keep it simple science
ABN 54 406 994 557

PO Box 2575
PORT MACQUARIE NSW 2444
(02) 6583 4333 FAX (02) 6583 9467
www.keepitsimplescience.com.au
mail@keepitsimplescience.com.au

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Photocopy Master Sheets

Years 9-10

Resources & Technology

Disk filename = "22.Resources"

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Topics Available

Year 7-8 General Science

Disk Filename	Topic Name
01.Energy	Energy
02.Forces	Forces
03.Matter	Solids, Liquids & Gases
04.Mixtures	Separating Mixtures
05.Elements	Elements & Compounds
06.Cells	Living Cells
07.Life	Living Things
08.LifeSystems	Plant & Animal Systems
09.Astronomy	Astronomy
10.Earth	The Earth
11.Ecosystems	Ecosystems

Year 9-10 General Science

Disk Filename	Topic Name
12.Waves	Wave Energy (inc. Light)
13.Motion	Forces & Motion
14.Electricity	Electricity
15.Atoms	Atoms & Elements
16.Reactions	Compounds & Reactions
17.DNA	Cell Division & DNA
18.Evolution	Evolution of Life
19.Health	Health & Reproduction
20.Universe	The Universe
21.EarthScience	Earth Science
22.Resources	Resources & Technology

Year 11-12 Science Courses

Biology

Preliminary Core
Local Ecosystem
Patterns in Nature
Life on Earth
Evolution Aust. Biota
HSC Core
Maintain. a Balance
Blueprint of Life
Search for Better Health
Options
Communication
Genetics:Code Broken?

Chemistry

Preliminary Core
Chemical Earth
Metals
Water
Energy
HSC Core
Production of Materials
Acidic Environment
Chem.Monit.&Mngment
Options
Shipwrecks, Corrosion...
Industrial Chemistry

Earth & Envir. Science

Preliminary Core
Planet Earth...
Local Environment
Water Issues
Dynamic Earth
HSC Core
Tectonic Impacts
Environs thru Time
Caring for the Country
Option
Introduced Species

Physics

Preliminary Core
World Communicates
Electrical Energy...
Moving About
Cosmic Engine
HSC Core
Space
Motors & Generators
Ideas to Implementation
Options
Quanta to Quarks
Astrophysics

All Topics Available as PHOTOCOPY MASTERS and/or KCiC

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Black & White, A4 portrait-orientation for clear, economical photocopying.

KCiC = Key Concepts in Colour
Full colour, formatted for on-screen study and data projection. PDF + Powerpoint®
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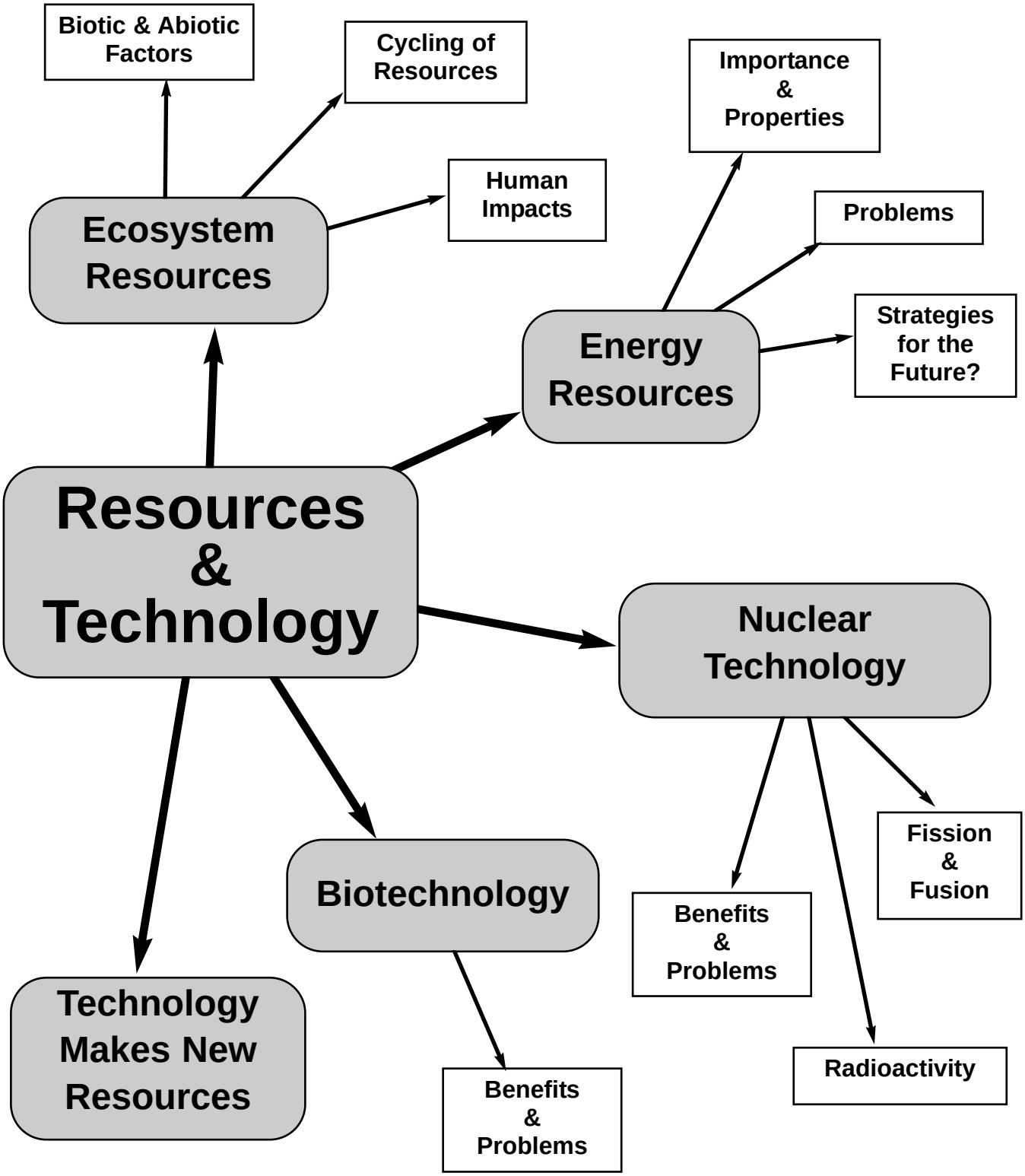
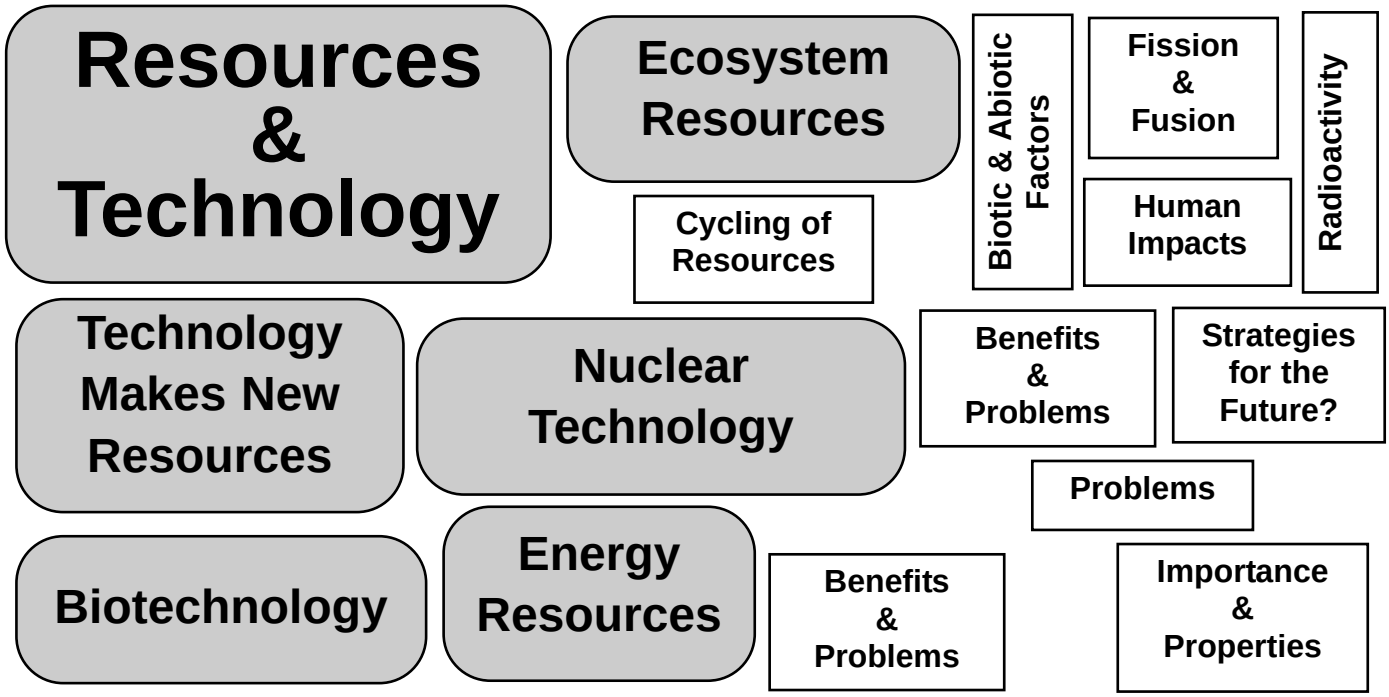
"Mind-Map" Outline of Topic

This topic does not belong neatly to any single discipline of Science.
It is a collection of quite different parts, with a common theme.



Make your own "Mind-Map" TITLE PAGE.
Cut out the boxes. Sort them into an appropriate lay-out on a page of your workbook, then glue them down. Add connecting arrows and colour in.



