Education for Sustainability

Spaceship Earth

Teacher's guide

Version 1.0

GreenKiwi
Learning for many lifetimes

Spaceship Earth

Teachers Guide
Version 1.0

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Contents

Overview

Target: Year 7-8, Curriculum Level 3-4

Background

Spaceship Earth is the first course developed as part of a broader programme of courses with an 'Education for Sustainability' approach.

Education for Sustainability is not new. Sustainability is an interdisciplinary approach and provides a useful framework for the teaching of existing curriculum. In fact most of the material used in this programme has emerged from the integration of a broad range of content from existing learning areas, such as: science, social sciences, technology and health and physical education.

A sustainability framework provides relevance and context for these learning areas. It also allows pupils – citizens of the future – to engage in and take responsibility for creating a sustainable future.

As an approach **Education for Sustainability** requires pupils to develop:

1. **Knowledge and understanding** of the key concepts

2. **Attitudes and values** that promote a concern for the present and future well-being of our planet and all of the life that it sustains. These attitudes and values include excellence, innovation, participation, responsibility, cooperation, diversity and of course, sustainability.

3. **Key competencies** that promote active learning – including universal competencies such as thinking (critical thinking, creative thinking and problem solving; systems thinking and planning), communicating (competent users of words, numbers, images, actions and technology to share information, ideas and experiences), managing self (setting goals and plans, self disciplines, self assessment) relating to others (listening, sharing ideas, co-operating/collaborating, leading/following), participating and contributing (understanding rights and responsibilities, getting involved in the community).

Spaceship Earth

Basic Premise

New Zealand is planning to send a huge manned spaceship on a exploration of our solar system which will take 200 years. The class is asked to help plan what the spaceship would need to take (and not take) in order to sustain itself for that length of time.

Learning objectives

Earth is like a spaceship – it is a closed, finely balanced and finite system

This extended 'thought experiment' will help students discover a number of concepts related to the nature of closed ecosystems – the point being that earth itself is a closed, finite ecosystem and it's sustainability is dependent on choices that people make.

The earth is so big that describing the issues of sustainable development is too abstract (human impacts are not obvious). Spaceship Earth scales down the earth's systems and amplifies human impact on them – therefore making them more obvious. If anything goes wrong then the consequences will be dire.

Students will discover the key life-sustaining 'services' that earth's environment provides – air, fresh water, food, waste treatment, raw materials for goods, energy – and how humans impact on them.

The spaceship will need to replicate these services. By having to decide how to replicate these services students will learn the purpose and value of these natural services and how the earth sustains them. They will also learn about humans 'consume' these services and how our population puts pressure on them.

Students will learn about the concept of sustainability which essentially relates to maintaining the quality of earth's services now and into the future. This is a balance of meeting the needs of humans whilst maintaining the balance between the enduring quality and quantity of the earth's services.

The course will also teach aspects of social sustainability – in particular how populations' patterns of consumption affects the natural services that are available. It will also cover community and the cultural commons.

Sustainability

Sustainability is about understanding, and living within, the limits of the earth's finely balanced environment. The only free and abundant resource we have is sunlight, all other resources are finite and often non-renewable – including air, water and land.

The four main concepts that the Spaceship Earth Course focuses on are balance, limits, (closed) systems and the commons. Within these concepts there are a range of learning objectives.

Sustainability concepts

Key concept	Learning objective
Systems	• Understand systems as the context for decision-making. • In systems 'causes' often have multiple 'effects' – some of which may be unknown. The precautionary principal states that unless the outcome is assured be careful! • Whole system thinking – interdependence, dynamics and change. Sustainability implies a clear understanding of the interrelationships between environmental, social and economic systems. • Cycles and renewability. Everything is 'recycling' – air, water, food, soil, even rocks. • Systems exist in time as well as space. Students will learn that choices and actions made in the past affect the present and choices made in the present affect the past.
Balance	• As a system the earth is reasonably resilient and there is a dynamic equilibrium between the subsystems – but humans are putting enormous pressure. • Balance refers to the quality of the natural systems. If they are unbalanced within themselves and with each other there will be problems.
Limits	• Earth is a finite system apart from free energy from the sun. • The best resources are renewable and/or recyclable with no loss of quality. • We should not extract resources from the ground.
Commons	• The concept of natural 'services'. This course talks about 'natural services' and 'cultural services'. They benefit all humans and all living things. No-one owns these services and no-one has the right to damage or degrade them. • That upon which we depend and for which we are all responsible.

* Closed systems are a theoretical concept – in reality no system can be completely closed – there are only varying degrees of closure. Apart from radiation, notably light, there is very little that enters or leaves Earth.

How to use the course

Spaceship Earth can be customised to suit time, level and curriculum requirements.

The course is divided into ten separate modules each focussed on a different area of sustainability. Each module can be taught in one or more periods. The content has been planned so that it can be taught in one term with one module per week presented in three periods. In some modules there is more content than others.

The content provided is not intended to be prescriptive. The idea behind Spaceship Earth was always to create a framework and a context for existing curriculum. If you have better ways of teaching this material use them. In other words use the framwork as a means and not as an ends. Change the content any way you deem fit.

The course is wide-ranging and therefore only scratches the surface of some topics. However, by being introduced to this framework, students will be able to contextualise prior learning as well as future learning.

Whilst the material has been thorougly checked and reviewed there are bound to be some errors and some unintended omissions.

When examples have been provided they are not intended to be exhaustive. I'm sure students and teachers alike will come up with many examples we could ever have thought of.

Generally, the guide for each module follows this format:

1 Learning objectives

2 Module plan

3 Curriculum achievement objectives

4 Vocabulary

5 Lesson 1

6 Lesson 2

7 Lesson 3

8 Homework (for the week)

9 and, in some cases additional material

The lessons may be an inquiry, a discussion of background information, a reading, a brainstorm, an experiment or other activity – or some combination of these.

Spaceship Earth: the Mission

The New Zealand Government is sending a scientific mission to outer space. A huge manned spaceship is being sent to map the whole solar system. The whole mission will take 200 years.

It is still the planning stages and our job is to decide what the ship has to take so that the people on it will be able to sustain themselves for 200 years.

In order to do that we will need to replicate Earth's life-supporting services such as freshwater, energy, food and air. We will also look at how human populations sustain their well-being, culture and organisation.

The ten different topics we will study are shown in the table to the right.

The spaceship itself will be made using futuristic technology and will be able to last for more than 200 years.

For the sake of this project – and to make the Spaceship more "Earth-like" – there are a few rules:

	Module
1	The Solar System
2	Energy
3	Water
4	Air
5	Food
6	Materials
7	Waste
8	Culture
9	Population
10	Organisation

Spaceship Earth Rules

	Rule:
Size/area	The ship can be any size up to the limit of 2.1 hectares/person. This is the current ecological footprint of the earth.
Propulsion	The Spaceship will be propelled by harnessing gravitation forces. Whilst this might seem unrealistic it IS how the earth moves (albeit in a fixed orbit). The point of the rule is that **there is no need to take or manufacture any type of fuel for propulsion**.
Sunlight	The growing conditions on the spaceship will be the same as earth's. Sunlight will be the same as earth's i.e. the energy from the sun won't diminish as the spaceship moves away from it and seasonal sunlight affects (more/stronger in summer and less/weaker in winter) will occur. **Night and day:** The spaceship will slowly rotate, once every earth day. This will effectively replicate the rotation of the earth.
Waste	All waste must remain on the ship, no waste can be jettisoned into space.
Gravity	Gravity on the spaceship will be the same as that on earth.

Curriculum

Curriculum achievement objectives

Each module has at least one, or usually more, prescribed links to specific achievement objectives in various learning areas. The table on the following two pages shows the list. It is not an exhaustive; whilst the focus areas are science, health, social studies and technology by using activities, inquiries, experiments and project work there is flexibility and scope to cover a wider range of learning areas including English (e.g. presentations, written reports etc), Maths (e.g. calculations, population statistics etc), and Arts (drama/role playing, music and entertainment).

Vision, principles and values

The course has been designed to reflect the vision, principles and values of the new curriculum and to help develop students' key competencies.

In particular, the whole course relates to the principles of 'Coherence' and 'Future focus' and also the values of equity, ecological sustainability, and community and participation.

Key competencies

Some particular ways in which the course will develop students key competencies are in:

Thinking	Relating to others	Using language, symbols and texts	Managing self	Participating & contributing
• Critical thinking – in particular decision-making skills • Systems thinking – being able to conceive systems over space and time and think of causes and effects within and between systems	• Class brainstorming • Group activities • Group decision-making	• Reports, essays and presentations. • Graphs and diagrams	• Completing homework and individual tasks to a self-set high standard	• Understand rights and responsibilities as citizens of the earth • Active citizenship

Curriculum links

	Learning objectives	Focusing questions	NZC Achievement objectives
1 Earth & the Solar System	Apart from free energy from the sun the earth is a finely balanced, closed and finite system – like a huge spaceship!	• Explain concept and rules • Provide an outline of the course • Discuss basic criteria for closed systems and sustainability • The solar system	**Science: Earth systems** • Develop an understanding that water, air, rocks and soil, and life forms make up our planet – and recognise that these are earth's resources **Science: Astronomical systems** • Investigate the components of the solar system, developing an appreciation of the distances between them.
2 Energy	Energy is transformed from one type to another. There are many uses and sources of energy. Discover what is clean and efficient energy.	• What will energy be used for? • How can energy use be made more efficient? • Where will energy come from? • Discuss the pros/cons of each energy source	**Science: Physical inquiry & physics concepts** • identify and describe everyday examples of sources of energy, forms of energy, and energy transformations.
3 Water	Water is finite resource. Water is crucial for life and must be looked after.	• Where will water come from? • How much will be needed? What for? • Where will it go to? How will it be treated? •	**Science: Interacting systems** • Investigate the water cycle and its effect on climate, landforms and life
4 Food	Food sustains life. Life is food. Food is recycled through ecosystems. Food chains/webs. Diversity of life.	• What food will be taken? Will it keep? • Will you grow food? Why? How? • What is food? • What else do you need to grow and cook food?	**Science: Life processes** • Recognise that there are life processes common to all living things and that these occur in different ways. **Science: Ecology** • Explain how living things are suited to their particular habitat and how they respond to environmental changes, both natural and human-induced.
5 Goods and materials	There is a lot of STUFF. Some is important for survival and some isn't.	• What other goods will need to be taken? e.g. clothes, bedding, cleaners, parts etc • Will you make things as you need them and/or repair them when they wear out?	**Health/PE: Science and technology** • Experience and demonstrate how science, technology, and the environment influence the selection and use of equipment in a variety of settings. **Characteristics of technology** • Understand how society and environments impact on and are infl uenced by technology in historical and contemporary contexts and that technological knowledge is validated by successful function.
6 Air	Clean air sustains us and much other life – so we need to keep it clean.	• What will keep air breathable? • Discuss the CO2 cycle • Discuss plant/animal respiration	**Chemistry and society** • Relate the observed, characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.

	Learning objectives	Focusing questions	NZC Achievement objectives
7 Waste	There is no such thing as waste in a closed system – it is either 'food' for something else – or a poison.	• What waste will there be? • What will be done with it?	**Technology: Technological products** • Understand that materials can be formed, manipulated, and/or transformed to enhance the fitness for purpose of a technological product. **Technology: Technological systems** • Understand how technological systems employ control to allow for the transformation of inputs to outputs.
8 Community – culture & work	Learn what types of things people do and how people maintain their well-being and sustain the strength of their culture.	• What roles will people perform? • How will people fill their time? • What sort of things will be needed to ensure the physical and mental well-being of the community onboard	**Social studies:** • Understand how people pass on and sustain culture and heritage for different reasons and that this has consequences for people. **Health/PE: Community resources** • Investigate and/or access a range of community resources that support well-being and evaluate the contribution made by each to the well-being of community members.
9 Population & consumption	Learn about population demographics and how they relate to consumption patterns around the world. Ecological footprint.	• How many people will be needed? What types? • How does the population relate to the size and resources of the spaceship? • What happens if the population get's too big/small?	**Social studies:** • Understand that events have causes and effects **Social studies:** • Understand how people make decisions about access to and use of resources.
10 Citizenship	Learn why all people must cooperate, be responsible and live within the limits and rules of the system.	• How will people organise themselves and get along fairly and equally? • How will important decisions be made? • Who is responsible for what?	**Social studies:** • Understand how people participate individually and collectively in response to community challenges **Social studies:** • Understand how the ways in which leadership of groups is acquired and exercised have consequences for communities and societies **Health/PE: Relationships** • Identify the effects of changing situations, roles, and responsibilities on relationships and describe appropriate responses.

The Solar System

Learning objectives

Students will:

- be able to identify the main components of the solar system
- discover the importance of the sun to life on earth
- discover that the earth is a system that is part of a larger astronomical system

Module plan

Part 1	• Explain the mission and the objectives of the course • Go over the vocabulary that will be used • Read 'Our Wonderful Sun' to the class and discuss
Part 2	• Inquiry: Our Pet Planet
Part 3	• Experiment: Modelling orbits in the Solar System
Homework	• The Moon

Website links

http://solarsystem.nasa.gov/index.cfm

http://solarsystem.nasa.gov/planets/index.cfm

 |

Curriculum achievement objectives

Science: Planet Earth & Beyond: Astronomical systems Investigate the components of the solar system, developing an appreciation of the distances between them.			
Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of the components of the solar system and the distances between them	Can express a clear understanding of the components of the solar system and the distances between them	Can express a basic understanding of the components of the solar system and the distances between them	Expresses an inaccurate and/or limited understanding of the components of the solar system and the distances between them

Vocabulary

System	A combination of things or parts that form a whole
Sustain	To keep something going, to make it last.
Gravity	Gravity is the mutual attraction between two objects. It manifests itself as the 'pull' that a large, heavy object like the sun has over a smaller, lighter object like the earth. The earth has a 'pull' over the moon and it also 'pulls' people to the earth.
Orbit	The path a planet follows around the sun (for example).
Solar system	The system of planets, dwarf planets, moons, comets and other matter that is held by the gravity of the Sun.
Diameter	The length of a straight line from one side of a shape (like a circle or sphere) to the other and passing through its center.
Astronomical unit	A unit of length, equal to the mean distance of the earth from the sun: approximately 150 million km. Abbreviation: AU
Astronomy	The study of the physical universe outside the earth's atmosphere.
Solar radiation	The light, heat and other types of radiation (like UV rays) that comes from the sun.

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What we will find out about in this course

- the Earth's life supporting natural systems – and how they connect with each other
- why these systems are essential for life
- how humans impact on these systems and why we must look after them, and
- how humans work together to make these systems last

A journey through the solar system

Our solar neighborhood is an exciting place. The Solar System is made up of all the planets that orbit our Sun. In addition to planets, the Solar System also consists of moons, comets, asteroids, minor planets, as well as dust and gas.

Gravity and orbits

Everything in the Solar System orbits around the Sun. The Sun contains about 98% of all the material in the whole Solar System. The larger an object is, the more gravity it has. Because the Sun is so large, its powerful gravity attracts all the other objects in the Solar System towards it. At the same time, these objects, which are moving very rapidly, try to fly away from the pull of the Sun. The result of the planets trying to fly away, at the same time that the Sun is trying to pull them inward is that they constantly travel around the sun which is called orbiting.

(Teacher note: this explanation of gravity is Newtonian. Newton's theory of gravitation has been superceded by Einstein's General Theory of Relativity which is more accurate. However, most modern non-relativistic gravitational calculations are still made using Newton's theory because it is a much simpler theory to work with than General relativity and gives sufficiently accurate results for most applications.)

How did the Solar System form?

This is a difficult questions for scientists to understand because the creation of our Solar System took place billions of years before there were any people around to witness it!

Scientists think that the Solar System evolved from a giant cloud of dust and gas. This matter began to gravitate together. As it did so it moved in a giant circle much like water goes the drain in a circle.

At the center of this spinning cloud of gas and dust a small star begin to form. This star grew larger and larger as it collected more of the dust and gas that was collapsing into it.

Further away from the star forming in the middle were smaller clumps of dust and gas that were also collecting. The immense pressure in the forming star created heat and the star eventually ignited forming our Sun, while the smaller clumps became the planets, minor planets, moons, comets, and asteroids.

A Great Storm

Once ignited, the Sun's powerful solar winds began to blow. These winds slowly pushed the remaining gas and dust out of the Solar System.

With no more gas or dust, the planets, minor planets, moons, comets, and asteroids stopped growing. The four inner planets of our solar system are much smaller than the four outer planets. Why is that?

Because the inner planets are much closer to the Sun, they are located where the solar winds are stronger. As a result, the dust and gas from the inner Solar System was blown away much more quickly than it has from the outer Solar System. This gave the planets of the inner Solar System less time to grow.

Another important difference is that the outer planets are made up largely of gas, and water, while the inner planets are made up almost entirely out of rock and dust. This is for the same reasons. As the outer planets grew larger, their gravity had time to accumulate massive amounts of gas, water and dust.

The Solar System has over 100 'worlds'

There are only eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

However, the Solar System is made up of over 100 worlds that are every bit as fascinating. Some of these minor planets and moons are actually larger than the planet Mercury.

Others, such as Io, a moon of Jupiter, have active volcanoes. Europa has a liquid water ocean, while Titan, a moon of Saturn, has lakes, rivers, and oceans of liquid methane.

The Asteroid Belt, The Kuiper Belt, And The Oort Cloud

You may have heard about the Asteroid Belt. This band of asteroids sits between the orbits of the planets Jupiter and Mars. It is made up of thousands of objects too small to be considered planets. Some of them no larger than a grain of dust, while others, like Eros can be more than 160 kilometres across. A few, like Ida, even have their own moons.

Further out, beyond the orbit of the dwarf planet Pluto sits another belt, known as the Kuiper Belt. Like the Asteroid Belt, the Kuiper Belt is also made up of thousands, possibly even millions of objects too small to be considered planets. A few of these objects, like Pluto, are large enough that their gravity has pulled them into a sphere shape.

These objects are made out of mostly frozen gas, with small amounts of dust. They are often called dirty snowballs. However you probably know them by their other name: comets.

Every once in a while one of these comets will be thrown off of its orbit in the Kuiper Belt by gravitational perturbations caused by the large outer planets and is then attracted towards the inner Solar System where it slowly melts in a fantastic show of tail and light.

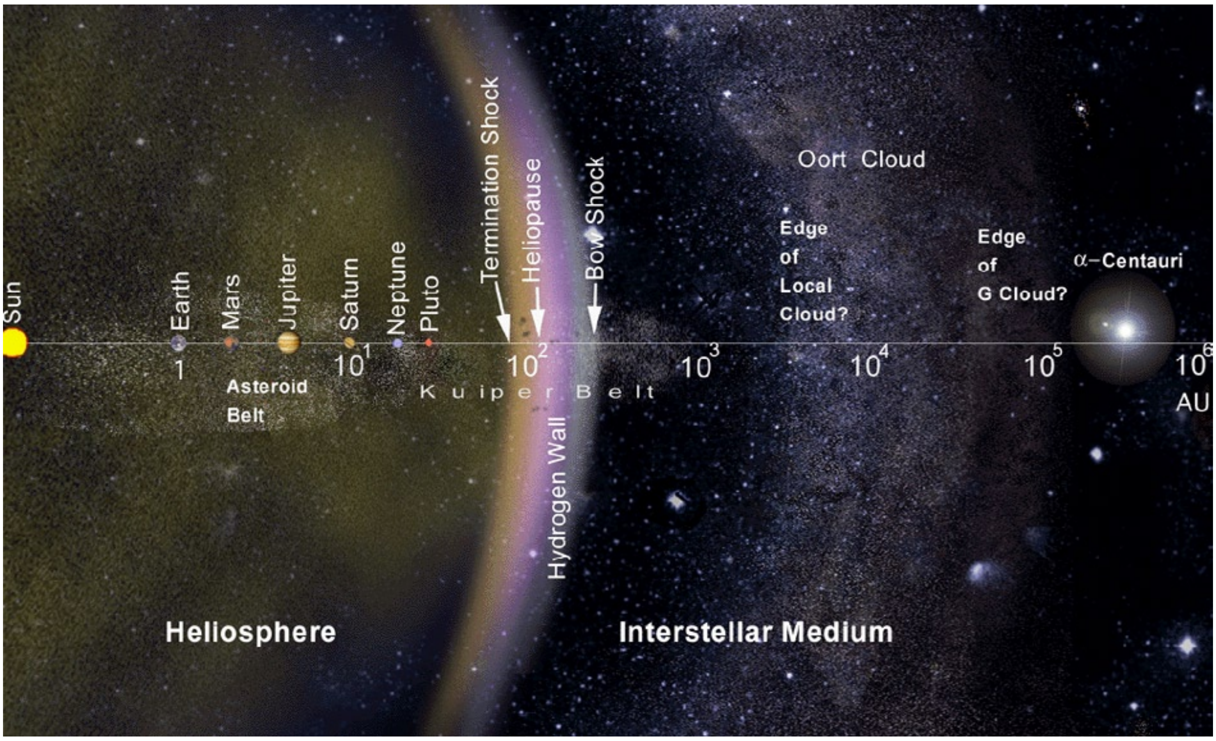
Beyond the Kuiper Belt sits a vast area known as the Oort Cloud. Here within this jumbled disorganized cloud live millions of additional comets. These comets do not orbit the Sun in a ring or belt. Instead each one buzzes around in a completely random direction, and extremely fast velocities.

Beyond The Oort Cloud

The Sun's solar winds continue pushing outward until they finally begin to mix into the interstellar medium, becoming lost with the winds from other stars. This creates a sort of bubble called the Heliosphere. Scientists define the boundaries of the Solar System as being the border of the Heliosphere, or at the place where the solar winds from the Sun mix with the winds from other stars.

