. Primary data because it was collected by the CSIRO scientists themselves.

9. How has measurement changed since 1970? Many more greenhouse gasses can be measured

10. How can the scientists tell if carbon dioxide comes from the burning of fossil fuels? It has no ^{14}C.

11. What are the three sources of atmospheric carbon dioxide? The ocean, the biosphere (plants and animals) or from fossil fuels

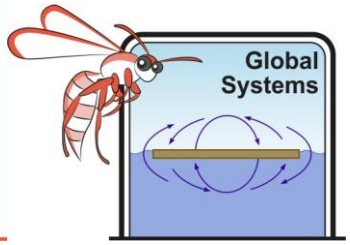
12. What was the conclusion of this research? The burning of fossil fuels essentially drives the increase of carbon dioxide in the atmosphere.

13. What two factors were compared in the graph at the end of the clip? Carbon dioxide produced as a result of changes in land use and from burning of fossil fuels.

14. Which of these two possible forcing factors demonstrated the greatest increase since 1840? Burning fossil fuels

Why did the graph not extend before 1840? There is no data for Australia.

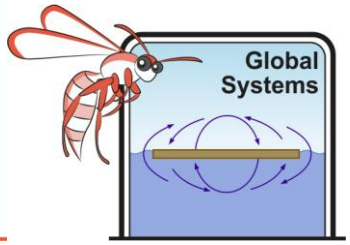
Students are then asked to bring their findings together in a report. Some students may prefer creating a poster



Using the information you have collected, write a brief report on these findings by CSIRO's scientists. You will be constructing a report bases on evidence-based arguments. It will need a title, catchy introductory sentence and three paragraphs of information that should convince the reader the findings are meaningful.

Marks allocated

1. Title and author (2 marks)
2. Introductory sentence which explains what will follow (2 marks)
3. Key words (5 marks)
4. Brevity (1 mark)
5. Three paragraphs covering three concepts (3 marks)



The Enhanced Greenhouse Effect – Student Activity

We need accurate data to scientifically measure changes in the forcing factors that are responsible for the Enhanced Greenhouse Effect (Global Warming). Two government bodies, the Bureau of Meteorology (BoM) and CSIRO have been collecting data that has been used to produce the State of the Climate 2014 report.

1. What is the area of responsibility of the Bureau of Meteorology? _____

_____

2. Is this a world-renowned group of independent scientific experts? _____

3. What do the letters CSIRO refer to and what is the purpose of this organisation? _____

_____

_____

4. Is this a world-renowned group of independent scientific experts? _____

5. What is an isotope and what are the three most common isotopes of carbon? _____

_____

_____

View: http://www.bom.gov.au/state-of-the-climate/

6. What did the scientists want to do? _____

_____

7. From how many stations is data being collected? _____

8. Is this primary data, secondary data or proxy data? Explain your answer. _____

_____

9. How has measurement changed since 1970? _____

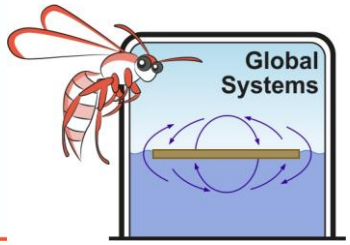
_____

10. How can the scientists tell if carbon dioxide comes from the burning of fossil fuels?

_____

11. What are the three sources of atmospheric carbon dioxide? _____

_____



12. What is the conclusion developed from this research? _____

_____

13. What two factors were compared in the graph at the end of the film clip? _____

_____

14. Which of these two possible forcing factors demonstrated the greatest increase since 1840?

_____

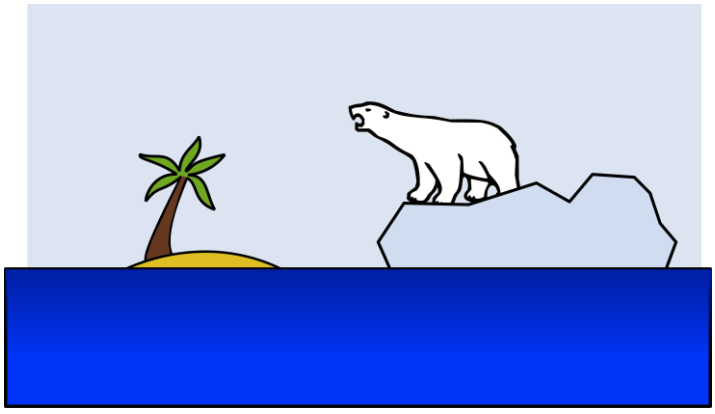
15. Why did the graph not extend before 1840? _____

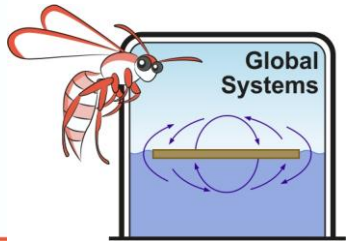
Bring it all together

Using the information you have collected, write a brief report on these findings by BoM and CSIRO scientists. You will be constructing a report bases on evidence-based arguments. It will need a title, catchy introductory sentence and three paragraphs of information that should convince the reader the findings are meaningful.

Marks allocated

1.	Title and author	(2 marks)
2.	Introductory sentence which explains what will follow	(2 marks)
3.	Key words	(5 marks)
4.	Brevity	(1 mark)
5.	Three paragraphs covering three concepts	(3 marks)





El Niño & La Niña – Teacher Notes

Changing conditions in the atmosphere and hydrosphere influence both weather and climate. What is the difference between weather and climate? Weather refers to day-to-day changes whereas climate describes seasonal changes over years.

We shall be searching for scientific information regarding a major influence on Australia's climate.
What key words would you use to search for information about this? Australia's climate, meteorology, Bureau of meteorology, BoM,

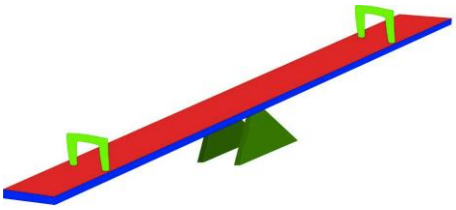
Materials per student

- Access to the Internet and library reference books
- A copy of your school's directions on writing a bibliography for references

ENSO

Australian weather patterns are influenced by **ENSO** (El Niño Southern Oscillation). ENSO describes a cycle of atmospheric and oceanic temperature change over the Pacific Ocean. The name "El Niño", or boy child, comes from Peruvian fishermen who recognised that sometimes warm water would arrive along their coast in time for Christmas celebrations. In their language "El Niño" means the little boy. The converse, when warm water moves towards the eastern coast of Australia, is called "La Niña" or little girl. Weather patterns oscillate between El Niño and La Niña in an irregular cycle.

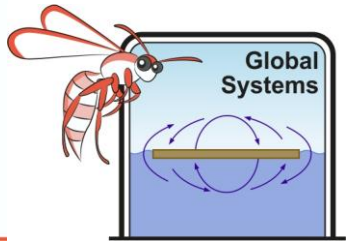
El Niño



La Niña

Driven by density, cold water from southern polar region travels northwards at great depth as part of the Global Conveyor Belt described in elsewhere in this package. Running northwards from Chile to Peru it is called the Humboldt Current and has one of the world's richest and most diverse marine ecosystems. These waters move very, very slowly and are rich in nutrients gained in the Antarctic Ocean. Surface waters near the Equator are however heated by the sun and lie in a distinct layer above the cold current. The sharp interface between warm and cold is called the "**thermocline**". Warm less dense surface waters are easily moved by prevailing Trade Winds from the east. Moisture carried in wind (convection currents) above the warm water produces rainfall for either the eastern Australian coastline or for the Pacific coast of South America including Ecuador, Peru and Chile. The changing conditions of the cycle also influences weather, its effects influencing climate as far as India to the west of the International Date Line and east to the tornado belts of the United States of America.

Our Bureau of Meteorology has daily updated information on ENSO at:
http://www.bom.gov.au/climate/enso/
An excellent North American perspective on this phenomenon can be found at
http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html.



El Niño & La Niña – Teacher Notes

El Niño

Under El Niño conditions less warm water flows towards Australia. Because winds are weak most of the warm water and the rain bearing air above them will remain away from the Australian coast. On the tropical western coast of South America the increased volume of warm surface water depresses rising nutrient rich cold currents reducing fishing stocks. The quantity of fertiliser produced from sea bird droppings is also reduced as these birds feed on marine life.

Effects in Eastern Australia and Indonesia	Pacific Ocean	Effects in South America
Droughts Agriculture restricted Fires frequent	Warm surface waters extend towards Peru Trade winds weaken	More rain (April-October) Flooding near the equator Good for agriculture Upwelling of cold nutrient rich seawater supressed Low fertiliser production Poor fishing

La Niña

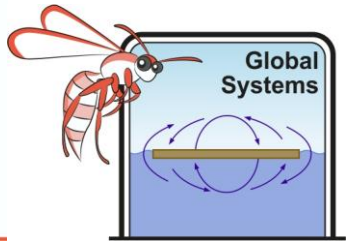
Under La Niña conditions trade winds strengthen and more warm water and moist wind flows towards Australia. Sea level can be up to one metre higher at the Eastern Australian coast than in Peru. Eastern Australia experiences more rain and cyclone events, whilst the converse occurs in Peru.

Effects in Eastern Australia and Indonesia	Pacific Ocean	Effects in South America
Rain and cyclones Good for some agriculture Flooding Mosquito borne disease increase	Warm surface waters extend towards Australia Trade winds strengthen	Less rain Poor agriculture Upwelling of cold nutrient rich seawater returns Good fishing Good fertiliser production

Records in rocks, sediments, corals and tree rings indicate that this irregular two to seven year cycle is not a recent phenomenon. It has been influencing our climate for over 10,000 years and probably longer. Proxy data because these changes have not been observed or measured directly but can be inferred.

The effect of ENSO on Western Australia

Warm water forced over by the Trade Winds forces its way between Indonesia and Australia into the Indian Ocean and south down the coast of Western Australia. ENSO variation affects the Leeuwin Current, which flows southwards down our coast bringing warm nutrient poor water. Under El Niño conditions Western rock lobsters larvae are carried further offshore and adult lobsters are smaller and take longer to mature. In La Niña times inshore larval transport is assisted and whale shark



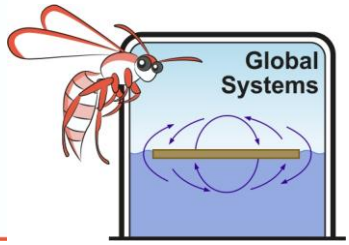
movement changes. Some coral bleaching has been attributed to increased water temperatures also.

The effect of enhanced global warming on ENSO

Our climate is influenced by variation in heat exchange between the hydrosphere and the atmosphere resulting from the interaction of cooling deep waters and warming surface waters. It is difficult to predict the effect of a warming climate on this phenomenon. Warming will of course affect polar waters decreasing the rate of production of cold nutrient rich, fertilising waters moving north and weakening trade winds. Some researchers have suggested that warming has already produced "El Niño Modoki", a different form of ENSO created weather pattern resulting in more variability within each year and an overall decrease in rainfall. They suggest Modoki events have a greater impact on Australian weather than El Niño.

Notes: Predicting El Niño and La Niña events

Factors controlling oscillation between El Niño and La Niña are complex and are only beginning to be understood. Both events and consequences are highly variable and difficult to predict.
The ability to plan in advance to offset the effects of drought, fires and a change of food stocks would be a tremendous advantage for those who live on either side of the Pacific. Many models have been created but none to date are sufficiently accurate as too many factors are involved in tipping the balance in one direction or the other.



El Niño & La Niña – Student Activity

Changing conditions in the atmosphere and hydrosphere influence both weather and climate.
What is the difference between weather and climate?

_____

_____

We shall be searching for scientific information regarding a major influence on Australia's climate.
What key words would you use to search for information about this?

_____

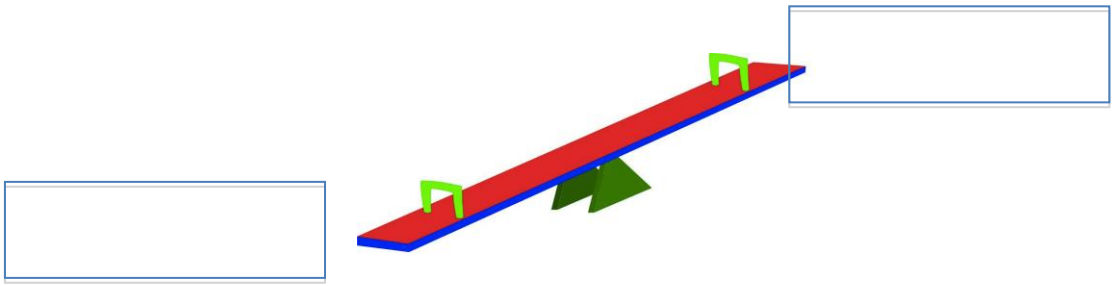
Materials per student

- Access to the Internet and library reference books
- A copy of your school's directions on writing a bibliography for references

What does ENSO stand for and what climatic changes does it describe? _____

_____

Between which two weather patterns does the weather oscillate?



Describe what happens to create an **El Niño** event and what the consequences of this event are on people living in Peru and in Eastern Australia.

_____

_____

_____

_____

_____

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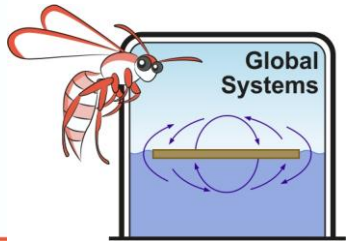


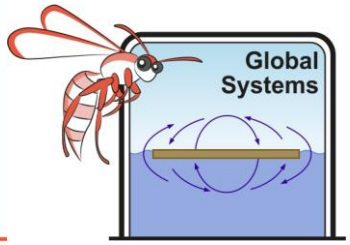
El Niño & La Niña – Student Activity

Describe what happens to create a **La Niña** event and what the consequences of this event are on people living in Peru and in Eastern Australia.

Records in rocks, sediments, corals and tree rings indicate that this irregular two to seven year cycle is not a recent phenomenon. It has been influencing our climate for over 10,000 years and probably longer. Are these records primary data, secondary data or proxy data? Explain your answer

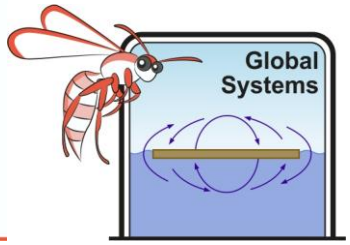
The effect of ENSO on Western Australia
What effect does ENSO have on the western coast of Australia?

The effect of enhanced global warming on ENSO
Suggest two ways in which climate warming could affect ENSO and climate patterns in Australia



Bibliography

Greenhouse Effect – Teacher Review



M E R E E S D U O L C D I E T
A N W A V L L F P V O L N R C
E A S E D I N A U T A O C E E
T H T T R I T I M E L C R H F
S T G A N U A I N I L I E P F
R E L E E A O T S O N S A S E
V M L Q N H L P I O U A S O H
T G A S K H K P A O P T E R E
G W N S O L A R H V N O X D A
E D I X O I D N O B R A C Y T
D E N Z Y M E S C I C E T H I
L G A L A E F I L E L H T Z N
L P I Y R F O S S I L A Q A G
R O L G A T M O S P H E R E W
K C A B D E E F G N I L O O C

Write the words related to the greenhouse effect below.

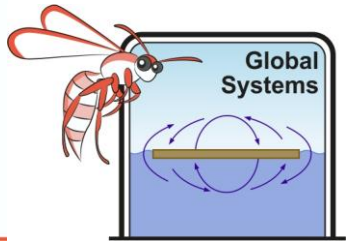
ANIMALS
ATMOSPHERE
CARBONDIOXIDE
CLOUDS
COAL
COLD
COOLING
EFFECT
EL NINO
ENHANCE
ENZYMES
FEEDBACK
FOSSIL
FUEL
GAS
GREENHOUSE
HEAT
HEATING
HYDROSPHERE
INCREASE
LA NINA
LIFE
METHANE
OIL
PLANTS
POSITIVE
RADIATION
SOLAR
STEAM
WATER VAPOUR

What does "The Greenhouse Effect" describe? The effect gasses (Greenhouse Gasses) have in retaining solar radiation within the Earth's atmosphere.

Diagram

Which is the most common greenhouse gas in our atmosphere? H_2O - water vapour
Which is the most effective greenhouse gas in our atmosphere? CH_4 - methane
Which greenhouse gas is produced through volcanic outgassing? CO_2 - carbon dioxide
Which greenhouse gasses are produced through burning fossil fuels? CO_2, CH_4, NO_2,
Has the greenhouse effect always been considered problematic? Explain your answer. No. The retained warmth has permitted life to flourish on Earth. Only recently has CO_2 produced from burning fossil fuels produced the enhanced greenhouse effect resulting in an increasing rate of global warming.

Greenhouse Effect – Teacher Review



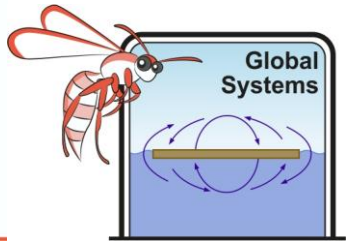
What is positive feedback? Positive feedback occurs when the initial stimulus is enhanced/increased by the effect.

Give an example of positive feedback producing the enhanced greenhouse effect.

1. Burning fossil fuel produces CO_2.
2. Increased CO_2 in the atmosphere increases retention of heat from solar radiation.
3. Increased atmospheric heat causes water vapour levels to increase in the atmosphere.
4. Water vapour is a greenhouse gas which causes the atmosphere to retain even more heat.

What can we do to reduce the enhanced greenhouse effect? Reduce the use of fossil fuels (etc).

Greenhouse Effect – Student Review



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E A S E D I N A U T A O C E E
T H T T R I T I M E L C R H F
S T G A N U A I N I L I E P F
R E L E E A O T S O N S A S E
V M L Q N H L P I O U A S O H
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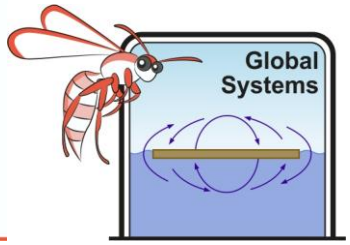
G W N S O L A R H V N O X D A
E D I X O I D N O B R A C Y T
D E N Z Y M E S C I C E T H I
L G A L A E F I L E L H T Z N
L P I Y R F O S S I L A Q A G
R O L G A T M O S P H E R E W
K C A B D E E F G N I L O O C

Write the words related to the greenhouse effect below.

Draw a diagram describing the greenhouse effect.



Greenhouse Effect – Student Review

What does "The Greenhouse Effect" describe? _____

_____

_____

Which is the most common greenhouse gas in our atmosphere? _____

Which is the most effective greenhouse gas in our atmosphere? _____

Which greenhouse gas is produced through volcanic outgassing? _____

Which greenhouse gasses are produced through burning fossil fuels? _____

Has the greenhouse effect always been considered problematic? Explain your answer. _____

_____

_____

_____

What is positive feedback? _____

_____

Give an example of positive feedback producing the enhanced greenhouse effect (Global warming).