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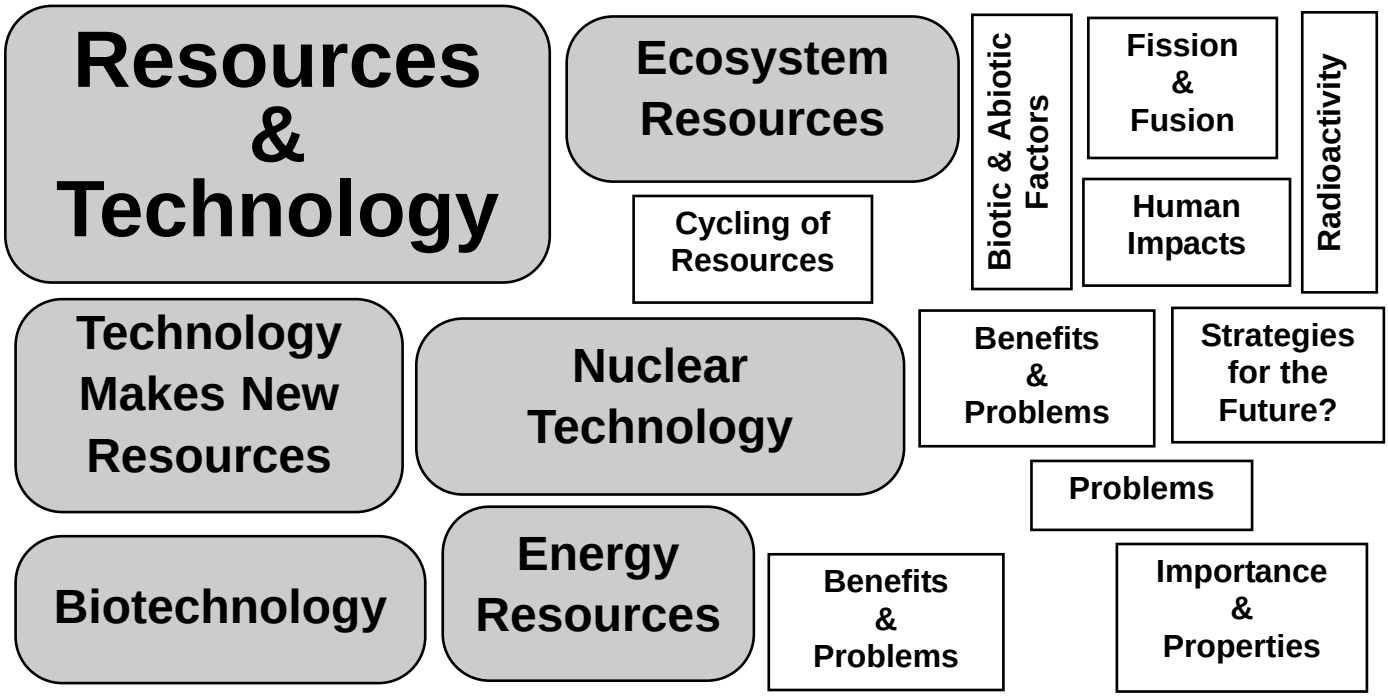

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Resources in an Ecosystem

Ecology is the study of living things and their environment.
An ecosystem is all the living things in a place, plus the physical environment in which they live.

An ecosystem can be as large or as small as you like. The whole Biosphere of the Earth is one ecosystem, or you might study just one little rockpool as an ecosystem.

One valley can be an ecosystem, or an entire continent... it just depends on how large, or small an area you want to study.

Every ecosystem requires resources, such as food, living space, shelter, oxygen and water.

These resources can be divided into 2 types.

Abiotic (Non-Living) Resources

Amount of Water

Amount of Light (e.g. for plants)

Amount of O_2 and CO_2 gases

Temperature Range

Soil Quality

All these things (and many more) can have a huge effect on which plants and animals can live in any particular ecosystem.

For example, no plants can live in a totally dark cave, or the deep ocean, because there is no light for photosynthesis.

Very few plants and animals can survive in a desert, or on an ice-cap because of the extreme temperatures and/or lack of water.

Biotic (Living) Resources

The "community" is all the living things within the ecosystem being studied. All the plants, animals and microbes are part of the community.

They all depend on each other, and interact with each other in many important ways.

Food

Animals need to eat other living things.
Examples:
- kangaroos eat grass.
- spiders eat insects.
- monkeys eat fruits.

Helpers

Many living things help each other to survive. e.g. plant flowers provide nectar to feed insects, birds, bats, etc. In return, these animals pollinate the flowers. This relationship is called "Mutualism".

Parasites & Diseases

Some living things are parasites and feed from others without killing them. Some microbes cause infectious diseases.

Competitors

Many living things face competition from other species that need the same food, or the same nesting sites, or the same living space. Competition is a life-or-death struggle.

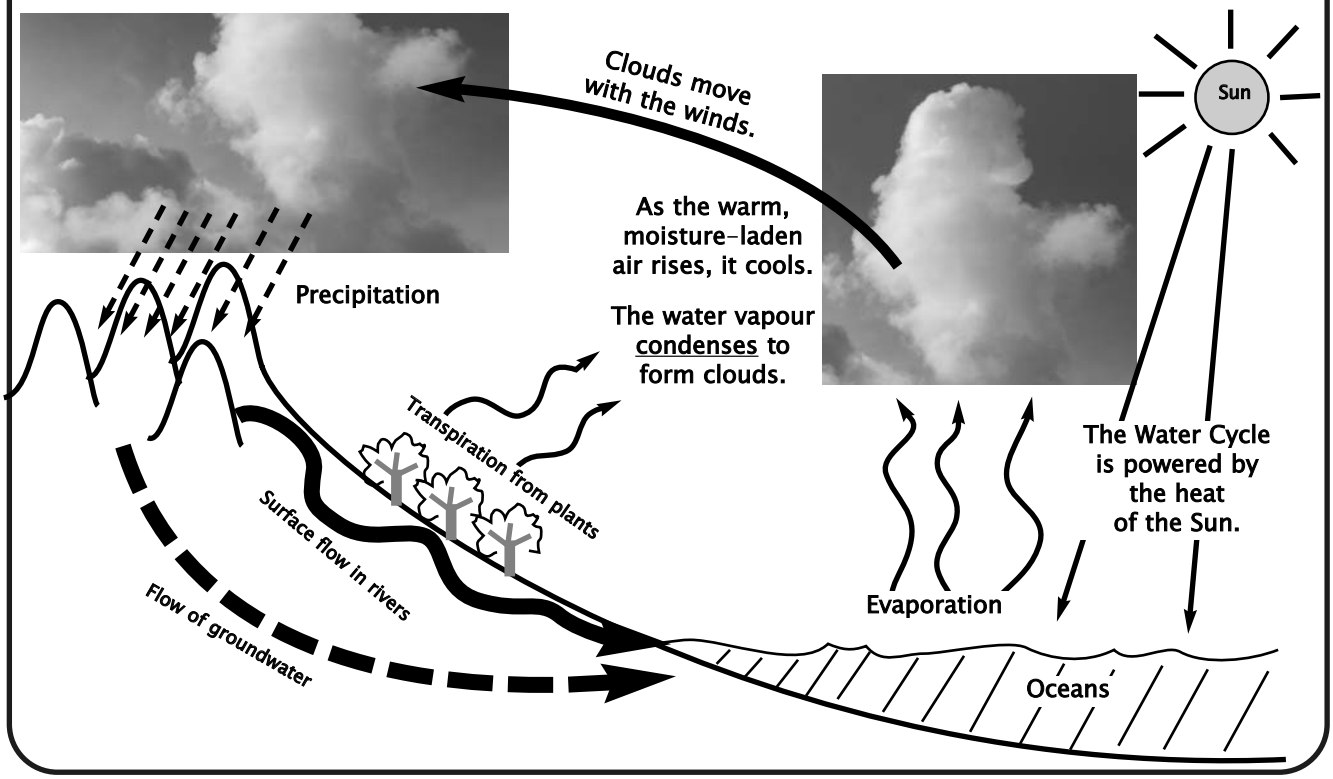
Resources (such as food) are essential for survival of any living thing in any ecosystem. Other factors might make life easier, or more difficult.

Cycling of Ecosystem Resources

In every ecosystem there needs to be a constant input of energy.
In most ecosystems, the energy input is the heat and light of the Sun.
Other resources, such as water, oxygen or calcium, are constantly re-cycled.

You should already know about

The Water Cycle

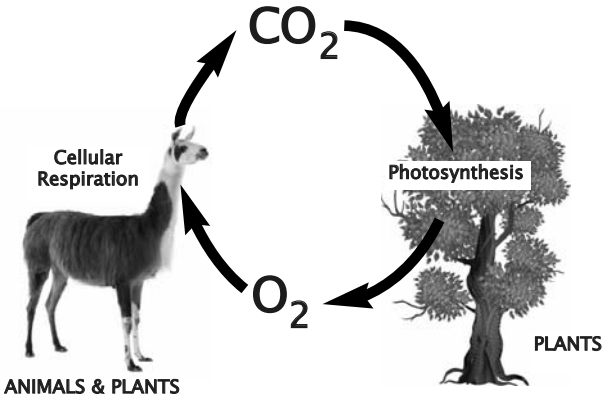


Cycling of Vital Chemicals

Many vital chemicals are constantly re-cycled in nature.

CO_2 & O_2 Cycle

The processes of photosynthesis and cellular respiration are connected by this well-known cycle.



Nitrogen

is cycled between N_2 gas in the atmosphere and nitrate ions (NO_3^-) in soil which is vital for plant growth. Animals excrete wastes such as Ammonia (NH_3) and urea which join the cycle.

Certain types of soil bacteria are involved in the conversions from one nitrogen chemical to another.