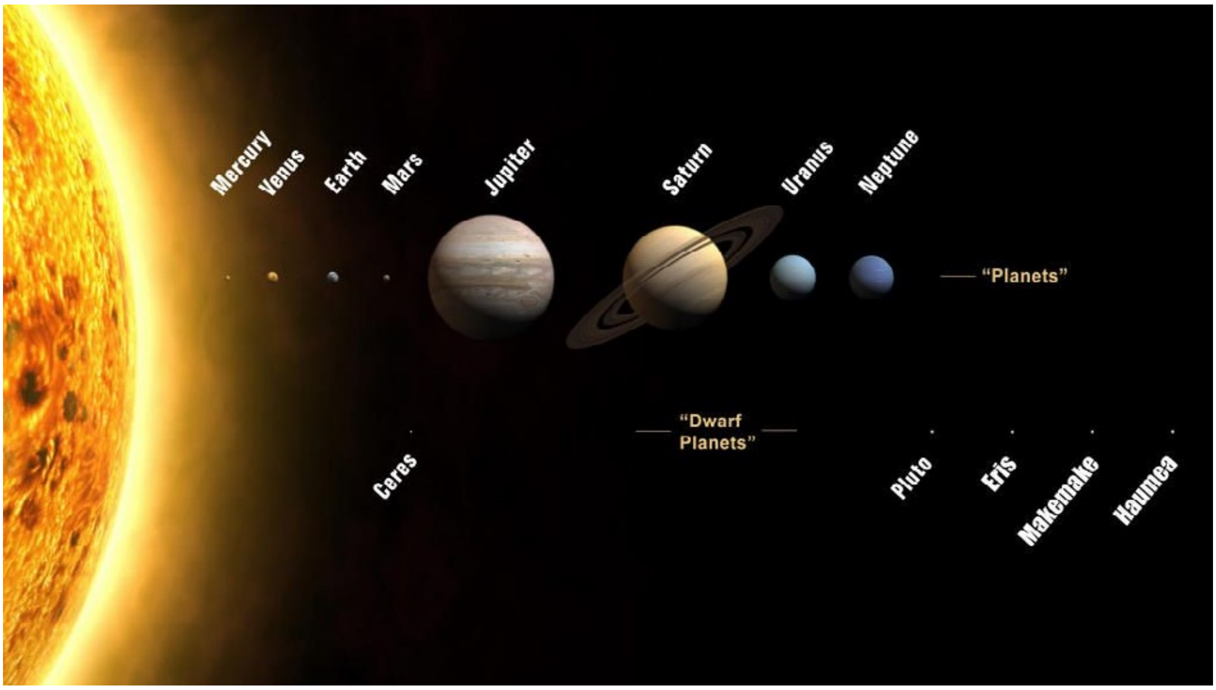
The Heliosphere extends out from the Sun to a distance of about 24 billion kilometres, which is more than 160 times further from the Sun than is the Earth.

The solar system in pictures



The solar system, in logarithmic scale. This diagram shows the outer extent of the heliosphere, the Oort cloud and Alpha Centauri. Using logarithms allows us to see a very large scale on a smaller scale, like this picture.

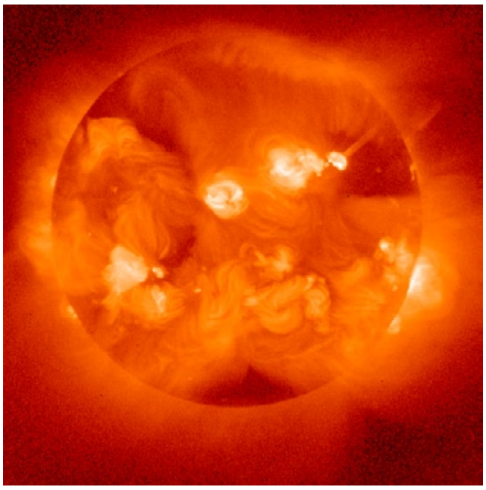
Source: Wikipedia



Solar System diagram showing relative planet (and sun) sizes. Note that the planet sizes are to scale but the distances between them are not. The sun is much, much bigger than earth.

Source: The International Astronomical Union / Martin Kornmesser, updated by the author

Our wonderful sun



The Sun is essential for life on earth. The sun affects us all day, every day – even at night when we can't see it.

Sunlight supports almost all life on Earth. It does this by providing the energy for photosynthesis in plants. Plants are the start of nearly all food chains.

The Sun's energy also drives the Earth's climate and weather. Without the heat energy from the sun we would all freeze. The weather affects landforms, the rock cycle, the water cycle, the atmosphere and many other natural systems which all have an impact on humans and other life.

The enormous importance of the Sun on the Earth and particularly on humans has been recognized since pre-historic times, and the Sun has been revered and regarded by some cultures as a god. In fact Sol was the name of the Sun God in Roman mythology and is where our word 'solar' comes from.

Sustainable, renewable, unlimited

The energy from the sun will sustain life and many of earth's life-giving, natural systems for several billion years to come. This is such a long time that in human terms it is unlimited.

The energy coming from the sun is clean compared to the use of oil and gas which emit the greenhouse gas carbon dioxide when they are burnt.

Energy from the sun is also essentially free although you need to buy solar (photovoltaic) panels to transform the radiant energy from the sun into usable electricity. Many families can afford to buy these panels which will pay for themselves with the free electricity.

As already mentioned the sun's energy drives the weather and the water cycle which create wind- and hydro-power.

Insolation

Insolation is a measure of solar radiation energy received on a given surface area in a given time. The energy from the sun arriving at the earth is enormous. It is estimated that the insolation on the Earth surface is 3.2 million exajoules per year, which is close to 7000 times the amount of energy (of any form – petrol, gas, electricity) used by people. Put another way, the current consumption of energy in the world in one year is equal to the average solar energy reaching the entire Earth's surface over a period of only one hour and 16 minutes.

More detailed information about how the Sun affects humans is provided in following modules: energy, water, food and air.

The Sun and the planets

The Sun The Sun is huge (diameter: 1,392,000 km). It is extremely hot, about 5,500°C on the surface and much, much hotter in the core (approximately 13,600,000°C). The Sun is mostly made of the gases Hydrogen and Helium which is burning in a process called fusion.
Mercury Mercury is tiny (4,880 km) and rocky. It has almost no atmosphere (just a hint of helium). Temperatures are generally hot, but extremely variable, ranging from -180 C on the space-facing side to 400 C on the star-facing side.
Venus Venus is also medium small (12,100 km). The atmosphere of carbon dioxide is so thick that we can't see the rocky surface beneath it, but need our radar probes. The temperature is very hot (480°C).
Earth Earth is medium-small (12,750 km). The surface is made of liquid water and rock with some carbon compounds. The atmosphere is mostly nitrogen and oxygen with some carbon dioxide and water vapor. The temperature is moderate (21°C).
Mars Mars is small (6786 km) and rocky. There is some water ice in polar regions and a thin atmosphere of carbon dioxide. The temperature is moderate (-23°C).
Jupiter Jupiter is the largest (143,000 km) planet. It is a gas giant made of hydrogen and helium with no solid surface. It is also cold (-150°C) in the upper atmosphere, but increases in temperature and pressure and becomes liquid in the interior.
Saturn Saturn is large (120,500 km) and has an extraordinary ring system. It has no solid surface, but is a giant mass of hydrogen and helium gas outside and liquid hydrogen inside. It is cold (-180°C).
Uranus Uranus is similar to Neptune except that it has a small ring system. It is medium large (51,000 km) and made of liquid hydrogen and helium. It also has a thick atmosphere of hydrogen, helium and methane and is very cold (-210°C).
Neptune Neptune is medium large (49,500 km) and made of liquid hydrogen and helium. It has a thick atmosphere of hydrogen, helium and methane. It is very cold (-220°C).

Planet data

Planet	Orbit			Diameter	Mass	Gravity	Density	Moons	Rings	Composition (Approx)		
	M km	AU	Year	k km	10^{24}kg					Rock	Metal	Other*
Sun	0	0	0	1390	2 M	28	7.6	9	0			100%
Mercury	57.9	0.39	88d	4.88	0.33	0.38	5.41	0	0	58%	42%	0%
Venus	108	0.72	225d	12.1	4.9	0.91	5.25	0	0	61%	39%	0%
Earth	150	1	365d	12.76	6	1	5.52	1	0	55%	45%	0%
Moon	0.38	1	28d	3.48	0.074	0.17	3.3	0	0	92%	0%	8%
Mars	228	1.52	687d	6.79	0.64	0.38	3.9	2	0	91%	9%	0%
Jupiter	778	5.2	11.9y	143	1,900	2.53	1.3	58	1	15%	0%	85%
Saturn	1425	9.52	29.5y	120.5	570	1.14	0.7	30	8	0%	0%	100%
Uranus	2870	19.2	84y	51.1	87	0.9	1.3	21	11	0%	0%	100%
Neptune	4490	30	165y	49.5	100	1.14	1.7	8	4	9%	0%	91%
Pluto	5910	39.5	248y	2.35	0.013	0.08	2	1	0	42%	0%	58%

* Including gas, liquid and ice

Orbit

figures shown are in

1. millions of kilometers (M = million),
2. astronomical units (1 AU = average distance of earth to sun), and
3. number of earth days

Mass is a measure of how much matter an object has. Weight is a measure of how strongly gravity pulls on that matter. Thus if you were to travel to the moon your weight would change because the pull of gravity is weaker there than on Earth but, your mass would stay the same because you are still made up of the same amount of matter.

How do we know all this stuff?

Inquiry: Your 'Pet' Planet

1. Divide class into 9 groups and assign one planet per group. Have each group read information about their planet either in books, on the internet or use 'The Planets' pages and 'Planet Data' page.
2. (An informative, well designed site is at NASA: http://solarsystem.nasa.gov/planets/index.cfm)
3. Then on a large (A3) card stick a photo (or a drawing) of the planet and the filled in planet report form.

Planet report:

Planet name		
Named after		
Diameter (km)		
Distance from sun	Kilometres	
	Astronomical units	
Mass (x10^{24}kg)		
Gravity (earth = 1)		
Number of moons		
Number of rings		
Made of	Rock:	
	Metal:	
	Gas, ice and water:	
Characteristic features		
Other interesting facts		

Planet report:

Planet name		
Named after		
Diameter (km)		
Distance from sun	Kilometres	
	Astronomical units	
Mass (x10^{24}kg)		
Gravity (earth = 1)		
Number of moons		
Number of rings		
Made of	Rock:	
	Metal:	
	Gas, ice and water:	
Characteristic features		
Other interesting facts		

Experiment: Modeling Orbits in the Solar System

Objective:

Students will construct a distance scale model of solar system in a long hallway, quad or playing field and observe that the solar system is mostly empty space. They will observe that outer planets are much farther apart than inner planets and learn that it takes a long time to travel through the solar system.

Background:

Most of the volume of the solar system is just empty space. The planets orbit the Sun at distances that are thousands of times larger than their planetary diameters. It is thus difficult to make models that show both distances between and sizes of the planets together. Among the smaller bodies, moons orbit each of the planets except Mercury and Venus, while tiny asteroids and comets orbit the Sun in elliptical orbits.

Materials:

- Cards with photos and reports of the Sun and planets to use in presentations
- Solar System Data table (Page 8)
- Length of string 40 metres long, knotted every meter

Teacher preparation

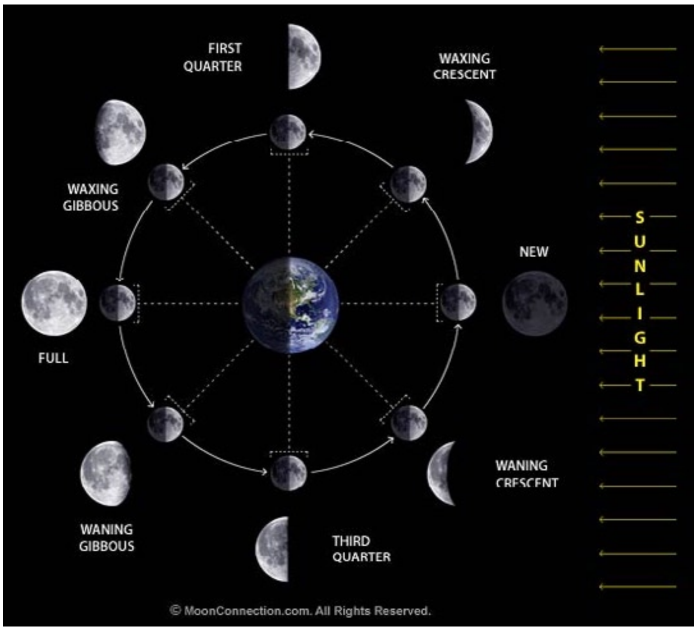
Collect materials and prepare 40m knotted string for measuring.

Select a location to lay out your solar system. This can be a hallway, gym or athletic field, but for the 1 m scale needs to be 40 m long.

Classroom procedure:

1. Each group calculates the distance of their planet from the Sun in AU (AU = astronomical unit = Earth distance from the sun) based on data in table.
2. Set up Sun photo at the designated "central point".
3. Each group measures distance from Sun to their planet with knotted string (scale is 1 AU = 1 and marks the location with chalk if indoors or a stick/stone if outdoors. Hold photo/report above mark.
4. Students will now present their planets to the class. Walk with the students through the solar system from the Sun to Pluto. At each planet or dwarf planet have the students report what they learned about their planet and answer questions.
5. Discuss distances in solar system and empty space. Have students stand at each planet and wave. Have students guess the size of Sun at this scale (marble).
6. Illustrate time required for space travel.
7. Assume that the spacecraft is traveling 65,000 km/hr. Calculate the time it takes to travel from Earth to Mars, Jupiter, and Neptune. Why are these calculated times not the same as the actual spacecraft times? [The planets are moving in near-circular orbits as the spacecraft travels between them. The spacecraft's path, or trajectory, is not a straight line, but a complex curve, and its speed is sometimes boosted by a "gravity assist" as it passes another planet.]

Homework: The Moon



Study the diagram which shows the phases of the moon and how they relate to the position of the sun, the earth and moon relative to each other.

1. If you can see the moon tonight draw it's shape:
   (If you can't see the moon tonight draw the moon the last time you remember seeing it.)

2. What phase of the moon have you drawn?

   ____

3. What will be the phase of the moon in two weeks from now?
   (Clue: It takes 4 weeks for the moon to orbit the earth)

   ____

4. What causes the different phases of the Moon?

   ____

   ____

   ____

5. How heavy would you be on the moon?
   (Divide your mass in kilograms by 6)

   ____

6. Why will you be so much lighter?

   ____

   ____

7. What causes the tides on Earth?

   ____

Energy

Learning objectives

Students will:

- be able to identify different energy sources that humans use and the 'pros' and 'cons' for each one in order to decide which type/s of energy will be best on the spaceship.
- learn about energy efficiency – how sources of energy are transformed into useful energy and how transformation losses, as well as inefficient use, increase the amount of energy required.
- discover the limits of fossil fuels and the unlimited energy of the sun (and renewable energy).

Module plan

Part 1	• Discuss what energy is • Discuss how energy gets transformed – and energy gets lost in the process • Experiments: Comparing light bulbs, Insulation
Part 2	• Discuss what people use energy for • For each type of use discuss ways to save energy • Activity: Energy use on Spaceship Earth
Part 3	• Discuss sources of energy • Discuss the pros and cons of each source of energy for the Spaceship • Activity: Energy Quiz
Homework	• Home energy audit

Website links

Curriculum achievement objectives

Science: Physical inquiry & physics concepts Identify and describe everyday examples of sources of energy, forms of energy, and energy transformations.			
Excellent	Merit	Achieved	Not achieved
Can identify and describe most everyday examples of sources, forms and transformations of energy in a thorough and accurate manner.	Can identify and describe many everyday examples of sources, forms and transformations of energy in a clear manner.	Can identify and describe some everyday examples of sources, forms and transformations of energy in a basic manner.	Cannot correctly identify and describe everyday examples of sources, forms and transformations of energy.

Vocabulary

Energy	Energy is defined the capacity to perform work. Energy makes everything work – lights, people.
Electricity	Electricity is one type of energy. Electrical energy is the movement of electrical charge. It is a secondary source of energy which means that it is created from another (primary) form of energy.
Fuel	Fuel is matter that can be burned or altered in order to obtain usable energy.
Fossil fuel	Examples of fossil fuels are coal, natural gas and oil. They are extracted from the ground and are the fossil remains of plants and other organisms.
Biofuel	A biofuel is biological matter like wood, vegetable oil and biogases that can be burned for usable energy.
Renewable energy	These are sources of energy that are renewable in a short period of time. Sunlight is constantly renewing, hydro dams get refilled when it rains or snow melts, even though wind comes and goes you can never use it all up.
Non-renewable energy	People will never be able to use up all the sunlight but they will be able to use up all the oil, gas and coal. In fact it is possible that all of the oil and gas will get used up this century.

What is energy?

Energy makes things work. In fact scientists describe energy as the ability to do work. Work is defined as force times the distance through which it acts. Work is the transference of energy. Energy is a property of something, there is no such thing as just pure energy.

Questions	Answers
What is energy?	Energy is the ability to do work.
What are some forms of energy?	Forms of energy include: light, sound, heat, mechanical and chemical.
Where does our energy come from?	The Sun is the source of almost all energy on Earth that humans use.
What is force?	A force is a push or a pull. Forces can transfer energy from one object to another.
What is work?	Work equals the force on an object multiplied by the distance the object moves while the force is being exerted.
How are work and energy related?	Work is a way of transferring energy from one system to another or converting energy from one form to another.
What is power?	Power is the rate at which energy is transferred from one system to another or converted from one form to another.

Energy moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs on the radio and lights our homes. Energy makes our bodies grow and allows our minds to think.

People have learned how to change energy from one form to another so that we can do work more easily and live more comfortably. The ultimate source of nearly all of the energy that humans use is from the sun including food, firewood, most electricity (geothermal energy is not from the sun) and petrol.

Forms of Energy

Energy is literally everywhere and is found in many different forms such as light, heat, sound and movement. All forms of energy falls into two categories: stored (potential) energy and moving (kinetic) energy.

Stored (potential) energy	Moving (kinetic) energy
Chemical energy is energy stored in the bonds between atoms in molecules. It is the energy that holds these particles together. Examples are Wood, Petrol and Coal	**Electrical Energy** is the movement of electrical charges. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrical charges moving through a wire is called electricity. Lightning is another example of electrical energy.
Mechanical energy Stored mechanical energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.	**Radiant energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.
Nuclear energy is energy stored in the nucleus of an atom. It is the energy that holds the nucleus together. Energy can be 'released' when the nuclei are combined (called fusion) or split apart (called fission). Nuclear power plants split the nuclei of uranium atoms – fission. The sun combines the nuclei of hydrogen atoms – fusion.	**Thermal energy**, or heat, is the internal energy in substances––the vibration and movement of the atoms and molecules within substances. Geothermal energy is an example of thermal energy.
Gravitational energy is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.	**Motion energy** is the movement of objects and substances from one place to another. Objects and substances move when a force is applied according to the Laws of Motion. Wind and waves ares examples.
	Sound energy is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate – the energy is transmitted as a wave.

Conservation and transformation

To scientists, conservation of energy is not about 'saving' energy. The scientific law of conservation of energy means that energy cis neither created nor destroyed. When we use energy, it doesn't disappear, it just changes from one form of energy into another – and this is called energy transformation. Energy changes form (transforms) but the total amount of energy stays the same.

A car's combustion engine burns fuel – transforming the chemical energy in the fuel (petrol, diesel or gas) into mechanical energy which ends up moving the wheels (it also produces a lot of heat which is why car engines are very hot). Photovoltaic (solar) cells transform radiant energy from the sun into electrical energy.

Transformation examples:

Hydro Dam (Potential (gravitational) energy) > Falling water (kinetic (moving) energy) > Electrical energy

Petrol (Potential chemical energy) > Car movement (Kinetic (mechanical) energy) + Heat (Kinetic (thermal) energy)

Sunlight (Kinetic (radiant) energy) > Wood (Potential (chemical) energy)

Wood (Potential (chemical) energy) > Heat (Kinetic (thermal and radiant) energy)

Energy efficiency and transformation losses

Converting one form of energy into another form usually involves the loss of usable energy. Energy efficiency is the amount of USEFUL energy that is transformed.

A perfect, energy-efficient machine would change all the energy used into useful work. If we take the example of a car, when the engine burns petrol to move the car along it also creates a lot of heat. In fact, a car's engine creates much more heat energy than it does movement (kinetic) energy, so it not very efficient.

In fact, most energy transformations are not very efficient. The human body is a good example.

Your body is like a machine, and the fuel for your machine is food. Food gives you the energy to move, breathe, and think. But your body isn't very efficient at converting food into useful work. Your body is less than five percent efficient most of the time. The rest of the energy is lost as heat. You can really feel that heat when you exercise!

So:

Energy efficiency = useful output ÷ total energy input

Incandescent bulbs vs Compact Fluorescent Lamps

Another illustration of transformation losses can be seen by comparing different types of light bulbs.

Do the light bulb experiment!

When electricity is generated and moved to your house or school there are losses all the way.

Uses of energy

Human's use a lot of energy. In a sense it is the harnessing and transformation of different sources of energy that has allowed us to advance human civilisation and provides us with the high standard of living we enjoy in the modern world. Not all people in the world are as lucky as us though. In poor and developing countries people use much less energy than us in the developed world.

Electricity "energises" our TVs, computers, lights, refrigerators, washing machines, and heaters, to name only a few uses.

We also use energy to run our cars and trucks. Both the petrol used in our cars, and the diesel fuel used in our trucks are made from oil. The propane that fuels our outdoor barbeques and makes hot air balloons soar is made from oil and natural gas.

Energy is also used in industry to run machines, furnaces and factory belts.

Supply and demand

There must be balance between supply (i.e. sources of energy) and demand (ie uses of energy). If there is a higher demand than there is supply prices go up and some people miss out.

Peak oil

One day we will use up all the fossil fuels on earth. Many experts believe that we have already come to the time when the world's oil production is at it's maximum – usually know as 'peak oil' for short. After we reach the time of 'peak oil' production the supply of oil will decrease – the price of oil will go up and many people won't be able to afford it.

What can we do about it?

Efficiency

The first thing we can do is to reduce the amount of energy we use by using it efficiently (e.g. by using compact fluorescent bulbs instead of incandescent ones) or simply by not using it (e.g. turning appliances off at the wall or turning lights off when we don't need them).

Alternatives

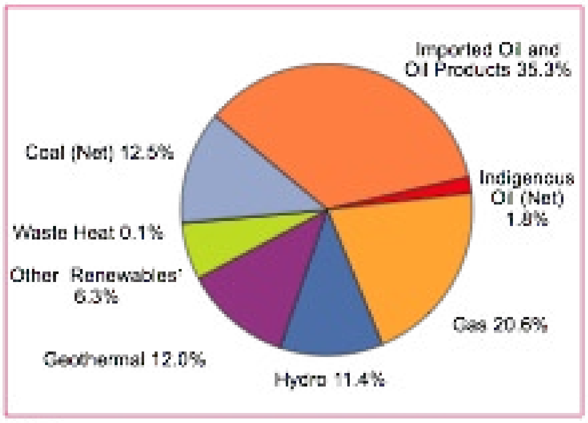
The second thing we can do is use alternative sources of energy, including:

1. Solar energy
2. Wind energy
3. Hydro energy
4. Geothermal energy
5. Marine energy
6. Biomass energy

Sources of Energy

We use many different energy sources to do work for us. Energy sources are classified into two groups—renewable and nonrenewable. Both renewable and nonrenewable energy can be converted into secondary energy sources like electricity and hydrogen.

Figure A.2b: Total Primary Energy Supply Shares for 2006



Note:
¹ 'Other Renewables' includes solar water heating and electricity generation from wind, biogas and wood.