_____

_____

_____

_____

_____

_____

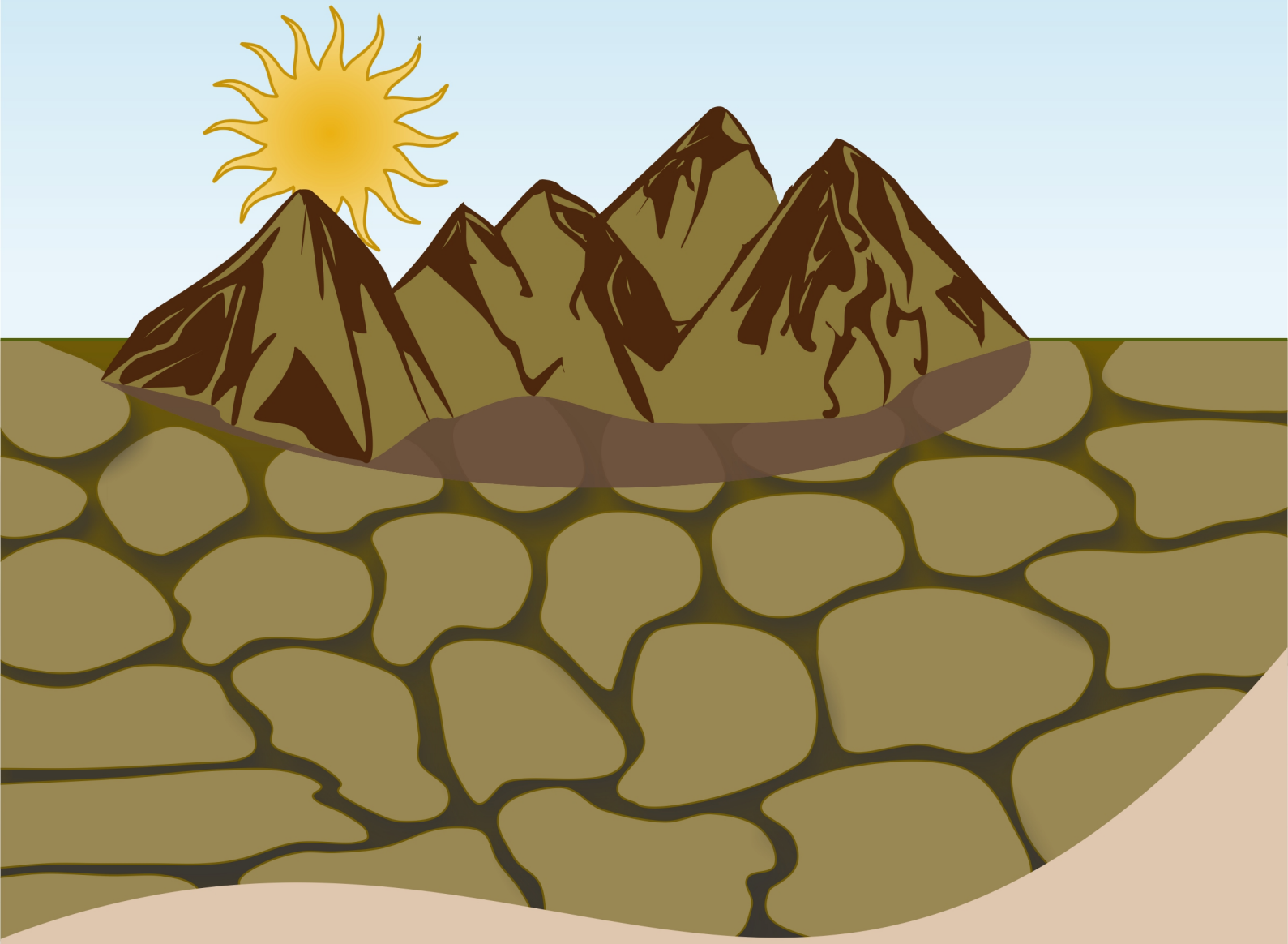
What can we do to reduce the enhanced greenhouse effect? _____

_____

_____

_____

Climate Change



Climate Change - Teacher Background

Biodiversity relates to the variety of life found in an area. This includes the different plants, animals and microorganisms, their genes and the ecosystems of which they are a part. The number and variety of species is a simple measure of its "health", its ability to respond to change at a natural rate. Mass extinctions require over 50% of species to become extinct. There have been five mass extinctions and many minor extinction events.

Major changes in planetary biodiversity

Not all major changes to the range of species present on Earth are only directly attributable to climatic changes. It is thought that the amazing 550 million year old soft-bodied Ediacaran fossils found in South Australia were only preserved in sea floor sands because predators had not yet evolved. When traces of worms and other burrowing scavengers appear in the rocks above, all these species became extinct. The new species that appeared in the overlying layers of rock may contain the ultimate ancestor of animal life, as we know it.

Major climate changes, usually tied to tectonic events have massively impacted on biodiversity.

Desertification and extinction events

Massive belts of red desert sandstone crossing many tectonic plates infer large continents and extremely hot climate extending over geologically long periods. This dune sandstone is from Permian times (220mya) when the climate slowly became very hot and dry resulting in the largest mass extinction on Earth. During the "Great Dying" 6% of all marine species, 70% of all terrestrial species, 57% of all families and 80% of all genera were lost. Desertification and species loss progressed over a 30 million year period. It took more than 10 million years for life on the planet to recover and a further ten million years before coral reefs were established in the sea and forests regained the land.

Past Ice Ages and extinction events

During the Permian (250 to 220my), Ordovician (450my) and Pre Cambrian (600 – 900my) glacial deposits on all continents, including those at low latitudes, suggest that ice covered most of the planet almost reaching the equator. During these "Snowball Earth" episodes life became almost extinct.

Although the "Snowball Earth" period ended with the extinction of many life forms, the rapid increase of oxygen in the atmosphere afterwards resulted in "Eden Earth" when there was a massive growth of new, more complex and specialised species. The pale stripes (striae) on the gneiss from near Minginew in our Central Wheat belt are scratches from rocks trapped in ice at the bottom of glaciers during the Permian glaciation.

Climate Change - Teacher Background

Some factors controlling surface temperature variation: Milankovic Cycles

Recently we have uncovered evidence that Earth's surface temperature cycles between 12°C to 22°C over fairly regular 100,000-year cycles. These are named Milankovic Cycles after the Serbian scientist who first researched and described them when held as a prisoner of war during WW1.

They result from:

- Variable solar output due to Sun activity
- Variable distance between Earth and Sun due to gravity variations from planets on an elliptical orbit (orbital eccentricity, axial obliquity and precession)
- Interplanetary dust

.

Comparison of ancient and recent climate change rates.

Although radical changes occurred in the past and were responsible for extinctions, they occurred slowly over tens of millions of years. This is much slower than the rate of warming over the last century. We can also read the "fingerprints" of recent climate change to interpret possible cause. Increase in the Sun's radiation would be expected to warm both upper and lower atmosphere and result in days warming more than nights. In contrast greenhouse warming would result in cooling of the stratosphere, as heat would be retained in lower levels of the atmosphere and cause nights to be warmer than days.

That global climate patterns slowly change is a given. With the exception of rare severe changes, which cause global extinctions most organisms have time to respond to the changes by moving their geographic range, changing their behaviours or natural selection favours those who most suit the new conditions and their characteristics become dominant with the group.

Historic influence of man

"Whatever befalls the Earth befalls the sons of the Earth. Man does not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself." (Chief Seattle, 1854)

The Pleistocene (Ice Age) represents the last cold stage from which we are recovering to enter into a warmer period. During the Pleistocene the population of modern humans in the world was reduced to about 600 breeding pairs living in tropical Africa as great glaciers covered most of the landmasses except between the tropics. We know this from genetic evidence collected during National Geographic's human genome project. Other hominid species such as the Neanderthals and Denisovans died out at the end of the Ice Age in the Northern Hemisphere. When the ice retreated modern humans spread out to cover the great plains of the world inhabiting all of the continents except (until recently) Antarctica.

In Western Australia over the last 50,000 years there have been major changes in species diversity. The arrival of man and his fire-stick culture, along with climatic change, have resulted in a more arid period. Soft leaved trees were replaced by sclerophylls such as eucalyptus. Some scientists believe that humankind's arrival in Australia was the critical tipping factor involved in the extinction of our mega fauna about 30,000 years ago. Europeans, who arrived about 300 years ago, introduced plants, animals and European farming practices that rapidly accelerated this loss of local plant and animal species.

Biodiversity can be examined at two levels:

1. Macro-variation amongst different species
2. Micro-variation within one species.

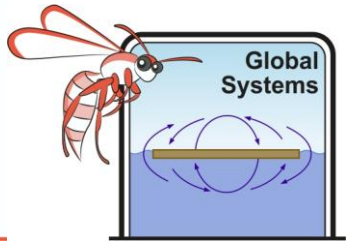
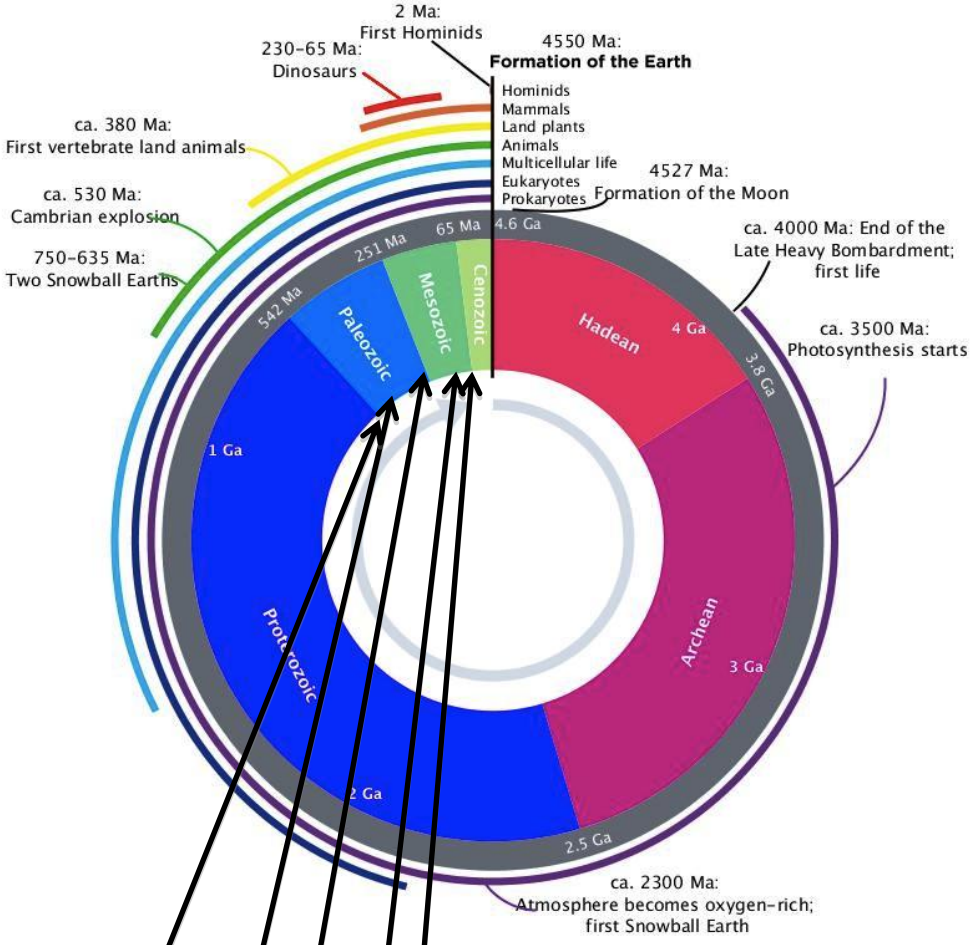


Diagram interpretation and using research data

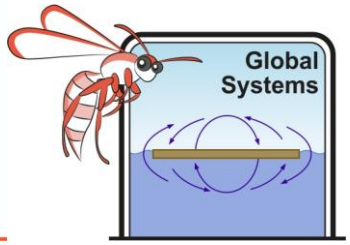
Biodiversity relates to the variety of life found in an area. This includes the different plants, animals and microorganisms, their genes and the ecosystems of which they are a part. The number and variety of species is a simple measure of its "health" i.e. its ability to respond to change at a natural rate. Extinction reduces both the number of species and variation within each species.

During the geologic past of our planet Earth has suffered many greater and lesser periods of extinction of life. The end of the Permian period was marked by the greatest known extinction on Earth, The Great Dying. We lost 96% of all species, 6% of all marine species and it is the only extinction that affected insects. The event occurred slowly over tens of millions of years rather than in rapid response to a single event and recovery took ten to twenty million years. Those organisms that survived are the ancestors of all organisms present on Earth today. Only the genes of those who survived were available to provide the variety of new species to fill the ecological niches left.



Major extinctions are designated as those in which more than 50% of species alive at that time became extinct. There are five major extinctions. Find information to fill the table below using the Internet or reference books. Mark when each extinction occurred on the diagram above.

Name	Time	Major groups lost	Animals benefitting
Cretaceous-Palaeogene (K-T)	65Ma	75% loss. Tropical marine animals, non-avian dinosaurs, plants	Mammals & birds
Triassic-Jurassic	200Ma	70-75% loss. Non-dinosaurian archosaurs, theraspids & most large amphibians	Dinosaurs
Permian-Triassic	251Ma	96% See above	Archosaurs
Late Devonian	450-400Ma	70% loss. Life in shallow seas	Marine life
Ordovician-Silurian	430Ma	Trilobites, brachiopods & graptolites	No "winners"



Extinctions & Climate Change – Teacher Notes

Forcing factors contributing to mass extinctions

When we study extinctions, corals can give us critically important information as to some of the forcing factors. Coral reefs endure a long time and their fossil history is relatively well known, as they are excellent reservoirs for oil and gas.

If extinctions were caused by ***meteorite or asteroid impact***, all coral species would be equally affected by heat and dust and would become extinct in a very short time, perhaps even within a few years. Fossil records show that in all major extinction events the coral loss took place over geologically long periods. So although meteorite impacts may be a contributing factor, they are not the only cause of major extinctions. Many past meteorite impacts had little effect on biodiversity.

Similarly ***increasing ocean temperature*** could have caused coral bleaching due to its effect in enzyme efficiency but again the extinction event was over geologically long periods of tens of millions of years.

Scientists suggest that the critical factor was an ***increase in CO_2 in the atmosphere*** from volcanic outgassing. NOAA scientists (National Oceanic and Atmospheric Administration – USA government research body) used information gained from natural outgassing of the Mauna Loa volcano in Hawaii to support this proposition. They followed the geological concept that "The present is the key to the past" as suggested by James Hutton.

1. Describe what effect an increase of atmospheric CO_2 would have on corals?
    1. Corals have internal skeletons to support the animals' bodies.
    2. Coral skeletons are made from calcium carbonate.
    3. CO_2 dissolved in water produces carbonic acid (hydrogen carbonate ions).
    4. Carbonic acid would remove calcium carbonate and weaken the skeletons
    5. Corals would weaken and die as the ocean became progressively more acidic.

$$CO_2 + H_2O + CO_3^{2-} = 2HCO_3^-$$

2. Would increased ocean acidity also affect shelled organisms such as mussels, oysters and clams? Yes

More recent threats to species diversity

Since the beginning of the Industrial Revolution powered by burning fossil fuels, we have released increasing amounts of CO_2 to be absorbed and shared by both ocean and atmosphere. Carbon dioxide enhances the greenhouse effect causing atmospheric temperature rise.

NOAA scientists assert that the pH of surface waters has fallen 0.1 pH units.

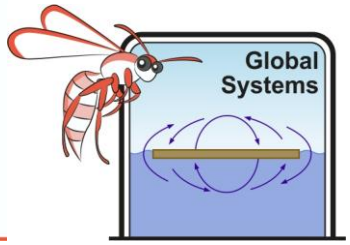
Have ocean surface waters become more or less acidic? They have become more acidic.

However since pH is registered on a logarithmic scale, 0.1 pH units represents a 30% increase in the rate of ocean acidification.

Some scientists suggest that the increased acidification may benefit marine photosynthetic algae.

Why is this so? Photosynthetic organisms use CO_2 with water and energy from the Sun to create sugars for their energy needs. The increased levels of CO_2 may increase the rate of photosynthesis.

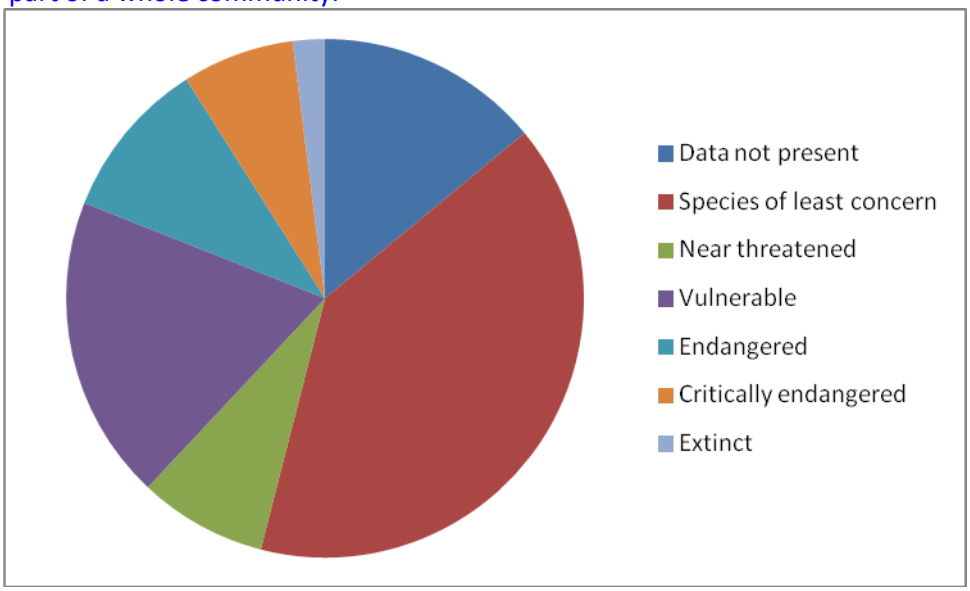
Initial studies suggest that with land plants, increasing CO_2 initially produces a growth spurt but the increase is not sustained. More research is required.



Scientists studying present species loss in their research area have collected the following data.

Species classification	Number	Percentage
Data not present	6,584	14%
Species of least concern	19,032	40%
Near threatened	3,931	8%
Vulnerable	9,075	19%
Endangered	4,891	10%
Critically endangered	3,325	7%
Extinct	373	2%

Using this data, calculate the percentage species loss for each classification and draw a suitable graph to present the data in a simpler form. A pie chart would be best because it demonstrates species as part of a whole community.



Why would the researchers include species for which they have no data? Because they are still part of the whole community being studied. Not including them would skew results.

Does this information represent a mass extinction is taking place? Explain your answer. No. A mass extinction requires 50% species loss.

Past Ice Ages and extinction events

Several times during Earth's geological history our planet has become much colder. Not all of these Ice Ages led to extinctions however. Our most recent (Pleistocene) Ice Age stretched from about 2.6 million years ago to about 20,000 years ago. It varied in time of onset, geographic spread and intensity across the planet and included several warm interglacial periods. We suspect some of these variations result from a combination of:

- Variable sun output activity
- Variable path of the Earth round the sun due to gravitational pull from other planets
- Variations of axial tilt

During the Pleistocene the population of modern humans (Homo sapiens sapiens) in the world was reduced to about 600 breeding pairs living in tropical Africa as great glaciers covered most of the landmasses except between the tropics. Life was harsh and food scarce. We know this from genetic evidence collected during National Geographic's human genome project. Other hominid species such as Neanderthal man (Homo neanderthalensis) and Denisovan man (Homo denisova) died out around the end of the last glacial maximum or soon after. Genetic evidence suggests that all these

groups interbred, as we share common genes. After the ice retreated modern humans spread out to cover the great plains of the world hunting game and collecting fruits, seeds and berries. Another hominid (Homo sapiens floresiensis) commonly known as "The Hobbit", perished more recently.
Are modern humans, Neanderthals and Denisovans separate species? Explain your answer. They are the same species as they could interbreed.
Did Ice Age events increase or decrease hominid species variation or numbers? Variation decreased within the one species as sub-groups died out. Numbers decreased also.

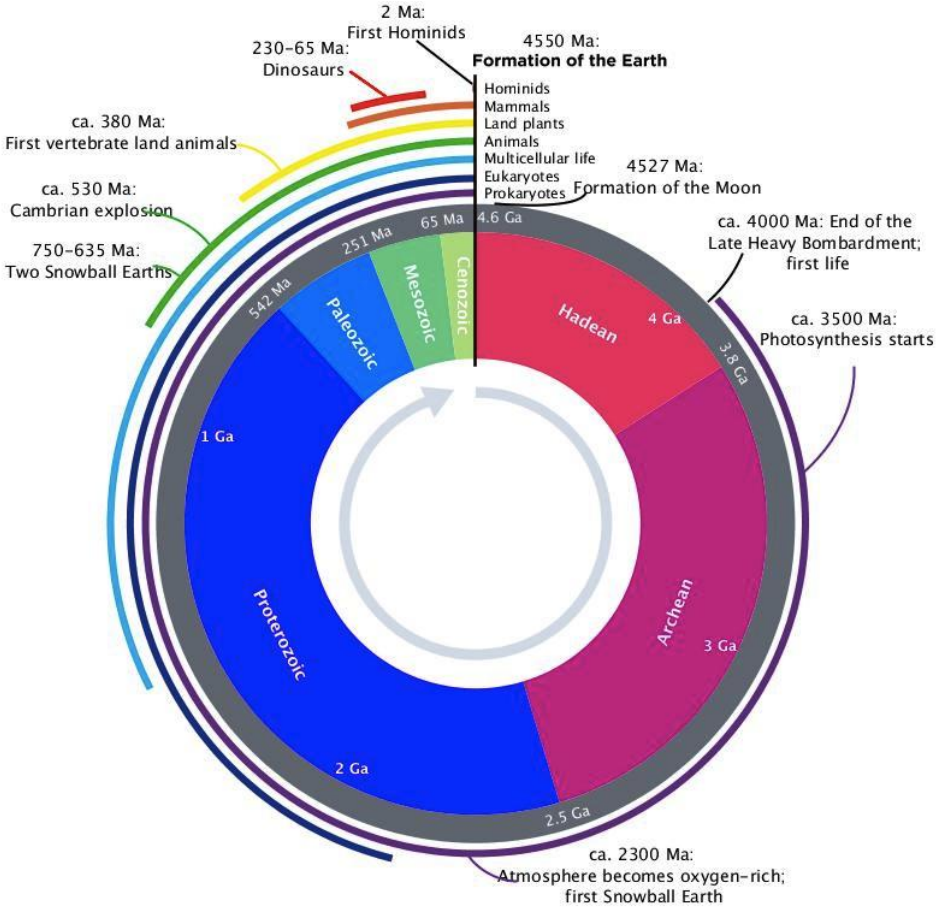
Although there is evidence of this last Ice Age glaciation in the Eastern States, in Western Australia only a little is found as glacial moraines south of the Stirling Range. Some remnant Gondwanaland vegetation is found here as well as remnants of Ice Age vegetation on the Range. However we do have evidence of earlier Permian glaciation near Minginew in the Central Wheat Belt. Rocks frozen into glacier ice scraping over them produced the white scratches visible on this rock surface.
If you found these scratches when studying these rocks would they be primary data, secondary data or proxy data?
They would be proxy data, as glaciation would be inferred.