Other important substances which are re-cycled over and over include:

Phosphate, Sulfate, Calcium and Iron

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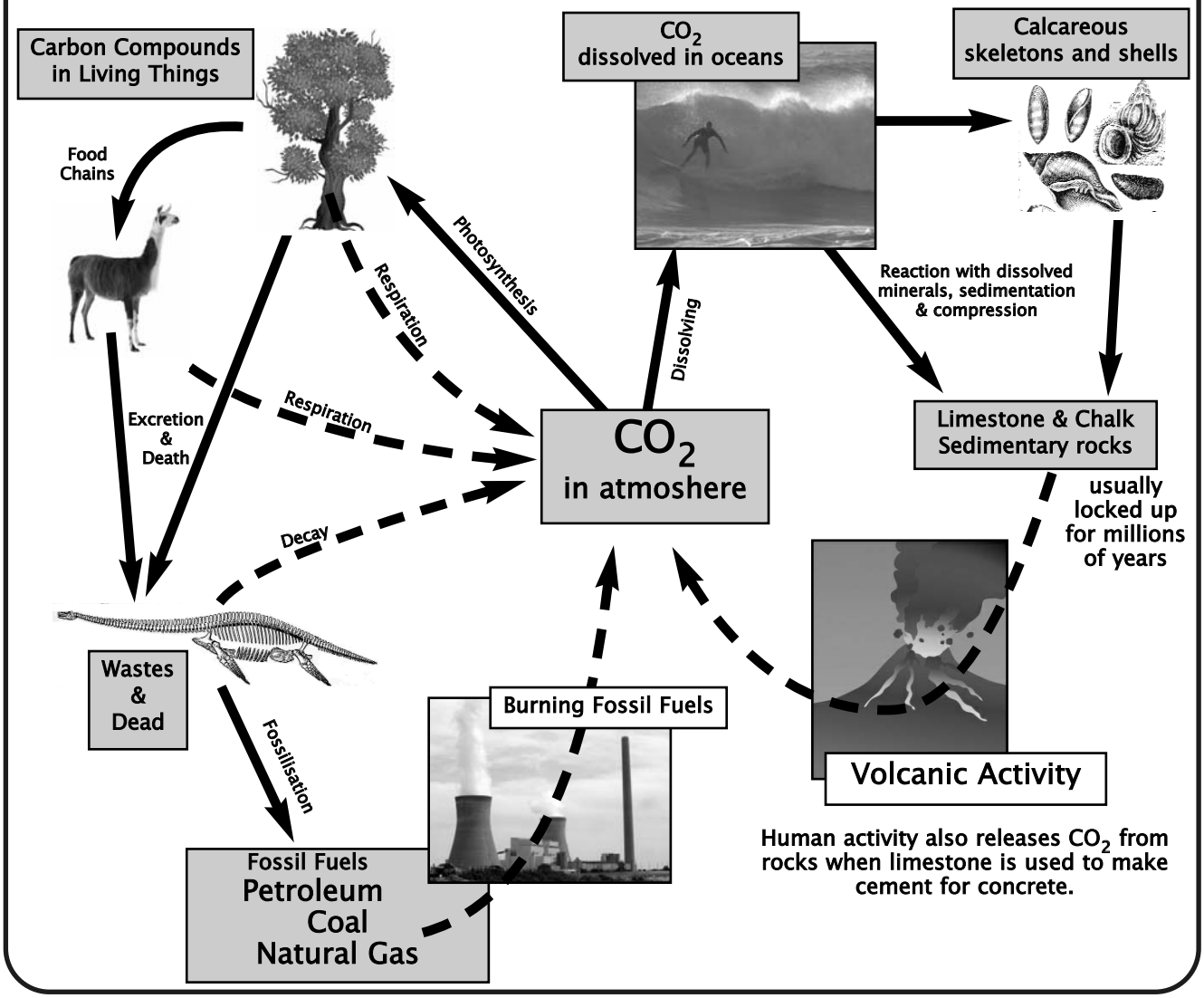
The Carbon Cycle

The CO_2 - O_2 cycle shown previously, is only a small part of a larger cycle which involves living things, the oceans, fossil fuels and even Plate Tectonics.



Human activity also releases CO_2 from rocks when limestone is used to make cement for concrete.

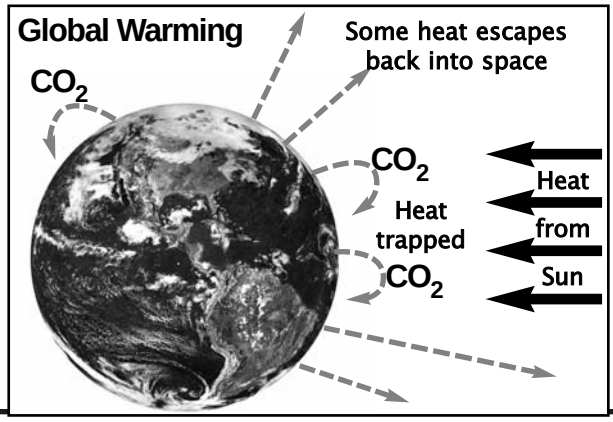
Carbon Dioxide, "Greenhouse" & Global Warming

Burning fossil fuels (coal, petroleum) produces huge amounts of CO_2. We know that the level of CO_2 in the air has increased significantly over the past 100 years or so.

Volcanic activity can also release huge amounts of CO_2 gas.

The Earth absorbs heat from the Sun, and the surface warms up. As the surface warms, some of the heat radiates back into space, so the Earth cools again.

CO_2 gas "traps" some of the heat which would normally escape into space. This "Greenhouse Effect" is now believed to be causing the whole world to warm up.



This "Global Warming" is causing climate change so that weather patterns may be disrupted and many natural environments may be destroyed over the next century.

The ice around the poles is beginning to melt. If the ice caps melted completely, the sea level could rise by more than 100m.

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Worksheet 1
Resources in Ecosystems

Student Name.....

Fill in the blank spaces.

Every ecosystem has certain needs, or requirements which can be divided into 2 groups:

a)..... resources are not alive. These include the amount of b)..... for photosynthesis, the amount c)..... and the important gases d)..... and .....

The e)..... resources are alive. Animals need plants or other animals for f)..... Many living things help each other. For example, many plants make g)..... in their flowers to feed insects, birds or bats. The animals help the plant by h)..... it.

In every ecosystem there has to be a constant input and flow of i)..... All the chemical resources, however, are j).....

The "Water Cycle" is driven by the k)..... Water l)..... into the atmosphere and then m)..... into clouds. Rain, hail or snow n)..... from the clouds. The cycle is completed by o).....

The Carbon-Oxygen cycle involves the cycling of gases p)..... and ..... between the processes of q)..... and cellular respiration. This is only a small part of the larger "Carbon Cycle". This includes CO_2 dissolving in the r)..... and ending up in s)..... rocks for millions of years. CO_2 is returned to the atmosphere by t)..... activity. The cycle also involves u)..... fuels.

Human use of coal & petroleum has increased the level of v)..... in the atmosphere. This is w)..... more heat, leading to x).....

Worksheet 2
Ecosystem Resources

Student Name.....

1. Divide these items into Abiotic and Biotic resources.
Temperature, water, food plant, sunlight, predator, disease germ, oxygen, prey, soil quality.

2. Apart from water, oxygen and CO_2, list 3 other chemicals which are constantly re-cycled in ecosystems.

3. List 2 main processes which <u>remove</u> CO_2 gas from the atmosphere.

4. List 3 <u>natural</u> processes which return CO_2 gas to the atmosphere.

5. How does CO_2 gas cause a "Greenhouse Effect"?

6. How might this affect ecosystems?

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Human Impacts on Ecosystems

Many human activities have important impacts on natural ecosystems. Some impacts affect living things directly, while others upset the natural re-cycling of vital chemicals such as CO_2 or phosphates. The "Greenhouse Effect" and Global Warming were already mentioned... here are some other serious human impacts.

Loss of Habitat

Very simply, humans clear forests, fill wetlands and divert streams to make room for our towns and cities and for our agriculture. For example, only about 3% of Australian rainforests remain, from those present 200 hundred years ago.

Clearing of natural environments is disaster for many species. They are specially adapted to their habitat and cannot survive elsewhere.

Eutrophication

Eutrophication **occurs when rivers and streams are over-fertilised by human sewerage and agricultural run-off.**

Although sewerage is treated to make it safe to the environment, the effluent still contains minerals which act as a fertiliser. Typically, the treated effluent from our sewer systems is discharged into waterways.

Similarly, when farmers use fertiliser on their crops and fields, some will eventually be washed into creeks and rivers during rainy weather.

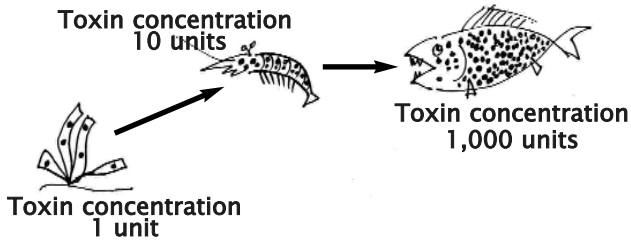
The result is that algae living in the waterways are stimulated to grow in over-abundance, often choking waterways and blocking light from other water plants. Later, great masses of algae die off and their decay uses up all the oxygen in the water, so that many fish and other organisms suffocate.

Biological Magnification

<u>Pesticides</u> and industrial poisons, even in very small amounts can build up in living communities by "biological magnification"...

***Example*: the level of a toxic chemical in a shrimp might be quite low, but a fish which eats many shrimp in a year ends up with a concentration of toxins 100 times higher... and so on up through the food chain.**

Biological Magnification



Scientists are currently alarmed by a world-wide decline in populations of <u>amphibians</u> (frogs & toads). It is suspected that various human-made chemicals are disrupting the reproduction and development of many species which are vital links in the food webs in many ecosystems.

Introduction of Alien Species

Many species from other places have been brought to Australia, either deliberatly or accidentally, and released. The list includes plants such as prickly pear, lantana and bitou bush, and animals such as rabbits, foxes, pigs, camels, and cane toads.

All of these species, and many others, have become major problems in the ecosystems.

Why Alien Species are Bad News

The "aliens" find themselves in an environment in which the normal predators and diseases are not present to keep their population in check.

They are often more ruthlessly efficient in using resources, and so they "out-compete" the natives.

Many ecosystems around the world are being disrupted by "alien" species introduced by humans.

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Balancing Human Needs With Ecosystems

Is it possible to balance human needs and activities with the natural ecosystems? Can we continue to enjoy modern lifestyles, while also preserving and protecting ecosystems in a sustainable way? On this page are some of the basic strategies which are already possible, or are being implemented and need to be continued and extended.

Ecological Flows in Streams

Many of our rivers are dammed for hydro-electricity and/or irrigation schemes. So much water is extracted from streams, that there is not enough water still flowing to sustain the river and wetland ecosystems.

Scientists can help by developing crop varieties which need less irrigation. Farmers can help with farming methods that use water more efficiently.

Wildlife Refuges & Corridors

Farmers and land owners are now finding that is in their best interests to keep patches of forest on farmland, or re-plant native vegetation on non-productive land. This can often help preserve populations of native birds and insects which help keep pest species in check.

Corridors of natural scrub and bush allow native species to move or migrate without having to cross totally cleared crop or grazing land. This helps species to find mates and new territories and maintain genetic diversity, instead of becoming isolated and "in-bred". As you know from other topics, genetic diversity is essential for survival of a species.