Non-renewable energy

In New Zealand, most of our energy comes from nonrenewable energy sources. The graph on the right shows that the non-renewable resources – coal, oil/petrol and gas – total 70.2%.

These energy sources are called non-renewable because their supplies are limited and cannot be renewed. The oil we use, for example, was formed millions of years ago from the remains of ancient sea plants and animals. Whilst this process is probably still happening it is very, very slow. Human's can't make more.

Renewable energy

Renewable energy sources include biomass (e.g. wood, biogas), geothermal, hydro, solar, and wind energy. They are called renewable energy sources because they are replenished in a (relatively) short time. Day after day, the sun shines, the wind blows, and the rivers flow. In New Zealand we use renewable energy sources mostly to make electricity. Nearly 70% of our electricity is from renewable sources.

Primary versus secondary

Electricity is a secondary source of energy and must be made from primary sources of energy. Secondary sources of energy — energy 'carriers' — are used to store, move, and deliver energy in easily usable form.

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Primary versus secondary

Electricity is a secondary source of energy and must be made from primary sources of energy. Secondary sources of energy — energy 'carriers' — are used to store, move, and deliver energy in easily usable form. Hydrogen is another example of a secondary energy source. Hydrogen can be made (by sending an electric current (electrolysis) through water. It can then be stored, distributed and then 'burned' at a later date.

Uses of energy on the spaceship

Think about what energy will be used for on the spaceship. (Don't forget that the spaceship is propelled by gravitational energy – and doesn't need energy for propulsion (moving))

1. Students are to suggest what energy will be used for, giving as many examples as possible and write them onto the "Energy uses" worksheet providing examples:

Uses	Examples and notes
Heating and cooling	Space heating and/or cooling.
Transport	The spaceship may be extremely large. How will people get around? There is likely to be large or heavy loads that need to transported. Forklifts, electric buggies, electric scooters, elevators, escalators.
Appliances	Fridges and freezers, washing machines, dryers, kitchen appliances
Tools, machines and equipment	All sorts of equipment for maintenance, repairs and building, making things, medical and dental equipment, cleaning etc.
Lights	Lights will be needed at night and for internal rooms.
Water heating	Hot water is used for cleaning.
Water system and treatment	Pumps, UV filters etc.
Computers, navigation and monitoring systems	Electricity will be needed at all times to run these systems – navigation, steering, thermostats, sensors
Entertainment	TVs, stereos, DVD players,
Air treatment	Air filtration and fans.
Other	

Energy efficiency on the spaceship

The ship is limited in size so it will want to take and/or generate as little energy as possible.

2. Discuss energy efficiency. What are the benefits of efficiency?

Efficiency is the difference between supplied energy and useful energy (see theory). The light bulb experiment illustrates this.

3. For each type of energy use ask students to think about how you will be able to conserve and/or not waste energy

Use	Conservation and efficiency
Heating and cooling	• Insulation (it is extremely cold in space so the spaceship will need to be super-insulated) • Good design and layout • Using waste heat (in a perfectly insulated environment heat will not be lost and can be recycled).
Transport	• Bikes • Scooters • Electric – forklifts, golf carts
Appliances	• Use high efficiency appliances • Turn off standby • Shared laundry and kitchen
Tools	• Take hand tools
Lights	• Turn off lights not in use • Use the correct bulb strength
Water heating	• Short showers • Cold water clothes washing
Water treatment	• Use as little water as possible
Computers and navigation system	
Entertainment	• Turn off standby • Use acoustic instruments
Air filtering, fans	

Energy use worksheet

1. Write down the different energy uses on the Spaceship giving examples. Think of 2-3 ways that energy can be saved and/or not wasted.

Energy use	Examples	Conservation and efficiency

Sources of energy

A Ask students to list ALL the possible sources of energy that they can think of

B Define renewable/non-renewable and clean/dirty energy and ask the students to put each energy source onto the following matrix:

	Clean (Non-carbon)	Dirty (Carbon)
Renewable	Solar Hydro Marine Wind Geothermal	Biomass*: Wood Ethanol
Non-renewable	Nuclear	Fossil fuels: Oil, Gas, Coal

* Burning biomass releases CO2 into the atmosphere. This CO2 is then recaptured IF the biomass is regrown and would then be 'carbon neutral'.

2. Brainstorm the pros and cons of each type of energy for the spaceship and get students to write them on the worksheet? Decide what energy source/s the spaceship will use.

Energy source	Pros	Cons
Solar (photo-voltaics)	• Clean (no CO_2 emissions) • Abundant, won't run out • Don't need to carry it	•
Wind	• Clean (no CO_2 emissions)	• Intermittent i.e. not reliable • Not available on the Spaceship
Nuclear	• Clean (no CO_2 emissions)	• Radioactive waste • Needs water for cooling • Danger of leak or even meltdown
Wood	• Renewable (if grown onboard)	• Dirty (CO_2 emissions) • Heavy and takes room • What happens if it runs out?
Oil and natural gas	• Easy to transport and store	• Dirty (CO_2 emissions) • Heavy and takes room • What happens if it runs out? • Flammable/Explosive
Coal	• Easy to transport and store	• Dirty (CO_2 emissions) • Heavy and takes room • What happens if it runs out?
Geothermal	• Clean (no CO2 emissions) • Renewable	• Not available on the Spaceship
Organic waste use	• Renewable (if grown onboard)	• Dirty (CO_2 emissions)
Hydro	• Clean (no CO2 emissions) • Renewable	• Not available on the Spaceship
Other		

Measuring energy

One of the basic measurements of energy is called a joule (J). (There are other units of measure for energy such as calories and British Thermal Units (BTUs).)

One joule is the amount of energy needed to lift a mass of one kilogram to a height of one metre. A piece of buttered toast contains about 315,000 joules (or 315 kilojoules) of energy. With 315,000 joules of energy you could:

- Jog for 6 minutes
- Bicycle for 10 minutes
- Walk briskly for 15 minutes
- Sleep for 1.5 hours
- Run a car for 11 seconds at 50 kilometers per hour
- Light a 60-watt light bulb for 1.5 hours

Power measurement

The power of energy

Power is not the same as energy. Power is how quickly energy is being used which is called the **rate** of energy use. In other words it is the amount of energy used in a period of time.

1 joule of energy for 1 second = 1 watt of power

1 watt of power for 1 second = 1 joule of energy

Watts, Kilowatts and Megawatts

A watt (W) is the standard unit of power. A watt is equal to one joule of energy for one second.

A watt is a very small unit so we also use kilowatts, megawatts and even gigawatts. A kilowatt (kW) is one thousand watts, and a megawatt (MW) is one million watts. A light globe uses between 50 and 100 watts, a car engine uses about 25 kilowatts, and a large power station produces about 500 megawatts or more.

Watt-Hours and Kilowatt hours

A watt-hour is a confusing term because it is not a unit of power, like the watt. It is an amount of energy and is used by electricity companies to price their electricity. Electricity bills show how many kilowatt-hours (kWh) of energy was used and the price per kWh. For example, a 100W light bulb run for ten hours will use one kilowatt-hour of energy i.e.:

100 x 10 = 1,000 watts = 1 kilowatt.

Can you work out how many joules there are in a kilowatt-hour?

1,000 watts x 60 minutes x 60 seconds = 3,600,000 joules = 3.6 megajoules

Famous names

The joule is named after a James Prescott Joule (24 December 1818 – 11 October 1889) an English physicist and beer brewer whose study of the relationship between heat and mechanical work helped lead to the discovery of the law of conservation of energy (first law of thermodynamics).

The watt is named after James Watt (19 January 1736 – 25 August 1819) who was a Scottish inventor and engineer whose best known work was to significantly improve the steam engine which is considered to have started the industrial revolution.

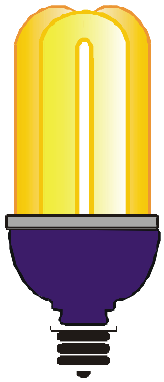
Experiment: Energy efficiency of light bulbs

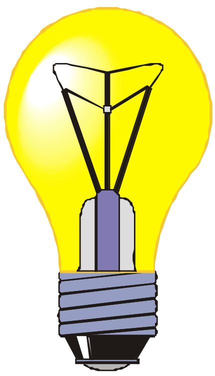
Questions:

1. Does a high watt bulb produce more heat than a low watt bulb?
2. Does an incandescent bulb produce more heat than a fluorescent bulb?

Possible Hypotheses:

1. A high watt bulb does/does not produce more heat than a low watt bulb.
2. An incandescent bulb does/does not produce more heat than a fluorescent bulb.





Materials:

- Lamp stand
- Thermometer
- 10-watt incandescent bulb
- 100-watt incandescent bulb
- 10-watt compact fluorescent bulb
- 20-watt compact fluorescent bulb

Procedure:

1. Put a 10-watt incandescent bulb in the lamp and turn it on.
2. Hold the thermometer 15 centimeters above the bulb for one minute and record the temperature. Turn off the lamp.
3. Let the bulb cool, remove it, put in the 100-watt lightbulb, and turn it on.
4. Repeat Step 2.
5. Repeat the procedure with the fluorescent bulbs.

Analysis and Conclusion:

1. Is more heat produced when more light is produced?
2. Which light bulbs are more energy efficient – incandescent or fluorescent? Why?

Homework: Home energy efficiency audit

1. Insulation

Ask an adult at home how much insulation you have in the ceiling?

- ☐ None (-5 points)
- ☐ 140mm or less (2 points)
- ☐ 140-170mm (5 points)
- ☐ 180mm or more (7 points)

Note:

Score ☐

2. Windows

How many layers of glass do your windows have?

- ☐ Single-glazing (0 points)
- ☐ Some double-glazing (3 points)
- ☐ All double-glazing (5 points)

Note:

Score ☐

3. Thermostat

At what temperature do you set your thermostat when you're home and awake?

- ☐ 22°C or more (0 points)
- ☐ 20-21°C (2 points)
- ☐ 19°C or less (5 points)

Note:

Score ☐

4. Draughts and weatherstripping

Check windows and doors to see if you have weatherstripping and no draughts

- ☐ None (0 points)
- ☐ Some (2 points)
- ☐ All and/or no druaghts (5 points)

Note:

Score ☐

5. Lights

How often do you turn lights off when you leave a room?

- ☐ Almost Never (1 points)
- ☐ Sometimes (3 points)
- ☐ Always (5 points)

Note:

Score ☐

6. Light Bulbs

Count the number of compact fluorescent light bulbs (CFLs) you have in your house.

- ☐ No CFL bulbs (0 points)
- ☐ 1–4 CFL bulbs (3 points)
- ☐ 5 or more CFLs (5 points)

Note:

Score ☐

7. Cooking

How often does your family keep the lids on pots and pans when cooking meals?

- ☐ Almost never (0 points)
- ☐ Sometimes (2 points)
- ☐ Always (5 points)

Note:

Score ☐

8. Appliances

Search your house for the ENERGY STAR® labels, how many did you find?

- ☐ No labels (0 points)
- ☐ 1–2 labels (2 points)
- ☐ 3 or more labels (5 points)

Note:

Score ☐

9. Water Heater

Find the Energy Guide label on your water heater and look at the efficiency rating. How much energy does it use compared to similar models?

- ☐ Uses the most energy (0 points)
- ☐ Uses average amount of energy (2 points)
- ☐ Uses the least energy (5 points)

Note:

Score ☐

10. Laundry

At what water temperature do you wash your clothes?

- ☐ Mostly HOT water (0 points)
- ☐ Mostly WARM water (2 points)
- ☐ Mostly COLD water (5 points)

Note:

Score ☐

11. Hot Water Use

How much time do you spend in the shower?

- ☐ 15 minutes or more (0 points)
- ☐ 10-15 minutes (2 points)
- ☐ Less than 10 minutes (5 points)

Note:

Score ☐

Notes

Total score ☐

Maximum possible 62

Water

EfS objectives

Students will:

- learn about the water (hydrological) cycle and be able to identify and describe the individual processes involved
- discover that water is a finite, non-renewable resource and must be looked after – conserved, recycled and treated
- discover some of the special properties of water that make it so useful for organisms

Module plan

Part 1	• Go over the vocabulary that will be used • Discuss the water cycle • Activity: Quiz (The water cycle)
Part 2	• Discuss water use at home and on the spaceship • Activity Reading: Water on the International Space Station
Part 3	• Discuss the urban water treatment process • Experiment: The Solar Distiller
Homework	• Water use in the home

Website links

http://ga.water.usgs.gov/edu/watercyclesummary.html

http://www.h2know.org.nz/

Curriculum achievement objectives

Science: Interacting systems Investigate the water cycle and its effect on climate, landforms and life			
Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of the water cycle and the effects it has on life, landforms and climate.	Can express a clear understanding of the of the water cycle and the effects it has on life, landforms and climate.	Can express a basic understanding of the water cycle and the effects it has on life, landforms and climate.	Expresses an inaccurate and/or limited understanding of the water cycle and the effects it has on life, landforms and climate.

Vocabulary

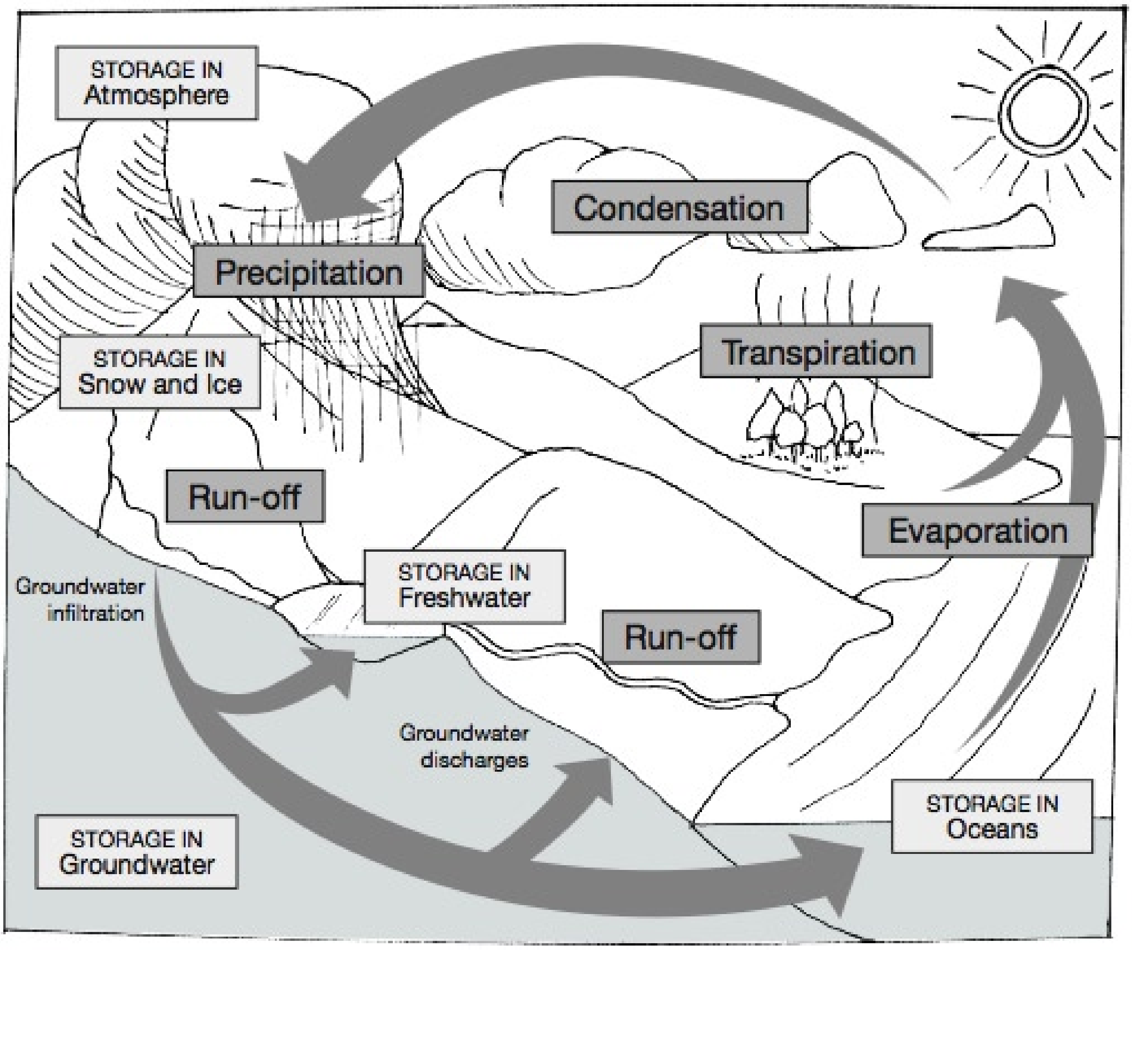
The water cycle	The continuous process by which water is circulated throughout the Earth and its atmosphere.
Evaporation	To convert or change into a vapor i.e. gas
Condensation	To covert or change from a gas to a liquid
Precipitation	The falling products (e.g. rain, snow, hail) of condensation in the atmosphere
Transpiration	The passage of water through a plant from the roots through the vascular system to the atmosphere
Distillation	The evaporation and subsequent collection of a liquid by condensation as a means of purification
Relative Humidity	Humidity is the amount of water vapor in the air. Relative humidity is expressed as a percentage of the maximum amount that the air could hold at the given temperature

The water cycle

Q: Where does the water on earth come from? and
Where will the water come from on the Spaceship?

Scientists do not know for sure where earth's water came from but it's likely that nearly all of the water on earth has existed since the earth was formed. The point is that hardly any water, if any, is made on earth any more. So water is limited and non-renewable. On Spaceship Earth all water will need to be taken.

Discuss the water cycle on earth. Show the following diagram and discuss each of the 'steps' in the cycle.



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The water cycle has no starting or ending point, the different steps of the cycle are described here:

Step	Description
Evaporation	The sun shines on water in rivers, lakes, streams, wetlands and oceans and makes the water warmer. This turns some of the water into vapor or steam. It is like the steam that rises out of the bath. The water vapor leaves the lake or ocean or river and goes into the air, where it becomes a cloud. Water on the ground, on plants and in the soil from rain, dew and frost can also evaporate The water vapour is pure (fresh) water, even water that evaporates from the salty ocean (the salt which is dissolved in the oceans does not evaporate). **Transpiration** Plants draw water from the soil through their roots which then moves to the leaves where it is released into the air – this is called transpiration.
Condensation	The water vapour in the air will turn back into liquid droplets when it cools down again. The higher up you go the colder it gets (has anyone been up into the mountains?). All of these tiny liquid droplets make up clouds.
Precipitation	When the temperature is warm, like during the spring or summer, clouds get so full of water that rain starts to fall. The rain falls onto seas or onto land where it runs into streams and rivers. The water in the streams and rivers runs into lakes and finally into the ocean.. Snow is just like rain except it falls when the air is cold, like during late autumn and winter. Snow usually stays on top of the ground until it melts, then it turns into water and runs into streams and rivers. Some of the water from melted snow also goes into the ground for plants and people to drink.
Run-off	Rivers and streams carry the water that comes from rain and melted snow into the ocean. They sometimes can carry this water a long way. When the weather is warm, sometimes the sun makes the rivers and streams warm and some of the water evaporates. Some of the rain that falls soaks into the ground (this process is known as infiltration) and stays there until plants drink it or until it goes deep enough into the ground that it is called "groundwater". Groundwater moves under the ground towards the ocean. Groundwater is the water that comes out of a natural spring or a well that has been dug by people. Some water is extracted by plants and animals and for human use.
Reservoirs	Water is stored in lakes, seas and oceans. Oceans are like really big lakes. Rivers and streams carry water that comes from rain and melted snow into the lakes and oceans. When water gets into the oceans, it mixes and becomes salty from the minerals that are dissolved in the water. When the sun shines on the oceans, the water gets warmer and becomes vapor, which goes into the air and becomes a cloud. And the cycle starts all over again. **Ice** Some of the snow that falls onto mountains (and at the north and south poles) stays there a long time because it is so cold most of the time it can't melt. This snow turns into ice and sometimes becomes glaciers. Snow and ice on the top of mountains can stay there sometimes for hundreds of years before it finally melts and runs into the streams and rivers.

Source: U.S. Environmental Protection Agency

Some leading questions

Evaporation	What happens to a puddle on the playground when the rain stops and the sun shines? What happens when you boil water in a pot?
Condensation	What is happening when you can see your breath on a cold day? or What is happening when the mirror in the bathroom fogs up?
Precipitation	Has anyone been to an indoor swimming pool or into a sauna and seen water dripping from the ceiling?
Run-off	When you water the garden or a pot-plant where does the water go? What happens if you over-water the garden?

Uses of water

All of the water that will be needed on the Spaceship for the whole 200 year journey will have to be taken.

Q How will water be used on the Spaceship?

Students are to suggest a list of the types of use and make notes on a worksheet

Types	Examples and notes
Drinking	
Showers	
Washing hands	
Washing clothes	
Irrigation	Crop, pasture and animal watering, Watering gardens/plants
Cooking/Kitchen	
Cleaning	
Fighting fires	
Generating electricity	
Making things	Water is used in nearly every manufacturing process
Toilet flushing	Are there other alternatives?
Cooling	engines, machines

Water on the Spaceship

Q How water will be managed on the spaceship

Efficiency

The ship is limited in size so it will want to take as little water as possible. Water is heavy and takes up room. It will also need to be recycled (see below) which will use energy which will also need to be conserved.

Q: For each type of water use think about how you will be able to save and/or not waste water.

Use the "Every drop counts at home" factsheet for ideas.

Types	Conservation and efficiency
Drinking	Always make sure you drink enough water but also make sure you don't waste any
Showers/Baths	Take shorter showers rather than baths
Washing hands, brushing teeth	Don't keep tap running
Watering plants	Water the roots, use mulch
Cooking	Don't keep tap running
Cleaning	Don't keep tap running
Toilets	If it's yellow, let it mellow

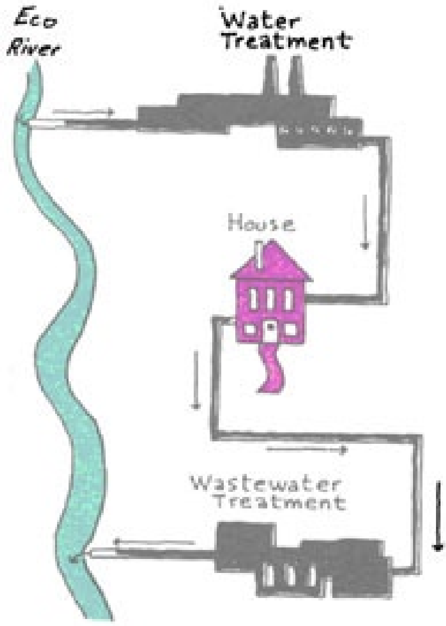
Recycling

Water will need to be recycled (collected and treated).

Discuss the water treatment process

Do the "Water on the Space Shuttle" activity.