Snowball Earth

There have been three major occasions when Planet Earth has been almost covered by ice threatening a major extinction event. These are called "Snowball Earth" events.
Using the first diagram on this worksheet, list below when these extinctions took place.
2,300 Ma One extinction
750 – 635Ma Two extinctions

Diagram interpretation and using research data

Biodiversity relates to the variety of life found in an area. The number and variety of species is a simple measure of its "health" i.e. its ability to respond to change at a natural rate.
During the geologic past of our planet Earth has suffered many greater and lesser periods of extinction of life. Only the genes of those who survived were available to provide the variety of new species to fill the ecological niches left.



Major extinctions are designated as those in which more than 50% of species alive at that time became extinct. There are five major extinctions. Find information to fill the table below using the Internet or reference books. Mark when each of the five took place on the diagram above.

Name	Time	Major groups lost	Animals benefitting
Cretaceous-Palaeogene (K-T)			
Triassic-Jurassic			
Permian-Triassic			

Extinctions & Climate Change – Student Activity

Name	Time	Major groups lost	Animals benefitting
Late Devonian			
Ordovician-Silurian			

Using coral to discover forcing factors contributing to mass extinctions

We know a lot about normal growth of present coral reefs. Coral reefs endure a long time and their fossil history is relatively well known, as they are excellent reservoirs for oil and gas. Mass extinctions are marked by a loss of coral reef growth over millions of years.

If extinctions were caused by ***meteorite or asteroid impact***, all coral species would be equally affected by heat and dust and would be extinct in a very short time, perhaps even within a few years. Fossil records show that in all the extinction events the dying took place over geologically long periods. So although meteorite impacts may be a contributing factor, they are not the only cause of major extinctions.

Similarly ***increased ocean and atmospheric temperature*** resulting from volcanic outgassing of CO_2 could have caused coral bleaching due to its effect on enzyme efficiency.

Scientists suggest that the critical factor was indeed an ***increase in CO_2 levels in the atmosphere and ocean*** from volcanic outgassing ***causing a change in ocean chemistry***. NOAA scientists (National Oceanic and Atmospheric Administration – USA government research body) used information gained from studying natural outgassing of the Mauna Loa volcano on the surrounding ocean.

What chemical effect would atmospheric CO_2 have on the ocean? _____

Describe what effect an increase of atmospheric CO_2 would have on corals?

1. Corals have internal carbonate skeletons to support the animals' bodies.

_____

_____

_____

2. Would increased ocean acidity also affect shelled organisms such as mussels, oysters and clams?

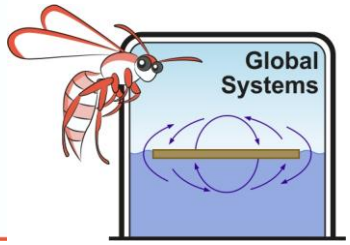
_____

More recent threats to species diversity: Data measurement

Since the beginning of the Industrial Revolution, powered by burning fossil fuels, we have released increasing amounts of CO_2 to be shared by both ocean and atmosphere. Carbon dioxide enhances the Greenhouse Effect causing atmospheric temperature rise.

NOAA scientists assert that the pH of ocean surface water has fallen 0.1pH units.

Has ocean surface water become more or less acidic? _____



Some scientists suggest that the increased acidification may benefit marine photosynthetic algae. Why is this so? _____

_____

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Species loss data

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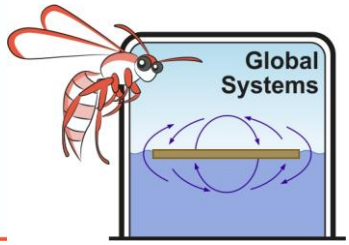
Using this data set calculate the percentage species loss for each classification and draw a suitable graph to present it in a simpler form.



Why would the researchers include species for which they have no data? _____

_____

_____

Does this data represent a mass extinction? Explain your answer. _____

_____

Past Ice Ages and extinction events

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Are modern humans, Neanderthals and Denisovans separate species? Explain your answer.

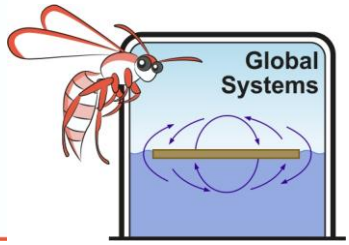
_____

Did Ice Age events increase or decrease hominid species variation or numbers? _____

_____

Although there is evidence of this last Ice Age glaciation in the Eastern States, in Western Australia only a little is found as glacial moraines south of the Stirling Range. Some remnant Gondwanaland vegetation is found here as well as remnants of Ice Age vegetation on the Range. However we do have evidence of earlier Permian glaciation near Minginew in the Central Wheat Belt. Rocks frozen into glacier ice scraping over them produced the white scratches visible on this rock surface. If you found these scratches when studying these rocks would they be primary data, secondary data or proxy data?

_____



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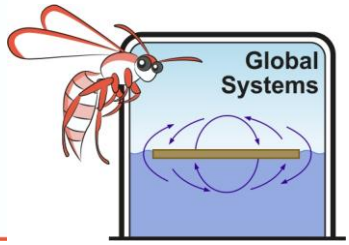
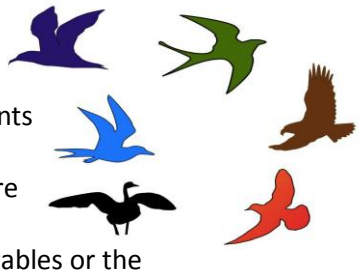


Fire & Biodiversity Loss – Teacher Notes

Communities survive change if they are given time to adapt. It is the increased rate of change in the environment that creates a loss of biodiversity.
Species cannot survive if their numbers fall below the "tipping point" because genetic diversity is reduced limiting ability to combat natural loss and change.

Many Australian plants and animals are well adapted to cope with drought and fire. An enhanced Greenhouse Effect could however result in longer hotter drier summers and an increased frequency of lightning strike. Devastating fires could become more frequent affecting the survival of many species. With the advent of man, however, fires in some places have become more frequent and hotter, and the areas available to the species have become more restricted. The Environmental Protection Authority's *State of the Environment Report 2007* stated that fire is a major factor in the loss of biodiversity in Western Australia. Fire reduces both the numbers within a species and the numbers of species.

Students will be asked to model what happens to a group of six different species living in an area, half of which suffers from fire every year. The creatures give birth to one offspring per pair per year. Species cannot interbreed and produce fertile offspring.



<u>Aim</u> To model the effect of fire on biodiversity

Each colour represents a different species of bird and each toothpick represents an individual bird. Birds can only mate with another of the same species. Mating occurs annually and only one chick survives to grow to be an adult. Fire attack is assumed to be random (at the toss of a coin). The activity may be a teacher demonstration where the class individually note the results on their tables or the table provided might be used.

Materials per group

- Six different coloured sets of 15 toothpicks. Alternatively sets could be made of coloured straws cut in sections, beads or confetti. Retain extra toothpicks etc. to use as young.
- A desk top or paving slab divided into two sections marked 'Heads' and 'Tails'
- A coin for tossing
- Table for data (provided)

Method

1. Separate the toothpicks into 5 breeding pairs of each colour. Retain the extra toothpicks for "young" at the end of the breeding season.
2. Mix the breeding pairs and spread randomly across the desk top marked into "Heads" and "Tails"
3. Toss a coin to decide which area is devastated by fire and remove the toothpicks/animals.
4. The surviving birds form pairs, breed and the numbers for each species entered in the table
5. Continue this process for five fires over five years, recording your data.

Students first mix the toothpicks randomly and cast them onto the divided surface. This represents the spread of the creatures over their territory. Toss a coin to decide which area is devastated by fire. These creatures are removed. Note the number of survivors in each group in the data table. Each pair of creatures can produce one offspring per year. Add the offspring numbers to the parent numbers and repeat the process to obtain data for five years.

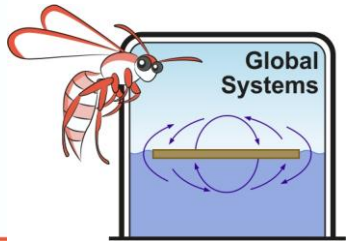
Fire & Biodiversity Loss – Teacher Notes

What assumptions were made? The two remaining organisms were male and female.

This is an example of data collected in a trial run

Numbers	Black	Blue	Purple	Red	Brown	Green	Total
Numbers at beginning of year 1	10 5 pairs	10 5 pairs	10 5 pairs	10 5 pairs	10 5 pairs	10 5 pairs	60
Numbers after first fire	7 3 pairs	3 1 pair	5 2 pairs	4 2 pairs	5 2 pairs	3 1 pair	
Young born to each pair	3	1	2	2	2	1	
Numbers at beginning of year 2	10 5pairs	4 2 pairs	7 3 pairs	6 3 pairs	7 3 pairs	4 2 pairs	38
Numbers after second fire	8 4 pairs	4 2 pairs	3 1 pair	4 2 pairs	4 2 pairs	3 3 pairs	
Young born to each pair	4	2	1	2	2	1	
Numbers at beginning of year 3	12 6 pairs	6 3 pairs	4 2 pairs	6 3 pairs	6 3 pairs	4 2 pairs	38
Numbers after third fire	4	5	2	3	4	0	
Numbers born to each pair	2	2	1	1	2	0	
Numbers at beginning of year 4	6 3 pairs	7 3 pairs	3 1 pair	4 2 pairs	6 3 pairs	0	26
Numbers after fourth fire	4 2 pairs	3 1 pair	3 1 pair	4 2 pairs	3 1 pair	0	
Young born to each pair	2	1	1	2	1	0	
Numbers at beginning of year 5	6 3 pairs	4 2 pairs	4 2 pairs	6 3 pairs	4 2 pairs	0	24
Numbers after fifth fire	2	1	2	5	0	0	
Young born to each pair	1	0	1	2	0	0	
Numbers alive after five years	3 2 pairs	1	3 1 pair	7 3 pairs	0	0	14

Biodiversity can refer to variety within a species and between species.
After five years:
Within each species, what percentage of biodiversity lost?
Black birds reduced from 5 breeding pairs to 2 breeding pairs – 60% loss
Blue birds were reduced from 5 breeding pairs to one individual – 90% loss and no chance of breeding. 100% loss when that bird dies – recall last Tasmanian Tiger story
Purple birds were reduced from 5 breeding pairs to 1 pair – 80% loss
Red birds were reduced from 5 breeding pairs to 3 breeding pairs – 40% reduction
Brown birds were reduced from 5 breeding pairs to no birds by the end of the fourth yar. – 100% loss
Green birds were reduced to no birds at the end of the third year. – 100% loss
Why cannot individuals of different species not form pairs? They might form pairs but cannot produce viable offspring.
Why would a reduction to two breeding pairs affect the species chances of survival? One random event could wipe out the entire species. Since these few survivors share the same genes their offspring will be less variable and less able to survive any chance of environment. Inbreeding can cause any weaknesses to become more common. (Relate to zoos swapping animals to widen the gene pool)



Between the species, what percentage of biodiversity was lost? Only three of the original six species remained after five years - 50% loss

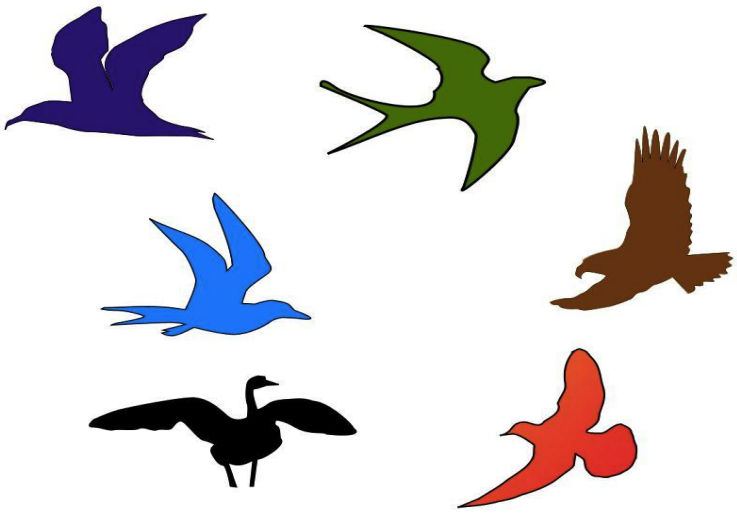
Students may wish to discuss the critical numbers to ensure survival and other factors (competition for food, partners, shelter, nesting areas etc) which will affect species numbers.

Fire & Biodiversity Loss – Student Activity

Communities survive change if they are given time to adapt. It is the increased rate of change in the environment that creates a loss of biodiversity. Species cannot survive if their numbers fall below the "tipping point" because genetic diversity is reduced limiting ability to combat natural loss and change.

Many Australian plants and animals are well adapted to cope with fire. With the advent of man, however, fires in some places have become more frequent and hotter, and the areas available to the species have become more restricted. Climate change due to the enhanced Greenhouse Effect could result in longer hotter summers and increased frequency of lightning strike. Devastating fires could become more frequent. The Environmental Protection Authority's *State of the Environment Report 2007* stated that fire is a major factor in the loss of biodiversity in Western Australia. Fire reduces both the numbers within a species and the numbers of species.

Aim **To model the effect of fire on biodiversity**



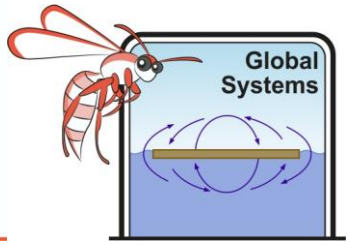
Each colour represents a bird of a different species and each toothpick represents an individual bird. Birds can only mate with another of the same species. Mating occurs annually and only one chick survives to grow to be an adult. Fire attack is assumed to be random (at the toss of a coin). The activity may be a teacher demonstration where the class individually note the results on their tables or the table provided might be used.

Materials per group

- Six different coloured sets of 15 toothpicks.
- A desk top or paving slab divided into two sections marked 'Heads' and 'Tails'
- A coin for tossing
- Table for data (provided)

Method

1. Separate the toothpicks into 5 breeding pairs of each colour. Retain the extra toothpicks for "young" at the end of the breeding season.
2. Mix the breeding pairs and spread randomly across the desk top marked into "Heads" and "Tails"
3. Toss a coin to decide which area is devastated by fire and remove the toothpicks/animals from that half. These have perished.



4. The surviving birds form pairs, breed and the numbers for each species are entered in the table (don't forget to add toothpicks back in for young born)
5. Continue this process for five fires over five years, recording your data.

Numbers	Black	Blue	Purple	Red	Brown	Green	Total
Numbers at beginning of year 1							
Numbers after first fire							
Young born to each pair							
Numbers at beginning of year 2							
Numbers after second fire							
Young born to each pair							
Numbers at beginning of year 3							
Numbers after third fire							
Numbers born to each pair							
Numbers at beginning of year 4							
Numbers after fourth fire							
Young born to each pair							
Numbers at beginning of year 5							
Numbers after fifth fire							
Young born to each pair							
Numbers alive after five years							

What assumptions were made above? _____

Biodiversity can refer to variety within a species and between species.

After five years:

Within each species, what percentage of biodiversity lost?

_____

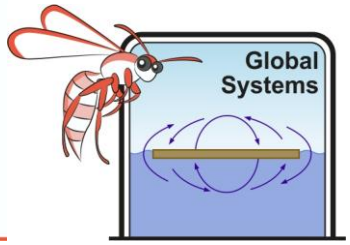
_____

_____

_____

_____

_____



Megafauna – Teacher Notes

There is often much discussion amongst scientists as to the cause or causes for global extinctions such as the one in which the dinosaurs became extinct. It occurred many millions of years ago so reliable information may be difficult to find, to measure and to interpret. In the past people have suggested that dinosaurs were suddenly and catastrophically wiped out by one of the following forcing factors:

- Climate change
- Volcanic eruptions and the fires they started.
- Noah's flood
- Asteroid impacts

Current research indicates that this global extinction event was not the result from one single catastrophic change. It occurred over 50 million years and was probably caused by a combination of cyclical climate warming enhanced by volcanic outgassing and that at various locations asteroid and meteorite impacts happened at different times.

Analysis of data from more recent rocks, marine sediments and ice cores indicates that single major forcing factors such as CO_2 outgassing from volcanoes increasing atmospheric and marine temperatures, changes in marine acidity because of increased atmospheric CO_2, and tectonic movements causing changes in marine current flow and heat distribution patterns have happened many times during Earth's history without immediate catastrophic results. Rather that a "tipping point" appears to have been reached as a consequence of interaction between many factors. Analysts suggest that although single forcing factors may be responsible for local changes in climate, vegetation and biodiversity there is no evidence of their causing great global extinctions.

Tipping points may be reversible. A case in point is the Pleistocene and Recent history of northern and central Australia where a variety of minor factors acting together has caused periods of alternating increase and decrease of rainfall. Vegetation has "flipped" between being savannah to rainforest to savannah to becoming rainforest and back again. The arid phase coincided with the loss of most of Australia's megafauna.

Piltdown Man

Often explanations are influenced by current beliefs and values. Our Australian Curriculum requires students to be able to make up their own minds based on the source and quality of data available. Sensible scientists are skeptical. In a famous case in Victorian England some hoaxer took the skull of a modern human and the jaw of an ape and "planted it" it in Piltdown quarry. There had been much discussion on the possible evolution of humans from apes. Up until then no evidence had been found to support that view. The Piltdown man" appeared to provide the missing link in the chain of evolution. Discoveries of other skulls of our ancestors have since shown that humans and apes have a common ancestor. The hoax was later uncovered when fluorine dating clearly demonstrated that the two bones were of different ages and came from different geographical sources. This had already been suspected as the bones were quite differently weathered and the jaw was much more robust than the skull. Geology students were suspected of planting it as a prank.

Why do you think the hoaxer planted the skull? To support the idea of evolution from apes. To make fun of the idea that humans evolved from apes. To confuse their professor. Fun.

How can you select reputable sources of information when you use the Internet? Write down 5 ways of making sure you are using good sites.
First check that what is written makes sense to you. Use reputable sites, check qualifications of writer, cross reference information sources, keep skeptical, consider writer's bias.

Megafauna – Teacher Notes

The extinction of Australian megafauna

As recently as 50,000 years ago Australia was home to many species of megafauna. Megafauna are species with a body mass over 45kg or being 30% or more massive than their present relatives. Giant marsupials such as Diprotodon, an herbivore, 2m tall, 3m long and weighing 2,700kg roamed the forests whilst Thylacoleo, a marsupial lion, hid up in the branches to jump down on its prey. Thylacoleo had massive jaws three times more effective than any recent lion. By about 40,000 years ago 90% of our megafauna was extinct. The remnant population of red kangaroos, emus and saltwater crocodiles are all that now remains of this group.

For comparison you have been given a photograph of a fossilised Diprotodon skull found in Victoria and dated at 50,000 years ago and another of a horse skull found at 80 Mile Beach on the north coast of Western Australia.

Skull found in Victoria (megafauna, Diprotodont) and recent horse skull found at 80 Mile Beach near Broome

What information do you need before you even start to compare these skulls?