National Parks & Nature Reserves

Native species are protected by our National Parks system. Professional scientists and rangers monitor the populations, control alien pest species, repair environmental damage and study the ecosystems to learn how to preserve them better.

We must continue to support the National Parks and vote for government leaders who will allocate funds to maintain existing parks and create new protected areas.

Sewerage Treatment

Modern sewerage systems are capable of treating wastes so thoroughly that the water is safe for re-cycling. This helps reduce water usage as well as ensuring that the material discharged back into the environment will not cause eutrophication. Unfortunately, not all communities have installed modern systems yet.

Laws to Protect Environments

Compared to (say) 50 years ago, there are now many laws to help prevent pollution which used to poison ecosystems by (for example) Biological Magnification of toxic chemicals.

Dangerous pesticides have been banned, petrol with lead additives removed from sale and industries are not permitted to discharge smoke, acidic or toxic gases, etc.

These standards must be maintained, and extended to protect ecosystems for all time.

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Worksheet 3

Human Impacts & Conservation

Student Name.....

Fill in the blank spaces.

Apart from "Global Warming", many other human activities have serious impacts on ecosystems.

We clear land for agriculture and towns. This results in loss of a)..... Many species are specially b)..... to their environment and cannot live elsewhere.

Pesticides and other pollutants can accumulate by "c)..... ....." through food chains.

"d)....." occurs when sewerage and farm run-off over-fertilises streams and causes overgrowth of e).....

Introduced species disrupt ecosystems because they f)..... with native species and they over-populate because their normal g)..... and ..... are not present.

Some of the strategies that help protect ecosystems are:

Ensure h)..... flow in streams by releasing water from dams and limiting the amounts taken for i).....

Maintain and enlarge our system of j)..... Parks. These help protect k)..... species and control l)..... species.

Encourage the planting of wildlife refuges and m)..... to allow native species to n).....

Modern o)..... systems can reduce cases of eutrophication.

Continue to enforce p)..... which protect the environment.

Worksheet 4
Human Impacts

Student Name.....

1.
What's so bad about humans clearing land? If native animals lose their habitat, why can't they just go and live somewhere else?

2. One of the worst ecological problems in New Zealand is a large, damaging population of Australian possums. Why are they a problem in NZ, when they're no problem in Oz?

3. **Years ago near Minamata, Japan, a factory was discharging very low levels (so low it was thought to be safe) of <u>mercury</u> into a bay. The people around the bay often ate the fish they caught. Later, many people suffered from mercury poisoning. The levels in their bodies were thousands of time higher than the levels discharged. (Mercury poisoning is now called "Minamata Disease".)**

a) What process was happening in the ecosystem?

b) Explain how the concentration of mercury may have increased.

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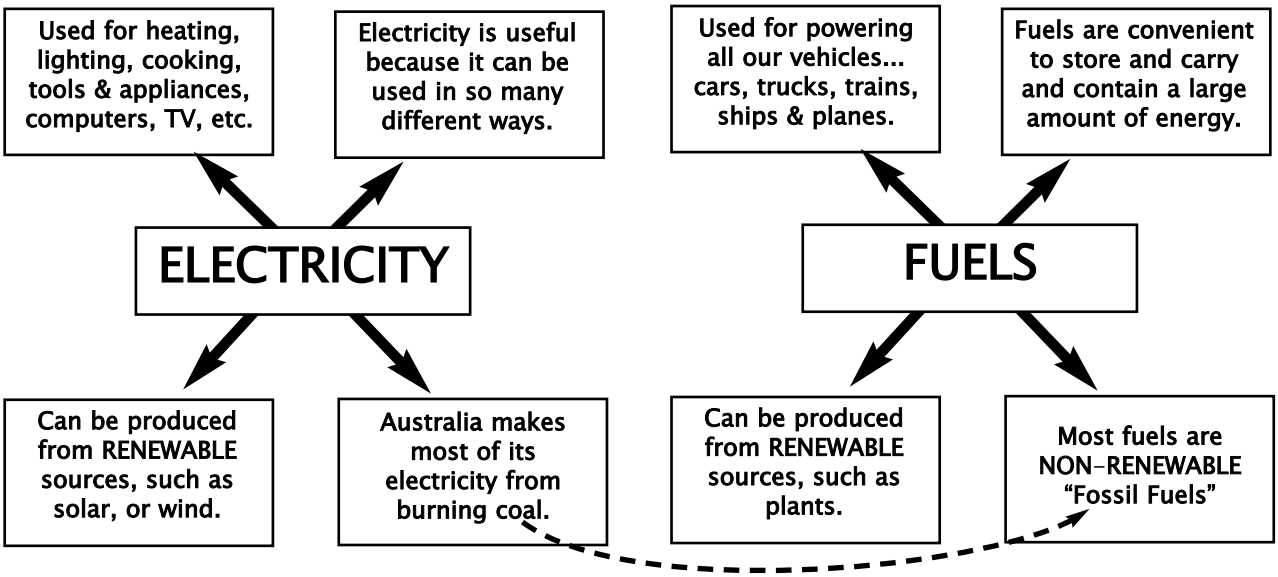
Energy Resources for Society (Revision)

Our society depends on energy for our homes, factories, transport & commerce.



Our Main Energy Sources are Fossil Fuels

Coal

Millions of years ago, many parts of the world were covered in great forests growing in swampy ground. When leaves and trunks fell, they did not rot away, but "composted" into peat-like deposits.

Layer after layer were buried by more and more deposits. Later, the material was buried under sediments of sand and mud and compressed and changed into coal.

Coal is fossilised plant matter, and still contains the Chemical Potential Energy that the plants stored when alive. This energy is released as heat when coal is burned.


Coal Mining

We use coal mainly for generating electricity, and for smelting iron ore to make steel.

Petroleum (Petra = rock, oleum = oil)

Petroleum is the fossilised remains of tiny sea creatures which died and settled into the mud of ancient shallow seas. Buried in sediments, their remains have been chemically changed, but still contain some chemical PE stored in the cells of the ancient creatures.


Oil Well Pump

Petroleum can be refined to make fuels like petrol, diesel and L.P.G.


Oil Refinery

Although there are some serious problems with the use of fossil fuels, our society is "addicted" to their use because they are embedded within our economy.

This economic dependance and some possible future solutions, are discussed soon.

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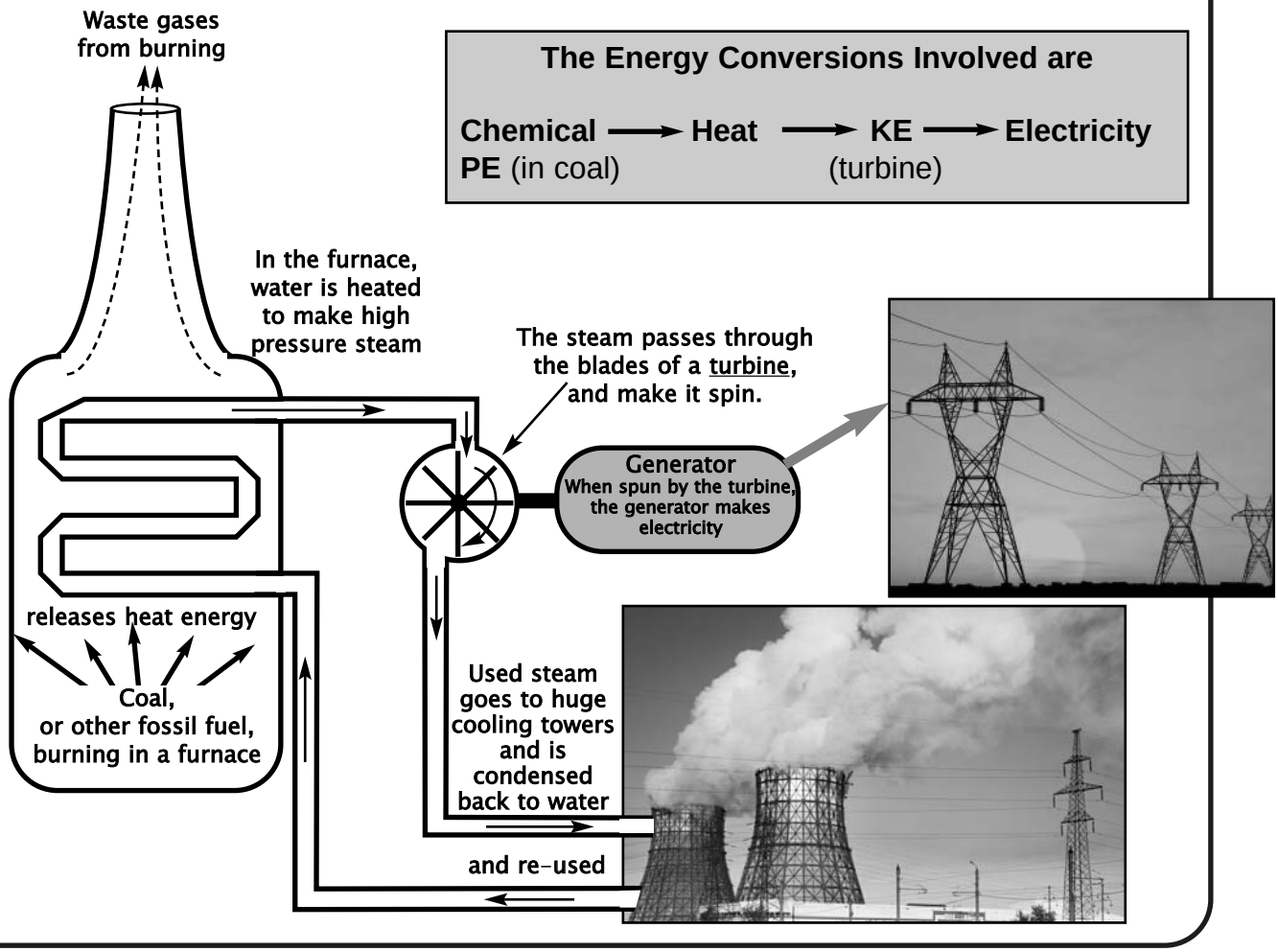
How We Make Electricity from Fossil Fuels

In Australia, we mostly burn coal. Petroleum gas, or other petroleum fuels could be used.



Problems With Burning Fossil Fuels

1. Non-Renewable

All fossil fuels are non-renewable resources and must eventually run out. Coal will last a few hundred years, but petroleum may run out within your lifetime.

