Natural Sciences
Grade 7-B (CAPS)

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EXPLORE
A World Without Boundaries

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-71 La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103 Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

No
Element

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

- Transition Metal
- Metal
- Metalloid
- Non-metal
- Noble Gas
- Lanthanide
- Actinide

Natural Sciences

Grade 7-B

CAPS

developed by

SIYAVULA
TECHNOLOGY-POWERED LEARNING

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AUTHORS' LIST

This book was written by Siyavula with the help, insight and collaboration of volunteer educators, academics, students and a diverse group of contributors. Siyavula believes in the power of community and collaboration by working with volunteers and networking across the country, enabled through our use of technology and online tools. The vision is to create and use open educational resources to transform the way we teach and learn, especially in South Africa.

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To learn more about the project and the Sasol Inzalo Foundation, visit the website at:

www.sasolinzalofoundation.org.za

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B10

ENERGY AND CHANGE

1 Sources of energy

KEY QUESTIONS:

- Why do we need energy?
- What do we mean by renewable and non-renewable energy sources?
- Why should we use non-renewable energy sources?
- What are fossil fuels?

NEW WORDS

- renewable
- non-renewable

1.1 Renewable and non-renewable energy

All living things need energy. We learnt in Life and Living that energy is one of the requirements for life. However, it is not only living things which need energy to move and carry out various processes. The machines and appliances in our world around us also need energy to do work. Where does the energy come from?

Many substances and organisms store energy which can then be used. We call them **energy sources**. Energy sources have energy that is stored within them and can be used to make something happen, for example, energy stored in petrol can be used to make a car go. In Grade 6 you learnt about the two main sources of energy: **renewable** and **non-renewable sources**. Do you remember what these terms mean?

Renewable sources are ones which can be recycled or reused. Non-renewable sources cannot be reused and so there is a limited amount available and when that runs out there will be none left. Let's do a quick revision to see how much you remember from Grade 6.

ACTIVITY: Classify sources of energy

INSTRUCTIONS:

1. Study the following images which show different sources of energy.
2. Use the images to answer the questions that follow.

Natural gas - gas burning on a stove top.

Oil - An oil rig sinks a drill into the ocean floor to reach the oil deposits.

Sunlight - The Sun is a source of energy.


Biofuel- manure decomposes to produce methane gas.


Wood.


Coal - A coal mine.


Wind - wind turns this windmill.


Uranium - mining for uranium underground.


Hydropower - A large hydroelectric power station.

QUESTIONS:

1. Draw a table in the following space to classify the energy sources in the images as either renewable or non-renewable. Give your table a heading.

TAKE NOTE

Uranium is the source of energy for nuclear power stations.

2. What do we mean when we say that something is renewable or non-renewable? Explain this in your own words.

3. Why do you think we mostly use non-renewable energy sources?

___

___

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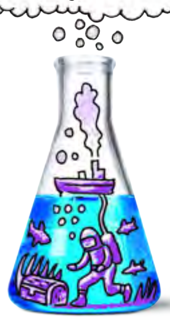
Let's now have a closer look at some of the most common sources of energy.

NEW WORDS

- consistent
- reservoir
- nuclear
- hydropower
- hydrocarbon
- biofuel
- methane
- fossil fuel
- greenhouse gases



Non-renewable sources

The non-renewable energy sources most commonly used in our world today are **fossil fuels**. Fossil fuels are the non-renewable sources, oil, coal and natural gas. Why do you think they are called **fossil** fuels?

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Fossil fuels

Where do we most often see fossil fuels in our everyday lives? Look at the following images for a clue.

VISIT

The story of petroleum (video).

bit.ly/19iQ31o

Putting petrol into a car at a petrol station. Petrol is made from crude oil.

Coal is used in most of our power stations in South Africa.

Petrol and diesel are used mainly as fuel for cars, trucks and motorbikes. They are produced from **crude oil**, which is a fossil fuel formed from the remains of dead prehistoric animals. Crude oil contains a lot of energy which can be used. Crude oil is a non-renewable energy source because it takes millions of years to produce crude oil and so we cannot produce more when the existing reserves are finished.

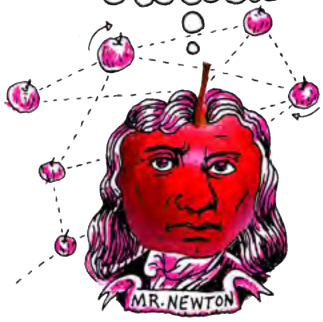
Coal is most commonly used as a source of energy by power stations to generate electricity. We will learn more about this later in the term. Coal can also be burned in fires to keep warm or in coal stoves to cook our food.

Natural gas is the common name used to describe a mixture of gases. Natural gas is found in deep underground rock formations and usually with other fossil fuels, such as oil and coal. The biggest part of the gas mixture is a gas called **methane**. Methane is a gas which burns easily and releases a lot of energy when it is burnt. Natural gas is used for cooking, heating and producing electricity.

Natural gas has to be reached in underground reservoirs by drilling down wells such as these.

DID YOU KNOW?

Coal comes from the Old English term *col*, from the 13th century which meant 'mineral consisting of fossilized carbon'.