Source — Why should I value the information from the person who took the photographs? Source of skulls known. Picture from reputable scientist

Scale — Are both pictures to the same scale - - are they physically comparable? YES

Integrity — Have any changes been made in the data to suggest a bias of interpretation? NO

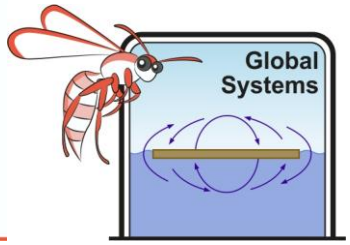
Both are to the same scale and have not been interfered with. (Actually the skull on the right has had teeth removed to test the effect of Coca Cola on teeth – seriously erosive).

How old can the horse skull be? Explain your answer. About three hundred years. Post arrival of European settlers.

Are both skulls from the same type of creature? No. Although they have similarities, they have many obvious differences. One is from a mammal and the other is from a marsupial.

How can we use the modern horse skull on the right to interpret the life of the animal whose skull is on the left? What clues can we use?

1. Both are herbivores having sharp chisel shaped front teeth (incisors) for cropping grass and leaves and large rear teeth (molars) for grinding them to release their goodness. The classic gap between both teeth is the diastermat that allows animals to rotate their lower jaw – chew. These were both animals that grazed on grasses for their food source – herbivores.
2. Both skulls are approximately the same size suggesting the animals are about the same size.
3. Eye sockets at the side of the head suggest that both are herbivores and need a wide range of sight to notice any carnivores.



4. The bumps at the back of the skull are for muscle attachment and suggest both are quadrupeds.

Can we definitively state that both creatures were herbivores and about the same size? NO. This is just the best interpretation AT THIS TIME WITH THE INFORMATION AVAILABLE.

How did the megafauna become extinct?

Materials per student or group of three

- Scrap paper
- Internet access and reference books

You may wish to discuss with students how to select reliable sources of information

Scientists have suggested that:

1. Higher levels of oxygen in the atmosphere caused low global atmospheric moisture levels decreasing rainfall and resulting in the loss of their food sources
2. As part of normal climate variation cycles, Australia became drier changing the vegetation from rainforest and soft grasses to hard leaved eucalypts and rough grasses such as spinifex.
3. Megafauna being large were less able to compete with smaller competitive species for their increasingly restricted food sources
4. The drying climate brought an increased frequency of droughts and lightning strikes which resulted in more fires
5. The arrival of Aboriginal people caused them to be hunted to extinction.
6. The use of Aboriginal firestick farming favoured the survival of hardy rough grasses such as spinifex that were a poor food source for megafauna.

Give each group one of the suggestions above and ask them to quickly individually research it. They are to choose two sources that are reliable and make rapid notes.

Megafauna – Student Activity

Piltdown Man

Sensible scientists are skeptical.

In 1913 in Victorian England, a hoaxer took the skull of a modern human and the jaw of an orangutan and "planted it" in Piltdown quarry where it was later found. There had been much discussion on the possible evolution of humans from apes. Up until then no evidence had been found to support that view. This skull appeared to provide the missing link in the chain of evolution. The hoax was later uncovered in 1953 when fluorine dating clearly demonstrated that the two bones were of different ages and came from different geographical sources. This had already been suspected as the bones were quite differently weathered and the jaw was much more robust than the skull. Geology students were suspected of planting it as a prank. Discoveries of other skulls of our ancestors have since shown that humans and apes have a common ancestor.

Why do you think the hoaxer planted the skull? _____

_____

CSIs say, "Trust the data, only the data"

How can you select reputable sources of information when you use the Internet to collect data? Write down 5 points that may help other students make good choices

1. _____
2. _____
3. _____
4. _____
5. _____

The extinction of Australian megafauna

As recently as 50,000 years ago Australia was home to many species of megafauna. Megafauna are species with a body mass over 45kg or being 30% or more massive than their present relatives. Giant marsupials such as Diprotodont, an herbivore, 2m tall, 3m long and weighing 2,700kg roamed the forests whilst Thylacoleo, a marsupial lion, hid up in the branches to jump down on its prey. Thylacoleo had massive jaws three times more effective than any lion. By 40,000 years ago 90% of our megafauna was extinct. The remnant population of red kangaroos, emus and saltwater crocodiles are all that now remains of this group.

Megafauna footprints in SW Western Australia (Sthenurus?)

Megafauna – Student Activity

For comparison, you have been given a photograph of a fossilised Diprotodont skull found in Victoria and dated 50,000 years ago and another of a horse skull found at 80 Mile Beach on the north coast of Western Australia. Any data you collect should reflect consideration of its source, scale and its scientific integrity.


Skull found in Victoria (megafauna, Diprotodont) and recent horse skull found at 80 Mile Beach near Broome

What information do you need before you even start to compare these skulls?

Source _____

Scale _____

Integrity _____

How old can the horse skull be? Explain your answer. _____

_____

Are the skulls from the same type of creature? Explain your answer. _____

_____

How can we use the modern horse skull on the right to interpret the life of the animal whose skull is on the left? What clues can we use?

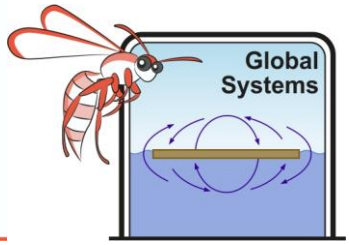
_____

_____

_____

Can we definitively state that both creatures were herbivores and about the same size? _____

_____



Megafauna – Student Activity

How did the megafauna become extinct?

Materials per student or group of three

- Scrap paper
- Internet access and reference books

Scientists have suggested that:

1. Higher levels of oxygen in the atmosphere caused low global atmospheric moisture levels decreasing rainfall and resulting in the loss of megafauna food sources
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5. The arrival of Aboriginal people caused them to be hunted to extinction.
6. The use of Aboriginal firestick farming favoured the survival of hardy rough grasses such as spinifex that were a poor food source for megafauna.

You will be given one of the above suggestions to rapidly research. Note your findings below

Source 1 _____

Findings _____

_____

_____

_____

_____

Source 2 _____

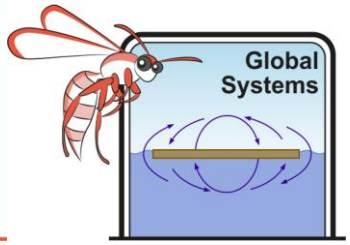
Findings _____

_____

_____

_____

_____



Megafauna – Student Activity

Share your findings with others of your small group and come to a consensus on the main points you agree upon. Write these below.

_____

_____

_____

Appoint a spokesperson to report on you group's findings to the class. The teacher may board these.

Discuss which (if any or all) were the major forcing factors in the long-term demise most of our megafauna.

The class found that _____

_____

_____

_____

_____

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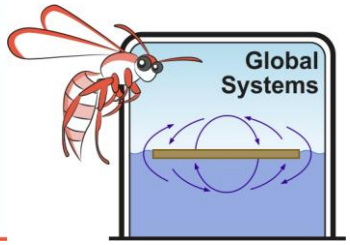
_____

_____

_____

_____

Climate Change - Teacher Review



N R U A S O N I D R R E S N I
O D E C I N S U E Z X E O V M
I Y I N I E O S S T G I O E G
T T E P N V E W I A T L T T T
A I L E R A O N B A C S E E H
C S G A R O C K C A Y H S C Y
I R P C V T T I N S L L I T L
F E H E I I F O O A A L C O A
I V S O C I V C D M L O L N C
T I N S D I E R I O R I I I O
R D V I A M E N U A N F M C L
E O C Z R M A S L S I T A A E
S A B I O D I V E R S I T Y O
E Z E S U O H N E E R G E Y N
D M E T E O R I T E G N A H C

Write down below the words that relate to biodiversity.

ACIDIFICATION
AGES
ANIMALS
BIODIVERSITY
CHANGE
CLIMATE
CORAL
DESERTIFICATION
DINOSAUR
DIPROTODONT
DIVERSITY
ECOSYSTEM
EXTINCTION
FIRE
GENES
GREENHOUSE
ICE
MASS
METEORITE
MILANKOVIC
RESEARCH
SNOWBALL
SPECIES
SUN
SURVIVAL
TECTONIC
THYLACOLEON
VOLCANO

What is meant by biodiversity?

Biodiversity relates to the variety of life found in an area. This includes the different plants, animals and microorganisms, their genes and the ecosystems of which they are a part.

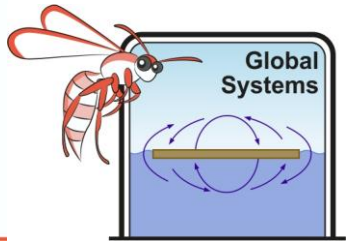
How does climate change relate to changes in biodiversity? Give two examples.

Living things are adapted to suit their environment. If the climate changes, both the living and non-living environment is affected.

When there was a change to a drier and hotter climate, about 70,000 to 50,000 years ago many species of macropods died out because their fodder sources of soft leaved trees and grasses declined. – Loss of variety of species.

Smaller members of some species such as wallabies had more success than their larger counterparts because they required less food and could tolerate hard leaves. In time there were more small members within each species – Loss of variety within species.

Climate Change - Student Review



N R U A S O N I D R R E S N I
O D E C I N S U E Z X E O V M
I Y I N I E O S S T G I O E G
T T E P N V E W I A T L T T T
A I L E R A O N B A C S E E H
C S G A R O C K C A Y H S C Y
I R P C V T T I N S L L I T L
F E H E I I F O O A A L C O A
I V S O C I V C D M L O L N C
T I N S D I E R I O R I I I O
R D V I A M E N U A N F M C L
E O C Z R M A S L S I T A A E
S A B I O D I V E R S I T Y O
E Z E S U O H N E E R G E Y N
D M E T E O R I T E G N A H C

Write down below the words that relate to biodiversity.

What is meant by biodiversity? _____

_____

_____

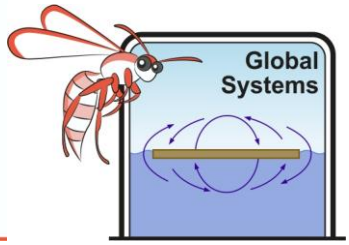
How does climate change relate to changes in biodiversity? Give two examples from past extinction events.

_____

_____

_____

Sea Ice and Permafrost



Sea Ice - Teacher Background

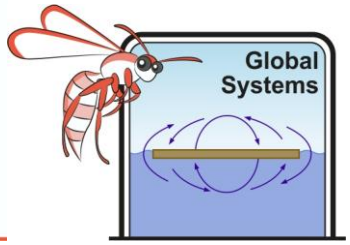
The cryosphere comprises of those parts of the surface of Earth where water is in the form of ice (Cryos = ice, sphere = ball).

Ice caps, glaciers, ice shelves and icebergs are considered to be land derived. They are the result of accumulated snowfall. Sea ice however is frozen seawater. Sea ice regulates exchanges of heat, moisture and salinity in Polar Regions. It insulates the relatively warm underlying seawater except where cracks (leads) permit loss. In the Arctic, sea ice can build up over many years and be well over 3m thick whereas in the Antarctic sea ice melts and reforms every year. Ice in the Antarctic Ocean averages only 0.5m in thickness.
"Global Conveyor Belt" activities (in the Ocean Currents section) explain how ice, cold winds, low air temperatures and increased sea salinity at the poles are drivers for the Global Conveyor Belt. This current transfers heat around the world through moving enormous quantities of water at depths of over 200m. Cold winds and water at the pole freeze out (almost) fresh water to form ice. When comparing Arctic and Antarctic sea ice, differences between land based ice (cap, glacier and shelf) in the east and western sea ice have to be factored in. In the Arctic, almost all ice is from frozen sea ice.

Arctic sea ice covers between 14 and 16million km^2
Antarctic sea ice covers between 17 and 20million km^2
About 7% of the world oceans are covered by sea ice

Because ice is less dense than water it floats. About 7% of the ocean or 23 million km^2 is covered by sea ice. Sea ice is not pure fresh water but can contain up to 0.5% salt, mostly sodium chloride. NOTE By international convention, seawater salinity is usually expressed without units.

Sea ice (pack ice) affects heat exchange between air and water. When it freezes, air is trapped within the interlocking ice crystals. This creates an insulating layer between the atmosphere and the ocean and prevents heat escaping from water. The ice in an Inuit's igloo is not only good construction material it is a good insulator also. Sea ice coverage varies with the seasons. In the Arctic pack ice averages 3m thick whereas in the Antarctic it is often between 0.5 and 1 m thick. This means that Antarctic sea ice is more sensitive to temperature change.



Sea Ice - Teacher Background

In 2014 a study by the University of California and NASA suggested that a “tipping point” had been reached on the West Antarctic Ice Sheet and that progressive melting has now become unstoppable. Melting is the result of a change of winds that circulated warmer water farther under the ice shelves. The observed retreat of six glaciers, which feed this sheet, would cause a rise in global sea level of just under 1m by the end of this century and a total of about 4m over the next few centuries.
A series of feedback loops mean that once started melting accelerates.

1. Warm sea water causes sea ice to melt
2. This melting thins the ice so that it melts faster and pulls the landward ice down slope after it.
3. This further thins and mobilises the landward ice.

Most of the information on rate of melt is gained from satellite photography.

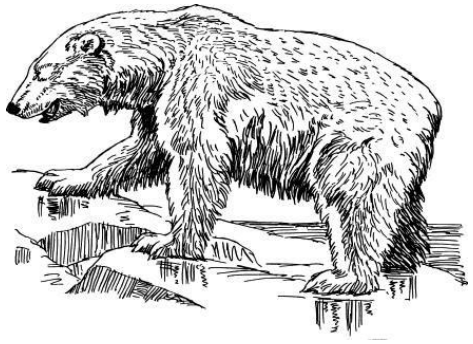
These winds are also responsible for the recent parching of South Western Australia. The change of winds means the annual arrival of rain bearing depressions during winter along the south coast is becoming less frequent. “Antarctica is stealing more of Australia’s rainfall … we get fewer storms chased up into Australia”, Dr Nerile Abram, lead researcher, ANU’s Research School of Earth Sciences. These researchers used annual seasonal data since AD 1000 recorded in Antarctic ice cores and South American tree rings

Insulating Effect - Teacher Notes

Aim **To demonstrate that ice insulates seawater.**

Materials

- Two beakers
- Two thermometers
- Water
- Radiant heat from sunlight, a bar heater or from a microscope lamp



Method

Before the lesson

1. Pour 100mL of water into one beaker
2. Set the pen upright in this beaker and freeze. When the ice has formed tap out the ice disc and remove the pen.

Students:

1. Half fill both beakers with water
2. Place the ice disc (prepared by your teacher) in one beaker with the thermometer inserted through to the water below.
3. Place the other thermometer in the ice-free beaker
4. Apply radiant heat from above.
5. Measure temperature increase of the water in the beaker over 20 minutes

Results/observations

Draw up a table for your results
To ensure precision and accuracy, which units shall you use for time and for temperature? _____

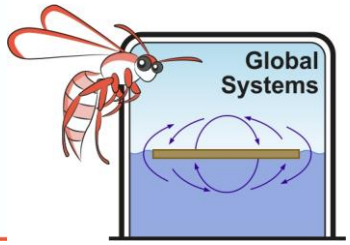
Time	Water temperature of container with ice (^{o}C)	Water temperature of container without ice (^{o}C)	Comments

(In my experiments, the container without ice had reached ambient temperature (25^{o}C) in 7 minutes and 30 seconds. Ice was still remaining on the other container 12 minutes later and water below was still 16^{o}C)

Conclusion
What conclusion can you draw from these results? Ice is an efficient insulator
Discussion
Why do you think ice is a good insulator? Frozen ice has air trapped between the ice crystals. Air is a good insulator. Ice has a reflective surface, which will return radiant heat to the atmosphere (albedo effect).

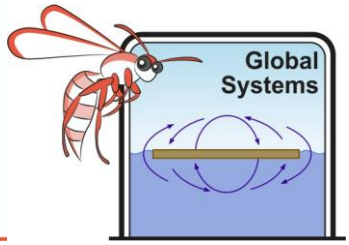
How will increased sea ice melt affect polar bears in the northern oceans? Polar bears hunt for fish and seals from sea ice. Their hunting habitat will disappear.

Insulating Effect - Teacher Notes



ALBEDO: Albedo is the degree to which radiant energy is reflected from a surface. Ice reflects radiant heat from its surface back into space. This is known as the albedo effect. When ice melts heat is retained in the atmosphere causing further melting.
In the geological past Earth has iced over several times. During the “Snowball Earth” times in the Ordovician most of the planet was ice covered. Albedo from the white surface dropped surface temperatures to -40°C. Present surface temperature is 15°C.

https://nsidc.org/arcticseaicenews/
NSIDC State of cryosphere data was used for this worksheet and can be accessed for up to date mapping of changes.



Insulating Effect - Student Activity

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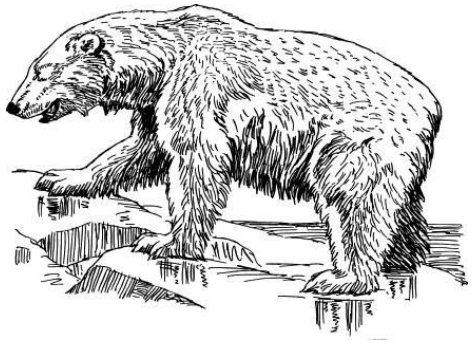

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Conclusion
What conclusion can you draw from these results? _____

_____

Discussion
Why do you think ice is a good insulator? _____

_____

How will increased sea ice melt affect polar bears in the northern oceans? _____

_____

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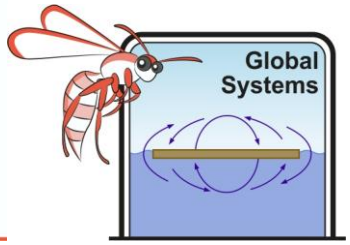
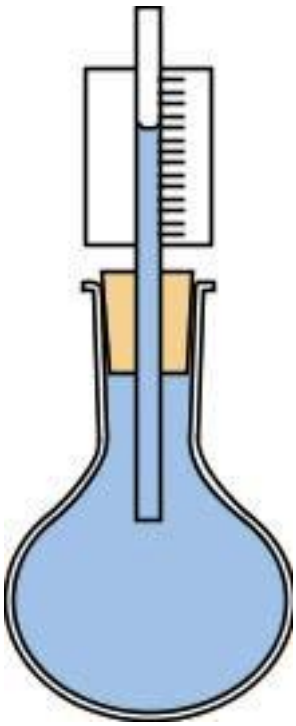


Sea Ice & Heat - Teacher Notes

AIM **To find if heat can raise water level**



Materials per group

- A Florence flask or conical flask
- Stopper with hole for glass tube
- Glass tube
- Bunsen burner or gas stove and match
- Wire gauze
- Tripod
- Stand and clamp if necessary
- Marking pen (or masking tape)
- Water and food colouring if preferred
- Internet access

Method

1. Gently push the glass tube through the rubber stopper
2. Fill the flask to the top with cold water
3. Gently press the stopper with tube into the mouth of the flask until it is sealed. (Water displaced by the stopper should rise within the tube
4. Mark the height of the water level in the tube with a marker pen (or masking tape)
5. Light the burner and adjust to create a blue flame.
6. Heat the base of the flask and mark any changes in water level until the water nears boiling, then cease the activity.
7. Let the equipment cool before disassembling it.

Safety Considerations

What safety considerations do we need to take before and during this experiment?

General Lab rules.
Care pushing the tube through the stopper. This can be prepared earlier for a boisterous class.
Making sure the tube is the right length to fit into the flask without touching the bottom.
Knowing the correct sequence in which to light a burner and how to attain a blue flame.
Leaving glassware until it is cool.
Leaving the tripod until it is cool and only holding it by the base of one leg.

Results/Observations

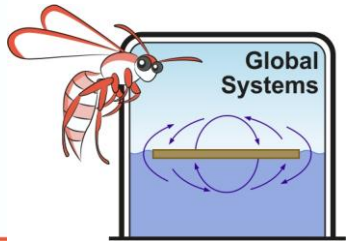
What did you observe as the water in the flask heated. The water level rose

Conclusion

To what conclusion can your results lead? The water level rose as it was heated.

Discussion

Why did the water level rise? Kinetic energy from heat accelerated movement of molecules of water and they took up more space/increased volume.