2. Pollution means contamination by unwanted, dangerous substances.

Burning coal can produce sulfur dioxide gas which is acidic. It can lead to "Acid Rain" which destroys forests and kills plant & animal communities in lakes & streams.

Burning petroleum fuels in vehicle engines produces waste gases which cause "smog". This damages people's lungs and results in many health problems.

3. Global Warming

Burning fossil fuels produces huge amounts of the gas carbon dioxide (CO_2).

Check your family's latest electricity bill:
it will tell you how many tonnes of CO_2 have been released to make your electricity.

CO_2 in the air is known to "trap" heat which would normally escape into space. Increased CO_2 levels can cause a "Greenhouse Effect" which is now believed to be causing the whole world to warm up.

This "Global Warming" will cause climate change so that weather patterns will be disrupted and many natural environments may be destroyed in the next century.

Economic Dependance

Cheap & Convenient

We use coal because it is, literally, as cheap as dirt. Basically, you dig it up and then burn it. The greatest cost is transporting the coal from mine to power station.

That's why in Australia, most coal-burning power stations are located near the coal mines.

Liquid petroleum fuels (e.g. petrol) are convenient to store, transport and handle... perfect as fuel for vehicles. In addition, petroleum fuels contain a lot of energy packed in a small volume.

As well as fuel, petroleum chemicals supply us with cheap plastics and chemicals for making everything from toys to carpets, clothing, paints, cosmetics, pesticides and medicines.

Dollars, Jobs, Votes

Because of the energy and convenience of fossil fuels, huge industries have developed around them. Not only the coal industry and petrol companies, but the car manufacturers, electricity supply companies and makers and retailers of electrical goods, lawn mowers and air conditioners all rely on a constant supply of cheap electricity and fuel, or else their goods won't sell.

Banking and financial systems rely on the flow of goods and materials around the world. We now live in a "Global Economy".

Millions of families rely on this inter-connected system for their jobs and the income to purchase goods and possessions. From it, most people enjoy a comfortable and entertaining lifestyle.

Governments rely on the flow of revenue from profitable businesses and tax-paying citizens to provide hospitals, schools, roads and all the other "infra-structure" we need.

Right or wrong, the use of fossil fuels has given us many benefits.
The "global economy" depends on cheap, convenient energy.
Our comfortable lifestyle would suffer if it all changed suddenly.

Why Things Must Change

Fossil Fuels are Non-Renewable

Our coal deposits will last for a few hundred years, but petroleum will run out soon, probably within your lifetime.

Therefore, it is essential we find substitute renewable fuels.

Global Warming is Real

In 2008, an international group of top scientists commissioned by the United Nations studied all the evidence and concluded that "Global Warming" IS happening and IS the result of human-caused CO_2 increases. This is mostly due to our over-use of fossil fuels.

No more denial!

Climate Change

It is difficult to predict exactly what will happen whether we act or not.

However, if we do nothing and continue as before, it seems certain that weather patterns will be disrupted and many ecosystems will be destroyed. Human food production could be devastated as rainfall patterns change.

Ultimately, if the ice-caps melt, the sea-level could rise over 100m. This would submerge many major cities and affect millions of people.

We must at least try to prevent disaster.

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Strategies for Change

Many people think that "someone" needs to solve the world's problems. "Someone" includes governments, scientists and that vague "they", as in "<u>they</u> should stop all that pollution and destruction and global warming!" In fact, the power for change lies in the hands of every person...

Think Globally, Act Locally

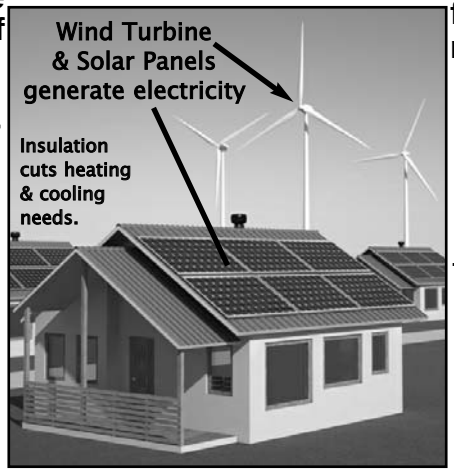
Use Less Electricity

Instead of demanding that power stations stop burning coal, or stop releasing CO_2, just remember that they only do that because someone demands the electricity they generate. That "someone" is you.

Every one of us can make decisions to use less electrical energy. It's not that difficult to reduce electricity usage by (say) 10%. If every household did that, CO_2 emissions would be reduced by millions of tonnes per year.

We have the technology for everyone to have solar hot water systems. We have the technology for every household to be like the one pictured. It just costs money, and governments will help subsidise part of the cost.

What cost if we don't?



Use Less Fuel

We all know about using public transport, or ride a bike or walk to avoid so many car trips... it all helps.

What about simply buying cars with smaller engines? Smaller = cheaper AND less fuel = less emissions!

What about buying local goods? Not only does that support local businesses and jobs, but local goods use less fuel for transport to shops and markets.
("Local" might mean your area, or simply Australian-made instead of imported)

Recycle

It takes a lot less energy to recycle metals, glass or paper than to make new. Everytime you remember to put trash in the recycle bin, you help reduce CO_2 emissions.

Role of Governments

In a democracy, the people get the quality of government they deserve.

Governments can act by providing infra-structures to <u>help people make choices</u> which help the planet.
e.g. ensure that re-cycling services exist, and give subsidies when people install solar power houses.

Governments can support and encourage scientific research into energy alternatives and emission-control technology.

Governments can support international treaties to combat Global Warming,
but only if we vote for leaders who will do these things!

The Need for Research

When times are tough economically, one of the first things often cut from budgets is scientific research funds.

It would be a "false economy" to try to save money by reducing research.

Scientific research is vital in the search for alternative energy sources, or the development of ways to reduce emissions of greenhouse gases.

More than ever, scientific research needs to be supported by governments and businesses by providing funding and facilities for research.

Case Study: Ethanol to Replace Petrol?

A possible alternative fuel to replace petrol is ethanol.
We can already buy petrol with 10% ethanol in it. With different engines we could run cars on 100% ethanol. Is this a good idea?

Fuel or Food?

Ethanol is made by fermentation of sugar (from sugar cane) or starch from wheat or corn. The fermented "brew" is distilled to obtain ethanol. The technology to do this is well established.

<u>Total replacement</u> of petrol by ethanol is just not practical because we use food crops as the starting material. It can be calculated that to totally replace petrol with ethanol we would have to use 75% of the world's farmlands to grow crops for ethanol production.

Many countries can barely feed the people now, so 100% ethanol usage would result in mass starvation.

What we need is the technology to start with plant wastes (stalks, etc) so food production is not affected.
We cannot do that yet... research needed!

Greenhouse Friendly?

Ethanol is hailed as being "carbon-neutral" because the CO_2 released by burning it is the same as the amount absorbed by the growing plants.

In itself, this is true, but the use of fertilisers, crop transport and the distillation of the ethanol rely upon a lot of fossil fuel usage. Overall, ethanol is not much better than petrol.

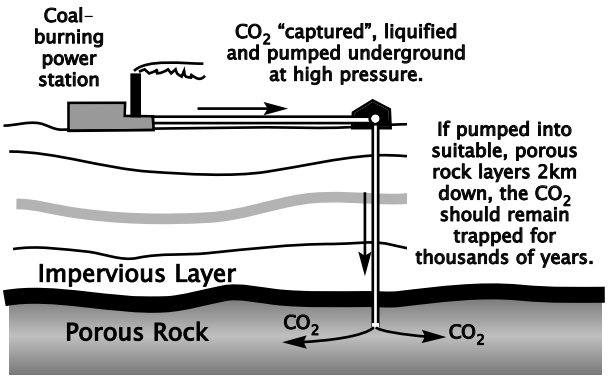
However, ethanol IS renewable. When petrol runs out, we will need ethanol for our vehicles.

To make it truly "greenhouse friendly" and carbon-neutral we will need to (for example) use solar-powered distillation.

Ethanol is not yet a solution.

Case Study: Carbon Capture & Storage?

Many people talk about "Clean Coal Technology", referring to "Carbon Capture & Storage" (CCS) as if it is proven and ready to go.



Theoretically, CCS could allow us to continue using coal to make electricity, without any emission of greenhouse gas. A "pilot plant" began operating in Victoria in 2008 to research the pumping methods and the stability of underground storage. Australia leads the world in this research.

However:

1. It may be another 20 years before new power stations are built with "carbon-capture" systems.

2. No-one knows the cost and feasibility of retro-fitting existing power stations with carbon-capture equipment.

3. How long the liquified CO_2 will remain trapped underground is not known.

CCS <u>may</u> be a good option, but it will not help us in the short term.

Australia has huge reserves of coal, so this idea is very attractive, but it is not yet a solution. More research needed!

keep it simple science

Worksheet 5
Using Fossil Fuels

Student Name.....

1. Why are coal and petroleum called "fossil fuels"?

2. Give an outline of how electricity can be made by burning coal.

3. a) What is meant by "pollution"?

b) List 2 kinds of pollution which can result from burning fossil fuels.

4. List some of the factors that have caused our society to become dependant on fossil fuels.

5. Explain the difference between "renewable" and "non-renewable" fuels, naming one of each in your answer.

6.
a) Outline some strategies (which are possible now) for reducing the usage of household electricity.

b) Outline some strategies (which are possible now) for reducing the usage of vehicle fuels.

7. Ethanol is already being used to replace part of our petrol usage.

a) Why is it impossible to totally replace petrol with ethanol with current technology?

b) What new technology is needed to make ethanol truly "carbon-neutral"?

8. a) What is CCS technology? Explain how it could lead to "clean coal" power.

b) Is it likely that CCS technology will be in use soon? Explain your answer.

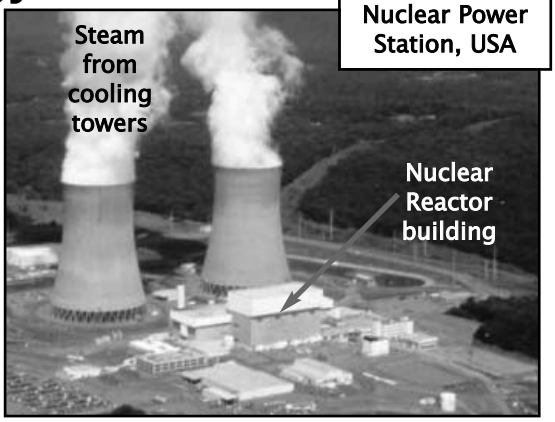
Nuclear Technology

Solution or Worse Problem?