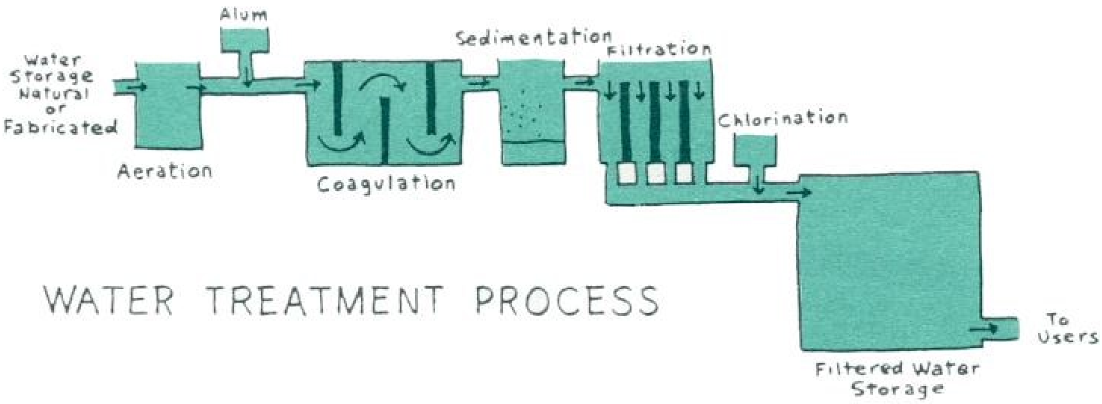
Water treatment process



Most New Zealanders are served by a public water supply system. The water we drink is usually obtained from either rivers, lakes, reservoirs or groundwater (wells). Because the water is often polluted and unsafe, the water supply must first pass through a treatment process.

1. Usually the first step is aeration, in which water is sprayed into the air to release trapped gases and to absorb oxygen for better taste.
2. Next, a chemical such as alum is used to help remove dirt from the water.
3. As the alum dissolves it forms small, sticky particles (called floc) that attract dirt and bacteria. This process is called coagulation.
4. The weight of the floc is enough to cause the floc to sink to the bottom during the process called sedimentation.
5. The clear water above the layer of floc then flows to the filtration basin. Here the water passes through layers of fine sand, gravel and charcoal to remove any remaining impurities.
6. Then a disinfectant, usually chlorine, is added to kill the bacteria that has not been removed by the treatment process.

Now the water is ready to enter the public water supply, storage and distribution system.



Theory

What is water?

Water is the essential component of all life.

It covers 70% of the Earth's surface. It composes about 75% of the human body and 90% of blood and sap.

97% of Earth's water is in the oceans, 2% is frozen in icecaps, and only 1% is fresh, but much of this is inaccessible, deep under the surface.

You probably know water's chemical description is H_2O. Water is known as a compound because its molecules are made of two different types of atoms. One water molecule is made of one atom of oxygen bound to two atoms of hydrogen.

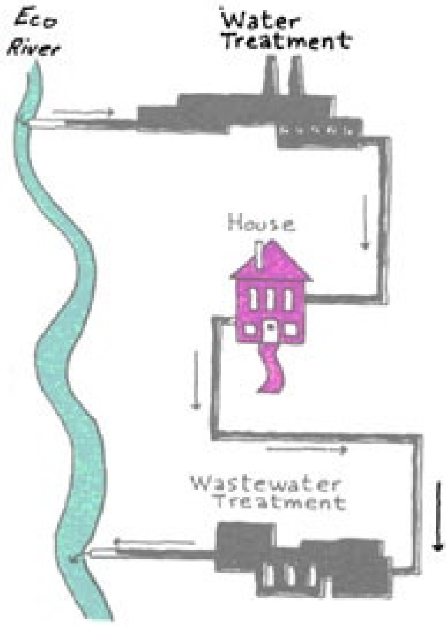
Why is water so essential to life?

What are the physical and chemical properties of water that make it so unique and necessary for living things? When you look at water, taste and smell it - well, what could be more boring? Pure water is virtually colorless and has no taste or smell. But the hidden qualities of water make it a very interesting subject.

The following are some key reasons why water is so important to all life on Earth (including people):

It is a liquid	Water is a liquid over ranges and temperatures (0°-100°C) found on the surface of the earth which allow the building of complex molecules. Water freezes at 0° Celsius (C) and boils at 100°C (at sea level). Water is unusual in that the solid form, ice, is less dense than the liquid form, which is why ice floats.
It is a good solvent	A solvent is a chemical that is good for dissolving other chemicals. Water dissolves more substances than any other liquid. For life water is good for carrying valuable chemicals, minerals, and nutrients through our bodies and through the whole environment
It is 'sticky'	Water molecules attract each other (because of a property called polarity) and so water is kind-of 'sticky' and elastic*. This is called having high 'surface tension' which among other things allows blood, which is about 90% water, to move through tiny blood vessels. * You can see this well when you fill a glass with water to nearly overflow and you will see that the water bulges out.
It is neutral	Pure water has a neutral pH of 7, which is neither acidic nor basic. This means that is an ideal 'medium' for cellular fluids and other body fluids, like blood.
It is abundant	Water is abundant, so it is more likely than any other compound, to be involved in life.
It [stabilises] heat change in the environment	Water can absorb a lot of heat before it begins to get hot (this is known as a high specific heat index). This is why water is so good as a coolant – in a car's radiator for example. The high specific heat index of water helps slow the rate at which the air changes temperature which is why the temperature change between seasons is gradual rather than sudden, especially near the oceans.

Weather and climate



Weather is a very complex subject and water plays a very important part in the weather. Weather occurs primarily due to density (temperature and moisture) differences between one place and another. These differences can occur due to the sun angle at any particular spot, which varies by latitude from the tropics. In other words, the farther from the tropics you lie, the lower the sun angle is, which causes those locations to be cooler due to the indirect sunlight.

Climate is a broader term than weather. Weather relates to a particular area at a particular time. Climate relates to weather patterns over large areas over longer periods of time.

We will talk more about weather in the Module about Air.

There will be no weather as such on the spaceship but there will be humidity.

Humidity

Humidity is the amount of water vapor in the air. Humidity is an important measure used in forecasting weather. Humidity indicates the likelihood of precipitation (rain, snow, hail etc), dew, or fog. There needs to be 100% humidity for water to condense and for clouds to form. The temperature at which this happens is called the dew point. Dew point normally occurs when a mass of air has a relative humidity of 100% which is a result of cooling.

High humidity makes people feel hotter outside in the summer because it reduces the amount of evaporation of perspiration off the skin. Has anyone been to a humid place like Queensland or Singapore? What did it feel like?

Humidity effects on electronics and other things (important on the spaceship)

Water conducts electricity and high humidity in electronic equipment may cause a short-circuit. Very high humidity causes corrosion (rusting) in electronics whereas too low humidity may make materials brittle by drying them out. Low humidity can also create buildup of static electricity, which may result in malfunction.

A particular danger to electronic items is condensation. When an electronic item is moved from a cold place (e.g. garage, car, shed) to a warm, humid place (e.g. the house), condensation may coat circuit boards and other electronics leading to a short circuit inside the equipment. Such short circuits may cause substantial permanent damage if the equipment is powered on before the condensation has evaporated. A similar condensation effect can often be observed when a person wearing glasses comes in from the cold. It is advisable to allow electronic equipment to acclimatise for several hours, after being brought in from the cold, before powering on.

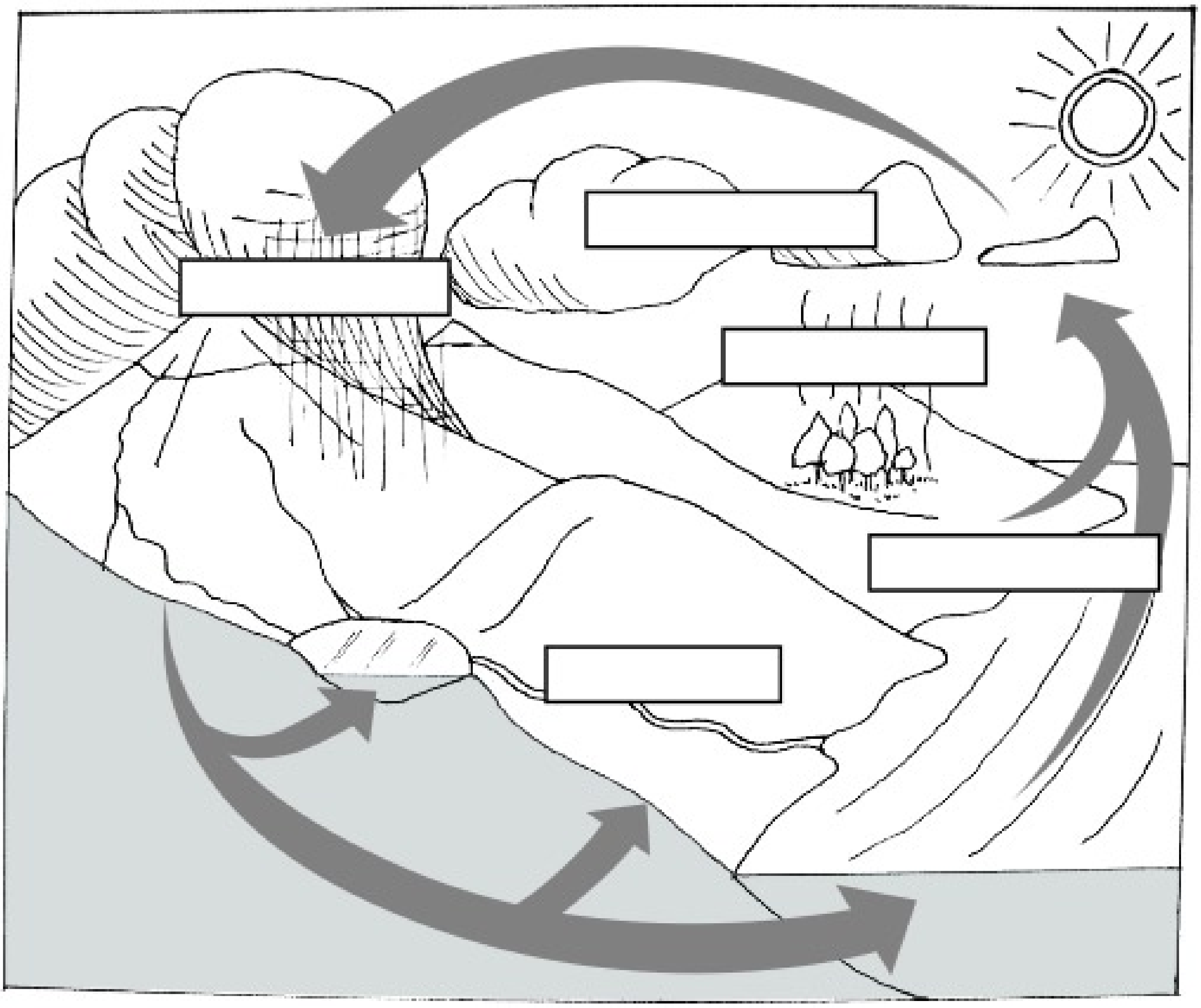
Humidity – high and low – also affects other materials such as rubber seals, wooden frames and furniture, fabric items such as curtains, mattresses, upholstery and carpet and so on. Water itself can degrade materials over time and the presence of water also allows micro-organisms to live and they will accelerate the degradation.

On the spaceship water vapour will come from things like cooking, baths, showers, breathing and perspiration, and from the transpiration of plants. The humidity will need to be controlled, excess water in the air can be collected and recycled.

Activity: Quiz

Name: ______________________________ Class: ________ Date: ______________

1. What is the name of the substance that is very important to us that is liquid, colourless, odourless and tasteless? ________________
2. As water vapour cools, it ________________ into clouds of tiny water droplets.
3. The ________________ is the giant heat engine that starts the water cycle.
4. What is the process in the water cycle where plants 'breathe out' water vapour, which also rises? ________________
5. Name the process where water is turned into water vapour by the sun, and rises into the air. ________________
6. Air temperature and pressure causes the clouds to break apart and rain, hail or snow falls. This is called ________________
7. Label each section of the water cycle below:



Homework

For your whole family estimate your daily water consumption.

- Using the information from worksheet and you own water saving ideas the students talk to their family about ways they can use less water.

Home water use calculation

Water use		litres	x Times a day =	Total
Toilet	half flush	5		
	full flush	11		
Shower		100		
Bath	half full	60		
	full	120		
Brushing teeth	tap running	5		
	tap off	1		
Washing hands		4		
Washing dishes	sink	15		
	dishwasher	30		
Cooking a meal		10		
Drinking	glass of water	.25		
For the following uses work out how many times a week you do these and divide by 7				
Housecleaning	general	80		
Washing cars		180		
Washing pets		50		
Watering garden		400		

Family Total (A)	
divided by **Number of people in your house**	
equals **Daily water consumption/person**	
multiplied by **Number of people on Spaceship Earth**	200
equals **Daily 'home' water consumption on Spaceship Earth**	

Saving water at home

In the bathroom

- Taking shorter showers.
- Turning off the tap when cleaning your teeth.
- Using less shampoo and soap because it is better for your skin, hair and the environment.
- Using environmentally friendly cleaning products, such as low phosphate detergents.
- Using a bin for your rubbish, don't put it down the sink or in the toilet.
- Using the half-flush toilet button when you can.
- Installing a water efficient shower head when your old one needs replacing.
- Fixing all leaking taps.

In the garden and outside

- Watering the garden early in the morning or in the evening because less water evaporates when it is cooler.
- Watering the roots and soil around the plants rather than spraying the leaves and flowers.
- Using a trigger action hose or watering can instead of a running hose or sprinkler.
- Fitting a timer to your sprinkler.
- Watering less often to encourage plants and lawns to grow deeper roots. A good soaking every now and then will help make plants and lawns healthier during dry periods.
- Using a broom and not a hose to clean paths and driveways.
- Washing your car on the lawn.
- Fixing all leaking taps.
- Put mulch over your garden soil, it will help stop evaporation.

In the kitchen

- Using a plug in the sink when you rinse fruit and vegetables.
- Fixing all leaking taps.
- Using a fats and oils container, like a used milk carton, for all your old cooking oils. When it's full, put it in the rubbish bin.
- Using environmentally friendly cleaning products such as low phosphate detergents.
- Having a composting system for food scraps.
- Using a sink strainer to minimise rubbish being washed down the sink.
- Fully loading the dishwasher and washing machine before using them.

Additional activities

Spreading the word!

Students decide on ways to inform the younger members of the school about saving water. Activities to spread the word may include:

- writing stories and/or making information books for younger children
- role plays
- murals
- designing signs about saving water.

The students photograph or film the steps they took in educating the younger children. This record forms the basis of a written reports to local papers, regional radio and TV stations, websites and environmental magazine.

Experiment: Solar distiller

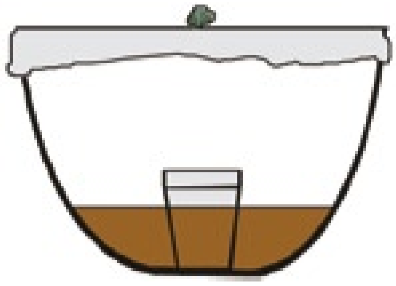
Questions:

1. Can you distill clean water from muddy water?
2. Can you distill clean water from salty water?

Possible Hypotheses:

1. You can/cannot make clean water from muddy water.
2. You can/cannot make clean water from salty water.

Materials:



1. Two large glass bowls
2. Clear plastic wrap
3. Masking tape
4. Two small stones
5. Two small glasses
6. Two tablespoons of dirt
7. Two tablespoons of salt
8. Water

Procedure:

1. Fill both plastic containers with one inch of water. Mix the dirt into the water in one and the salt into the other.
2. Place one empty glass upright into the middle of each plastic container. Make sure it remains empty.
3. Cover both plastic containers tightly with plastic wrap and seal them with tape. Place a small rock in the middle of the plastic wrap directly over the glass but not touching it.
4. Place the stills in a sunny place for two hours. Examine any water that forms in the glass. Record your observations.

Analysis and Conclusion:

1. Did the stills make clean water?
2. Can you explain how they worked?
3. Can you imagine a situation in which knowledge could save your life?
4. Is the distilling process similar to the water cycle on earth? In what ways?

Air

Learning objectives

Students will:

- Be able to describe what air is and be able to identify is main constituents including CO_2
- Be able to describe the main processes in thte carbon cycle and the greenhouse effect
- Be able to describe the structure of the atmosphere and some of it's properties like air pressure
- Discover that the spaceship will need to replicate the air of earth.

Module plan

Part 1	• Go over the vocabulary that will be used • Ask what aspects of air will need to be managed on Spaceship Earth • Discuss the composition of the air • Reading: Breathing Easy on the Space Station
Part 2	• Discuss the atmosphere and air pressure • Experiment: Air Pressure
Part 3	• Discuss the carbon cycle • Discuss breathing • Experiment: Greenhouse effect in a jar
Homework	•

Website links

http://science.nasa.gov/headlines/y2000/ast13nov_1.htm

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Curriculum achievement objectives

Science: Planet Earth and Beyond: Earth Systems

Appreciate that water, air, rocks and soil, and life forms make up our planet and recognise that these are also Earth's resources.

(Note that other modules address this achievement objective as well)

Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of the components of the air and the atmosphere.	Can express a clear understanding of the the components of the air and the atmosphere.	Can express a basic understanding of the the components of the air and the atmosphere.	Expresses an inaccurate and/or limited understanding of the components of the air and the atmosphere.

Vocabulary

Air	A mixture of nitrogen, oxygen, and minute amounts of other gases (and even liquids and solids) that surrounds the earth and forms its atmosphere.
Atmosphere	A layer of gases that surrounds the earth. It transports heat and water and filters out deadly ultraviolet radiation.
Air pressure	The force exerted by air on any surface in contact with it.
Wind	The movement of air in the atmosphere.

What is air?

Composition

Air is made up of gases as well as a small amount of solids and liquids.

Components of dry air	Volume %
Nitrogen	78.0842%
Oxygen	20.9463%
Argon	0.9342%
Carbon dioxide	0.0384%
Other	0.0020%

Balance

The composition of air has developed over a long period of time and is finely balanced.

If there was too much oxygen, for example, then things like wood would burn easier, faster and for longer. It would be dangerous because fire would start very easily and would be very hard to put out. You can snuff out a fire by stopping it's access to oxygen.

If there was too little oxygen animals would die. Animals breath in (inhale) air for the oxygen it contains and breath out (exhale) air which contains the CO_2 that is formed in respiration. Using the sun's energy plants change CO_2 and water into carbohydrates and O_2 in a process called photosynthesis.

If there is too much carbon dioxide the atmosphere warms up because of the greenhouse effect.

Emissions and the greenhouse effect

Certain gases in the atmosphere (known as greenhouse gases e.g. carbon dioxide) trap the sun's heat – just like the glass in a glasshouse/greenhouse does – this is called the greenhouse effect.

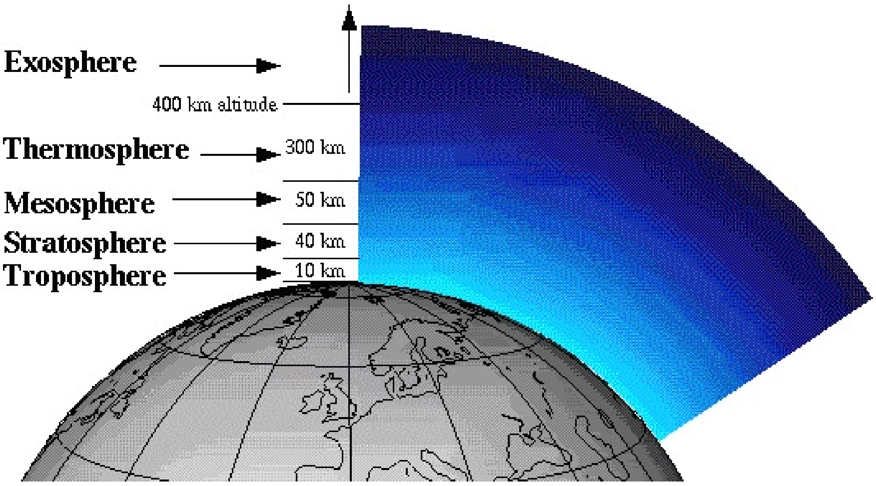
Whilst this is a natural process and helps to balance the earth's temperatures to support life if there is more CO_2 in the atmosphere than normal atmosphere will get warmer than normal. A warmer atmosphere will change climate.

Burning things creates CO_2 (and other gases and particles (gases are invisible so what you see when you see smoke are particles and water vapour)).

Human's burn fuels which increases the amount of CO_2 in the atmosphere and most scientists believe this is warming the atmosphere up and therefore changing the world's climate.

What is the atmosphere?

The atmosphere is the layer of air around the earth.



Types	Height above earth	
Troposphere	0 km to 10 km	• The closest layer to the Earth • Contains 75% of the atmosphere's gases • Weather clouds and smog occur in the troposphere
Stratosphere	10 km to 45 km	• The ozone layer is located here • The jet stream is located here • Little or no water vapor here
Mesosphere	45 km to 95 km	• The coldest part of the atmosphere
Thermosphere	95 km to 400 km	• Warmest layer of the atmosphere. • Lower layer of thermosphere is called the IONOSPHERE • Ionosphere made of electronically charged particles. • Reflects radio waves
Exosphere	400 km and beyond	• Outer most layer of our atmosphere • Very very few air molecules in this layer • No clear boundary between this layer and space

What aspects of air will need to be managed on the spaceship?

The air on earth sustains life. Animals breath air into their lungs and extract oxygen from it.

The air on earth is sustained by natural processes (although human impacts are altering the composition of the air faster than nature can maintain it).

The "atmosphere" on the spaceship will be artificial and will need to be managed in order to replicate the "natural services" provided here on earth that maintain the quality of the air.

1. What is air? Ask students to think about what air is.
2. Thinking about the sorts of things that air 'does' discuss what properties of air will need to be managed on the spaceship.

Property	Aspects	Discuss
Air composition	Percentages	• What is air? • The importance of maintaining balance
	Oxygen	• Important for metabolism • Discussed in 'respiration'
	CO_2	• Breathing and photosynthesis • The carbon cycle
	Water vapour	• The water cycle • Humidity (discussed in the Water module)
	Pollutants	• Ammonia and other 'off-gassing' will need to be filtered out on the Spaceship.
Air pressure		• Human's and all life have evolved to survive in certain air pressures.
Air circulation		• Wind, Weather
Air temperature		• Including the Greenhouse effect

Air pressure

Air pressure is the force exerted on you by the weight of tiny particles of air (air molecules). Although the molecules of air are invisible, they still have weight and take up space. Since there's a lot of "empty" space between air molecules, air can be compressed to fit in a smaller volume. When it's compressed, air is said to be "under high pressure". Air at sea level is what we're used to, in fact, we're so used to it that we forget we're actually feeling air pressure all the time!