Sea Ice & Heat - Teacher Notes

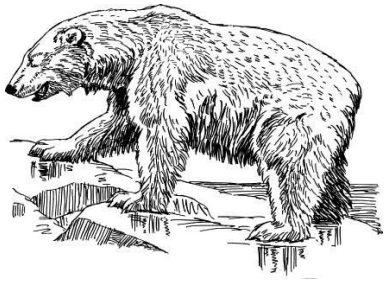
What happens to the sea if global temperatures rise? It will expand and sea levels will rise

As a result of global warming, the greatest increase to sea level comes not from melting ice but from thermal expansion

Visit http://www.climatechange.gov.au/climate-change/climate-science/climate-change-impacts/western-australia and answer the following questions

Which state has the longest coastline? WA
How will accelerated global warming impact on our coastal zone? Sea level rise will lead to more storm surges impacting on coastal settlements, infrastructure and ecosystems
Over the twentieth century what has the average sea level rise been? 1.7mm per year
What has this increased to over the last 15 years? 3.2 mm per year

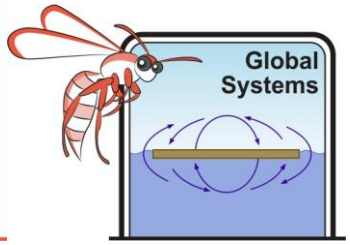
Extension
How can these findings be used to help with planning for dealing with an increasing rate of global warming? Higher temperatures will make sea levels rise all over the world. Planning for roads, railways, commercial infrastructure and housing will have to take this rise into account.



What effect would a few degrees rise in temperature have on a polar bear?
Polar bears feed on fish that live in warm water insulated under sea ice. Melting sea ice means they would lose their food. Loss of sea ice would mean they would have to swim from land. Rising sea levels would flood low -lying coastal land. They would have to travel farther to find a decreasing food source

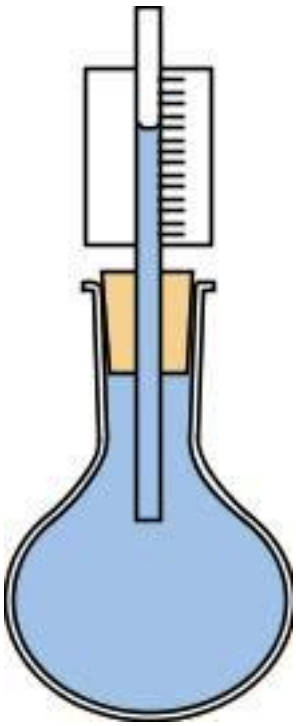
People living in high mountainous areas well away from our poles are also going to be affected by rapidly increasing temperatures. How can this be?
These people are dependant on melt water from glaciers. As the glaciers melt away faster than the ice is replaced then their agriculture could be severely impacted.

Possible Extension
In Australia, the majority of people live within the coastal zone and are at risk of rising sea levels. The Australian government has developed a series of sea level rise maps to illustrate the potential impacts. Students may wish to visit this site and find out how they themselves may be affected. These can be viewed at the following site: http://www.ozcoasts.gov.au/climate/sd_visual.jsp



Sea Ice & Heat - Student Activity

AIM **To find if heat alone can raise water level**



Materials per group

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Safety Considerations

What safety considerations do we need to take before and during this experiment?

_____

_____

Results/Observations

What did you observe as the water in the flask heated? _____

_____

Conclusion

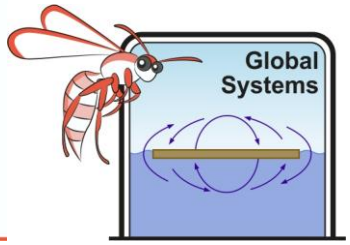
To what conclusion can your results lead? _____

_____

Discussion

Why did the water level rise? _____

_____



Sea Ice & Heat - Student Activity

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_____

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Which Australian state has the longest coastline? _____

How will accelerated global warming impact on our coastal zone? _____

_____

_____

What was the average sea level rise over the twentieth century?_____

What has this increased to over the last 15 years? _____

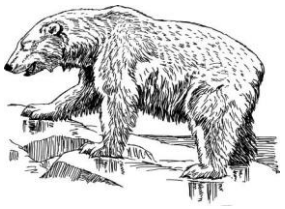
Extension

How can these findings be used to help with planning for dealing with an increasing rate of global warming?

_____

_____

What effect would a few degrees rise in temperature have on a polar bear?



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People living in high mountainous areas well away from our poles are also going to affected by rapidly increasing temperatures. How can this be?

_____

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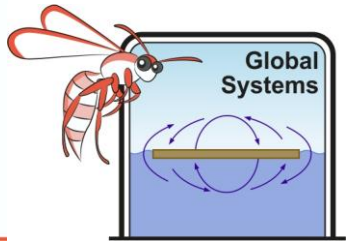


Sea Ice Thickness -Teacher Notes

Sea ice regulates exchanges of heat, moisture and salinity in Polar Regions. It insulates the relatively warm underlying seawater except where cracks (leads) permit loss. In the Arctic sea ice can build up over many years and be well over 3m thick whereas in the Antarctic sea ice melts and reforms every year. Ice in the Antarctic Ocean averages only 0.5m thick and varies greatly with the seasons.

Aim **To observe if the thickness of ice affects the rate of its melt**

Materials per student

- Two containers. One tall and narrow (plastic drinking cup) and another wide and flat (fast food container or meat tray)
- Water
- Freezer
- Timer/watch
- Basin or pneumatic trough

Method

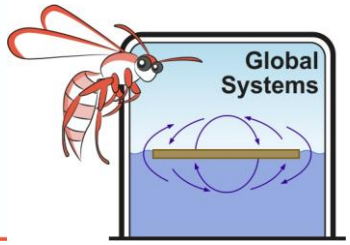
1. Place the same volume of water in each container and freeze until solid.
2. Remove both blocks of ice and float in water at room temperature.
3. Measure how long it takes the blocks to melt.
   To curb student impatience if this is a teacher demonstration, placing the blocks in direct sunlight through a window or using a radiant heater can increase the rate of melting or using heat generated microscope lamps (least effective). My experiment at 32^{o}C indoors had the thinner ice sheet melted in 5 minutes while the four times thicker block took 8 minutes. I selected a container, which would produce one sheet four times thicker than the other to reflect the difference between Arctic and Antarctic sea ice.

Which units shall you use to measure time to ensure precision? Minutes and seconds.

Observations

The thick block (Arctic ice) took _____

The thin block (Antarctic ice took _____



Sea Ice Thickness -Teacher Notes

Conclusion

Did the thickness of the ice affect its rate of melting? Yes. Thin ice melts faster than thick.
Why would this be? The thin ice had a greater surface area to absorb radiant heat. Conduction is a slow process but the thinner the ice the less time it would take. Thin ice contains less air and thus less insulation.

Discussion

How could this activity be improved? Float ice on a 3.6% saline solution to represent seawater. Ensure one sheet was four times thicker than the other to reflect difference between Arctic and Antarctic sea ice. Repeat and average results.

How does this activity relate to penguins?

1. Most penguins live in the Southern Oceans on thinner (Antarctic) ice.
2. Penguins have to cross shelf ice to travel from their rookeries (nesting places) to reach open sea where they can forage for food.
3. Early ice break up may cause some penguins to float away from their rookeries leaving their young to perish
4. They also rest and recover from hunting fish on sea ice.
5. If ice is too thick they may have to travel too far to reach open water.
6. If ice melts too quickly they will have no resting areas.

An Adélie penguin

Melting of sea ice and snow will result in ocean warming. The effect is called "polar amplification"

Extension

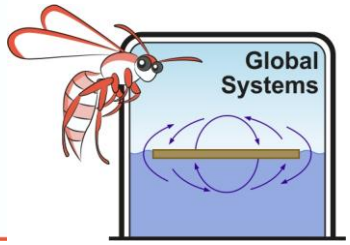
Design an experiment to find out the effect that increasing air temperature and water temperature will have on rate of melt.
Some climate change modelling suggests that temperatures will increase by 4°C in the next one hundred years. Design an experiment to find out the effect that increasing air temperature one degree every 25 years will have on rate of sea ice melt.

Students may wish to use the headings below to rough out their experiments.

Aim To observe how four increases of 1°C affect sea ice thickness _____(1 mark)
Dependant Variable Thickness of ice _____(1 mark)
Independent variable Increments of 1°C _____(1 mark)
Which variables will be controlled? Same ice thickness, same water, no wind etc. ____(3 marks)

Materials (Selected for accuracy and precision) _____(4 marks)
Method _____(4 marks)
Results/observations Should readings be represented as a graph or a table? If a graph is chosen, which style of graph should it be? Remember to include units. _____(4 marks)

Remember to include your rough draft with your final copy. Total /18 marks



Sea Ice Thickness - Student Activity

Sea ice regulates exchanges of heat, moisture and salinity in Polar Regions. It insulates the relatively warm underlying seawater except where cracks (leads) permit loss. In the Arctic sea ice can build up over many years and be well over 3m thick whereas in the Antarctic sea ice melts and reforms every year. Ice in the Antarctic Ocean averages only 0.5m thick and varies greatly with the seasons.

Aim **To observe if the thickness of ice affects the rate of its melt**

Materials per student

- Two containers. One tall and narrow and another wide and flat
- Water
- Freezer
- Timer/watch
- Basin or pneumatic trough

Method

1. Place the same volume of water in each container and freeze until solid.
2. Remove both blocks of ice and float in water at room temperature.
3. Measure how long it takes the blocks to melt.

Which units shall you use to measure time to ensure precision? _____

Which is the dependent variable? _____

Which is the independent variable? _____

Observations

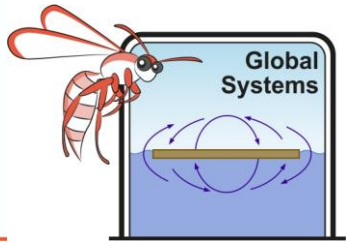
The thick block (Arctic ice) took _____

The thin block (Antarctic ice took _____

Conclusion

Did the thickness of the ice affect its rate of melting? _____

_____



Sea Ice Thickness - Student Activity

Discussion

How could this activity be improved? There are several answers._____

_____

_____

How does this activity relate to penguins? There are several answers.

_____

_____

_____

_____

An Adélie penguin

Extension

Design an experiment to find out the effect that increasing air temperature and water temperature will have on rate of melt.

Some climate change modelling suggests that temperatures will increase by 4°C in the next one hundred years. Design an experiment to find out the effect that increasing air temperature one degree every 25 years will have on rate of sea ice melt.

You may wish to use the headings below to rough out your experiment.

Aim _____(1 mark)

Dependant Variable _____(1 mark)

Independent variable _____(1 mark)

Which variables will be controlled? _____(3 marks)

Materials (Selected for accuracy and precision) _____

_____(4 marks)

Method _____

_____

_____(4 marks)

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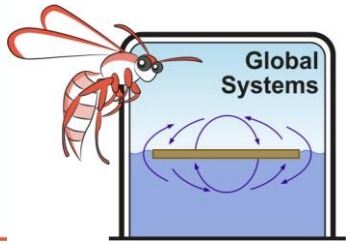


Melting Sea Ice - Teacher Notes

There is a major general misconception that any sea level rise resulting from an increased rate of global warming/ the enhanced Greenhouse Effect, is due to melt water from ice shelves. This can feel counterintuitive to some people.

1. **<u>AIM</u> To find if melting sea ice raises sea level**

Materials per student or group

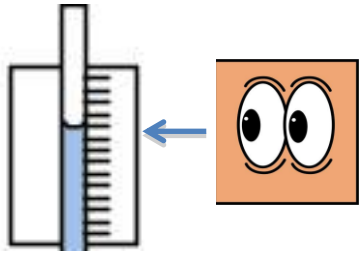
- Two large measuring cylinders
- A Pasteur or transfer pipette
- Water (and food colouring if desired)
- Ice cubes to represent sea ice.

Method

1. Approximately two thirds fill both measuring cylinders with water
2. Add food colouring if desired
3. Place ice in one of the cylinders
4. Using the Pasteur pipette, adjust water levels in the two cylinders until both are identical
5. Note the level in the table below
6. Leave until ice has melted (about 5 minutes)

Hypothesis Write your hypothesis here. If the ice melts then the water level will rise …or… If the ice melts then the water level will not rise

What do you have to do to get an accurate reading and avoid parallax mistakes? Take your eye down to the level of the liquid and read from the base of the meniscus.



Observations/Results

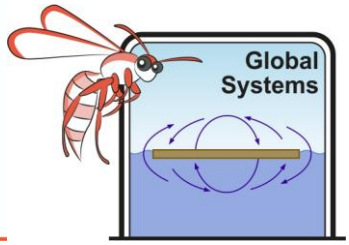
	Volume of water	Volume of water + ice
Before melting (initial volume)	90mL	90mL
After melting	90mL	90mL

Conclusion

To what conclusion does the data collected lead you? The water level did not rise. If the climate warms then sea level rise is not due to melting sea ice.

Discussion

Why were two measuring cylinders used when only one had ice? One was used as a "CONTROL" against which any change could be measured



Melting Sea Ice - Teacher Notes

Why did we use measuring cylinders rather than beakers? Scientific data must be observable and MEASURABLE. Any increase or decrease in water level could not be measured in a beaker. They also make checking that the levels in both cases were the same easier.

How could this experiment be improved? Repeat for accuracy. Use salt water.

Did this experiment support or not support your own hypothesis? Depends on their hypothesis.

Sea ice melting does not contribute to rising sea levels but melting land ice does.
Explain how melting land ice (ice cap and glaciers) can contribute to sea level rise. Water from melting land ice will run downhill and be added to the sea increasing its volume and causing sea level to rise. This rise will flood low-level coastal land bringing warmer water inland to warm the glaciers causing further flooding.

Melting Sea Ice - Student Activity

There is a general misconception that any sea level rise resulting from an increased rate of global warming/the enhanced Greenhouse Effect, is due to melt water from ice shelves.

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Materials per student or group

- Two large measuring cylinders
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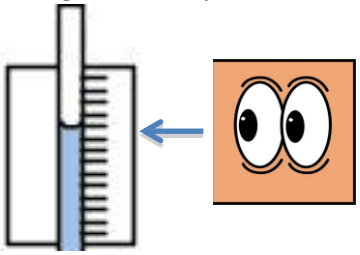
5. Note the level in the table below
6. Leave until ice has melted (about 5 minutes)

Hypothesis Write your hypothesis here. _____

_____

What do you have to do to get an accurate reading and avoid parallax mistakes?



_____

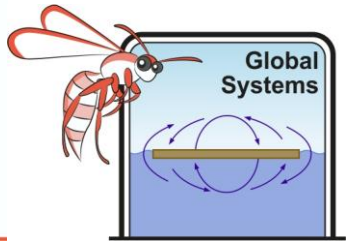
_____

Observations/Results

	Volume of water	Volume of water + ice
Before melting (initial volume)		
After melting		

Conclusion _____

_____



Melting Sea Ice - Student Activity

Discussion

Why were two measuring cylinders used when only one had ice?

_____

Why did we use measuring cylinders rather than beakers? _____

_____

How could this experiment be improved? _____

_____

Did this experiment support or not support your own hypothesis? Explain your answer.

_____

_____

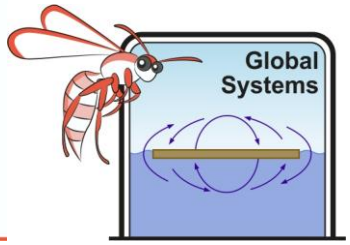
Sea ice melting does not contribute to rising sea levels but melting land ice does.

Explain how melting land ice (ice cap and glaciers) can contribute to sea level rise. _____

_____

_____

_____



Permafrost - Teacher Background

Permafrost is frozen rock, soil and organic materials. It occurs at high altitudes and high latitudes and acts as a long-term carbon sink. Permafrost can vary in thickness from 1 meter to 1,500 meters. It occupies 25% of the land in the Northern Hemisphere occurring in a belt of land stretching from Siberia to China and in North America. In the Southern Hemisphere it is found in Antarctica, the Antarctic mountains and in the Andes Mountains. Ground must remain frozen for two consecutive years to be classified as true permafrost. Presently most of the permafrost has remained continuously frozen since the last Ice Age. More shallow permafrost was added during cold periods about 6,000 years ago and about 400 years ago.

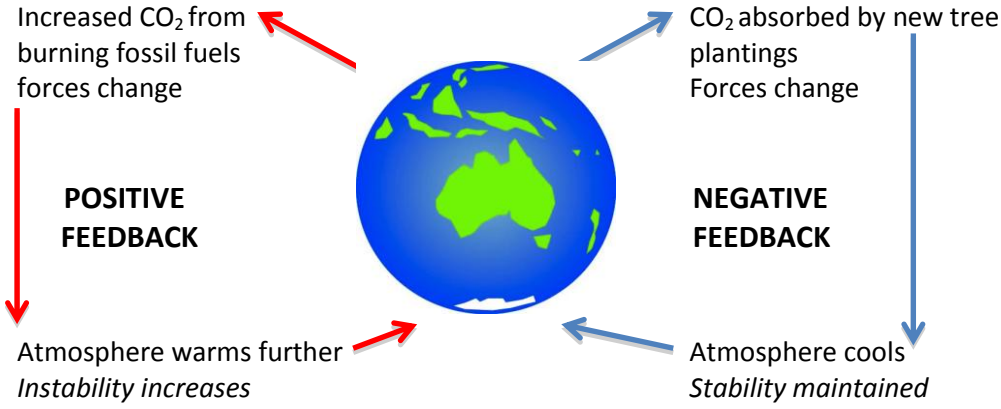
Permafrost can be used as a proxy thermometer as it melts and freezes in response to changes in air temperature. Canadian studies have suggested that there is a distinct time lag between atmospheric warming and melting due to the great depth of permafrost.

Current changes to permafrost and climate change

There are two major problems that will occur if global warming forces permafrost melting:

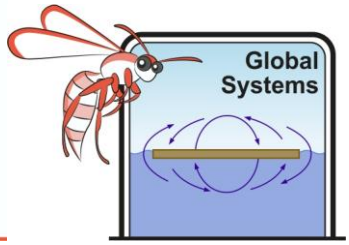
1. Increased volumes of stored methane and carbon dioxide will be released into the atmosphere. These are greenhouse gasses (or aerosols) and will cause increased melting.
2. Movement of the soil causing disruption of infrastructure such as pipelines, roads and buildings and of increased erosion and changes in water table and geomorphology.

Feedback loops and climate change



Climate is the result of many systems working together. To be stable, systems need to be self-regulating. Feedback loops permit systems to modify their response to change (forcing factors) to return to stable conditions.

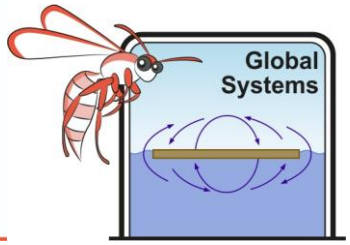
Positive feedback amplifies the effect of the forcing factor. E.g. If a child cries from fear shouting at them will only increase the fear and crying. Increased temperatures will melt permafrost and release methane and carbon dioxide. These are greenhouse gasses and will cause further heating of the atmosphere. The system becomes increasingly unstable.



Negative feedback reduces the effect of the forcing factor helping the system to return to normal. E.g. If a child cries from hunger, giving them food means they will no longer be hungry and will no longer cry. If the atmosphere is becoming warmer due to increased carbon dioxide, planting trees will absorb some of the forcing carbon dioxide, will reduce temperature rise and will work towards returning the system to stability.

Interesting fact: **Methane clathrates in the ocean**

Methane clathrates are also held under great pressure in ocean deeps. Warming will decrease water pressure and release these reserves. Geologists have suggested that one of the factors causing major extinctions such as the "Great Dying" between the Permian and Triassic times, was exacerbated by the release of methane clathrates from the sea. Enormous volcanic basaltic rock outpourings from vents built up the The Siberian Traps. Volcanic activity would have been accompanied by venting of huge volumes of carbon dioxide forcing global warming. Warm seas could no longer retain methane and it would have entered the atmosphere causing further lethal global warming. This was the greatest extinction of all time. 96% of all marine species died and 70% of all terrestrial species. It was the only known mass extinction of insects.



Permafrost Feedback Loops - Teacher Notes

Permafrost is frozen rock, soil and organic materials. It occurs at high altitudes and high latitudes and acts as a long-term carbon sink. Permafrost can vary in thickness from 1 meter to 1,500 meters. It occupies 25% of the land in the Northern Hemisphere occurring in a belt of land stretching from Siberia to China and in North America. In the Southern Hemisphere it is found in Antarctica, the Antarctic mountains and in the Andes Mountains. Ground must remain frozen for two consecutive years to be classified as true permafrost. Presently most of the permafrost has remained continuously frozen since the last Ice Age. More shallow permafrost was added during cold periods about 6,000 years ago and about 400 years ago.