In Europe and North America, up to 50% of electricity is generated by nuclear power plants.

Since they do not emit any greenhouse gases, many people argue that increased use of nuclear power could be a solution to the "Greenhouse Problem".

Others think that the danger of nuclear accidents (like Chernobyl, 1986) and the threat of terrorists getting hold of nuclear materials, is just not worth the risk.



Nuclear Power Station, USA

Although Australia has large reserves of uranium (the starting point for all nuclear energy) it is unlikely that we will vote for nuclear power in the forseeable future.

Nuclear Reactions

Although Australia seems unlikely to adopt nuclear power, we do make use of nuclear technology. To understand these things, you need to learn the science behind the technology.

Energy in the Nucleus

The nucleus of every atom is held together by the "strong nuclear force". This force is the strongest known. It is far stronger than electrical or magnetic forces, and billions of times stronger than gravity.

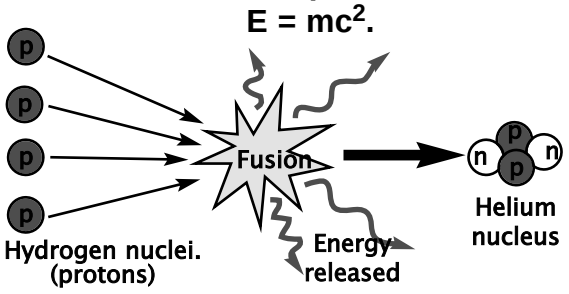
Certain kinds of reactions can release some of this Nuclear Energy.

Nuclear Fusion

is when 2 small nuclei are slammed together hard enough so that they join and become one.

A small amount of mass is converted to energy according to Einstein's famous equation

$E = mc^2$.



This is the process which powers the stars.

Nuclear Fission

Under certain conditions, a very large nucleus (e.g. uranium or plutonium) can break apart into smaller nuclei. Once again, a small amount of matter "disappears"... $E = mc^2$ is at work again!

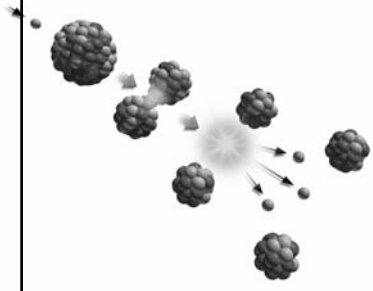



Photo of the atom bomb explosion on the Japanese city of Nagasaki, 1945.

This is the process occurring in a nuclear reactor used to generate electricity in many countries. It is also the energy source in an "atomic bomb".

keep it simple science

Radioactivity

Some atoms have an unstable nucleus and spontaneously "spit out" radiation. This "radiation-activity" can be very dangerous. It can also be very useful.

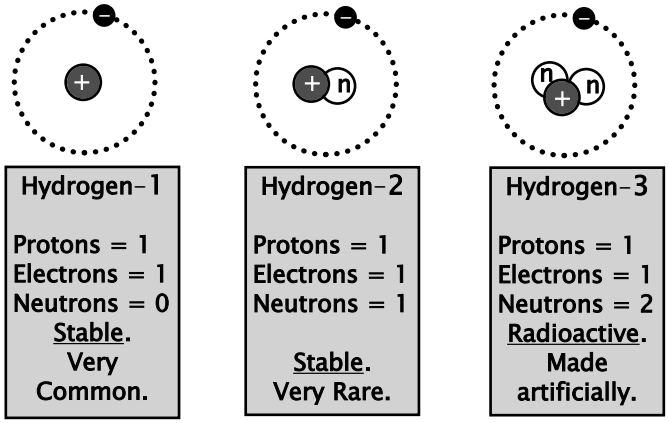
Isotopes

To understand radio-activity you have to learn about "isotopes".

You may have learnt that all the atoms of any chemical element are exactly the same as each other. Well, that's not quite true.

All the atoms of an element have exactly the same number of protons and electrons. That defines the "Atomic Number" and the number of electrons determines the chemical behaviour.

However, the number of neutrons may vary. For example, hydrogen has the smallest, simplest atoms of all, but there are 3 variations, or "isotopes".



All these atoms behave the same chemically. They each have only 1 electron and this causes them to behave as "hydrogen".

Their Atomic Mass Numbers are different because of the mass of the neutrons.
(Atomic mass = protons + neutrons)
The different names given to these atoms are based on their Mass Numbers.

The really big difference between them is that H-1 and H-2 are stable, but H-3 is unstable and radioactive. It spontaneously gives off radiation.

Every chemical element has isotopes, sometimes as many as a dozen. Many occur naturally, while others are made artificially in a nuclear reactor by bombarding stable atoms with neutrons from the fission reaction.

Forces in the Nucleus

Why are some atoms stable and others not? It depends on the mix of neutrons and protons in the nucleus.

Apart from hydrogen, all atoms have 2 or more protons in the nucleus. Protons have +ve electric charge and repel each other strongly. So, why doesn't the nucleus fly apart?

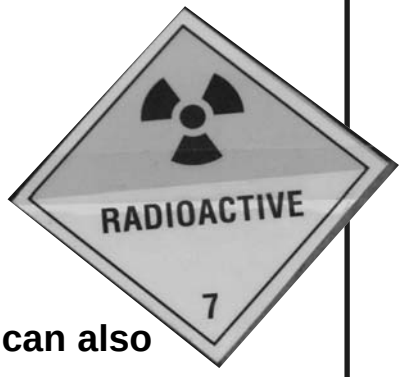
The atomic nucleus stays together because of an incredibly powerful force called simply the "strong nuclear force". This attracts both protons and neutrons to each other and can overpower the electrical repulsion, so long as there is a certain "balance" between protons and neutrons.

Radioactivity occurs when this balance is wrong.

Alpha, Beta & Gamma

An atom with the "wrong" ratio of protons and neutrons undergoes "radioactive decay".

It re-adjusts itself into a more stable form, but to do so it needs to get rid of energy and maybe some of its mass. This occurs by emitting high energy EM radiation (Gamma rays) and/or by "spitting out" a small, high-speed particle: either an Alpha particle or a Beta particle.



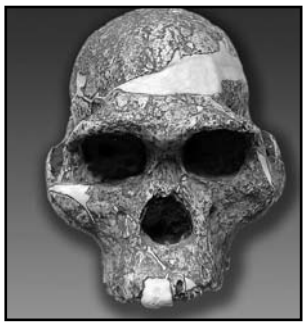
The alpha (α), beta (β) or gamma (γ) rays given off by a "radio-isotope" can be very dangerous, but can also be very useful.

keep it simple science

Uses of Radioactivity

Scientific Uses

One of the main scientific uses is to measure the age of rocks, fossils and artifacts from human history.



This relies on the fact that there are natural radio-isotopes in rocks, and in living things.

Each isotope "decays" into a new form at a predictable, mathematical rate.

By carefully measuring how much of an isotope remains in a rock or fossil, compared to how much has decayed into a new form, the age can be measured.

This is how scientists know, quite accurately, the age of the Earth, various fossils, or when an ancient city was built, or destroyed.

Perhaps the best-known isotope for "dating" is carbon-14 which can measure ages back about 40,000 years. It is used to date ancient civilizations, tools, and even to check old artworks.

Medical Uses

Modern medicine makes great use of radio-isotopes, mainly for cancer treatments and for diagnosis of a wide range of medical conditions.

Cancer Treatment

Cancer cells are more vulnerable to being killed by radiation than are healthy tissues. Certain types of cancer can be treated by introducing a radio-isotope into the patient's bloodstream. The isotope collects in a cancerous organ and the radiation destroys the cancer cells.

Diagnosis

A common way to get images of some tissues for diagnosis is to inject low-levels of radio-isotopes into a patient.

The radiation from the isotope is computer-analysed to build up a "picture" of what is happening in certain body tissues. One method, called a PET-scan can detect muscle-damage or chemical changes that are invisible in an X-ray. This allows early diagnosis of many conditions.

The isotopes used in medicine are all artificially made in a nuclear reactor.

Industrial Uses of Radioactivity

Aircraft Construction

It's just a little bit important that the wings don't fall off an aircraft. The problem is that it is very difficult to be certain that a welded metal joint is perfectly strong.

X-rays cannot penetrate metals, but high energy gamma rays can pass through. A gamma ray camera can then gather the radiation and form an image of the joint.

The gamma rays are provided by radio-isotopes such as cobalt-60 which emits highly penetrating gamma rays.

Killing Microbes

Gamma rays are very destructive to living cells. One application of this is to kill germs and sterilise things which need to be completely germ-free.

This idea is used in the manufacture of medical bandages and dressings.

As you can guess, suitable radio-isotopes are used as the source of gamma rays.

Research is being done to test if some foods can be better preserved by killing bacteria and fungi with radiation.

keep it simple science

Problems with Nuclear Technology

Risks of Nuclear Power

Many people point out the risk of accidents at nuclear power plants, such as happened at Chernobyl, 1986. This accident happened in a communist regime with poor training and safety standards. Today, such accidents are far less likely, but are still a worry.

Of greater concern is what to do with "nuclear waste". The uranium fuel rods in a power reactor have to be replaced regularly. The waste material is highly radioactive and will remain dangerous for thousands of years. Currently, millions of tonnes of such material is being stored in old mine shafts, or similar. No-one knows how to guarantee to keep this material safely isolated for even 100 years, much less thousands!

In this modern world of conflict, there is concern that terrorist organisations may get access to nuclear materials. Just a few kilograms of plutonium could kill thousands in a major city if exploded into dust by a "dirty bomb". An entire city could be rendered unsafe to live in for hundreds of years.

Risks of Medical & Industrial Radioisotopes

Radioisotopes used for diagnosis in medicine have short-lives (they decay away rapidly) and are used at very low radiation levels. There is some risk to the patient, but this is considered less than the risk of failing to treat or diagnose a serious disease.

There is also a risk to the staff who handle the materials and carry out the medical or industrial procedures day-after-day.

The risks are due to the ways that radiation affects living cells. This is dealt with in the next frame.