Weather forecasters measure air pressure with a barometer. Barometers are used to measure the current air pressure at a particular location in Pascals. (One pascal = one newton per square metre).

How much air pressure are you under? Earth's atmosphere is pressing against each square centimetre of you with a force of 1 kilogram per square centimeter. The force on 1,000 square centimeters is about a ton!

Why doesn't all that pressure squash me? Remember that you have air inside your body too, that air balances out the pressure outside so you stay nice and firm and not squishy.

Q: What happens if air pressure changes?

Why do my ears pop? If you've ever been to the top of a tall mountain, you may have noticed that your ears pop and you need to breathe more often than when you're at sea level. As the number of molecules of air around you decreases, the air pressure decreases. This causes your ears to pop in order to balance the pressure between the outside and inside of your ear. Since you are breathing fewer molecules of oxygen, you need to breathe faster to bring the few molecules there are into your lungs to make up for the deficit.

As you go up the mountain air pressure decreases. Lower air pressure also means lower air temperature.

Q: What do you think causes wind?

Air may not seem like anything at all; in fact, we look right through it all the time, but during a windstorm, air really makes its presence known. Wind is able to lift roofs off buildings, blow down power lines and trees, and cause traffic accidents as gusts push around cars and trucks.

Wind is moving air and is caused by differences in air pressure within our atmosphere. Air under high pressure moves toward areas of low pressure. The greater the difference in pressure, the faster the air flows.

Describing Wind

Wind is described with direction and speed. The direction of the wind is expressed as the direction from which the wind is blowing. For example, northerly winds blow from north to south, while westerly winds blow from west to east. Winds have different levels of speed, such as "breeze" and "gale", depending on how fast they blow. Wind speeds are based on the descriptions of winds in a scale called the Beaufort Scale, which divides wind speeds into 12 different categories, from less than 1 to more than 100 kilometres per hour.

Experiments: Air Pressure

1. While holding your hand on your ribs, take a deep breath and observe what happens to your chest. Did you feel it expand? Did you see it expand? How would you explain what happened?

   Your chest expands because, like blowing up a balloon, you are increasing the number of air molecules inside your lungs. The muscles in your chest and your diaphragm expand the chest so that your lungs expand in order to provide space for the increased number of air molecules.

2. Blow up a balloon and observe what happens. Does it expand? Why does it make a noise when it's popped?

   When a balloon is blown up, the air pressure inside the balloon slowly becomes greater than the air pressure outside the balloon. Since the balloon is made of rubber and is expandable, it grows larger and larger. When the balloon is popped, the air escapes instantly. The sound you hear is from the shock wave when the compressed air inside the balloon coming into sudden contact with the air outside the balloon.

3. Get a large empty plastic milk bottle with a screw top. Fill it about a quarter of the way full with very hot water. Cap it tightly and let it stand for about an hour. What did you expect to happen? What did happen?

   The milk jug will crumple in on itself. When you added the hot water, it caused the air temperature inside the jug to rise. While the container was sealed no air could get into or out of the jug. When the water inside the jug cooled, the air cooled and caused the pressure inside the jug to decrease.

   As the pressure on the inside walls of the jug decreased, the walls of the jug collapsed. Since there wasn't enough air pressure inside the jug to offset the air pressure on the outside of the jug!

Discussion Questions:

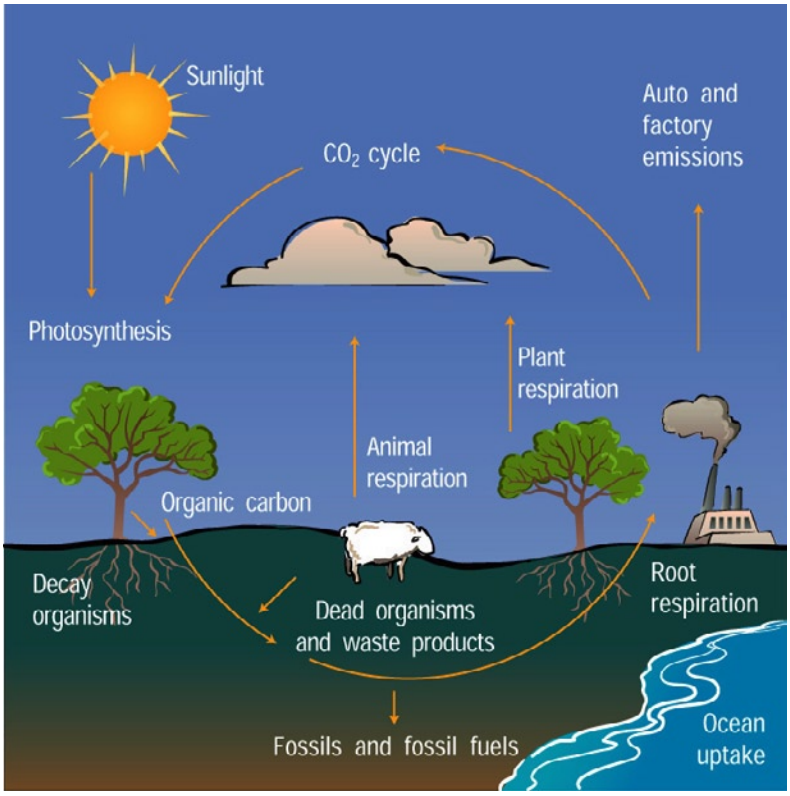
1. If you were on a mountain, would the weight of the air above you (air pressure) be greater than or less than it is now?
2. Why do hot air balloons rise?
3. Air weighs less than water, would you expect the pressure exerted by water to be greater or less than the pressure exerted by the same amount of air?

Carbon cycle

The carbon cycle is the cycle by which carbon is exchanged among the four major reservoirs of carbon. These reservoirs are:

1. The atmosphere
2. On the land
   All plants, animals, bacteria etc plus fresh water systems and non-living organic material e.g. soil
3. The oceans
   Including dissolved inorganic carbon and marine life (both living and dead)
4. The sediments/rocks including fossil fuels

Movements of carbon between these reservoirs occur because of different chemical, physical, geological, and biological processes such as breathing, photosynthesis and burning.



Source: http://eo.ucar.edu/kids/green/cycles6.htm

Carbon and life

All living things are made of carbon. Carbon is also a part of the ocean, air, and even rocks. Because the Earth is a dynamic place, carbon does not stay still. It is on the move!

In the atmosphere, carbon is attached to some oxygen in a gas called carbon dioxide.

Plants use carbon dioxide and sunlight to make their own food and grow. The carbon becomes part of the plant. Plants that die and are buried may turn into fossil fuels made of carbon like coal and oil over millions of years. When humans burn fossil fuels, most of the carbon quickly enters the atmosphere as carbon dioxide.

Greenhouse gases

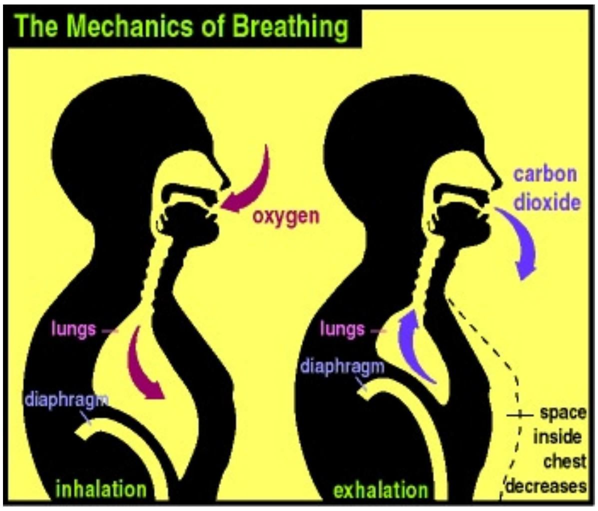
For millions of years the amount of carbon in each reservoir has been relatively stable. With the increase in human population and enormous increase of fossil fuel use (coal, petrol, gas) humans are changing the balance of carbon in the cycle.

Carbon dioxide is a greenhouse gas and traps heat in the atmosphere. Without it and other greenhouse gases, Earth would be a frozen world. But humans have burned so much fuel that there is about 30% more carbon dioxide in the air today than there was about 150 years ago, and Earth is becoming a warmer place.

Breathing

Human's and other animals need oxygen which is used to supply energy to cells (the by-product of this energy supply process is carbon dioxide (CO_2) which must be removed from the body)

We gain oxygen from the air and remove CO_2 by breathing. Oxygen rich air is inhaled into the lungs where the oxygen is transferred into the bloodstream and then carried to all parts of the body. At the same time CO_2 is moved from the bloodstream into the lungs and is exhaled out into the atmosphere.



Q: On the spaceship carbon dioxide (CO_2) will need to be removed from the air and (O_2) will need to be added. How will this be done?

Read the article about breathing easy on the Space Station and discuss.

Experiment: Greenhouse effect in a jar

Question

Can you make a miniature version of the greenhouse effect in a jar?

Materials

1 x large glass jar with a lid

2 x small thermometers

2 x pieces of cardboard slightly larger than the thermometers

2 x rubber bands

Procedure

5. Place each of the thermometers on top of the pieces of cardboard and secure them with the rubber bands. Put one thermometer into the jar with the cardboard side up so that the thermometer is not directly in the sun. Place the jar in a sunny place like a windowsill.
6. Place the other thermometer next to the jar with the cardboard side up so that it is also protected from the sun.
7. Record the temperatures of both thermometers at regular time intervals. For example this could be every 10 minutes for an hour, every half hour for a day or at the same time daily for a week.
8. Tabulate the data and present as a graph.

Analysis and conclusions

Discuss why the jar has a higher temperature, daily variations resulting from different light conditions and how the glass jar has a similar effect to the greenhouse gases in the earth's atmosphere.

Greenhouse gases in the atmosphere act like the glass in a greenhouse. They allow sunlight to pass through to the earth's surface. When sunlight hits the earth it heats the surface. As heat rises some of it is trapped by the greenhouse gases. If there were no greenhouse gases in the atmosphere the earth would be too cold to sustain life. If there are too many greenhouse gases the earth would be too hot for life, just like the planet Venus.

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Breathing Easy on the Space Station

Life support systems on the ISS provide oxygen, absorb carbon dioxide, and manage vaporous emissions from the astronauts themselves. It's all part of breathing easy in our new home in space.

Listen to this story (requires RealPlayer)

November 13, 2000 -- Many of us stuck on Earth wish we could join (at least temporarily) the Expedition 1 crew aboard the International Space Station (ISS). Floating effortlessly from module to module, looking down on Earth from a breathtaking height of 350 kilometers.... It's a dream come true for innumerable space lovers.

Right: An artist's rendering of the ISS as it currently appears.

But be careful what you wish for! Living on the Space Station also means hard work, cramped quarters, and... what's that smell? Probably more outgassing from a scientific experiment or, worse yet, a crewmate.

With 3 to 7 people sharing a small enclosed volume on the still-growing Space Station, air management is critical.

Life support systems on the ISS must not only supply oxygen and remove carbon dioxide from the cabin's atmosphere, but also prevent gases like ammonia and acetone, which people emit in small quantities, from accumulating. Vaporous chemicals from science experiments are a potential hazard, too, if they combine in unforeseen ways with other elements in the air supply.

So, while air in space is undeniably rare, managing it is no small problem for ISS life support engineers.

In this second article in a series about the practical challenges of living in space, *Science@NASA* examines how the ISS will provide its residents with the breath of life.

Making oxygen from water

Most people can survive only a couple of minutes without oxygen, and low concentrations of oxygen can cause fatigue and blackouts.

To ensure the safety of the crew, the ISS will have redundant supplies of that essential gas.

"The primary source of oxygen will be water electrolysis, followed by O_2 in a pressurized storage tank," said Jay Perry, an aerospace engineer at NASA's Marshall Space Flight Center working on the Environmental Control and Life Support Systems (ECLSS) project. ECLSS engineers at Marshall, at the Johnson Space Center and elsewhere are developing, improving and testing primary life support systems for the ISS.

Most of the station's oxygen will come from a process called "electrolysis," which uses electricity from the ISS solar panels to split water into hydrogen gas and oxygen gas.

Left: The ISS's first crew -- Bill Shepherd, Sergei Krikalev and Yuri Gidzenko -- aboard the Space Station. During their four-month stay, the crew will rely on the Station's hardware to provide breathable air.

Each molecule of water contains two hydrogen atoms and one oxygen atom. Running a current through water causes these atoms to separate and recombine as gaseous hydrogen (H_2) and oxygen (O_2).

The oxygen that people breathe on Earth also comes from the splitting of water, but it's not a mechanical process. Plants, algae, cyanobacteria and phytoplankton all split water molecules as part of photosynthesis -- the process that converts sunlight, carbon dioxide and water into sugars for food. The hydrogen is used for making sugars, and the oxygen is released into the atmosphere.

"Eventually, it would be great if we could use plants to (produce oxygen) for us," said Monsi Roman, chief microbiologist for the ECLSS project at MSFC. "The byproduct of plants doing this for us is food."

However, "the chemical-mechanical systems are much more compact, less labor intensive, and more reliable than a plant-based system," Perry noted. "A plant-based life support system design is presently at the basic research and demonstration stage of maturity and there are a myriad of challenges that must be overcome to make it viable."

Hydrogen that's leftover from splitting water will be vented into space, at least at first. NASA engineers have left room in the ECLSS hardware racks for a machine that combines the hydrogen with excess carbon dioxide from the air in a chemical reaction that produces water and methane. The water would help replace the water used to make oxygen, and the methane would be vented to space.

Right: The oxygen that humans and animals breathe on Earth is produced by plants and other photosynthetic organisms such as algae.

"We're looking to close the loop completely, where everything will be (re)used," Roman said. Various uses for the methane are being considered, including expelling it to help provide the thrust necessary to maintain the Space Station's orbit.

At present, "all of the venting that goes overboard is designed to be non-propulsive," Perry said.

The ISS will also have large tanks of compressed oxygen mounted on the outside of the airlock module. These tanks will be the primary supply of oxygen for the U.S. segment of the ISS until the main life support systems arrive with ***Node 3*** in 2005. After that, the tanks will serve as a backup oxygen supply.

Last week, while the crew were waiting for activation of a water electrolysis machine on the Zvezda Service Module, they breathed oxygen from "perchlorate candles," which produce O_2 via chemical reactions inside a metal canister.

"You've got a metallic canister with this material (perchlorate) packed inside it," Perry explained. "They shove this canister into a reactor and then pull an igniter pin. Once the reaction starts, it continues to burn until it's all used." Each canister releases enough oxygen for one person for one day.

"It's really the same technology that's used in commercial aircraft," he continued. "When the oxygen mask drops down, they say to yank on it, which actuates the igniter pin. That's why you have to give it a tug to begin the flow of oxygen."

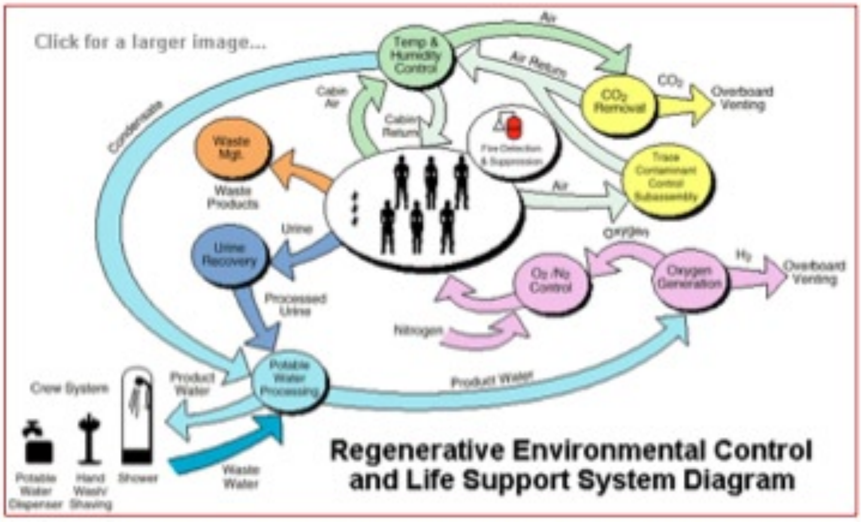
Keeping the air "clean"

At present, carbon dioxide is removed from the air by a machine on the Zvezda Service Module based on a material called "zeolite," which acts as a molecular sieve, according to Jim Knox, a carbon dioxide control specialist at MSFC.

The removed CO_2 will be vented to space. Engineers are also thinking of ways to recycle the gas.

In addition to exhaled CO_2, people also emit small amounts of other gases. Methane and carbon dioxide are produced in the intestines, and ammonia is created by the breakdown of urea in sweat. People also emit acetone, methyl alcohol and carbon monoxide -- which are byproducts of metabolism -- in their urine and their breath.

Activated charcoal filters are the primary method for removing these chemicals from the air.



Above: This diagram shows the flow of recyclable ("regenerative") resources in the Space Station's Environmental Control and Life Support System (ECLSS).

Maintaining a healthy atmosphere is made even more complex by the dozens of chemicals that will be used in the science experiments on board the ISS.

"In a 30 year period, there could be any number of different types of experimental facilities on board that could have any number of chemical reagents," Perry said.

Some of these chemicals are likely to be hazardous, particularly if they're allowed to combine in unforeseen ways, Perry said. Keeping these chemicals out of the air will be vital for the crew's health.

When the Space Station was first being designed, NASA engineers envisioned a centralized chemical-handling system that would manage and contain all the chemicals used for experiments. But such a system proved to be too complex.

"The ability for the Station to provide generic monitoring capability to try to cover the broad spectrum of chemicals that 15 plus years of basic research will require -- obviously that's not something that the Station itself can provide," Perry said.

"It really made much greater sense that each experimental facility on board the lab module would provide its own containment of its (chemicals), essentially maintaining responsibility for the chemicals from cradle to grave," Perry said.

Left: An illustration showing the location of Node 3, where the ECLSS life support equipment will be housed. Note that the Station components in the line of sight to Node 3 are transparent in this image.

A safety review for each proposed experiment will determine the level of containment that the rack-mounted experiment facilities must provide. In the event of a release, the crew will seal off the contaminated module and then follow procedures for cleanup, if possible.

But careful planning and well-designed hardware should minimize the risk of this scenario, enabling the crew of the Space Station to breathe easy.

Food

Learning objectives

Students will:

- Be able to describe what what food is and what it is for
- Discover food chains and will understand that energy is lost as you move up the chain
- Discover that food does not last and it will need to be grown on the Spaceship

Module plan

Part 1	• Go over the vocabulary that will be used • What is food? • The food chain.
Part 2	• Discuss keeping food • What are the different ways food is kept • Activity: How do people keep food
Part 3	• What sort of food will be grown? • How will it be grown? • Activity: Class Brainstorm: The pros and cons of taking animals
Homework	• The Food Chain

Curriculum achievement objectives

Science: Living World: Life processes Recognise that there are life processes common to all living things and that these occur in different ways.			
Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of food as a part of the life process common to all living things and that different organisms have different requirements and sources of food.	Can express a clear understanding of food as a part of the life process common to all living things and that different organisms have different requirements and sources of food.	Can express a basic understanding of food as a part of the life process common to all living things and that different organisms have different requirements and sources of food.	Expresses an inaccurate and/or limited understanding of food as a part of the life process common to all living things and that different organisms have different requirements and sources of food.

Vocabulary

Nutrition	the process by which organisms take in and utilise food
Diet	the particular foods eaten by a particular animal (e.g. a person) or group
Herbivores	consumers that eat plants
Carnivores	consumers that eat animals
Omnivores	consumers that eat plants and animals
Producers	organisms that produce their own food using energy from sunlight
Consumers	organisms that eat other organisms for food

What is food?

In the broadest sense food is the group of substances that supplies nourishment to organisms so that they can stay alive.

Food groups

There are four main groups of food chemicals:

1. Carbohydrate (including Fibre)
2. Protein
3. Fat
4. Vitamins and Minerals

For good health we require food from all the groups.

These should not be confused with 'types' of food e.g. vegetables, fruit, meat, eggs, nuts etc (see below). Many types of food contain more than one group of food, and milk contains all groups of food.

Carbohydrates Sugar and starch

Carbohydrates are used in the body to obtain energy. The energy in the body is used for:

- External activities (behaviour), such as work, sport, leisure - that is any movement of the body.
- Internal activities including breathing, pumping blood, digestion, growth and the activities of the immune system.

Carbohydrates are substances that contain carbon, hydrogen and oxygen and include sugars and starches. Carbohydrates are usually obtained from plant sources. They are broken down in the body to form glucose, and any that is not immediately required in stored in the liver and muscles as glycogen.

Plants use carbohydrates to build structures and they store any excess as starch (whereas, animals use protein to build structures and they store any excess as fat).

Plants make carbohydrates from a chemical reaction that converts CO_2 (carbon dioxide) and H_2O (water) into sugars/carbohydrates and oxygen. The reaction uses sunlight to energise it and a molecule called chlorophyll as the site for photosynthesis.

This is a chemical formula that shows what happens in a chemical reaction. On the left had side are the two chemicals (carbon dioxide and water) that go into the reaction, with light as an energy source and chlorophyll (the pigment that makes plants green) as the energy 'converter' these are changed into carbohydrates (sugars and starches) and oxygen.

Sugar We are all used to the type of white sugar crystals that we put on our cereal. This is known as sucrose by scientists and is only one of many types of sugar. Glucose is the simplest sugar and other common sugars found in foods are lactose (in milk and dairy products) and fructose (in many fruits). The difference between sugars is the number of carbon, oxygen and hydrogen atoms in them.

Starch is a 'complex carbohydrate'. This means that it is formed from a number of simple sugar molecules joined together. Plants store sugars in the form of starch. These starches are often collected in buds, seed heads and pods. Toward the end of the growing season, starch accumulates in twigs of trees near the buds. Also, fruit, seeds, rhizomes, and tubers store starch to prepare for the next growing season.

Fibre (Non-digestible carbohydrate)

In the human diet fibre (also called roughage) refers to the non-digestible carbohydrates in vegetables and fruit. Fibre may actually be 'fibrous', as in celery, or more like a jelly when it mixes in the stomach. Fibre, whilst not providing nutrients, does perform an important function in Fibre provides:

1. Bulk
2. Lubrication, and
3. Nutrition for friendly bacteria in the colon

When fibre is combined with water, it swells up and provides bulk to the digestive system. This makes it easier for food to pass through the intestines. Food also passes through the digestive system faster, so that waste products are retained for less time in the body.

Some fibre has the effect of lubricating the contents of the intestines and, therefore, makes the food pass through easily and in a timely manner. The benefits here are the same as for bulk.

In addition, friendly bacteria in the colon feed on fibre and they are therefore nourished by it. By helping these friendly bacteria, we enable them to help us to digest food. Also, by giving them support, they are more able to exclude other, less friendly bacteria, from our colons.