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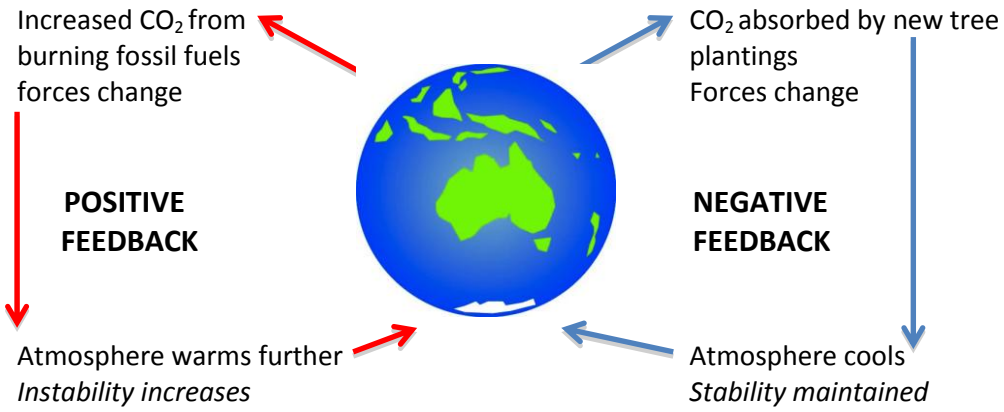
Feedback loops and climate change



Climate is the result of many systems working together. To be stable, systems need to be self-regulating. Feedback loops permit systems to modify their response to change (forcing factors) to return to stable conditions.

Positive feedback amplifies the effect of the forcing factor. E.g. If a child cries from fear shouting at them will only increase the fear and crying. Increased temperatures will melt permafrost and release methane and carbon dioxide. These are “greenhouse gasses and will cause further heating of the atmosphere. The system becomes increasingly unstable.

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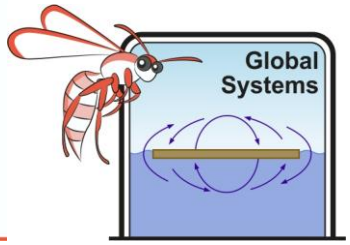


Permafrost Feedback Loops - Teacher Notes

Feedback loops

To be stable, systems need to be self-regulating. Feedback loops permit systems to modify their response to change (forcing factors) to return to stable conditions. Human beings depend on feedback loops to keep our bodies balanced and healthy.

A negative feedback loop reduces the effect of change and helps maintain balance within our bodies.

A positive feedback loop increases the effect of the change and produces instability.

Feedback scenarios

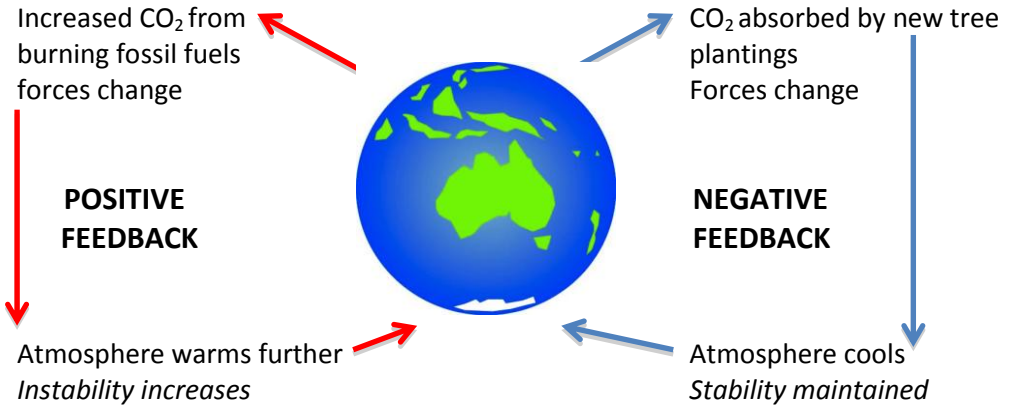
Which of the following feedback loops are positive and which are negative?

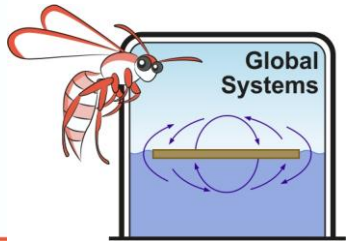
1. A student eats a whole bag of salty chips and becomes thirsty as a result. They drink two glasses of water and no longer feel thirsty. Negative feedback as the student is no longer thirsty.

2. Beer contains chemicals (diuretics), which make people thirsty. At home a teacher drinks two glasses of beer because they feel hot and thirsty. After twenty minutes they feel even thirstier and drink more beer. Positive feedback as they originally felt thirsty and now feel even thirstier.

3. Late for class, students run the last 200m very quickly. They arrive outside the door gasping for breath, however four deep breaths bring them back to normal and they calmly walk through the door. Negative feedback as the student is no longer gasping.

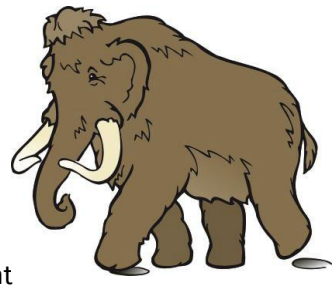
Like our bodies, climate stability is the result of many systems working together. Feedback loops can maintain a stable climate system. Human generated changes can produce ***forcing factors***, which can destroy balance. Burning fossil fuels pumps unusually high amounts of carbon dioxide into the atmosphere.





Permafrost Feedback Loops - Teacher Notes

The effect of climate change warming on permafrost



Permafrost is frozen soil, rock and organic materials. It occurs at high altitudes and high latitudes (near the poles). The ground must remain frozen for over two years. Most of our present permafrost has remained unmelted since the last Ice Age. Bacteria in the soil decompose organic matter producing methane and carbon dioxide as a by-product. These gasses are held within an ice matrix as clathrates. Permafrost acts as a long-term carbon sink. The bodies of woolly mammoths have been found in perfect condition in permafrost in Siberia. Studies in Canada suggest that permafrost areas are decreasing. If our climate warms due to increasing levels of greenhouse gasses, more soil will defrost and these gasses will dissolve into water and diffuse into the atmosphere to join other greenhouse gasses.

Will this increase in aerosol gasses result in positive or negative feedback? This is a positive feedback loop as the end result is that the initial stimulus is increased and system stability will not be maintained.

Write a flow chart (loop) or draw a labelled diagram describing the sequence of events that may be precipitated when permafrost starts to melt. Name the sinks and releasing factors for methane.

Initial sink permafrost soil
Releasing factor warming atmosphere
Leading to melting of permafrost soils
Leading to greenhouse gasses released into atmosphere (sink)
Leading to increased greenhouse gas levels in atmosphere
Leading to further warming of atmosphere (reinforcement or strengthening of original stimulus and the cycle continues.

Methane has a relatively short residence in the atmosphere. It only remains for about 10 years before it breaks down to form carbon dioxide and water. It is however twenty times more effective in heat retention than carbon dioxide.

Describe two forcing factors leading to global warming that occur when permafrost melts and methane levels in the atmosphere rise.

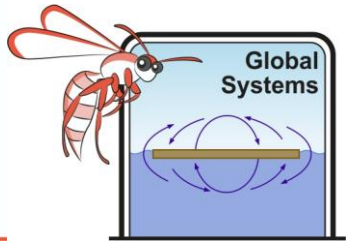
1. Methane is a greenhouse gas and will cause warming for about 10 years
2. When methane degrades/breaks down it forms carbon dioxide, which is also a greenhouse gas although it is ten times less effective.

Individual carbon dioxide molecules only remain in the atmosphere a few days before they dissolve into the ocean. To maintain equivalence of partial pressure however, for every molecule that is absorbed by the ocean, it releases one into the atmosphere to maintain balance.

If melting permafrost releases 12 molecules of carbon dioxide into the atmosphere:
How many molecules will be almost immediately absorbed into the sea? 12

After a short time how many molecules will remain in the sea? Six molecules as this will balance six molecules returning to the atmosphere.

What effect will these molecules of carbon dioxide have on the pH/acidity or alkalinity of the sea?
It will become more acid



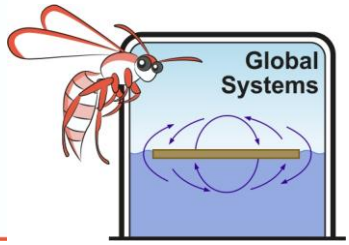
What effect might this change have on sea organisms which have carbonate shells or skeletons?
They will dissolve

Methane has a relatively short residence in the atmosphere. It only remains for about 10 years before it breaks down to form carbon dioxide and water. It is however twenty times more effective in heat retention than carbon dioxide. Reducing the amount of methane released into the atmosphere would produce a rapid reduction of temperature.

Interesting fact **Methane clathrates in the ocean**

Methane clathrates are also held under great pressure in ocean deeps. Warming will decrease water pressure and release these reserves. Geologists have suggested that one of the factors causing major extinctions such as the "Great Dying" between Permian and Triassic times was exacerbated by the release of methane clathrates from the sea. Enormous volcanic basaltic rock outpourings from vents built up the Siberian Traps. Volcanic activity would have been accompanied by venting of huge volumes of carbon dioxide forcing global warming. Warm seas could no longer retain methane and it would have entered the atmosphere causing further lethal global warming. This was the greatest extinction of all time. 96% of all marine species died and 70% of all terrestrial species. It was the only known mass extinction of insects.

Evidence for this theory lies with the rocks deposited at this time. The ratio of ^{13}C to ^{12}C indicates that methane from bacterial breakdown produced a very high proportion of the carbon found in the rocks.



Permafrost Feedback Loops - Student Activity

Feedback loops

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Feedback scenarios

Which of the following feedback loops are ***positive*** and which are ***negative***? Explain your answers.

1. A student eats a whole bag of salty chips and becomes thirsty as a result. They drink two glasses of water and no longer feel thirsty.

_____

2. Beer contains chemicals (diuretics) that make people thirsty. At home a teacher drinks two glasses of beer because they feel hot and thirsty. After twenty minutes they feel even thirstier and drink more beer.

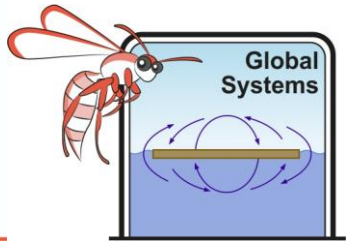
_____

3. Late for class, students run the last 200m very quickly. They arrive outside the door gasping for breath, however four deep breaths bring them back to normal and they calmly walk through the door.

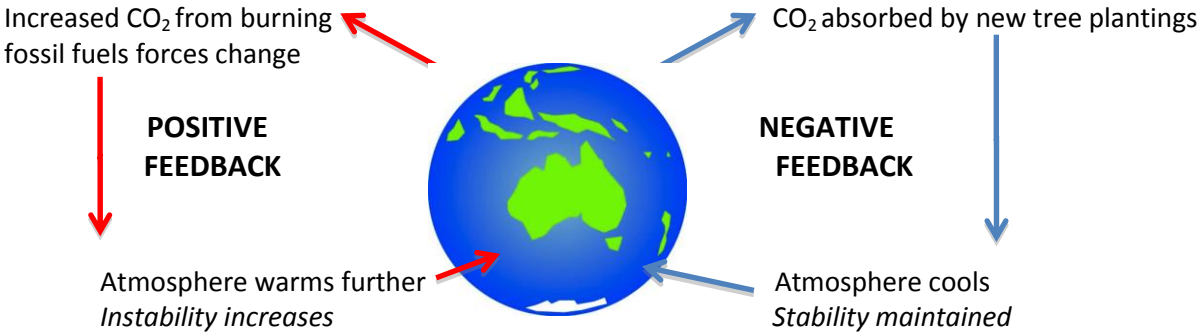
_____

Climate feedback loops

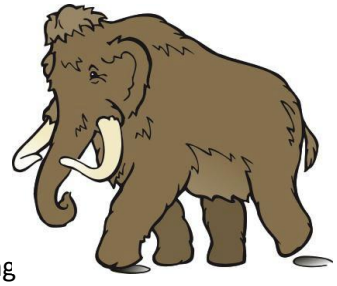
Climate stability is the result of many systems working together. Feedback loops can maintain a stable climate system. There should be balance between the rain that falls from the sky (condensation) and the evaporation from the ocean that returns to the sky (atmosphere). Human generated changes can produce ***forcing factors*** that can destroy balance. Burning fossil fuels pumps unusually high amounts of carbon dioxide into the atmosphere. The effect of this forcing factor can be negated however.



Permafrost Feedback Loops - Student Activity



The effect of climate change warming on permafrost

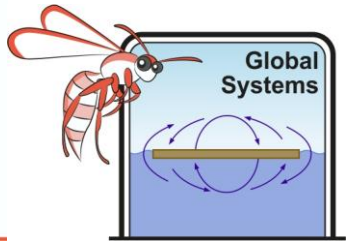


Permafrost is frozen soil, rock and organic materials. It occurs at high altitudes and high latitudes (near the poles). The ground must remain frozen for over two years. Most of our present permafrost has remained unmelted since the last Ice Age. Bacteria in the soil decompose organic matter producing methane and carbon dioxide as a by-product. These gasses are held within an ice matrix as clathrates. Permafrost acts as a long term carbon sink. The bodies of woolly mammoths have been found in perfect condition in permafrost in Siberia. Studies in Canada suggest that permafrost areas are decreasing. If our climate warms due to increasing levels of greenhouse gasses, more soil will defrost and these gasses will dissolve into water and diffuse into the atmosphere to join other greenhouse gasses.

Will this increase in aerosol gasses result in positive or negative feedback? _____

_____

Write a flow chart (loop) or draw a labelled diagram describing the sequence of events that may be precipitated when permafrost starts to melt. Name the sinks and releasing factors for methane.



Permafrost Feedback Loops - Student Activity

Methane has a relatively short residence in the atmosphere. It only remains for about 10 years before it breaks down to form carbon dioxide and water. It is however twenty times more effective in heat retention than carbon dioxide.
Describe two forcing factors leading to global warming that occur when permafrost melts and methane levels in the atmosphere rise.

_____

_____

Individual carbon dioxide molecules only remain in the atmosphere a few days before they dissolve into the ocean. To maintain equivalence of partial pressure however, for every molecule that is absorbed by the ocean, it releases one into the atmosphere to maintain balance.

If melting permafrost releases 12 molecules of carbon dioxide into the atmosphere:

How many molecules will be almost immediately absorbed into the sea? _____

After a short time how many molecules will remain in the sea? _____

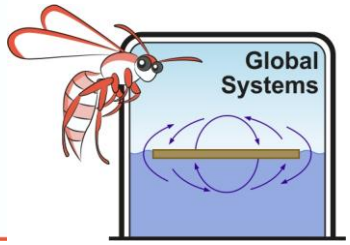
What effect will these molecules of carbon dioxide have on the pH/acidity or alkalinity of the sea?

_____

What effect might this change have on sea organisms which have carbonate shells or skeletons?

_____

Interesting fact Isotope analysis suggests one forcing factor causing the greatest mass extinction of life on earth was climate warming causing the release of methane from permafrost areas and ocean depths.



Permafrost Melting - Teacher Notes

Permafrost is frozen rock, soil and organic materials. It occurs at high altitudes and high latitudes and acts as a long-term carbon sink. Permafrost can vary in thickness from 1 meter to 1,500 meters. It occupies 25% of the land in the Northern Hemisphere occurring in a belt of land stretching from Siberia to China and in North America. In the Southern Hemisphere it is found in Antarctica, the Antarctic mountains and in the Andes Mountains. Ground must remain frozen for two consecutive years to be classified as true permafrost. Presently most of the permafrost has remained continuously frozen since the last Ice Age. More shallow permafrost was added during cold periods about 6,000 years ago and about 400 years ago.

AIM **To demonstrate an effect of repeated melting and freezing of soil**

Before freezing

After repeated thawing

Materials

- One take-away container
- Soil to almost fill the container
- Water to moisten soil
- 12 toothpicks
- Access to a freezer

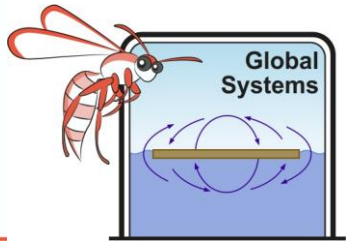
Method

1. Fill the take away container almost to the top with soil
2. Moisten the soil with water. It should be moist not wet.
3. Place toothpicks upright in a regular grid pattern in the soil
4. Freeze overnight
5. Observe the toothpicks and note any changes to grid
6. Soil surfaces are very rarely horizontal. Tilt up one end of the container
7. Thaw
8. Observe the toothpicks and observe any changes to grid
9. Observe the surface of the soil

Observations

Describe any changes to the toothpicks after freezing. NONE. They were still upright

Describe any changes to the toothpicks after thawing (and draw what they looked like in the space above) The toothpicks were no longer vertical.



Permafrost Melting - Teacher Notes

Describe the surface of the soil after thawing. The soil slumped to the downw
the container (LANDSLIDE!)

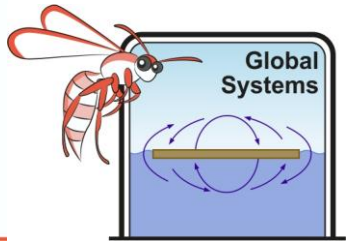
Conclusion
What did your observations tell you about the effect of freezing and thawing?
The soil becomes unstable and moves.

Discussion
What do you think would happen to a road or railway laid onto melting permafrost? It would twist and bend as the surface moved after thaw.

Dawson is a town in northern Canada, which is famous for gold mining, and buildings sinking into the ground due to seasonal permafrost melt. If possible, visit http://vimeo.com/23935951 and view the video for an amusing takes on living with (and without) permafrost in Northern Canada.

Using your findings
Explain how two other examples of infrastructure and services would be affected by melting permafrost.

Coastal erosion of previously ice hardened land affecting harbours, houses and roads.
Landslides due to thaw melt and loss of friction.
Ground subsidence due to thaw "swallowing" houses, hospitals, commercial buildings, roads and railways
Oil and gas pipelines being twisted and fractured
Changes in frost dependant plants and animal's habitats
Disappearance of rivers and lakes, which used to lie above the impermeable permafrost zone



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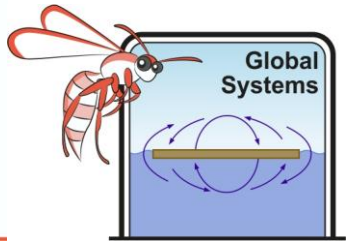
4. Freeze overnight
5. Observe the toothpicks and note any changes to grid
6. Soil surfaces are very rarely horizontal. Tilt up one end of the container
7. Thaw
8. Observe the toothpicks and observe any changes to grid
9. Observe the surface of the soil

Observations

Describe any changes to the toothpicks after freezing. _____

Describe any changes to the toothpicks after thawing (and draw what they looked like in the space above) _____

_____



Permafrost Melting - Student Activity

Describe the surface of the soil after thawing. _____

_____

_____

Conclusion

What did your observations tell you about the effect of freezing and thawing?

_____

_____

Discussion

What do you think would happen to a road or railway laid onto melting permafrost? _____

_____

_____

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Using your findings

Explain how two other examples of infrastructure and services would be affected by melting permafrost.

1. _____

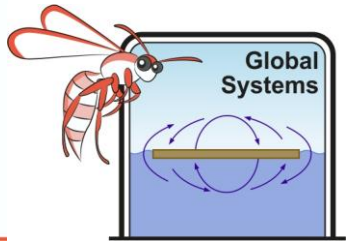
_____

_____

2._____

_____

_____



Methane Clathrates - Teacher Notes

Methane clathrates are methane gas (CH_4) held within a scaffolding of ice crystals. They are found frozen sinks in permafrost sinks. There are concerns that warming temperatures will release this greenhouse gas into the atmosphere.

Methane clathrates are also held under great pressure in ocean deeps. Just as global warming could cause the release of methane from permafrost areas, warming oceans will cause a decrease in pressure at depth releasing methane. Methane is a "greenhouse gas" and will cause further unstoppable warming and release. Geologists cause this cascade effect ***"The methane gun".***

Will the release of methane from ocean beds result in positive or negative feedback? Explain your answer. Positive feedback as the initial forcing factor was methane causing ocean warming. The release of methane that resulted would only increase the strength of the initial forcing factor.

Why do you think the scientists use the image of a gun for the release of methane? A bullet shot from a gun can't be stopped. Once methane is released it will continue to be released.