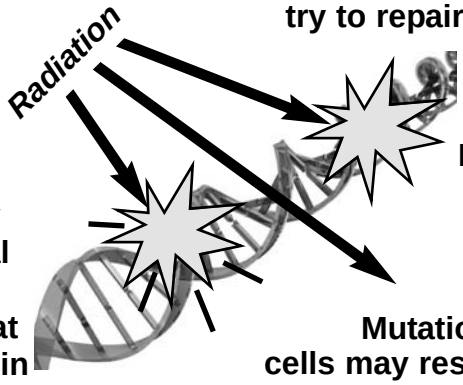
Modern safety standards ensure that the risk to staff is virtually zero.

Biological Hazard of Nuclear Radiation

Radiation Damages DNA

The main problem with nuclear radiation is that it can damage the DNA in a living cell.

Living cells have some ability to repair some of the damage, but large doses of radiation are highly destructive. Cells, tissues and vital organs can die and "<u>radiation sickness</u>" is then fatal. This is what happened to thousands of people in Japan in 1945. They survived the atomic explosions, but died horribly over the following days, or months.



Cancer & Mutations

If the DNA damage is non-lethal, it can still be very dangerous. As the cells try to repair the damage, many mistakes occur.

Mistakes in the DNA are mutations.

Some mutations cause cells to become <u>cancers</u>. Mutations in sperm & egg cells may result in birth defects.

High rates of cancer and birth defects have affected over 50,000 people near the Chernobyl power station since 1986.

keep it simple science

Worksheet 6
Nuclear Reactions

Student Name.....

Fill in the blank spaces.

Nuclear fusion is the process which powers the a)..... It occurs when small atomic nuclei are slammed together so that they b).....

Atomic "c)....." occurs when very large atomic nuclei (such as d).....) split apart. This process is used in a nuclear power station and in an e).....

In nuclear reactions, a small amount of f)..... "disappears" because it has been converted into g).....

"Isotopes" are atoms of the same element which have different numbers of h)..... in their nucleus. Many isotopes are stable, but others are i)..... and give off radiation as they "decay" into a new form.

The radiation can be of 3 types, known as j)....., ... and .....

Radioactivity has many uses. In Science, one important use is to find out the k)..... of fossils, rocks, etc.

In medicine, radioactivity is important for treating certain types of l)..... and for m)..... diseases, such as in a PET-scan.

In industry, radioactivity is used in a variety of ways, such as checking the strength of n)..... or to kill o).....

The main hazard of nuclear radiation is that it can damage the p)..... in living cells. Even low doses are dangerous because they may cause q)..... in the DNA. This can result in r)..... developing, or in s)..... in babies.

Worksheet 7
Nuclear Technology

Student Name.....

1.

a) Why do some people argue that we need more nuclear power stations?

b) Outline 2 reasons why others would oppose the building of more nuclear power stations.

2. Briefly explain the difference between nuclear fission and fusion.

3. The table shows the number of particles in each of 3 types of atom.

	electrons	protons	neutrons
atom P	17	17	19
atom Q	19	19	21
atom R	17	17	21

a) Which 2 atoms are isotopes? Explain.

b) It turns out that substance Q is radioactive. What does this mean?

c) Substance Q occurs naturally in some rocks, and decays over millions of years. How might this knowledge be useful?

keep it simple science

Biotechnology

Biotechnology refers to the use of living things to make resources (useful substances) for human use.

Penicillin & Antibiotics

Modern biotechnology began in the 1930's when the mould *Penicillium* was grown to extract the natural antibiotic drug penicillin.

Penicillin could cure a wide range of infectious diseases and treat infected wounds by killing bacteria.

Genetic Engineering (GE)

Today, biotechnology often relies on making changes to the DNA (the genes) of organisms so that they will make useful substances, or produce food more efficiently or economically.

One area of GE involves transferring a gene from one species to another to produce what is called a "Transgenic" plant or animal.

Chemical Weeding

One of the best known cases of GE involves a well known weed-killing chemical called "Round-Up"®. (Monsanto TM)

Various crop plants (corn, canola, etc) have been genetically engineered to contain a bacterial gene which makes the plant immune to the weed killer. This allows a field of growing crops to be sprayed to kill weeds without any damage to the crop itself.

This saves the farmer time and money and boosts the crop yield.

Inbuilt Insecticide

Another GE plant is cotton containing a bacterial gene for a chemical which kills insects. This means that the crop doesn't need to be sprayed with insecticides... any caterpillar which tries to eat the crop dies.

There are many other examples where GE is helping produce our resources.

Traditional Biotechnology

Biotechnology is nothing new. Humans have been using living microbes to make useful substances for thousands of years.

The use of yeasts (unicellular fungi) to make bread and brew beer and wine has been done since ancient times.

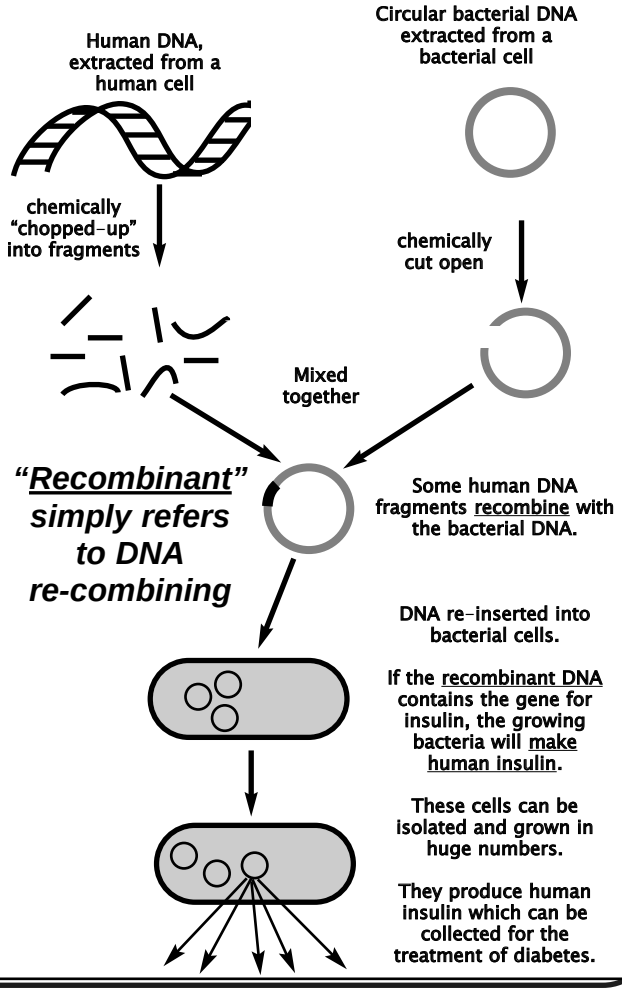
Similarly, bacteria have been used to turn milk "curds" into cheese for thousands of years.

Of course, no-one really understood how these processes worked until modern Science figured it out.

Human Insulin

Type I Diabetes is a killer disease in which a person's pancreas stops making the hormone insulin. Without insulin their cells cannot absorb glucose and they lapse into a coma and die. Early treatments relied on extracting insulin from animals at an abbatoir, but there were many side-effects and supplies were uncertain.

"Recombinant DNA" Technology now supplies pure human insulin.



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Benefits of Biotechnology

There are many possible benefits of biotechnology.
Here is a brief over-view of some that are possible now,
or being researched now and may become possible in the near future.

Cures for Genetic Diseases

Experiments are already underway to cure some genetic diseases (such as Muscular Dystrophy) which are caused by a single faulty gene. Copies of the normal healthy gene could be inserted into cells in affected organs using a harmless virus as a "gene carrier".

Improved Foods

GE plants and animals are already being used to increase yields, grow food which is more nutritious, disease resistant, longer-lasting, etc.

Producing Hormones

The example of insulin was given previously. Other examples include "transgenic" cows or sheep which produce human hormones or therapeutic chemicals in their milk.

Organs for Transplants

In future it may be possible to grow transgenic animals (e.g. pigs) which have human versions of "cell-antigens".

The organs of these animals could be used in human organ transplants without "tissue-rejection" problems.

Solving Pollution or Fuel Problems

It may be possible to use GE bacteria to "eat" oil spills or other pollution.

GE microbes might be able to digest plant wastes efficiently so we could make large quantities of ethanol (to replace petrol) without having to use food supplies, as we do now.

Problems with Biotechnology

As well as real and potential benefits, there are also many problems and worries.

Ecological Dangers

Many people worry about the possible danger to ecosystems if "transgenic" GE plants escaped into the wild and transferred their genes to wild species.

The result could be "super-weeds" which are resistant to disease, insects and herbicides. They might "take-over" and disrupt ecosystems.

Human Health

Some people are concerned about the possible effects of GE foods on human health.

They suggest that there could be long-term effects, such as increased cancer risks.

Ethics of Ownership

Currently, GE plants and animals are owned by big businesses which make large profits from them. This may lead to unfair control and exploitation.

Morality of Human GE

Some people consider it immoral to interfer with human genetics in any way.

Others worry that the moral issues may come in the future when (perhaps) human genes can be changed and modified at will.

Might people use GE for cosmetic reasons, or have their child's genes changed so they grow up better-looking or more athletic?

The ecological and health concerns can be investigated and assessed scientifically. The ethical and moral issues must ultimately be decided by peoples' opinions.

Technology Makes New Resources

Throughout this topic you have been made aware of problems, problems and more problems. It would be easy to conclude that our technology is simply not worth the trouble. Maybe we should give it all up and go live in a tree!

Despite the many problems of technology, you should not lose sight of the enormous benefits it has given us. In particular, technology produces many made resources which contribute to our health, comfort, entertainment and convenience.

Plastics

Plastics (including synthetic fabrics like nylon) have revolutionised everything from clothing to toys to drainage pipes, electrical appliances, furniture & cars.

It is now hard to imagine a world without plastic containers, plastic handles, plastic insulation, plastic coatings and paints.

Every plastic is a product of modern technology. Most are made from petroleum, but in future they will be made from plant-derived chemicals.

Medicines

Although some modern medicines are extracted from plants or fungi, many are synthetic products of a high-tech chemical industry.

Some pharmaceuticals are natural chemicals, but are made by biotechnology such as previously described for insulin production.

Drugs used to be discovered by trial-and-error. More and more they are now "designed" from a knowledge of how molecules fit together and affect each other.

Our chance to live a long, healthy life is largely due to technology.