Fibre is, therefore, necessary for a healthy and efficient digestive system.

Proteins

Like carbohydrates, proteins are composed of carbon, oxygen, and hydrogen, but they also have nitrogen and sometimes contain sulphur and phosphorus too. They are complex molecules.

Proteins are used by the body to:

1. enable growth, development and repair.
2. build structures such as muscles, tissues and organs, including the heart, lungs, digestive organs.
3. enzymes, such as those required for digestion.
4. hormones, such as those for the endocrine glands.

Proteins, therefore, are needed not only for obvious body structures, such as muscles, but also for the immune and digestive systems, etc.

Complete proteins are obtained from meat, fish and dairy products including eggs. Proteins can also be obtained from certain combinations of foods, for example, cereals and beans.

Fats and oils

Fats are an essential food. That is, the body requires its intake of fat every day for health and well-being. Like the other groups of food, when the body does not get the fat it needs, then illness results.

Fats are used by the human body:

1. In every cell structure. The brain is 40% fat.
2. To insulate the body.
3. To produce hormones.
4. To produce cholesterol (essential for cell membranes and bile salts, for example).
5. To absorb certain vitamins (A, D, E, and K).
6. To store energy.

Fats are composed of chemical substances called fatty acids and glycerol. Fats are not soluble in water. Fats are also called lipids. Sources of fat include animal products (e.g. meat, butter, eggs, fish) and vegetable oils.

Vitamins and Minerals

Vitamins are substances that are required in the diet for health and wellbeing. They are often grouped as fat-soluble or water-soluble. Fat-soluble vitamins are vitamins A, D, E and K. Water-soluble vitamins include vitamins C and B.

Minerals are non-organic substances that are required in the diet. While only small amounts of minerals are required in our diet, they are critical in building bones and teeth, regulating heartbeat and transporting oxygen from the lungs to the tissues.

Vitamins and minerals occur in a variety of foods. That is, by eating a variety of foods, you can get the necessary vitamins and minerals you need for health.

Deficiencies and excesses

Deficiencies and excesses in any of these groups of foods produce illness and lowered wellbeing.

Western diets are especially deficient in the minerals calcium and iron and in the Omega 3 fatty acids.

Calcium is obtained from, for example, milk and from eating canned salmon including the bones (salmon also contains Omega 3 fatty acids). Iron is often obtained from meat, especially liver.

Lacto-vegeterians can get their calcium from milk, and vegans (who do not eat any animal products) can get their calcium from fortified soy milk. To obtain your calcium requirements from non-animal sources, you would have to eat a very large amount of vegetables or fruits.

Eating well

You need to eat all the different types of food to get the full range of nutrients your body needs to operate properly. Because of the way the body works we need more of certain types of nutrients than others. This creates a 'formula' for the way our diets should be made up. This formula is not precise but if your diet is very different from this you may get sick.

Food Types

A healthy diet is one that contains a variety of different food types, and different foods from the same food type. There are 5 basic types of food:

1. Breads, cereals and potatoes
2. Fruit and vegetables
3. Milk and dairy products
4. Meat, fish, eggs and others
5. Foods containing fat, oils and sugar

Breads, Cereals and Potatoes along with Fruits and Vegetables are mostly made up of carbohydrates, with some vitamins and minerals. Carbohydrates provide energy. These food types should be consumed most.

Milk, dairy products, lean meat and fish are mostly made up of protein and other vitamins and minerals, such as calcium. We need these types of foods to grow bones and muscles. These food types are important - especially in children, and should be consumed regularly.

Foods that contain fat, oils and sugars include things like butter, chips, fizzy drinks and sweets. These foods are used to give us energy. This energy can be stored to use later. These food types should be eaten least.

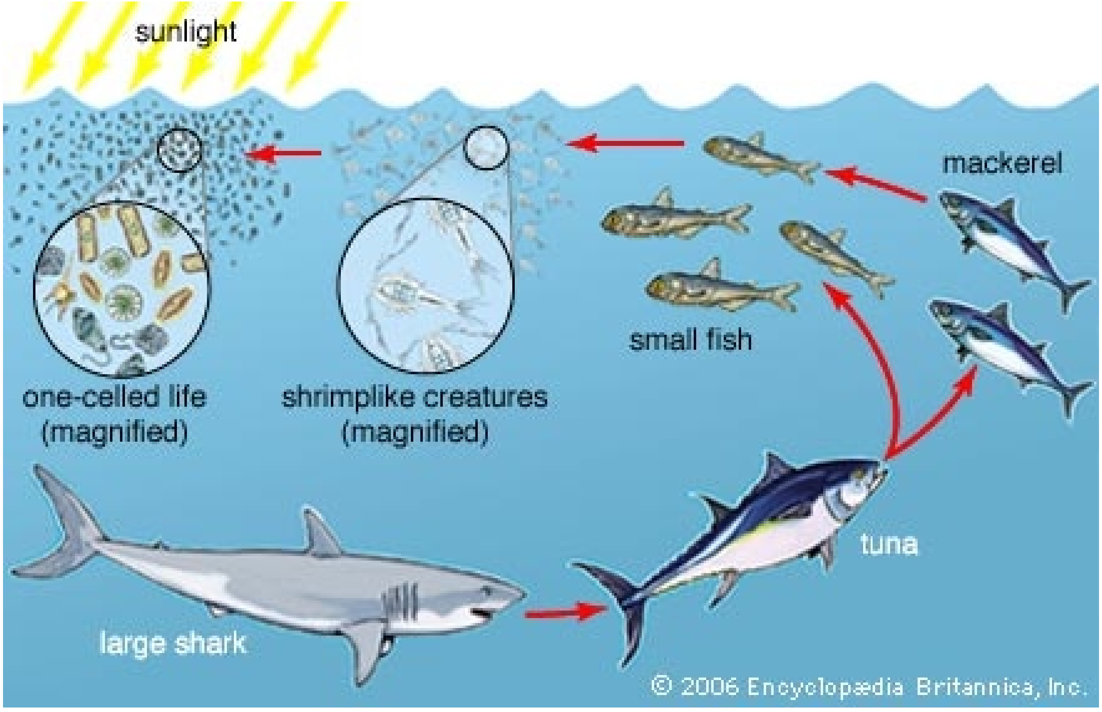
Different parts of plants can be food

Part of plant	Examples
Flower bud	broccoli, cauliflower, globe artichokes
Seeds	sweetcorn (maize), peas, beans
Leaves	kale, collard greens, spinach, beet greens, turnip greens, endive, lettuce
Leaf sheaths	leeks
Buds	Brussels sprouts
Stems of leaves	celery, rhubarb
Stem as a young shoot	asparagus, bamboo shoots, and ginger
Underground stem (tuber)	potatoes, Jerusalem artichokes, sweet potatoes, and yams
Whole young plants (sprouts)	soybean (moyashi), mung beans, urad, and alfalfa
Roots	carrots, parsnips, beets, radishes, turnips, and burdocks
Bulbs	onions, shallots
Fruits that are known as vegetables:	tomatoes, cucumbers, squash, pumpkins, capsicums/peppers, eggplant, okra, breadfruit and avocado
Legumes:	green beans, snap peas, soybean

Food chains

Every organism needs to obtain energy in order to live. Plants get energy from the sun, some animals eat plants, and some animals eat other animals.

A food chain is the sequence of what-eats-what in a biological community (known as an ecosystem).



Trophic Levels:

The trophic level of an organism is the position it holds in a food chain.

1. Primary producers (organisms that make their own food from sunlight and/or chemical energy from deep sea vents) are the base of every food chain – these organisms are called autotrophs. Phytoplankton are tiny plant organisms that live in the sea.
2. Primary consumers are animals that eat primary producers; they are also called herbivores (plant-eaters). Zooplankton are tiny animals that eat phytoplanton.
3. Secondary consumers eat primary consumers. Small anchovies eat zooplankton.
4. Tertiary consumers eat secondary consumers. Mackerel eat anchovies.
5. Quaternary consumers eat tertiary consumers. Tuna eat mackerel
6. Food chains "end" with top predators, animals that have little or no natural enemies (like an alligator, hawk, or shark). Sharks eat tuna.

Consumers are also known as heterotrophs. They can be either herbivores (plant-eaters), carnivores (meat-eaters) and omnivores (animals that eat both animals and plants).

When any organism dies, it is eventually eaten by detrivores (like vultures, worms and crabs) and broken down by decomposers (mostly bacteria and fungi), and the exchange of energy continues.

Some organisms' position in the food chain can vary as their diet differs. For example, when a bear eats berries, the bear is functioning as a primary consumer. When a bear eats a plant-eating rodent, the bear is functioning as a secondary consumer. When the bear eats salmon, the bear is functioning as a tertiary consumer (this is because salmon is a secondary consumer, since salmon eat herring that eat zooplankton that eat phytoplankton, that make their own energy from sunlight). Think about how people's place in the food chain varies - often within a single meal.

Chains and webs

Because many food consumers eat a number of different foods most food chains interconnect into much more complex webs.

Numbers of organisms

The arrows in a food chain diagram show the flow of energy, from the sun to a top predator. As the energy flows from organism to organism, energy is lost at each step. Because of this, there are usually many more plants than there are plant-eaters and more plant-eaters than meat-eaters.

Equilibrium

Although there is intense competition between animals, there is also an interdependence. When one species goes extinct, it can affect an entire food web and have unpredictable consequences.

As the number of carnivores in a community increases, they eat more and more of the herbivores, decreasing the herbivore population. It then becomes harder and harder for the carnivores to find herbivores to eat, and the population of carnivores decreases. In this way, the carnivores and herbivores stay in a relatively stable equilibrium, each limiting the other's population. A similar equilibrium exists between plants and plant-eaters. There can be seasonal variations in populations as well as variations caused by longer-term climatic patterns.

Human food production

Humans are unique because we have developed technology to farm food and to catch fish in large quantities. By clearing wild habitats to use for farmland people have decreased the number of organisms and there are many cases where people have causes the extinction of species.

It is possible to overfarm and overfish.

 |

How long does food last for

Where will the crew of Spaceship Earth get food from?

Shall they take it – or grow it? Or both? If they take it how long will the food last for?

Types	Shelf	Fridge	Freezer	Can or jar
Fruit/Vegetables				
Potatoes	1-2 months	1-2 months	12 months	2-5 years
Peas	No	3-4 days	8 months	2-5 years
Tomatoes	until ripe	2-3 days	6 months	1-2 years
Apples	1-2 days	3 weeks	8 months	2-5 years
Meat				
Fish	No	1-2 days	6 months	2-5 years
Chicken (whole)	No	1-2 days	12 months	2-5 years
Beef/Lamb	No	3-5 days	4-12 months	2-5 years
Bacon (fresh)	No	7 days	1 month	–
Sausages (fresh)	No	3-5 days	1-2 months	–
Dairy/Eggs				
Milk	No	7 days	3 months	12 months
Cheese (cheddar)	No	6 months	6 months	–
Eggs (in shell)	3-5 weeks	3-5 weeks	No	–
Baked				
Bread	2-4 days	7-14 days	3 months	–
Biscuits	2-3 weeks	2 months	8-12 months	–
Dry goods				
Flour (white)	12 months	–	–	–
Beans	12 months	–	–	–
Breakfast cereal	6-12 months	–	–	–
Coffee (instant)	12 months	–	–	–
Fruit	6 months	–	–	–
Herbs	1-2 years	–	–	–
Pasta	2 years	–	–	–
White rice	1 year	–	–	–
Spices	2 years	–	–	–
Vinegar	2 years	–	–	–

Source: http://www.pastrywiz.com/storage/

Activity: How do people keep food?

Learning objective

Students will get an appreciation of different types of food preservation and some of the ways that food is processed.

Q: As a class think of as many ways as possible that humans use to preserve food and write them on the whiteboard.

Q: Group students into threes and give them each a different preservation method and ask them to think about the pros and cons of that method. Students could find out:

1. How does the preservation work? e.g. salting 'dries' meat and inhibits bacterial growth
2. How long does the preservation last? Provide a range and/or give examples.
3. How it affects the quality of the food? e.g. salting makes the food salty, pickling makes it sour etc.
4. Is it a complicated process? i.e. is it resource intensive (energy, materials, labour)
5. Is it still commonly used? Why?

	Examples and comments
Refrigeration	
Freezing	
Drying and curing	Dehydrator Sun-drying Air drying Freeze drying
Preservatives	Salting Sugaring Pickling e.g. vinegar
Canning and bottling	
Vacuum sealing	
Cooking	Baking Smoking
Other	

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Growing food

Q: Will food need to be grown on Spaceship Earth? Yes/No

Q: What will they need to take/have in order to grow food? Discuss.

Growing food is a huge subject and we could do a whole course on just food but the idea of this exercise is to give students an idea of the services that nature provides

Vegetables, fruit and herbs

Sunlight	
Air	
Water	
Seeds	
Soil	
Pollinators	
Pest control	
Fertiliser	
Land	

Animals and fish

Q: What are the pros and cons of taking animals for food.

Pros	Cons
Meat, eggs, milk, milk products	We will need much more room for them. Because they are higher up the food chain they will have to be fed food that will have to be grown.
Hides	There might not be enough room, considering the limit of 2.1 hectares per person.
More food variety	We will need to take much more water and treat it etc.
High protein content, good source of protein	Animals create gases (CO_2 and methane) which will have to be dealt with.
etc	Will need to have vets
	etc

 |

Homework: Food chain

Word bank

arrows	herbivores	detrivores	lost
energy	consumers	top	omnivores
sea	photosynthesis	phytoplankton	meal
sun	sharks	carnivores	anchovies

Every organism needs to obtain energy in order to live. Plants get their energy from the ________________ and make their own food. Some animals eat plants (these animals are called ___________________________), some animals eat other animals (these animals are called ___________________________), and some animals eat both plants and animals (these animals are called ___________________________).

A food chain is the sequence of who eats whom in a biological community to obtain nutrition.

1. A food chain starts with the primary ___________________________ source, usually the sun.
2. The next link in the chain is an organism that makes its own food from the primary energy source. For example plants make their own food from sunlight using a process called ___________________________. These organisms are called autotrophs or primary producers.
3. Next come organisms that eat autotrophs; these organisms are called herbivores or primary ___________ ______________________– an example is zooplankton that eats ___________________________.
4. The next link in the chain is animals that eat herbivores; these are called secondary consumers – an example is an anchovy that eats zooplankton.
5. In turn, these animals are eaten by tertiary consumers -- e.g a mackerel that eats ____________________.
6. The tertiary consumers are eaten by quaternary consumers -- e.g. a tuna that eats mackerel.
7. Each food chain end with a ____ predator, an animal with no natural enemies (some examples are alligators, hawks, and ___________________________).
8. When any organism dies, it is eventually eaten by ____ (like vultures, worms and crabs) and broken down by decomposers (mostly bacteria and fungi), and the exchange of energy continues.

The ______________________ in a food chain show the flow of energy, usually from the sun to a top predator. As the energy flows from organism to organism energy is ________________________ at each step.

Some organisms' position in the food chain can vary as their diet differs. For example, when a bear eats berries, the bear is acting as a primary consumer. When a bear eats a plant-eating rodent, the bear is functioning as a secondary consumer. When the bear eats salmon, the bear is functioning as a tertiary consumer (this is because salmon is a secondary consumer, since salmon eat herring that eat zooplankton that eat phytoplankton, that make their own energy from sunlight). Think about how people's place in the food chain varies - often within a single ____.

Goods & Materials

Learning objectives

Students will:

- be able to identify and describe some of the factors of sustainable design. Sustainable goods:
  – have low embodied energy
  – have low material use
  – are made from renewable sources and/or recycled sources
  – are designed to be durable, recyclable and multi-purposed.
- be able to identify and describe the life of a product
- discover that materials have different properties that make them suitable for different goods
- get and insight into the complexity of the goods we use

Module plan

Part 1	• Discuss the 'life' of a product • What types of **goods** will be used on the spaceship • Homework: How can you make goods last longer
Part 2	• What types of **materials** will be used on Spaceship Earth • Inquiry: Different materials
Part 3	• Types of materials • Presentation of inquiry: Different materials
Homework	• Making things last

Curriculum achievement objectives

Science: Material World: Chemistry and Society Relate the observed, characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.			
Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of how the properties of many materials that are used to make textiles relate to technological uses and natural processes	Can express a clear understanding of of how the properties of some materials that are used to make textiles relate to technological uses and natural processes	Can express a basic understanding of how the properties of some materials that are used to make textiles relate to technological uses and natural processes	Expresses an inaccurate and/or limited understanding of of how the properties of materials that are used to make textiles relate to technological uses and natural processes

Vocabulary

Renewable	A commodity or resource, such as solar energy or firewood, that is inexhaustible or replaceable by new growth.
Natural	Natural materials are not man-made and are made by nature. Natural also often refers to materials and goods that are made from organic sources.
Synthetic	When applied to materials synthetic means man-made. However synthetic materials are ultimately made from naturally occuring raw materials
Recycle	Materials
Raw materials	Materials may be processed (changed) a number of times before they are made into a final product.

The 'life' of a product

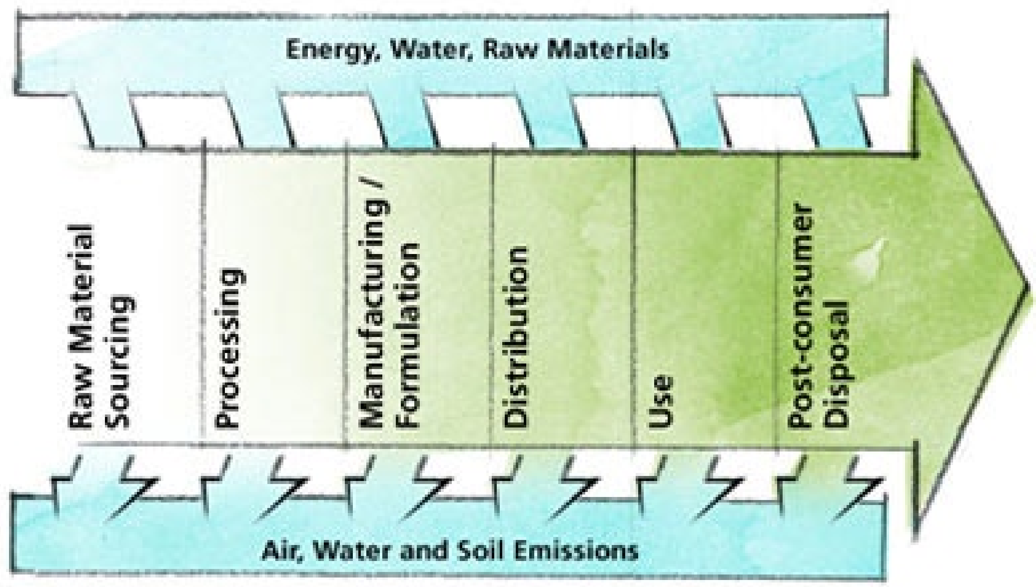
All goods have what is called a 'life'. Of course these goods are not alive – so it's a figure of speech (although they might be made from materials such a leather or cotton that were once part of a living organism).

The story of a products life

The 'life' of a product starts with the raw materials from which it is made. The raw materials are then processed so that they are in a form that will then be made into the product. The products are then distributed (which includes transporting, selling and warehousing) to the end user. The end user will use them and dispose of them in some way.

Throughout this life there is the input of energy, water and raw materials and the output of waste in the form of air, water and soil emissions.

A study done in America showed that only 6% of the raw materials that first went into making the product are actually in the product. This means that the other 94% is waste (which may or may not be recycled).



If the life of the product ends in a landfill (where it may take millions of years to break down) then the life is a linear one (it has a start and a finish) as shown in the diagram above.

Sustainable production

If, at the end of the product's life, it becomes the raw material for another, new product you have created a cycle. This is what recycling is. The ideal situation would be that you recycle all the materials in every product indefinitely. This is not often easy in practice but many designers are working to achieve this aim.

What types of goods will be needed

Make a list of all the types* of goods that will be needed. Also think about whether these types of goods will last 200 years.

Learning objective: The purpose of this exercise is for students to realise that there is 'a lot of stuff'.

Focussing question: What sorts of things that you have at home.

Q: What types of goods will be needed on the Spaceship

Get students to name goods and write them on the whiteboard in sets. Ask students if these types of goods will last for 200 years.

Types	Will it last 200 years	Description and comments
Clothes	No	
Bedding	No	
Shoes	No	
Cleaners	No	
Toiletries	No	Soap, shampoo, moisturiser, cosmetics
Medicines	No	
Furniture & upholstery	Yes/No	Upholstery could wear out
Paper and stationery	No	
Tools	Yes	If they are looked after
Sports goods	Yes/No	Rackets, clubs, balls etc. exercise gear
Dining and Kitchenware	Maybe	Cutlery, crockery, bowls, pots and pans, utensils. They will break, wear out. Stainless steel will last longer, glass and crockery will break.
Education/Entertainment		Books, DVDs, CDs/Music, instruments, games, books, artwork, hobbies
Computers, appliances and other equipment	Maybe	Could take backups, parts,
Other...		

* the idea is not to be too detailed but more to think about the breadth of goods that we use

Materials

Thinking about clothes, shoes and bedding make another list of all the types* of materials that will be needed to make and/or repair each type of goods. (NB: The list below is not exhaustive).

Learning objective

Students will learn that different materials can be used for the same purpose but there are advantages and disadvantages for each. Also the same materials can be used for many different purposes/designs.

Q: What materials can clothes, shoes, bedding and other fabrics be made from

Ask students to think of all the raw materials and write them on the whiteboard

		Used in			
Category	Examples of materials	Clothes	Bedding	Shoes	Curtains/ Upholstery
Natural materials	Wool				
	Cotton				
	Hides/skin (esp. leather)				
	Silk				
	Fur and hair				
	Linen: hemp, jute, flax				
	Down/feathers				
	Rubber				
Synthetic materials	Nylon				
	Acrylic				
	Vinyl (PVC)				
	Polyester/Fleece (PET)				

Inquiry: Materials

This inquiry could be done by individual students or in groups of 2-3.

Each person/group to choose (from a hat?) one of the textile materials listed above (or you could choose from any list of materials). Using the library and the internet students will find out about their material using the format below (and on the worksheet).

Time permitting students could present their inquiry to the class for discussion otherwise the inquiries could be put on the wall so that students can all see them.

Learning objective

Students will discover that different materials have different properties/characteristics that make them suitable for their purpose. They will also find out that different materials are produced in different ways and have different impacts on the environment.