<u>Aim</u> **To demonstrate that pressure can cause a gas to become denser**

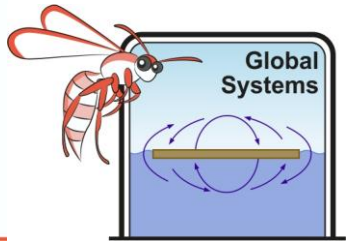
The Cartesian Diver, named after the French philosopher René Descartes demonstrates that under pressure gas volume decreases and its density increases. The "diver" has trapped gas. Squeezing the sealed bottle will increase pressure inside the diver and it/he/she will sink.

Materials

- Used cool drink bottle
- Small tube sealed at one end or a plastic transfer pipette cut off about 5cm from the bulb
- Plasticine or clay
- Option – permanent ink pen to draw face and arms on the diver. (This diver is a mermaid!)

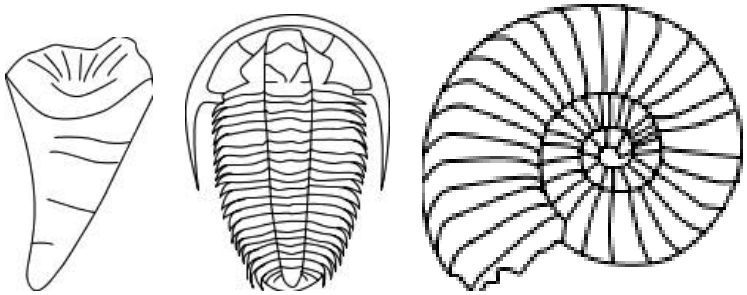
Method

1. Fill bottle with water to about 4cm from the top.
2. Half fill the tube/diver with water
3. Add an open collar of plasticine to the neck of the tube to create negative buoyancy
4. Drop diver open end down into the bottle. Adjust plasticine collar until the diver floats just below the surface (negative buoyancy)
5. Seal the bottle. If the cap leaks then seal with the fleshy pad at the base of your thumb as demonstrated in the picture
6. Squeeze the sealed bottle
7. Observe
8. Repeat



Methane Clathrates - Teacher Notes

Geologists have suggested that one of the factors causing major extinctions such as the "Great Dying" between Permian and Triassic times was the release of methane clathrates from the sea.



Rugose coral, trilobite and ammonite. – All extinct

Enormous volcanic basaltic rock outpourings from fissure eruptions like those in Iceland today built up 5Km high mountains called the Siberian Traps. Volcanic rock in Siberia and Iceland has been compared by many geologists and are similar. Volcanic activity would have been accompanied by venting of huge volumes of carbon dioxide forcing global warming. Studies of other rocks from this time in China have shown major abnormalities in the ratio of carbon-12 to carbon-13 and to carbon-14. Four fifths of the abnormally large amount of carbon-12 can be explained from volcanic venting but one fifth does not have a known source. Other scientists have found that methane produced at depth anaerobically by bacteria contains high amounts of carbon – 12. Perhaps high CO_2 levels produced global warming and warm seas could no longer retain methane at depth. The gas would have risen and would have entered the atmosphere causing further lethal global warming. The high levels of CO2 would have used up free oxygen starving marine and land plants.
This was the greatest extinction of all time (The Great Dying). 96% of all marine species died and 70% of all terrestrial species. It was the only known mass extinction of insects. It took 20 to 30 million years for coral reefs to reform and forests to be re-established.
Evidence for this theory lies with the rocks deposited at this time. The ratio of ^{13}C to ^{12}C indicates that methane from bacterial breakdown produced a very high proportion of the carbon found in the rocks.

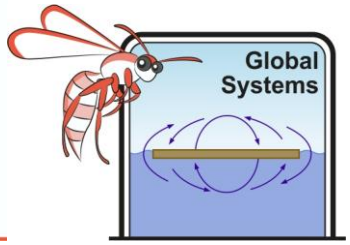
From the information above:
Which information could be considered as primary data?

- Comparison of rocks from Iceland & Siberia
- Study of other rocks from this time from China
- Carbon isotope ratio data from these rocks

Which information would be secondary data?

- Study of volcanic rocks by other geologists
- Methane produced at depth contains high amounts of carbon-12

Which would be considered as proxy data and what conclusions could be made from these?
Volcanic activity would be accompanied by venting of CO_2
High levels of CO_2 would produce global warming
Four fifths of the carbon-12 could be explained by volcanic activity
Global warming would warm seas
Warm seas would release methane clathrates
Oxygen in atmosphere and ocean would be depleted
Plants would have died



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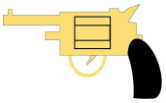

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_____

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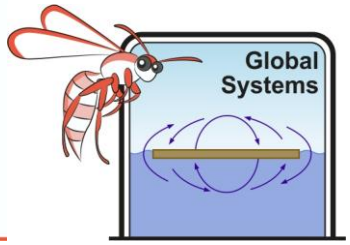
8. Repeat

Observations

_____

_____

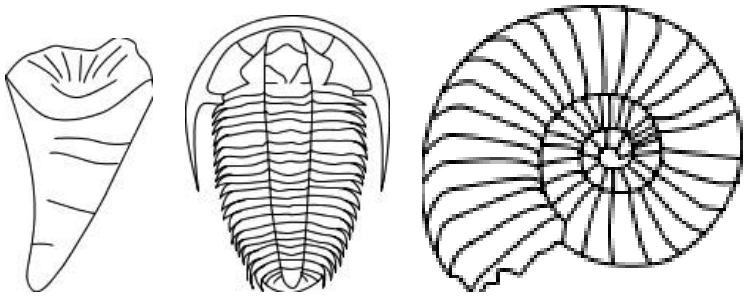


Methane Clathrates - Student Activity

Conclusion

Why do you think the position of the diver/mermaid changed? _____

_____



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From the information above:

Which information could be considered as primary data?

_____

Which information would be secondary data?

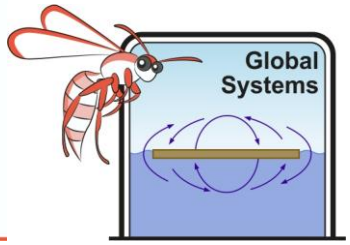
_____

Which would be considered as proxy data and what conclusions could be made from these?

_____

_____

Sea Ice & Permafrost - Teacher Review



N L H Y S L E M W E Q A H E G
O E B H E S E C R O R L X G R
I V M V C T E U I N V T O L E
T E E E H L T N O A I R D A A
A L B A L S A I K N E I E C T
R A N W I T R T C C H S B I D
O E Y O M C I T H F I E L A Y
P S M U E W I N A R U H A L I
A R H L I O S L G K A D T T N
V A F L N Q L W V F Z T X N G
E E P E R M A F R O S T E D O
R N O I S N A P X E K N S S J
E P O T O S I M E L T Q I F E
O X S J G D G G E T N M V I M
T H E R M A L P O T L H X Q I

Write the 23 words relating to sea ice and permafrost below

ALBEDO
CLATHRATES
EVAPORATION
EXPANSION
EXTINCTION
FALL
GLACIAL
GREATDYING
HEAT
ISOTOPE
LEVEL
MELT
MELTING
METHANE
MOISTURE
PERMAFROST
REFLECRION
RISE
SEAICE
SEALEVEL
SOIL
THERMAL
THICKNESS

What is the main reason for sea rise as a result of global warming? Thermal expansion

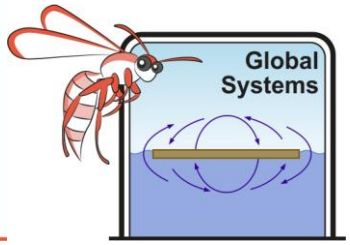
Does melting of sea ice have a major or minor effect on sea level? Minor

What is albedo? The capacity of a surface to reflect solar radiation.

Which surface is the most effective for reflecting solar radiation, a light surface or dark surface?
A light surface.

What is permafrost? Permafrost is frozen rock, soil and organic materials. It occurs at high altitudes and high latitudes and acts as a long-term carbon sink.

What happens when permafrost melts in a town?
All roads, electrical wires, plumbing, water services and fuel services are disturbed. Home bases become unstable.



Sea Ice & Permafrost - Student Review

N L H Y S L E M W E Q A H E G
O E B H E S E C R O R L X G R
I V M V C T E U I N V T O L E
T E E E H L T N O A I R D A A
A L B A L S A I K N E I E C T
R A N W I T R T C C H S B I D
O E Y O M C I T H F I E L A Y
P S M U E W I N A R U H A L I
A R H L I O S L G K A D T T N
V A F L N Q L W V F Z T X N G
E E P E R M A F R O S T E D O
R N O I S N A P X E K N S S J
E P O T O S I M E L T Q I F E
O X S J G D G G E T N M V I M
T H E R M A L P O T L H X Q I

Write the 23 words relating to sea ice and permafrost below

What is the main reason for sea rise as a result of global warming? _____

_____

Does melting of sea ice have a major or minor effect on sea level? _____

What is albedo? _____

_____

Which surface is the most effective for reflecting solar radiation, a light surface or dark surface?

_____

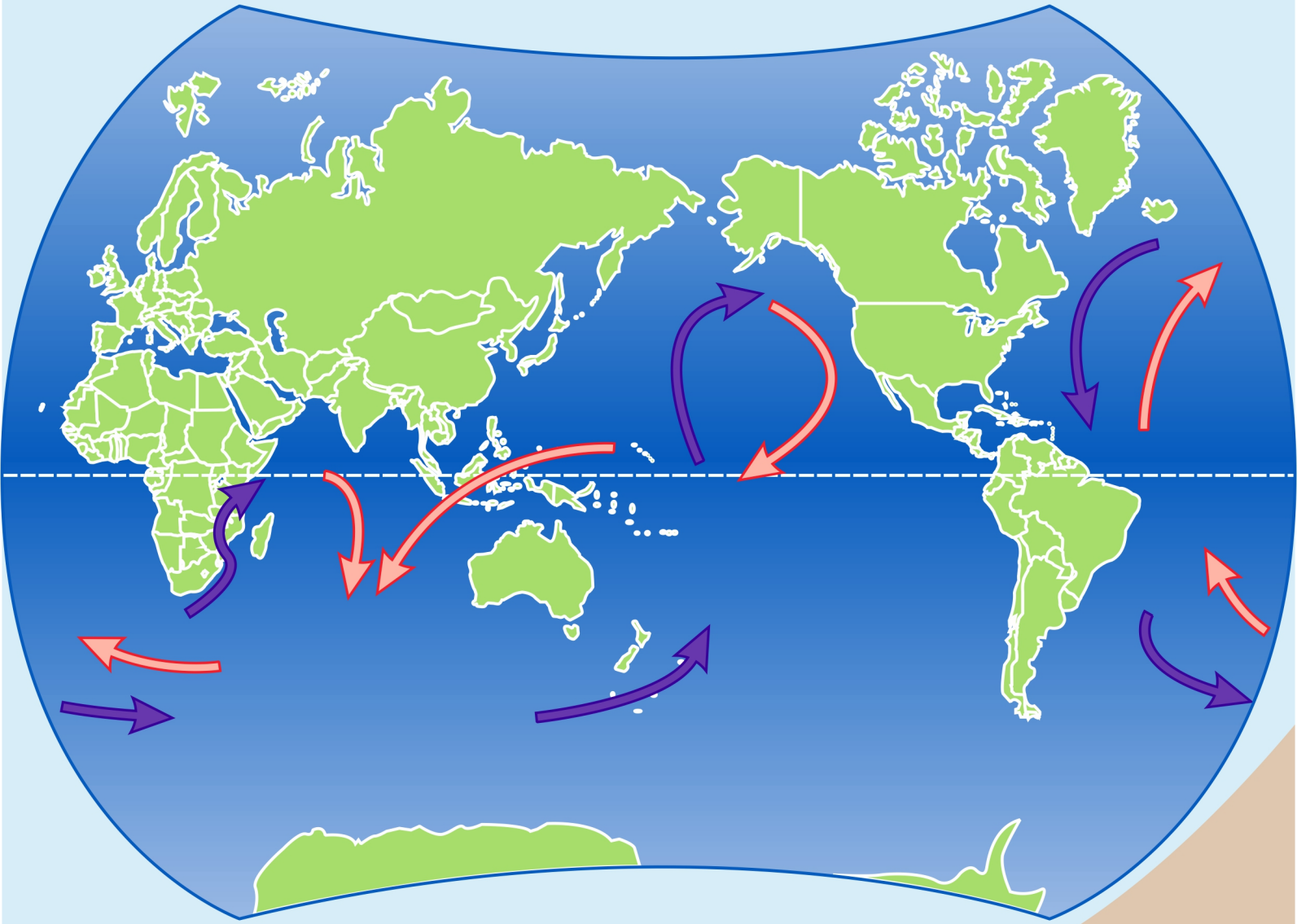
What is permafrost? _____

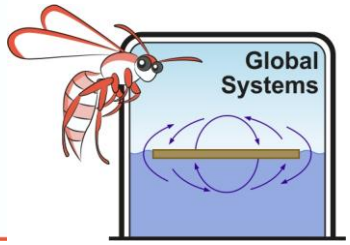
_____

What happens when permafrost melts in a town? _____

_____

Ocean Currents





Ocean Currents - Teacher Background

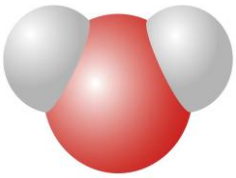
Factors that drive deep ocean currents

Temperature and Salinity Thermohaline Circulation

Exposed land gains heat from solar radiation and loses its heat by conduction and radiation back into the atmosphere. Although heat driven convection currents in the atmosphere respond quickly to change they play only a small part of the heat transfer systems that regulate the temperature of our atmosphere and climate of our planet.
Four fifths of our planet is covered by sea. Deep ocean currents are very important in transport of heat around the world. They may move more slowly than air currents but they transport more heat and are critical to our understanding of the forces that drive climate change.

The high capacity and density of water relative to air and the great amount of energy (latent heat) required to change state or phase from solid to liquid to gas makes the ocean a powerful stabilising agent for Earth's climate. In particular, oceans transfer significant amounts of heat from lower to higher latitudes.

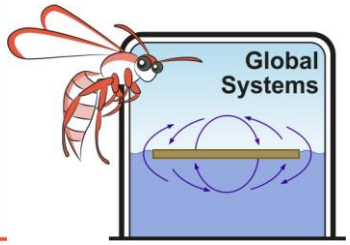
Superficial ocean currents are the result of wind and sub sea topography. They result in local mixing of surface waters. Their effect is minor and local. The great Global Conveyor Belt lies at greater depths. It is powered by density differences that result from changes in temperature and salinity. Visit
http://oceanservice.noaa.gov/education/pd/oceans_weather_climate/media/ocean_circulation.swf



When a substance cools, the kinetic energy of its molecules decreases permitting them to move closer together. This results in a density decrease. Water is anomalous in this respect. Ice (solid with lower kinetic energy) is less dense than water (liquid with higher kinetic energy). Water molecules are bound together by covalent bonding. Molecule movement decreases until 4^{o}C when another form of bonding comes into play. At 4^{c}C the molecules are sufficiently close together for weak hydrogen bonds to become important arranging the molecules into a hexagonal crystal lattice of ice that takes up more volume than liquid water did. The result is a solid state which is 9% less dense than liquid. Water is the only liquid that behaves in this manner.

Visit https://ed.ted.com/lessons/why-does-ice-float-in-water-george-zaidan-and-charles-morton for a 3.55minute animation and explanation.

When seawater freezes at the poles freshwater ice is formed and the remaining seawater becomes denser and sinks adding to the downward pull.
These currents initiated at the poles move millions of cubic metres in a great current that covers the globe. The events at the North and South Poles are slightly different. In the North Atlantic near the North Pole surface water chilled by Arctic winds sinks to about 2,000 metres. At that depth it overlays an even deeper hypersaline layer and flows south towards the equator and on to the Great Southern Ocean. In the Antarctic similar events occur but the effect is complicated by the occurrence of both sea ice, as in the northern hemisphere and an ice cap formed over land. In the Antarctic Ocean both flows converge to form the circumpolar current which transports water around the globe. Water remains in deep and polar regions longer as it is dense and slow moving (about one to three kilometres a day). As the water warms it rises to the surface and moves northwards to complete the cycle. Carbon isotope dating suggests that water may take hundreds to thousands of

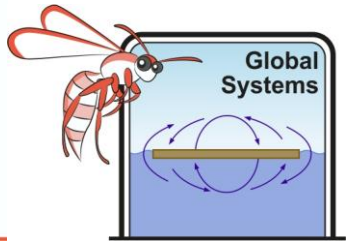


years to complete this cycle. About a third of water in the oceans is actively involved in these circulation patterns.

Climate change and the global conveyor belt

Any increase in global temperatures would affect the density of surface waters resulting in lower salinity. Any increase in precipitation brought on by temperature increase would also decrease salinity. The downward current drive would lessen.

Land ice (ice caps and glaciers) is more stable than sea ice. Monitoring of the Greenland ice cap shows it to be decreasing markedly recently. Both glacial melt and sea ice melt would decrease salinity. Ice acts as an insulator to underlying waters. Reduction in area of thickness would warm polar water decreasing downward current drive.
The albedo effect from ice reflects incoming solar radiation back into space. In the Arctic, sea ice (pack ice) averages three metres thick. In the Southern Ocean it measures only one metre thick. It expands and contracts with the seasons. A decrease in ice cover would cause further atmospheric warming.
Evaporation from the warm seas would increase the amount of water vapour in the atmosphere. Water vapour is a most effective Greenhouse Gas. All of these would produce a marked warming in our water and air temperatures.



Global Conveyor Belt - Teacher Notes

Factors that drive deep ocean currents - Temperature and density

Four fifths of our planet is covered by sea. Deep ocean currents are more important than marine surface currents or air currents in the atmosphere in the transport of heat around the world. Driven by temperature and salinity they create a "Global Conveyor Belt" which moves vast quantities of heat around the surface of the planet within the oceans. It may move more slowly than air currents but can transport more heat and is absolutely critical to our understanding of the forces that drive climate change.

What do we mean by density? Mass per unit volume

How can a change in temperature result in a change in density. As temperature (kinetic energy) increases, molecules bounce off each other more and move further apart. There is less mass per unit volume. Density decreases. Conversely as temperature decreases density increases.

Does this hold true for water? No. Water is anomalous. Its density increases until 4°C when it freezes and becomes ice. Ice is less dense than water due to weak hydrogen bonding forming an octagonal crystal lattice which has a larger volume than liquid water.

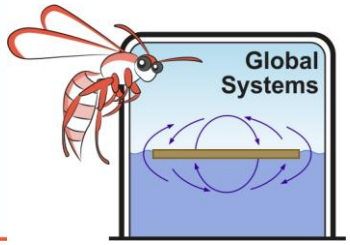
Students may visit: https://ed.ted.com/lessons/why-does-ice-float-in-water-george-zaidan-and-charles-morton for a 3.55minute animation and explanation

The Global Conveyor Belt (GBC) is started as a downward flow of water near the poles.

Aim To demonstrate how cold can initiate a downward flow of water

Materials per group

- A large glass beaker or transparent container almost full of water at room temperature
- A plastic bag with ice cubes
- A clothes peg or grip to hold the bag in position
- A dropper bottle with food dye or a small beaker of food dye and a Pasteur/transfer pipette)



Global Conveyor Belt - Teacher Notes

Method

1. Hang the bag of ice to one side of the transparent container (as above).
2. Leave for two minutes to allow the current to become established.
3. Gently drop food colouring onto the water's surface at the centre of the container. (Teachers of energetic classes may wish to pop round the class and do this part themselves).
4. Observe and note observations.

Results/observations

What did you observe? The dye moved towards the bag of ice cubes and was then swept downwards towards the bottom of the container.

Conclusion

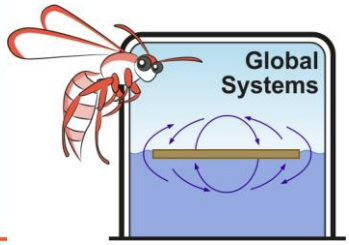
What conclusion do your observations draw you towards? As water temperatures approach freezing downward currents are produced.

Discussion

Explain how chilling water could create a downward current. Liquid water density increases as it cools and it will sink downward through warmer water creating a current.

At our poles, warm seawater comes in contact with frozen ice caps and ice shelves. What effect will this produce? Chilled water will form a downward current drawing more water after it.

How can this activity be improved? Repeat the activity. Control variables such as the volume of ice, size of bag, temperature of water, chemistry of dye etc. Use salt water to represent polar waters instead of fresh.