Silicon Chips & Modern Electronics

At the heart of all modern electronic devices and gadgets is the "silicon chip". It is a complex of microscopic electrical circuits engraved on a slice of a silicon crystal, grown by advanced chemical technology, and etched by a computer-controlled laser beam.

Hand-held GPS unit.

It talks to satellites and knows the exact location within metres.

Technologies involved in developing such a device include Chemical, Space, Electronics & Communications.

All our computer systems and networks depend on silicon chip technology.

All our communications networks including mobile phones, internet and TV are computer-based and therefore depend on silicon chips.

Our banking and financial systems run on computer networks.

None of your favourite entertainments including DVD movies, electronic games and personal music devices would be possible without electronic silicon-chip technology.

keep it simple science

Worksheet 8
Biotechnology

Student Name.....

Fill in the blank spaces.

Biotechnology refers to the use of a)..... to make useful substances. Traditional biotechnology includes the making of b)..... or ..... using yeast or bacteria.

In the 1930's the first antibiotic "c)....." was extracted from a mould.

Modern biotechnology often involves d)..... (GE). This may involve e)..... genes from one organism to another to form a "f)....." plant or animal.

Examples include crop plants with a g)..... gene which makes a toxin which kills insects. The crop does not spraying with h).....

The human gene for the hormone i)..... has been transferred into j)..... cells. The cells produce pure human hormone which is collected to treat k).....

Other potential benefits of biotechnology include curing some l)..... diseases by inserting a normal gene into cells affected by a defective one.

It may be possible to use GE animal organs for m)..... operations, or use GE microbes to digest n)..... ..... so they could be fermented to make o)..... fuel to replace petrol.

Some people worry about the threat to p)..... from GE "superweeds". Others are concerned about the q)..... of ownership or the r)..... of changing human genes.

Worksheet 9

Technology & New Resources

Student Name.....

1.
a) Where do plastics come from?

b) Before plastics, what materials were used for:
i) packaging foods?

ii) drainage pipes?

iii) clothing?

iv) toys?

2. What technology is at the heart of all modern electronic equipment?

3. Modern medicine uses many technologies to help us live long, healthy lives.
Give an example where your health could be helped by:
a) nuclear technology.

b) biotechnology.

c) electronics & computers.

d) chemical technology.

Topic Test
Resources & Technology

Student Name .....

Score = /26

Answer all questions in the spaces provided.

1. (8 marks)
Match each description to an item from the list. To answer, write the letter (A,B,C, etc) of the list item beside the description.

Description	matches with	List Item
a) Type of ecosystem resource which is not alive.		.....
b) Main greenhouse gas.		.....
c) Process of over-fertilizing algae in streams.		.....
d) Fossil fuels are NOT like this.		.....
e) Alternative liquid fuel made from sugar or corn.		.....
f) Nuclear reaction that "splits the atom".		.....
g) Isotopes have a different number of these.		.....
h) A living thing which has genes from a different organism.		.....

List Items Not all will be used. Some may be used more than once.

A. abiotic	E. renewable
B. protons	F. fission
C. CO_2	G. ethanol
D. transgenic	H. eutrophication
I. fusion	J. neutrons

2. (5 marks)
Draw a simple diagram to show the main features of the water cycle. Label the diagram to name the major processes occurring.

3. (3 marks)
List 3 factors which have contributed to our society becoming dependant on fossil fuels.

4. (3 marks)
Explain how re-cycling glass, paper, etc can help reduce "greenhouse gas" emissions.

5. (5 marks)
a) What are "isotopes"?

b) What is "radio-activity"?

c) Give an outline of one way that radio-isotopes are used in modern medicine.

d) Why is nuclear radiation dangerous to living things? Specifically, what does it do?

6. (2 marks)
Give an example of how Genetic Engineering (GE) helps us in either food production OR in a medical field.

Answer Section

Worksheet 1

a) Abiotic
b) light
c) water
d) oxygen & CO_2
e) biotic
f) food
g) nectar
h) pollinating
i) energy
j) re-cycled
k) Sun
l) evaporates
m) condenses
n) precipitate
o) run-off back to the sea (rivers, etc)
p) oxygen & CO_2
q) photosynthesis
r) oceans
s) sedimentary
t) volcanic
u) fossil
v) CO_2
w) trapping
x) global warming

Worksheet 2

1.

Abiotic	Biotic
temperature	food plant
water	predator
sunlight	disease germ
oxygen	prey
soil quality	

2.
Nitrogen, phosphate, sulfate, calcium, iron.
3.
Photosynthesis.
Dissolving in the oceans.

4. Volcanic activity, decay, cellular respiration.

5. It absorbs or traps some of the heat which would normally escape into space.

6. Trapping extra heat may cause global warming. Temperature change causes weather patterns to change, so ecosystems may get more (or less) rain, winds, cyclones, etc.

Worksheet 3

a) habitat
b) adapted
c) biological magnification
d) Eutrophication
e) algae
f) compete
g) predators & diseases
h) ecological
i) irrigation
j) National
k) native / endangered
l) alien
m) corridors
n) migrate
o) sewerage
p) laws

Worksheet 4

1.
Most species have adaptations to suit their particular habitat. They cannot survive in a different environment.
2.
In Aust. the possum population is kept in check by predators and diseases. In NZ, the possums have no natural enemies and they out-compete native species.
3.
a) Biological magnification.
b) Toxins like mercury accumulate as they move up a food chain. There might be tiny amounts in a plant, but more in the fish which eat the plant, then more again in the bigger fish. People were at the top of the food chain and accumulated high levels of mercury.

Worksheet 5

1.
Because they are formed from the fossilised remains of ancient living things.
2.
Heat from the burning fuel heats water to high-pressure steam. The steam spins a turbine and it drives a generator which makes electricity.
3.
a) Contamination by unwanted substances.
b) Can release sulfur dioxide gas which causes “acid-rain”. Petrol engines release gases which cause “smog”.
4.
1. Fossil fuels are cheap & convenient.
2. Industries have developed around them forming a “global economy”.
3. Millions rely on these industries for their job, money , lifestyle.
4. Governments rely on taxes from business and workers to fund health, schools, etc.

5.
A renewable resource can be produced for ever, by growing plants, animals, etc.
Examples = wood, wool, cotton.
Non-renewable resources cannot be replaced in any reasonable time.
Examples = petroleum, metals

Worksheet 5 (cont)

6.
a) Solar hot water systems.
Use solar cells & batteries for electric supply.

b) Buy smaller vehicles with smaller engines. Buy local goods which do not require so much transport.

7.
a) Current technology needs sugar or starch crops to make ethanol. This means using farming land to grow fuel. Total replacement would need 75% of the world's farmland.

b) Need to use solar power for the distillation and avoid petroleum-dependant fertilizers (etc) for plant growing.

8.
a) Carbon capture and storage.
The idea is to capture the CO_2 from a coal-burning power station and pump it deep underground where it will be trapped in suitable rock formations for thousands of years.

b) No. Power stations equipped for this may be 20 years away, and the feasibility of pumping and storage is only just beginning to be researched.

Worksheet 6

a) stars	**b) join together**
c) fission	**d) uranium**
e) atomic bomb	**f) mass**
g) energy	**h) neutrons**
i) radioactive	**j) alpha, beta & gamma**
k) age	**l) cancer**
m) diagnosing	**n) welded joints**
o) microbes	**p) DNA**
q) mutations	**r) cancer**
s) birth defects	

Worksheet 7

1.
a) Because nuclear power does not release greenhouse gases.
b) The dangers of nuclear accidents, and the problem of storage and disposal of nuclear wastes.
2.
Fission is the splitting of large nuclei. Fusion is the joining together of small ones.
3.
a) P & R are isotopes because they have the same no. of protons & electrons (same element) but different no. of neutrons.
b) The atoms are unstable and emit radiations.
c) It could be used to measure the age of the rocks.

Worksheet 8

a) living things	**b) bread or cheese**
c) penicillin	**d) genetic engineering**
e) transferring	**f) transgenic**
g) bacterial	**h) insecticide**
i) insulin	**j) bacteria**
k) diabetes	**l) genetic**
m) transplant	**n) plant wastes**
o) ethanol	**p) ecosystems**
q) ethics	**r) morality**

Worksheet 9

1.
a) made from petroleum chemicals.
b) i) paper, glass
ii) clay ceramics
iii) wool, cotton, fur
iv) wood, metal, wool

2. silicon chips

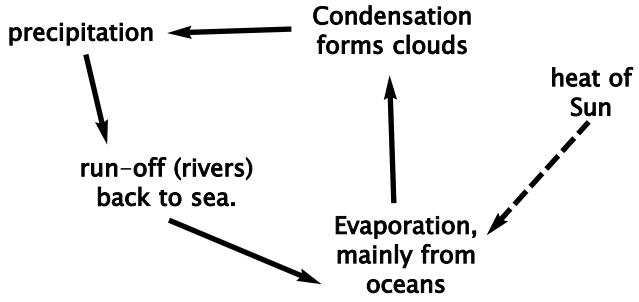
3. a) Radioisotopes might be used to diagnose or treat a disease.
b) GE might be used to obtain a human hormone to treat a condition e.g. diabetes
c) Diagnosis by ultrasound or CAT-scan relies on computers to analyse data.
d) Some medications are designed and made by advanced chemistry.

Topic Test

1.

a) A b) C c) H d) E e) G f) F g) J h) D

2.



3.

Fossil fuels are cheap and convenient. Many industries have developed around cheap energy, forming a huge global economy.
People rely on the jobs, money, lifestyle. Governments depend on tax revenues to fund health, schools, etc.

4.

It requires less energy to re-cycle than to make new paper, glass, etc. Less energy used means less emissions of greenhouse gases from coal-burning power stations or other fuel use.

5.

a) Isotopes are atoms of the same chemical element which have different numbers of neutrons.
b) Radioactivity is nuclear radiation coming from unstable isotope which "decay" to a more stable form.
c) Radio-isotopes can be injected into patients and the radiation analysed to help diagnose medical conditions, as in a PET-scan.
d) Radiation damages DNA in living cells.

6.

Example: medical.
The gene for human insulin has been transferred to bacterial cells. The bacteria produce human insulin which can be collected for treating diabetes.

Need to contact us?

keep it simple science
ABN 54 406 994 557

PO Box 2575
PORT MACQUARIE NSW 2444
(02) 6583 4333 FAX (02) 6583 9467
www.keepitsimplescience.com.au
mail@keepitsimplescience.com.au