Material inquiry

Name of material	
Is it natural or synthetic	
How is it processed or manufactured and turned into a usable fabric?	Short description of process. The idea is to get a notion of the complexity of the process and the number of inputs (energy, water and materials) and outputs (waste water, air emissions, waste materials) that go into manufacturing a seemingly simple material.
Where does this material come from?	Where in the world does it come from? Is it commonly made in New Zealand or do we import it? Why? Do we import it as a 'raw' material or in a finished/semi-finished product?
What it is used for?	What can this material be used for. Make a list of as many things as possible.
Design properties	What makes this a good material for it's purpose as a textile? e.g. is it: warm, soft, hard-wearing, waterproof, breathable, cool, light, comfortable, easy to clean, etc. Why is it better or worse than other materials?
	What makes it a good material for producing? e.g. Is it: cheap, plentiful, easy to work with, easy to produce etc Why is it better or worse than other materials?
	Can it be reused or recycled once it is manufactured? For what purpose?
Health, safety and environmental factors	Are there any bad health and safety impacts or bad environmental impacts involved in the manufacture, use or disposal of this material? e.g are any toxins or pollutants used/created in it's manufacture? Does it cause allergies? Is it biodegradable? Is it flammable?
Would this be a good material to use on Spaceship Earth?	Why?

Materials inquiry worksheet

Material inquiry	
Name of material	
Is it natural or synthetic	
How is it processed or manufactured?	Use a separate sheet of paper/s to describe the process
Where does this material come from?	
What it is used for?	
Design properties (Think in terms of advantages and disadvantages i.e. pros and cons)	
Health, safety and environmental factors	
Would this be a good material to use on Spaceship Earth? Why?	

Homework: making things last

Q: Why do things not last?

Some goods last longer than others. Students are to think of 3-5 different reasons why things don't last, giving two examples of each and two suggestions these can be fixed or avoided for each example.

[Michael to finish AND do blank worksheet]

Reason	Examples (x 2)	Suggested fixes (x2)
They are not stored properly or put away	My bike rusts in the rain	1. Put my bike in the garage/shed 2. Wipe my bike when it gets wet
	The dog chewed my shoes	1. Put my shoes in the cupboard 2. Train my dog better
They are not used properly	I used a knife as a screwdriver and bent it out of shape	1. Use the right tools for the right job 2. Put things where I can find them
	Dad put the wrong fuse in – and blew the stereo	1. Check and follow instructions 2. Make sure Dad follows instructions
They are not designed to last	My biro has run out	1. Use pens with refills 2. Use a pencil
	My sister's nappy is disposable	1. Use cloth nappies 2. Help my sister get toilet trained
They are badly designed	The handle on the cup was too small for my finger and it slipped	1. Ask for recommendations for goods 2.
		1. 2.
They are badly made	My broken toy was not glued well	1. Only buy good quality toys 2. Be careful with flimsy toys
	The sole came off my shoe	1. Buy good quality 2. Glue it back with stronger glue
Accidents	I dropped a bowl and it broke	1. Be careful 2. Don't lift things with wet hands
	I lost part of my game and now I can't use the game	1. Use something else instead 2. Put my things away properly
They are not maintained properly	My skateboard's wheels seized up	1. Clean my skateboard 2. Oil the wheels on my skateboard
		1. 2.

Homework: Making things last worksheet

Reason	Examples (x 2)	Suggested fixes (x2)
		1. 2.
		1. 2.
		1. 2.
		1. 2.
		1. 2.
		1. 2.
		1. 2.
		1. 2.
		1. 2.
		1. 2.

Waste

Learning objectives

Spaceship Earth (like the earth) is a closed, limited ecosystem. No waste can be jettisoned.

Students will learn:

- what waste is and what different types of waste are
- in the natural world all waste becomes food or resources for something else i.e. there is no waste
- different ways humans deal with waste
- the benefits of reducing, reusing and recycling

Module plan

Part 1	• Focusing question: What types of waste are there? • Waste at home • Activity: What types of work waste will there be on the spaceship?
Part 2	• Class brainstorm: What can be done with waste? • Activity: Recycling
Part 3	• Waste actvities
Homework	• How many years to disappear?

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Curriculum achievement objectives

Science: Nature of science: Technological Knowledge: Participating and contributing Explore various aspects of an issue and make decisions about possible actions			
Excellent	Merit	Achieved	Not achieved
Explored the issue of waste thoroughly & accurately in order to make effective decisions about possible actions	Explored the issue of waste carefully in order to make good decisions about possible actions	Explored the issue of waste basically in order to make decisions about possible actions	Did limited exploration of the issue of waste and/or make incorrect decisions about possible actions

Vocabulary

Waste	Useless consumption or expenditure
Rubbish	Material that is thrown out
Pollution	The contamination of soil, water, or the atmosphere by the discharge of harmful substances
Toxic	Acting as, or having the effect of, a poison; poisonous
Compost	A mixture of various decaying organic substances, as dead leaves or manure, used for fertilizing soil.
Recycle	To treat or process (used or waste materials) so as to make suitable for reuse

Answers to: How many Years to Disappear

Disposable Nappy:	500-600 years
Cotton sock:	5-6 months
Styrofoam cup:	1,000,000 years or more
Glass bottle:	1,000,000 years or more
Leather belt:	40-50 years
Block of wood:	10-20 years
Banana Peel	3-4 weeks
Paper Box:	1-2 months
Plastic Bottle:	1,000,000 years or more
Aluminium Can:	200-500 years

What types of waste are there?

Q: Discuss as a class or in smaller groups what types of waste people make and decide if these will be on the spaceship?

Types	Spaceship	Details
Food waste	Yes	• Food that has 'gone off' • Peelings and cuttings • Scraps and left-overs
Waste water	Yes	• Washing clothes • Dishwashing • Showers, baths
Sewerage	Yes	• Toilets
Garden waste	Yes	• Clippings, prunings, leaves
CO2 and gases	Yes	• From breathing and sweating (humans) • From soil and animals
Packaging	Yes	• Bottles, containers, boxes,
Medical waste	Yes	• Used bandages, medicines
End-of-life	Yes	• Things that are broken or worn out • Things that are not needed anymore
Cleaners/chemicals	Yes	•
Building waste	Some	•
Industrial waste	Some	• Waste from making things
Energy	Yes	•

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Waste at home

Everything we use CAN be wasted. Energy is wasted when we leave lights on when we're not in the room. Food is wasted if it goes off before it is used and then put into the rubbish. Appliances and electrical goods are thrown out. Packaging and paper is thrown out.

In nature all waste is food for another organism – so there isn't really any waste at all. Much human waste can also be used as 'food' for other things. This is what we mean when we say recycling. Food (although usually not meat or other animal products) and garden waste can be composted and used to make the soil in your garden better, for example.

Humans create waste that is bad too. Certain plastics, metals and toxic chemicals are very bad for the environment. They may not decompose for thousands or even millions of years. Toxins may pollute the environment so that plants and animals cannot live there – they die or, if they can, they move somewhere else.

Remember though that even if waste can be recycled it is still better not to waste it because energy, water and other resources have gone in to making of things – which recycling cannot replace.

Domestic (home) waste

Solid waste analysis was undertaken for North Shore City Council in July 2002 and showed the following composition:

Organic	51.2%
Paper	25.5%
Plastic	13.5%
Glass	2.2%
Rubber & textile	2.1%
Rubble & concrete	1.7%
Potentially hazardous	1.4%
Timber	0.3%

Much domestic waste can be composted or recycled (for example most organic and paper waste) but there are things that can't be recycled such as rubber and some textiles (like old carpet), certain plastics and packaging, concrete and rubble and some glass. All of this (plus whatever people don't put into their recycling bins) goes to landfills.

What can be done with waste?

As a class brainstorm all the main sources of waste that you can think of.

Types	What can be done with it?
Food waste	• Composting
Waste water	• Use for watering plants • Recycle
Sewerage	• Compost
Garden waste	• Compost
CO2 and gases	• Grow plants • Clean (filter) air
Packaging	• Recycle, reuse, use as fuel
Medical waste	• Burn/use as energy
Products at end-of-life	• Reuse parts • Things that are not needed anymore
Cleaners and chemicals	• Need to be neutralised somehow if they are toxic • It is better to use natural cleaners that do not need to be treated
Building waste	• Recycle
Industrial waste	• Waste from making things
Energy waste	• Waste energy can be used

Activity: Recycling

Q: What CAN you put in your recycling bins?

Look at the website for your local council. Find where they have the information about recycling in your community. Make lists of what can and can't be recycled.

Types of things	Examples

Q: What CAN'T be recycled? Why not? Is this needed on Spaceship Earth?

Types of things	Why not?

Do you recycle at home? Yes/No

Do you recycle as much as you are able to? Yes/No

Conclusions?

For more information about what can be recycled go to: http://www.econation.co.nz/recycle.html

Waste activities

English & Literacy

Ask pupils to discuss or debate what their responsibilities are in terms of creating and dealing with waste, either at school or at home.

Maths & Statistics

Measure the volume and weight of waste produced by the school in a day and work out from this the amount that would be produced in a year. Draw graphs of the amount of waste produced in different parts of the school.

Science

Learn about the role of micro-organisms in the breakdown of waste. e.g. through work on composting.

Investigate materials and their properties by grouping and classifying different types of waste materials and considering why they are used for specific purposes e.g. different types of plastic, paper and card.

Use the concepts of non-renewable and renewable resources, reuse and recycling to explore the way in which changes in materials are either reversible or irreversible.

Social sciences

Consider waste when identifying how people can improve the environment (e.g. by reducing their level of resource use) or damage it (e.g. by littering and over-reliance on landfill and incineration).

Use waste as an example when identifying and explaining the different views that people hold about topical geographical issues.

Study changes in packaging when identifying differences between ways of life at different times.

Consider the issue of waste when talking about attitudes towards people and places, and considering how they can show respect for them.

Technology

Challenge pupils to make things using largely or only waste materials. Consider the issue of waste when investigating and describing a range of packaging. Consider the extent to which containers such as packaging are necessary or whether they serve other purposes e.g. to make contents appear more attractive. When designing and constructing packaging, seek to minimise the amount of waste produced or seek to use materials that are reusable or recyclable.

Research and present findings about a particular aspect of waste, for example, the origins and uses of a specific material and how it is dealt with as a waste product.

The Arts

Investigate the use of waste materials in art and design and create their own works making use of waste materials.

Pupils could also look at the extent to which the materials used are capable of being recycled or reused.

Use waste materials to create musical sounds, either in their own right or when combined to form 'musical instruments'.

Homework: How many years to disappear

If you bury the following objects, mark how long you think it will take for them to disappear.

	0 - 1 year	1 - 100 years	100 - 500 years	500 - 1,000 years	1,000 - 1,000,000 years
Disposable nappy					
Cotton sock					
Styrofoam cup					
Glass bottle					
Leather belt					
Wooden block					
Banana peel					
Paper box					
Plastic bottle					
Aluminium can					

(Answers on page 92)

Q: Do you think there should be a rubbish tip on Spaceship Earth?

Why/Why not?

Community
culture and work

Learning objectives

Students will

- learn how the preservation of cultural histories and heritage contribute to sustainable communities
- be able to identify the different roles that people have in the community in order to sustain it
- be able to identify a range of cultural activities and ways in which we sustain our cultures

Module plan

Part 1	• Focusing question: What types of work do people do? • Activity: What types of work will be done on the spaceship?
Part 2	• Focusing question: What other cultural activities do people do? • Activity: What types of cultural activities will be done on the spaceship?
Part 3	• Sustaining culture • What will need to be taken on the Spaceship to sustain their culture
Homework	• Homework: Sustaining culture

Curriculum achievement objectives

Social Sciences: Social studies:

Understand how people pass on and sustain culture and heritage for different reasons and that this has consequences for people.

Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of how people sustain culture and heritage through work, cultural activities and cultural artifacts.	Can express a clear understanding of how people sustain culture and heritage through work, cultural activities and cultural artifacts.	Can express a basic understanding of how people sustain culture and heritage through work, cultural activities and cultural artifacts.	Expresses an inaccurate and/or limited understanding of how people sustain culture and heritage through work, cultural activities and cultural artifacts.

Vocabulary

Culture	the sum total of ways of living built up by a group of human beings and transmitted from one generation to another
Cultural activities	any activities that people undertake that make up part of their culture

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What will people do on the spaceship

All of the people on spaceship will need to work together. They are likely to do specialised tasks which they are responsible for. They will need to teach people in the next generation what they do.

Ask the class to 'brainstorm' all of the different things that people do and write them on the whiteboard. Students might like to think what their parents, grandparents and other relatives do.

From that full list ask the students to write down which ones will be needed on the Spaceship on their blank worksheets

Q: What types of work will be done on the spaceship?

Areas of work	Examples
Cooking and cleaning	'Housework'– cooking, cleaning
Farming and food	growing, processing food
Equipment	machinery operators, technicians (making and fixing), programmers,
Management	planners, leaders, supervisors, reporting
Childcare and education	carers, teachers
Healthcare	doctors, dentists, nurses, gym trainers, massage, chemists
Buildings	builders, plumbers, engineers
Entertainers	musicians, actors, directors
Experts & Academics	astronomers, scientists, technicians
Merchants	storekeepers, shopkeepers
Transport	spaceship crew, navigators, captains, freight,
Justice	Police, judges, courts, prisons
Other	

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Worksheet: What work will people do on the spaceship?

Areas of work	Examples

What cultural activities will occur on the spaceship?

Everything we do is part of our culture, including work. Ask the students to think about the types of things that people do other than work and write them up on the whiteboard as they are called out.

What other things than work will people do on the spaceship?

Types	Some examples
Sports and exercise	sports, gym, jogging, swimming, yoga, biking,
Ceremonies and rituals	weddings, church, graduations, powhiri, funerals/tangi
Socialising	parties, sharing meals, dating, 'going out', visiting friends/family, events
Entertainment	plays, movies, music, TV, radio, books, internet
Education	classes, learning, teaching, training, seminars/talks, books, internet
Hobbies	collecting, making things,
Holidays	travel, camping, sightseeing, hiking,
Play	board/card games, computer games, darts, make-believe games
Art and heritage	exhibitions, symposia, performances, classes, museums,
Other	
Paid work	see previous section
Unpaid work	housework, gardening, volunteering, childcare, shopping

Sustaining culture

Ask students to think about all the ways in which people sustain their culture and heritage.

What will need to be take to sustain their culture?

	Examples and notes
Photos	Photo albums, camaras
Art	Paintings, sculpture
Music	Music CDs, instruments, sheet music, songbooks
Artifacts	Memorabilia,
Movies	DVDs, video cameras,
Books	Books, magazines
Decorations	Ornaments
Personal items	Jewellery, accessories,
Other	

Homework

Tell five of your family members (grandparents, parents, brothers/sisters) about Spaceship Earth. (Try to get at least one from each generation if possible so that you can compare them). Ask each person what three things they would take on Spaceship Earth to remind them of their home and culture.

Who	What
Example:	Example:
Grandad	1. Sports awards 2. Favourite mug 3. Scrapbook
1	1 2 3
2	1 2 3
3	1 2 3
4	1 2 3
5	1 2 3

Q: What conclusions can you make from your research (write on the back if you need to):

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Population

Learning objectives

Students will learn:

- that the more people there are the more resources like food, water and materials are needed
- basic concepts around sustainable populations – biocapacity vs ecological footprint
- levels of consumption vary from population to population.

Module plan

Part 1	• Go over the vocabulary that will be used • Focusing question: What factors will affect the population on the Spaceship • Read 'Population' to the class and discuss • Activity: World Population
Part 2	• Read 'Population and consumption' and discuss • Activity: Population and consumption
Part 3	• Read Ecological Footprint and discuss • Activity: Ecological footprint
Homework	• Essay

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Curriculum achievement objectives

Social Sciences: Social studies: Understand how people make decisions about access to and use of resources.			
Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of how different populations have different types and levels of consumption of resources and natural services.	Can express a clear understanding of how different populations have different types and levels of consumption of resources and natural services.	Can express a basic understanding of how different populations have different types and levels of consumption of resources and natural services.	Expresses an inaccurate and/or limited understanding of how different populations have different types and levels of consumption of resources and natural services.

Vocabulary

Population	A population is a group of the same organisms (e.g. people) in a given place.
Population density	Population density is a measure of the number of organisms in a given area. For people it is usually measured in people per square kilometre.
Resources	Resources are things, usually of limited availability, that helps organisms survive. Examples are: water, energy, air, food/nutrients, soil, materials etc.
Consumption	This is the amount of resources that are consumed (used or wasted).
Biocapacity	Biocapacity is the population size of a species that the environment can sustain indefinitely, given the resources (food, habitat, water and other necessities) available in the environment.
Ecological footprint	Ecological footprint the amount of land an organism (person) requires as a to sustain their consumption (including the absorption of wastes).
Sustainability	Is when ecological footprint is equal to or less than biocapacity.
Unsustainability	Is when ecological footprint is greater than biocapacity.

The number of people on the Spaceship

We need to work out how many people will go on the Spaceship. There are a number of factors to consider when making this decision. Discuss with the class the factors will affect the population of the Spaceship.

What are the factors that will affect the number of people on the spaceship?

Factors	Examples and notes
Amount of resources available	Carrying Capacity (Biocapacity) The number of people will be limited by the supply of resources (food, energy, water, air, materials). What happens if some people eat more than they should? The amount of resources is affected by the size of the spaceship.
Size of the spaceship	Ecological Footprint and population density In this project the size of the spaceship is being determined based on the number of people. However the rule is that the spaceship cannot be bigger than 2.1 ha/person. We will calculate the maximum size of the spaceship later.
A 'range of people'	Demographics There will need to be a range of people – gender, ages, occupations.
What needs to be done	Culture and work In Module 8 students decided what needs to be done. We need to ensure that there are enough people on the spaceship to fill all the roles necessary to sustain it.
What is sustainable?	Population dynamics Birth rate, death rate and migration rate (the spaceship is a closed system so there will be no migration). What happens if more people are born than planned? Or die? Will there need to be contingency for this?

Population

A 'population' is a group of organisms of the same species. It is normally measured as the number of organisms. For humans it is usually given as the number of people in a particular area or place – like a town, region, country or for the whole world.

Table 9.1: World Population	
Year	World Population (millions of people)
1750	791
1800	978
1850	1,262
1900	1,650
1950	2,521
2000	5,978
2050	8,909

Demographics

On earth human populations are very diverse and to help society to make good decisions it is useful to count other characteristics than just the total number of people. These other sets of measurements are called Demographics (or demographic data). Commonly-used demographics include gender (sex), race, nationality, age, income, disabilities, education and employment.

What different demographic groups will be on Spaceship Earth?

Population density

Another aspect of population that affects planning and decision-making is population density.

Population density is the number of people in a given area and is measured in number of people per square kilometre.

A city has many people in a small area and therefore has a much higher population density than in the countryside where there are fewer people in a much larger area. Also, some cities have higher densities than others and some countries have higher densities than others (see Table 9.2 for examples).

Table 9.2: Population density of selected countries	
Country	Density (people/km^2)
New Zealand	15.95
Australia	2.87
USA	31.99
Japan	337.57
Singapore	7,022.81
India	356.93
United Kingdom	253.74

Overpopulation

In nature when population densities are too high the number of deaths (called the mortality rate) will increase because there are not enough resources – like food – to sustain them. When the population is too high for the available resources to be able to sustain it, it is called overpopulation.

When population densities are low birth rates increase because there are plenty of resources available. Sometimes if densities are very low, it may lead to extinction though because organisms cannot 'find' each other to reproduce.

Humans are a bit different because we can make decisions about how many births (and deaths) to have.

The human population

In the past 250 years the world's population has grown considerably. Advances in technology, farming and medicine have led to increased birth rates and decreased mortality rates. The question is: can the world sustain this many people indefinitely?

We can answer this question if we know two things:

1. What the earth's biocapacity is, and
2. What the average Ecological Footprint for each person is.

We will discuss these soon.

Population dynamics

Carrying capacity

The supportable population of a particular organism, given the food, habitat, water and other necessities available within an environment is known as the environment's carrying capacity for that organism.

Carrying capacity is thus the number of individuals an environment can support without significant negative impacts to the given organism and its environment. A factor that keeps population size at equilibrium is known as a regulating factor.

Population size changes because of three things: fertility rate, mortality rate and net migration rate.

Fertility rate	The ratio of live births in an area to the population of that area; expressed as births per 1000 population per year. Also known as Birth Rate.
Mortality rate	The ratio of deaths in an area to the population of that area; expressed as deaths per 1000 population per year. Also known as Death Rate.
Net migration rate	The difference between the number of people moving into an area/country (immigration) and people moving out of the area/country (emigration); expressed as migrants per 1000 population per year. A positive value represents more people entering the country than leaving it, while a negative value mean more people leaving than entering it.

Natural increase

The difference between the birth rate and the death rate is the "natural increase."

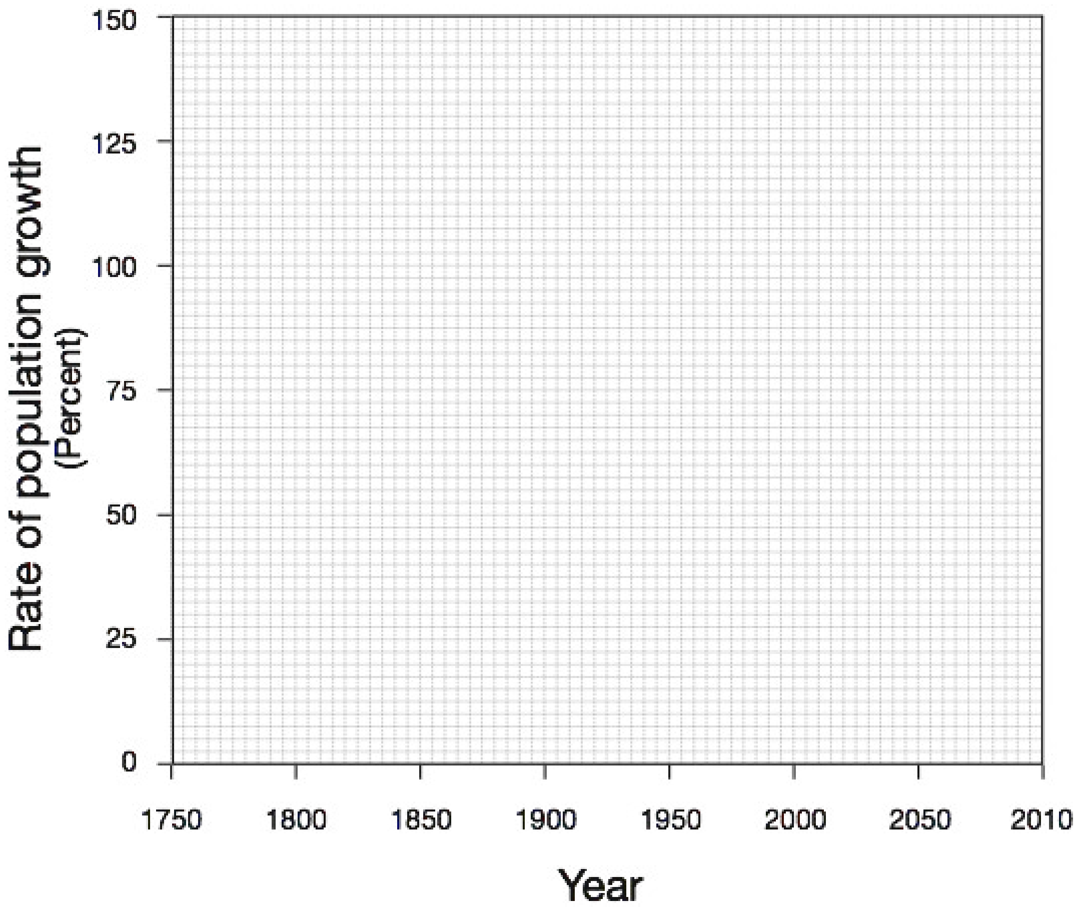
Below carrying capacity, populations typically increase, while above, they typically decrease. Population size decreases above carrying capacity due to a range of factors depending on the species concerned, but can include insufficient space, food supply, or sunlight. The carrying capacity of an environment may vary for different species and may change over time due to a variety of factors, including: food availability, water supply, environmental conditions and living space.