Global Conveyor Belt - Student Activity

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What do we mean by density? _____

_____

How can a change in temperature result in a change in density? _____

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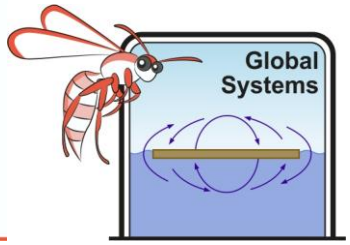

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Results/observations

What did you observe? _____

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Conclusion

What conclusion do your observations draw you towards? _____

_____

Discussion

Explain how chilling water could create a downward current. _____

_____

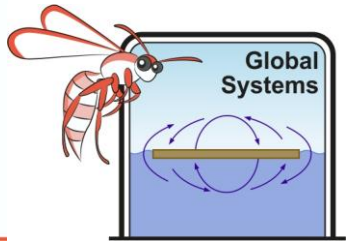
At our poles, warm seawater comes in contact with frozen ice caps, chilling winds and sea ice. What effect will these produce?

_____

How can this activity be improved? _____

_____

_____



Salinity & Density - Teacher Notes

Factors that drive deep ocean currents - Thermohaline Circulation

The great global conveyor belt runs deep under our oceans. It is powered by density differences that result from changes in temperature and salinity. When seawater freezes at the poles freshwater ice is formed and the remaining seawater becomes denser and sinks adding to the downward pull. This current initiated at the poles moves millions of cubic metres of water moving heat around our planet. It is estimated to take hundreds to thousands of years to complete its circuit.

Aim **To demonstrate how freezing water can change its chemistry and density.**

Activity 1 - Freezing out salt

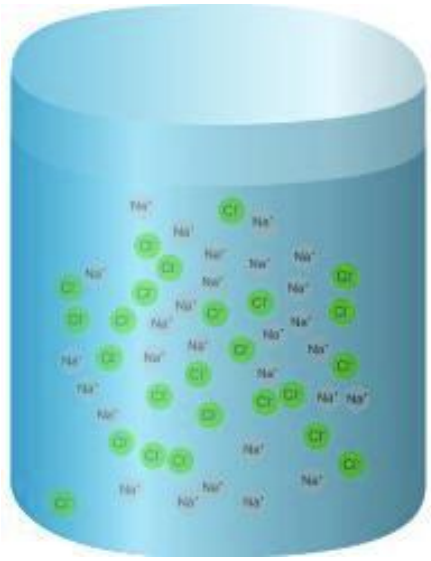
Teachers may prepare the chilled hypersaline water in advance and present separated samples for students to test in the classroom.

Which is the solvent? Water, H_2O

Which is the solute? Sodium Chloride, NaCl

Write an ionic equation for the dissolution of salt in water

$$NaCl\ (s) \rightarrow Na^+(aq) + Cl^-(aq)$$



Materials

- A large container of salty water (Super saturate sodium chloride in cold water)
- A freezer
- Two test tubes
- A dropper of silver nitrate solution

Method

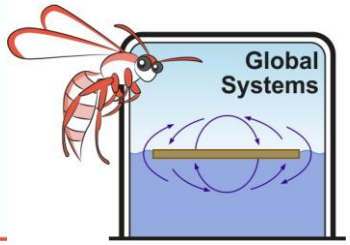
1. Leave the salt water overnight to freeze. Fresh water will form an ice crust leaving more the denser more concentrated salt solution below.
2. Melt a little ice from the crust into one test tube
3. Collect an equal volume of saline solution in the other test tube
4. Put three drops of silver nitrate into each test tube
5. Observe and note your observations

Alternatively a student may be asked to taste melted solid ice after separation with the liquid below and compare it with the liquid portion. (Humans can still taste salt in seawater diluted a hundred times). This observation is subjective and therefore not good enough to be considered clear scientific data.

Observation/results

What did you observe? A white precipitate formed at the base of the saline solution but not in the melted ice. The ice tasted fresh whilst the liquid tasted salt.

Salinity & Density - Teacher Notes



Conclusion

What do these results lead you to conclude? An insoluble silver salt was formed in the saline solution. The test does not PROVE that the precipitate is silver chloride but supports that hypothesis that it should be an insoluble silver salt

Did the ice contain salt? No

Discussion

Write an equation for the reaction which occurred. The equation written will depend on ability or prior knowledge of students.

silver nitrate + sodium chloride → silver chloride (precipitate) + sodium nitrate

$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

What would the above activity suggest would happen to sea water approaching freezing temperatures at the poles? Fresh water would be frozen out to create sea ice leaving the remaining liquid to be more saline.

How could this activity be improved? Repeat and control variables.

Activity 2 The effect of increased salinity on density

<u>Aim</u> To see if saline water is denser than fresh water

Materials To make a supersaturated or hyper-saline solution.

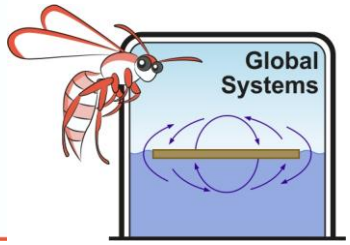
- A small beaker
- Hot water
- Salt (sodium chloride)
- A stirring rod or spoon

Method

1. Carefully pour hot water into the beaker until it is one third full
2. Add the salt
3. Stir vigorously until no more salt can be added
4. Add a little food colouring or dye
5. Leave to cool to room temperature

Materials To test differences in density between salt and fresh water

- A large test tube
- A test tube rack or beaker to hold it upright
- Hyper-saline water
- Fresh water
- A Pasteur or transfer pipette
- Kitchen towel if necessary



Salinity & Density - Teacher Notes

Method

1. Pour the coloured hyper-saline water into the test tube until it is half full.
2. Wipe away any splashes of coloured solution.
3. Place upright in rack or beaker (DO NOT MOVE THE TUBE AGAIN UNTIL THE END OF THE EXPERIMENT!).
4. Fill the pipette with fresh water and very gently flow it down the side of the test tube to form a layer about 1cm thick.
5. Leave and observe.

Observation The fresh water floated on/was more dense than the saline layer

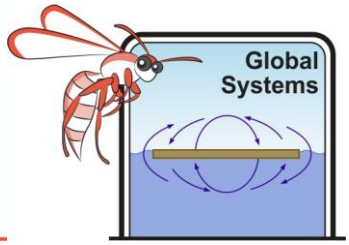
Conclusion What happens to seawater when it comes in contact with cold sea ice and chill polar winds? Freshwater freezes out to become ice and the remaining water becomes more saline.

Using the results of our GCB experiments, explain how cold and salinity could drive the Global Conveyor belt. Cold causes water to increase in density and freezing causes salt water to become denser as well. Denser liquid sinks to the bottom of the ocean where it can no longer be mixed by winds and waves and pulls more liquid down after it. The Global Conveyor belt is initiated at the cold ice rich poles. Cold water flows down towards the Antarctic. As it warms it returns to the surface and flows back towards the poles.

Extra for experts. The Global Conveyor Belt is an example of thermohaline convection. What does "thermohaline" mean? Thermo+ heat, haline=salt. The belt is driven by density differences that are the result of differing amounts of heat and salt concentrations

Fascinating Fact

The interface between the underlying dense haline solution and freshwater above refracts light beams. Light is refracted towards the normal in the denser medium. Hunters cut small holes through the ice and stand at the side motionless, waiting for prey. Creatures below cannot see through the interface as light is totally internally refracted. The Inuit can see the seal but the seal cannot see the hunter. It is only when the prey lies directly below the hunter is the hunter visible. If the hunter moves the prey can sense a shadow. Hunters unconsciously adjust their aim to account for light refraction.



Salinity & Density - Student Activity

Factors that drive deep ocean currents - Thermohaline Circulation

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Aim **To demonstrate how freezing water can change its chemistry and density.**

Activity 1 - Freezing out salt

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Which is the solvent? _____

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Write an ionic equation for the dissolution of salt in water

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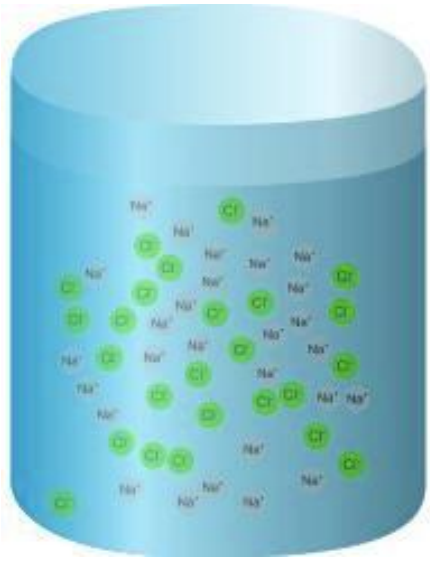


Materials

- A large container of salty water (Super saturated sodium chloride in cold water)
- A freezer
- Two test tubes
- A dropper of silver nitrate solution

Method

1. Leave the salt water overnight to freeze.
2. Melt a little ice from the crust into one test tube
3. Collect an equal volume of saline solution in the other test tube
4. Put three drops of silver nitrate into each test tube
5. Observe and note your observations

Observation/results

What did you observe? _____

_____

_____

Salinity & Density - Student Activity

Conclusion

What do these results lead you to conclude? _____

_____

Did the ice contain salt? _____

Discussion

Write an equation or equations for the reaction which occurred.

_____

_____

What would the above activity suggest would happen to seawater approaching freezing wind and water temperatures at the poles?

_____

How could this activity be improved? _____

Activity 2 **The effect of increased salinity on density**

Aim **To see if saline water is denser than fresh water**

Materials To make a supersaturated or hyper-saline solution.

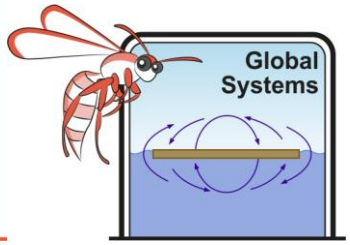
- A small beaker
- Hot water
- Salt (sodium chloride)
- A stirring rod or spoon
- A few drops of food dye

Method

1. Carefully pour hot water into the beaker until it is one third full
2. Add the salt
3. Stir vigorously until no more salt can be added
4. Leave to cool to room temperature

Materials To test differences in density between salt and fresh water

- A large test tube
- A test tube rack or beaker to hold it upright
- Hyper-saline water
- Fresh water (uncoloured)
- A Pasteur or transfer pipette
- Kitchen towel if necessary



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Method

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2. Wipe away any splashes of coloured solution.
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4. Fill the pipette with fresh water and very gently flow it down the side of the test tube to form a layer about 1cm thick.
5. Leave, observe and note observations.

Observations _____

_____

Conclusion

What can you conclude from the results of this experiment? _____

_____

Discussion

What happens to seawater when it comes in contact with cold sea ice and chill polar winds?

_____

Bringing it all together

From the results of our GCB experiments, explain how cold and salinity could drive the Global Conveyor belt.

_____

_____

_____

_____

Extra for experts. The Global Conveyor Belt is an example of thermohaline convection. What does "thermohaline" mean?

_____

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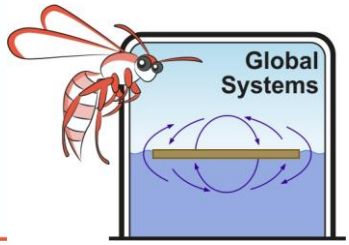
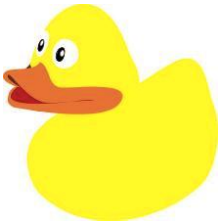
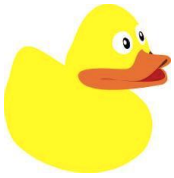


Duck Dispersal & Gyres - Teacher Notes

We get most of our information on ocean currents from satellites that are costly to build, launch and operate. NOAA and NASA satellites provide data on sea level altimetry, surface vector winds and sea surface temperature. Sometimes luck can provide a less high-tech. solution – thousands of yellow plastic ducks.



In January 1992, a ship carrying plastic toys was travelling from Hong Kong to the USA. It lost one of its containers overboard. When the container broke up, 28,000 plastic toys were loosed into the center of the Pacific Ocean. There were red beavers, green frogs, blue turtles and yellow ducks. Since then the bath toys have been carried away by surface currents and used by scientists to plot the direction and speed of these currents. They have travelled north along the Alaskan coast, been frozen in Arctic ice and even continued to float southward passing Greenland to enter the North Atlantic. Ducks have also washed up in Indonesia, and on the east coast of Australia. Exposure to sunshine has bleached the ducks and turtles white within a few years.

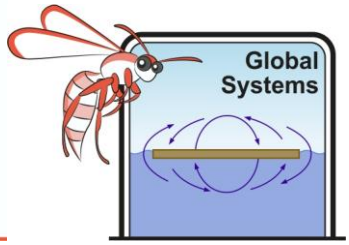


Volunteers gave their time to help map the location and progress of the ducks. They even landed on remote Arctic islands to clean up duck debris from the beach. Information gained gave accurate readings for strength and direction of surface currents. In particular it gave detailed data on the North Pacific Gyre. Gyres are vortexes of currents that collect and retain flotsam. About 2,000 ducks still continue to circle here even now. There are five major gyres; the Indian Ocean gyre, the North Pacific gyre, the South Pacific gyre, the North Atlantic gyre and the South Atlantic gyre. Most of the flotsam is land derived and too small to be seen by human eye. Land derived rubbish is a major pollutant for marine life.

Reporters can misinform the public by using misleading images. See below.

Famous friends working together at Scitech? No a cardboard cut out of the “Mythbusters”.

Duck Dispersal & Gyres - Teacher Notes



Some images purported to have been taken ten years after the cargo was lost was used by reporters and have bright yellow unweathered ducks. Another famous image accompanying a much read report on the North Pacific Gyre and its garbage used a picture taken of rubbish floating in an Indonesian harbor. Gyre pollutants are mostly too small to be seen by the human eye.

Scientists have to be skeptical. You may wish to visit http://www.youtube.com/watch?v=NBfi8OEz0rA for a very short but humorous video on the subject of believing what you appear to see.

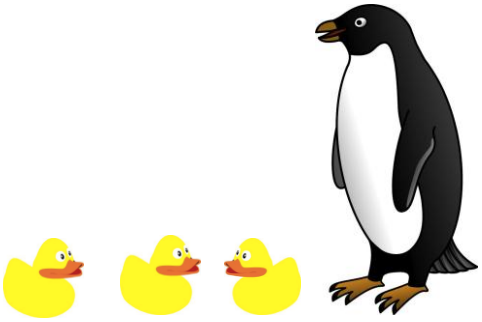
View the two photographs below. They may be of one of these Pacific travellers. List the incongruities (things which might suggest they are not true pictures) alongside.

Duck washed up on Australian shore August 2002

The duck is still yellow. It should be white.

The duck is in good condition, not roughened by weathering.

The sand has been dumped onto a flat white painted surface.



Ducks and Arctic Adele penguin on ice flow November 2009.

Both ducks and penguin are cartoon images

Penguins do not live in the Arctic, only in Antarctic and sub-Antarctic waters.

Ducks are bright yellow and not weathered

Your Task

Create an annotated poster or info graphic that tells the story of these ducks and of the currents and gyres they may have travelled through.

Materials per student or group

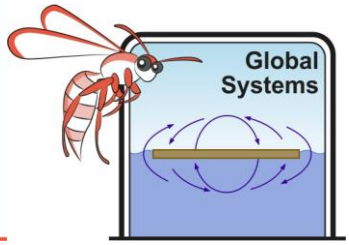
- Access to Internet and reference books.
- Paper, pens, printers

To ensure your work is scientifically and geographically accurate you will need to interrogate the Internet with Scientific skepticism.

DATE DUE _____

Extension

Students may wish to create a poster that can convincingly promote misinformation



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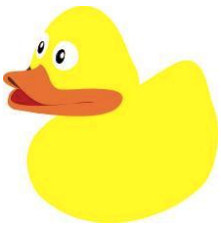

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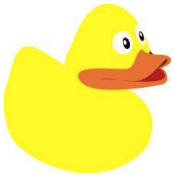

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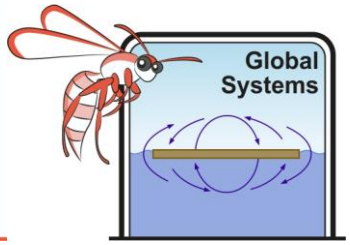

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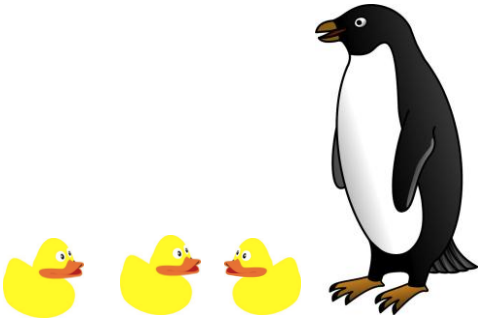
View the two photographs below. They may be of one of these Pacific travellers. List the incongruities (things which might suggest they are not true pictures) alongside.

Duck washed up on Australian shore August 2002

_____

_____

_____



Ducks and Arctic Adele penguin on ice flow November 2009.

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_____

_____

Your Task

Create an annotated poster or info graphic that tells the story of these ducks and of the currents and gyres they may have travelled through.

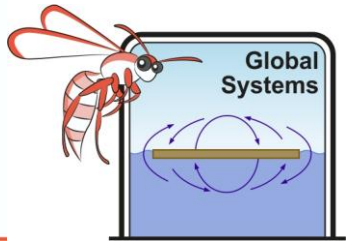
Materials per student or group

- Access to Internet and reference books.
- Paper, pens, printers

To ensure your work is scientifically and geographically accurate you will need to interrogate the Internet with Scientific skepticism.

DATE DUE _____

Ocean Currents - Teacher Review



K N P M R L E F R X G N G C H
S G O I S D A O L P S O Q U Y
X O S I I E Y B E O G I Y R P
N E L L T E A E O Y W T G R E
S A A A V C D W R L T A R E R
C H E N R Z E E A E G I E N S
L N O C B W D V M T A D N T E
K C U D O E A P N Z E A E S C
G W O X N D E E L O H R T A I
Q N W S R R U G S Y C O A L X
T G I P A E C A F R U S E T D
F T O T S K N I S V L R H M O
Y W U N O I T C U D N O C T O
Q R M E L T T R A N S F E R C
E D J P J S A L I N E Z Y O M

Write the 28 words relating to the Global Conveyor Belt below

CONDUCTION
CONVECTION
CONVEYOR
CURRENT
DEEP
DENSITY
DUCK
ENERGY
FLOW
GLOBAL
GYRE
HALIDE
HEAT
HYPER
ICE
MELT
OCEAN
RADIATION
RISES
SALINE
SALT
SEA
SEAWATER
SINKS
SOLAR
SURFACE
TEMPERATURE
TRANSFER

Write the three main reasons why maintaining deep ocean current flow is important to our planet.

1. They move heat (and cold) about the surface of the planet to maintain a relatively constant temperature in the atmosphere and hydrosphere.
2. They bring oxygen rich water up from the depths.
3. They bring nutrients up from the depths to feed krill that are the start of the marine food chain.

Where do these currents begin to move? The Arctic and Antarctic Oceans

Explain the processes that drive these currents? Cold winds freeze out fresh water from seawater. The remainder becomes hyper-saline, denser and sinks to start the current.

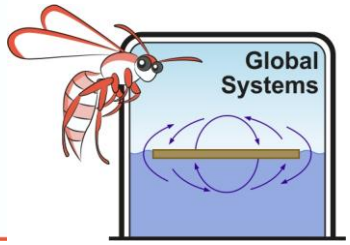
What happens to these deep currents when they reach tropical waters?

They are warmed by surface waters, become less dense, rise and mix with surface waters.

What effect might global warming have on these currents?

Global warming might melt polar ice and decrease the drive from freezing. Their flow might slow or cease. Fishing fields will no longer receive their nutrients and their dependant industries will cease. Any plants or animals dependant on them will suffer from a decreased food source.

Ocean Currents - Student Review



K N P M R L E F R X G N G C H
S G O I S D A O L P S O Q U Y
X O S I I E Y B E O G I Y R P
N E L L T E A E O Y W T G R E
S A A A V C D W R L T A R E R
C H E N R Z E E A E G I E N S
L N O C B W D V M T A D N T E
K C U D O E A P N Z E A E S C
G W O X N D E E L O H R T A I
Q N W S R R U G S Y C O A L X
T G I P A E C A F R U S E T D
F T O T S K N I S V L R H M O
Y W U N O I T C U D N O C T O
Q R M E L T T R A N S F E R C
E D J P J S A L I N E Z Y O M

Write the 28 words relating to the Global Conveyor Belt below

Write the three main reasons why maintaining deep ocean current flow is important to our planet.

_____

_____

_____

Where do these currents begin to move? _____

Explain the processes that drive these currents? _____

_____

_____

What happens to these deep currents when they reach tropical waters? _____

What effect might global warming have on these currents? _____

_____