Activity: World population growth

1. Calculate the percentage growth in world population from 1750 until 2050.

Year	World Population (millions of people)	Rate of increase (percent)
1750	791	–
1800	978	24%
1850	1,262	29%
1900	1,650	31%
1950	2,521	53%
2000	5,978	137%
2050	8,909	49%
2100		

2. In the space below create a line graph of the data in the table above.



3. What will the world population be in 2100 if the trend continues? Discuss first, extrapolate the graph and then calculate the population and put it in the table.

Population and consumption:

Consumption is the amount of 'resources' used by people. Resources are things are things like food, energy, water and building materials.

Consumption is not the same everywhere, some people consume more than others. You can see in Table 9.3 (to the right) that the richest people consume much more meat, fish, energy and paper than poor people.

Consumption is measured in different ways. One way that many countries use is to measure production. The idea being that whatever is produced is consumed (in other words: used or wasted). The most common measure is known as GNP, which stands for Gross National Product.

You can see from the Table 9.3 that GNP amongst the world's richest people is 60 times more than the world's poorest people.

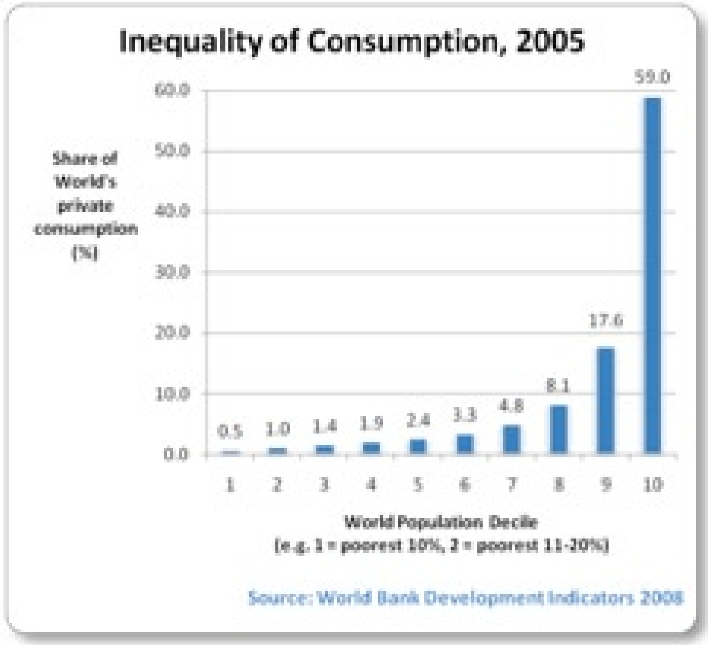
The graphs on this page show similar information.

Discuss

Table 9.3:
Differences between the richest and poorest people

Share of:	Richest 20%	Poorest 20%
World Population	1.2 billion	1.2 billion
World GNP	82.7%	1.4%
World trade	81.2%	1.0%
Commercial bank loans	94.6%	0.2%
Meat and fish	45%	5%
Energy consumption	58%	4%
Paper consumption	84%	1.1%
Telephone lines	74%	1.5%

Source: UNESCO
http://www.unesco.org/education/tlsf/TLSF/theme_b/uncofrm_b.htm



Graph source: Global Issues
http://www.globalissues.org/article/26/poverty-facts-and-statsuncofrm_b.htm

Activity: Population and consumption

Read the story below and answer the questions that follow:

1 Ask students to reach a conclusion about the use of energy and resources in different societies.

Ask what the world would be like if everyone consumed as much as the richest people. Would the earth be able to support this? What would our lives be like if we lived a lifestyle similar to indigenous populations or other people living in developing and undeveloped countries?

2 Will there be fair and equal consumption on Spaceship Earth? Why?

YES / NO

Ecological footprint

Another way to measure human consumption is the measurement of ecological footprint.

The Ecological Footprint measures humanity's demand in terms of the area of biologically productive land and sea required to provide the resources we use, and to absorb our waste.

The footprint of a country includes all the cropland, grazing land, forest, and fishing grounds required to produce the food, fibre, and timber it consumes, to absorb the wastes emitted in generating the energy it uses, and to provide space for its infrastructure (buildings, roads, ports, houses, etc).

Table 9.4
Ecological Footprint 2005 (global hectares per person)

	Area used for:	New Zealand	World
Cropland	growing crops	0.73	0.64
Grazing land	grazing animals	1.90	0.26
Forest land	timber, paper, pulp, fireword	0.99	0.23
Fishing grounds	catching fish	1.70	0.09
Built-up land	buildings, houses, roads, factories etc	0.17	0.07
Carbon*	offsetting CO2 emissions from fossil fuels	2.22	1.41
Total		7.70	2.70
Biocapacity	Total supply of productive land	14.10	2.10
Reserve/Deficit	This is the amount of land left over	6.40	-0.60

Source: World Wildlife Fund – Living Planet Report 2008

Ecological footprint is measured in global hectares (gha). Different land in different places has different ability to produce resources. To make it easier we average the land's productivity, so a global hectare is a hectare with world-average ability to produce resources and absorb wastes.

Also people consume resources and ecological services from all over the world, so their footprint is the sum of these areas, wherever they may be on the planet.

The World's Ecological Footprint

In 2005 the global Ecological Footprint was 17.5 billion global hectares, which when divided by 6.48 billion people means there is 2.7 global hectares per person.

The total supply of productive land and fishing grounds (or biocapacity) in 2005 was 13.6 billion global hectares, or 2.1 global hectares per person.

Humanity's footprint first grew larger than global biocapacity in the 1980s; this overshoot has been increasing every year since, with demand exceeding supply by about 25 per cent in 2005. This means that it took approximately a year and three months for the Earth to produce the ecological resources we used in that year. Another way of saying this is that we need 1.25 worlds to supply our needs.

New Zealand's Ecological Footprint

New Zealand has the sixth highest footprint in the world. Our footprint is 7.7 gha per person. If everyone in the world had the same footprint as us we would need 3.7 worlds to supply our needs!!! New Zealand has plenty of biocapacity though so as a country we have a reserve of land.

Class activity: Ecological Footprint

Length: 60 minutes

Learning Objectives:

Students will gain a perspective on comparative consumption habits in developing and developed countries and the effect that mass consumption has on natural resources and on the Ecological Footprint of a country and an individual. Students will be able to:

1. Describe some cultural and social differences between people living in developed and underdeveloped countries.
2. Compare the use of resources between these two types of societies.
3. Identify some ways in which humans positively and negatively affect the environment.
4. Recognise problems associated with human use of natural resources.

Teacher Preparation:

Print enough copies for individuals or groups of students of the following documents:

- Living Planet Report 2008 (Pages 14 and 15 with the Ecological Footprint information – copies at the end of this guide)
- Have students bring in several pictures of typical scenes and activities of western lifestyle, as well as contrasting pictures of indigenous populations or people living in developing countries.

Outline

Reading (20 minutes)

As a class read "Ecological Footprint" (Page 8) and study the graphs from pages 14 and 15 of the Living Planet Report. Students will learn that a person or country's ecological footprint is based on the amount of natural resources directly or indirectly consumed combined with the amount of pollution produced.

Questions (40 minutes)

In small groups, using the two pages from the Living Planet Report, ask the students to answer the following questions.

1. Which countries emit the most CO_2? (Specific countries or high, medium, low income countries)
2. Which countries have the largest ecological footprint? (Specific countries or high, medium, low-income countries)
3. Do you see a correlation between a country's wealth, CO_2 emissions, and the size of its ecological footprint?
4. How do consumption habits in different countries affect their ecological footprint?
5. Is it possible for New Zealander's to live a sustainable lifestyle (with a manageable ecological footprint) in a modern world using modern technology? If so, how? (What kind of changes will this require? How would our average lifestyle change?)

Homework:

Essay

Students can write essays or letters to the editor describing their thoughts on inequity in the use of natural resources, waste production, and pollution production around the world. How do lifestyles in one part of the world affect people living in other parts of the world? Who should be responsible and accountable and how?

Citizenship

Learning objectives

Students will learn

- For a community to be able to sustain itself there must be rules (laws, regulations, official protocols, etc) which each individual must adhere.
- People must get along and when there is conflict of interests these must be managed

Module plan

Part 1	• Discussion: What is Citizenship? • Activity: What are the values, attitudes and skills of a good citizen
Part 2	• Discussion: Getting along on Spaceship Earth • Activity: Getting along
Part 3	• Discussion: Decision making on Spaceship Earth? • Activity: Decision making styles
Homework	• A Good Citizen

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Curriculum achievement objectives

Social Sciences: Social studies: Understand how people participate individually and collectively in response to community challenges			
Excellent	Merit	Achieved	Not achieved
Can express a thorough & accurate understanding of how people can participate individually and collectively in response to community challenges	Can express a clear understanding of how people can participate individually and collectively in response to community challenges	Can express a basic understanding of how people can participate individually and collectively in response to community challenges	Expresses an inaccurate and/or limited understanding of how people can participate individually and collectively in response to community challenges

Vocabulary

Citizen	A citizen is a member of a social, political or national community who enjoys the rights and assumes the duties of membership.
Citizenship	Citizenship is the state of being a citizen of a particular social, political, or national community. Citizenship status, under social contract theory, carries with it both rights and responsibilities. "Active citizenship" is the philosophy that citizens should work towards the betterment of their community through economic participation, public service, volunteer work, and other such efforts to improve life for all citizens

Citizenship education

Citizenship education involves a wide range of different elements of learning, including:

- knowledge and understanding:
- e.g. about topics such as laws and rules, the democratic process, the media, human rights, diversity, money and the economy, sustainable development and world as a global community; and about concepts, such as democracy, justice, equality, freedom, authority and the rule of law;
- skills and aptitudes:
- e.g. critical thinking, analysing information, expressing opinions, taking part in discussions and debates, negotiating, conflict resolution and participating in community action;
- values and dispositions:
- e.g. respect for justice, democracy and the rule of law, openness, tolerance, courage to defend a point of view, and a willingness to listen to, work with and stand up for others.

It is artificial to try to separate out the learning of skills from knowledge, knowledge from values and so on. In practice, they are generally learned simultaneously rather than in isolation. For example, in presenting and explaining the findings of a survey to local council officials, young people will be building up their knowledge of local government and its functions at the same time as honing their skills of presentation.

The most effective form of learning in citizenship education is:

- active: emphasises learning by doing;
- interactive: uses discussion and debate;
- relevant: focuses on real-life issues facing young people and society;
- critical: encourages young people to think for themselves;
- collaborative: employs group work and co-operative learning;
- participative: gives young people a say in their own learning.

Learning of this sort requires a certain kind of climate in which to flourish – an environment that is non-threatening, in which young people can express their opinions freely and without embarrassment and use their initiative without undue fear of failure. Such a climate takes time to develop and is built up gradually.

What is citizenship?

Discuss what citizenship might mean.

Social Justice and Equity:	• Indentifying rights and responsibilities • Understanding the causes and effects of the inequalities within and between societies
Diversity	• The benefit of different cultures, values and beliefs • The benefits and strengths of a diverse natural environments
Globalisation and interdependence	• Awareness of interdependence within and between countries • World economic systems
Sustainable development	• Relationship between people and the environment • What is a sustainable lifestyle
Peace and conflict	• Causes and effects of conflict – locally and globally • Conditions conducive to peace

What are the values, attitudes and skills of a good citizen?

Traits	Examples and notes
Critical thinking	• Making informed decisions • Detecting bias and opinion
Ability to communicate	
Ability to challenge injustice and inequalities	• Concern for injustice and inequality
Respect for people	• Compassion and empathy • Sensitivity to the rights and needs of others • Having a sense of common humanity
Co-operation and conflict resolution	
Respect for diversity	• Respecting the rights of all to have an opinion • Valuing all people as equal and different
Concern for the environment	
Taking responsibility	

Getting along

Preventing conflict

Prevention is better than cure and most conflict is easily prevented if people can manage the way they get along with each other. There are a number of individual skills. Ask the students to think about ways in which people could get along better – and provide examples.

How will people get along better on Spaceship Earth?

Skills	Students to provide examples
Be kind	
Use polite words	
Listen carefully	
Think first	
Respect everyone	
Take turns	
Be honest	
Help others	
Share things	
Do your best	
Be patient	

Activities

1 In groups of 3-4, students could write and perform a short (2 minute) role play that highlights one of the traits above.

2 Students could pick one of the traits above and design a poster that will teach the skill to others. Posters could stuck to the wall for everyone to see.

Decision making on Spaceship Earth

Overview:

Part of being a good citizen is getting involved in the decision-making process. Important decisions that affect everyone on Spaceship Earth should be made with the input of everyone on the Spaceship.

There is often more than one different ideas (e.g. to solve a problem) which may conflict.

Everyone is different and different people use different styles, or combination of styles, when they need to agree on a decision.

Conflict

It is our perception of the situation that determines if a conflict exists. It is useful to assess our predominant conflict management style(s) because we tend to get stuck in one or two styles and apply them inappropriately. The emphasis is not on judging any style right or wrong because they may all be useful in different circumstances.

Objectives:

Identify personal management style/s, develop awareness of strategies used in conflict management style/s.

Decision-making styles

Name	Description	When this style is used
Shark	Competing **Is assertive and uncooperative** An individual pursues his or her own concerns at the other person's expense. This is a power oriented mode in which one uses whatever power seems appropriate to win ones own position.	• When you know you are right. • When you need a quick decision. • When you meet a steamroller type of person and you need to stand up for your own rights.
Koala Bear	Accommodating **Is unassertive and uncooperative** This is the opposite of competing. When accommodating, an individual neglects his/her own concerns to satisfy the concerns of the other person. There is an element of self-sacrifice in this mode.	• When the issue is not so important to you but it is to the other person. • When you discover that you are wrong. • When continued competition would be detrimental - "you know you can't win." • When preserving harmony without disruption is the most important - "it's not the right time."
Turtle	Avoiding **Is unassertive and cooperative** When a person does not pursue her/his own concerns or those of the other person. He/she does not address the conflict, but rather sidesteps, postpones or simply withdraws.	• When the stakes aren't that high and you don't have anything to lose - "when the issue is trivial." • When you don't have time to deal with it. • When it's not the right time/place. • When more important issues are pressing. • When you see no chance to get your concerns met. • When you have to deal with an angry person. • When you are totally unprepared, taken by surprise, and you need time to think and collect information. • When you are too emotionally involved and others around you can solve the conflict successfully.
Owl	Collaborating **Is both assertive and cooperative** This is the opposite of avoiding. Collaboration involves an attempt to work together to find some solution which fully satisfies the concerns of both persons. It includes identifying the underlying concerns of the two individuals and finding an alternative which meets both sets of concerns.	• When other's lives are involved. • When you don't want to have full responsibility. • When there is a high level of trust. • When you want to gain commitment from others. • When you need to work through hard feelings, animosity, etc. **The best decisions are usually made by collaboration.**
Fox	Compromising **Is intermediate in assertiveness & cooperativeness** The objective of compromise is to find a quick, mutually acceptable solution which partly satisfies both parties. It falls in the middle group between competing and accommodating. Compromising 'gives up' less than accommodating.	• When the goals are moderately important and not worth the use of more assertive modes. • When people of equal status are equally committed. • To reach temporary settlement on complex issues. • To reach expedient solutions on important issues. • As a back-up mode when competition or collaboration don't work.

Adapted from:
http://www.eduref.org/cgi-bin/printlessons.cgi/Virtual/Lessons/Social_Studies/Psychology/PSY0003.html

Homework

A Good Citizen

Find a story in a newspaper or magazine about someone who you think has been a good citizen. Write a short (100 words) explanation of why you think they are a good citizen and what you have learned from their example.

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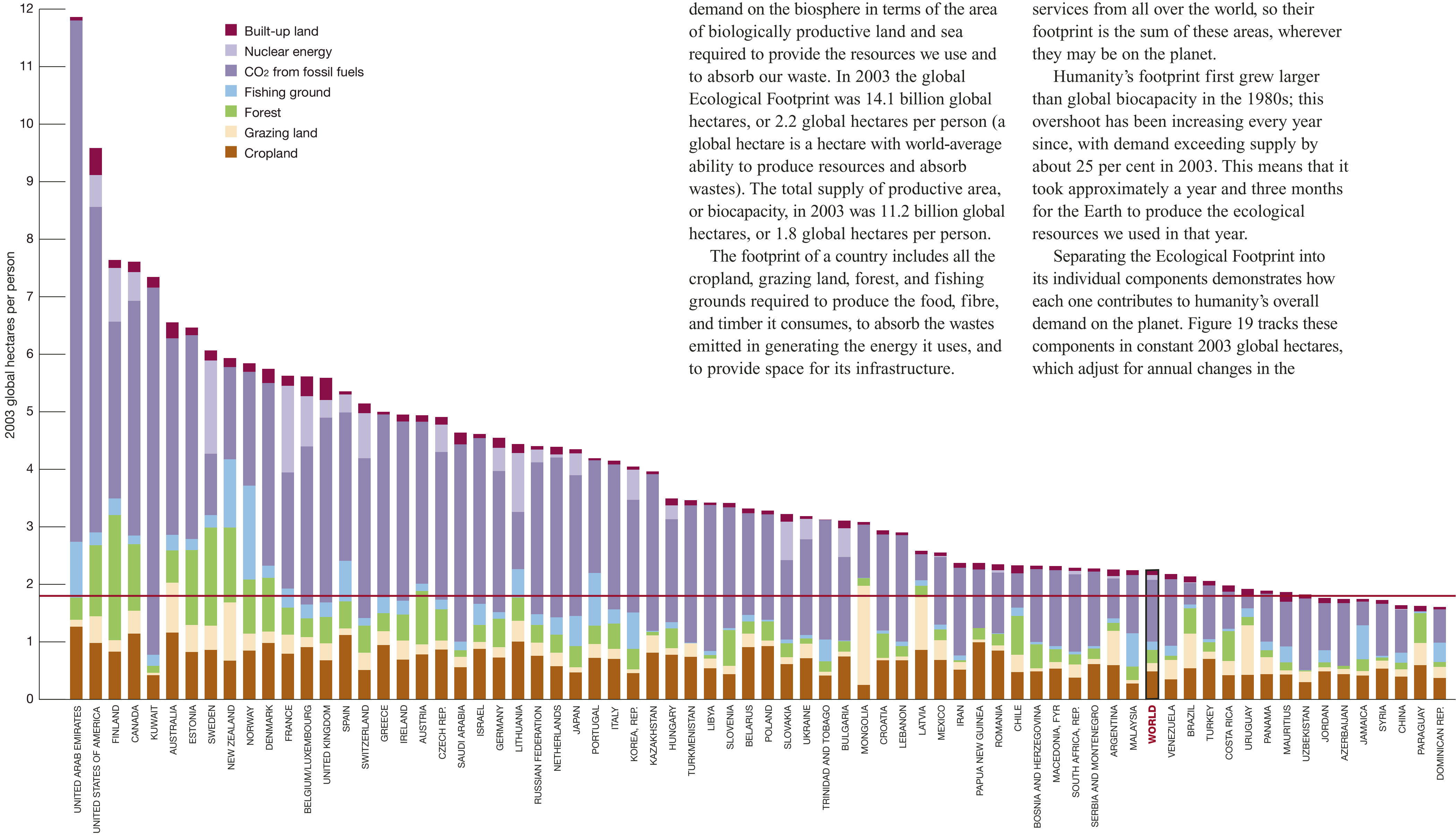
Fig. 18: **ECOLOGICAL FOOTPRINT PER PERSON, BY COUNTRY,** 2003



The Ecological Footprint measures humanity's demand on the biosphere in terms of the area of biologically productive land and sea required to provide the resources we use and to absorb our waste. In 2003 the global Ecological Footprint was 14.1 billion global hectares, or 2.2 global hectares per person (a global hectare is a hectare with world-average ability to produce resources and absorb wastes). The total supply of productive area, or biocapacity, in 2003 was 11.2 billion global hectares, or 1.8 global hectares per person.

The footprint of a country includes all the cropland, grazing land, forest, and fishing grounds required to produce the food, fibre, and timber it consumes, to absorb the wastes emitted in generating the energy it uses, and to provide space for its infrastructure.

People consume resources and ecological services from all over the world, so their footprint is the sum of these areas, wherever they may be on the planet.

Humanity's footprint first grew larger than global biocapacity in the 1980s; this overshoot has been increasing every year since, with demand exceeding supply by about 25 per cent in 2003. This means that it took approximately a year and three months for the Earth to produce the ecological resources we used in that year.

Separating the Ecological Footprint into its individual components demonstrates how each one contributes to humanity's overall demand on the planet. Figure 19 tracks these components in constant 2003 global hectares, which adjust for annual changes in the productivity of an average hectare. This makes it possible to compare absolute levels of demand over time. The CO_2 footprint, from the use of fossil fuels, was the fastest-growing component, increasing more than ninefold from 1961 to 2003.

How is it possible for an economy to continue operating in overshoot? Over time, the Earth builds up ecological assets, like forests and fisheries. These accumulated stocks can, for a limited period, be harvested faster than they regenerate. CO_2 can also be emitted into the atmosphere faster than it is removed, accumulating over time.

For three decades now we have been in overshoot, drawing down these assets and increasing the amount of CO_2 in the air. We cannot remain in overshoot much longer without depleting the planet's biological resources and interfering with its long-term ability to renew them.

Figure 18: The Ecological Footprint per person, by country. This includes all countries with populations greater than 1 million for which complete data are available.

Figure 19: Ecological Footprint by component. The footprint is shown in constant 2003 global hectares.

In both diagrams, and throughout this report, hydropower is included in the built-up land footprint and fuelwood within the forest footprint.

Fig. 19: **ECOLOGICAL FOOTPRINT BY COMPONENT,** 1961–2003