When talking about the methane component of natural gas, we are talking about non-renewable resources. Gas formed over thousands of years as organic matter decayed and the gas became trapped in wells which we now mine. However, as we we will see later, methane can also be considered a renewable resource. This is when methane is produced from degrading organic matter, such as animal waste, with the help of microorganisms.

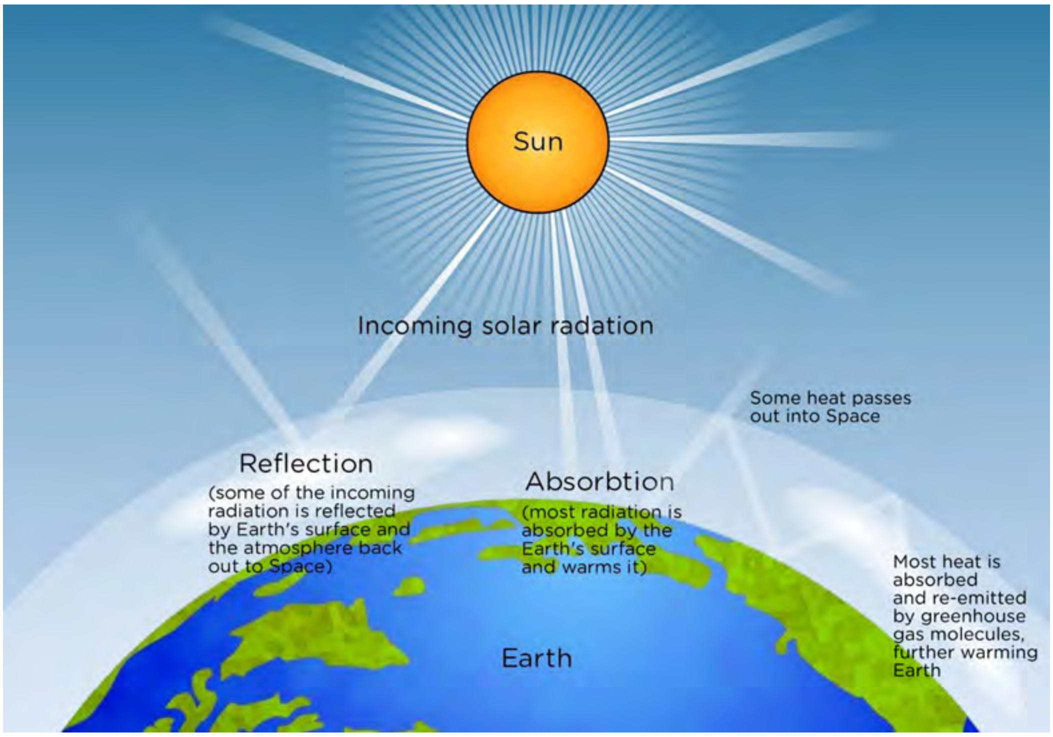
VISIT

The formation of coal.

bit.ly/14ZOOqv

Non-renewable energy sources play a huge role in our lives and the way our world works today. However, there are some major concerns about our reliance on non-renewable energy sources. Firstly, there is only a limited supply, so these energy sources will run out one day. We will then need to find alternative energy sources. Currently alternative energy sources are being explored, and used in a small scale in some places.

Another major disadvantage of burning of fossil fuels is that it releases **greenhouse gases** into our atmosphere. Greenhouse gases are present in our atmosphere and help to control the Earth's temperature. The Sun's radiation enters Earth's atmosphere. Some of the radiation is reflected by the atmosphere and Earth's surface. Most of the solar radiation is absorbed by the Earth's surface and converted to heat to warm the Earth. The Earth's surface emits heat. Some heat escapes out into space, but most is absorbed and re-emitted by the greenhouse gases to further warm the atmosphere and Earth's surface. This natural process is called the **greenhouse effect**.



VISIT

Play a simulation to learn more about the greenhouse effect

bit.ly/15vNiyQ

Do you know what an actual greenhouse is? It is normally a house made of glass, used to grow plants in. The glass also traps the Sun's energy and keeps the internal environment warm enough for the plants to grow. This is the same effect of the gases in the atmosphere.

A glass greenhouse traps the Sun's energy and provides a warm environment for the plants, just as the greenhouse gases in our atmosphere do.

But, our use of fossil fuels has released even more greenhouse gases, such as carbon dioxide. There is now an **excess** of greenhouse gases in the atmosphere. This reduces the amount of heat which escapes into Space and traps more heat within the Earth's atmosphere than before. This is causing the temperature of the atmosphere to rise, known as global warming.

Find out what else, besides burning fossil fuels, is contributing to an increase in greenhouse gases and write it below.

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Nuclear fuels

Energy can be produced by nuclear reactions. Do you remember that we spoke about the atom last term in Matter and Materials? Within the atom, the nucleus is held together by very strong forces. When the nucleus is broken apart, a huge amount of energy is released. This energy can be used in nuclear power plants to generate electricity. Two different nuclei can also collide at very high speeds to form a new atomic nucleus. The energy released is also used in nuclear power plants, however on a smaller scale than when nuclei are broken apart.

Some materials are better to use than others as nuclear fuels. One such substance is uranium. Uranium is an element. Find it on the Periodic Table and write its symbol and atomic number below.

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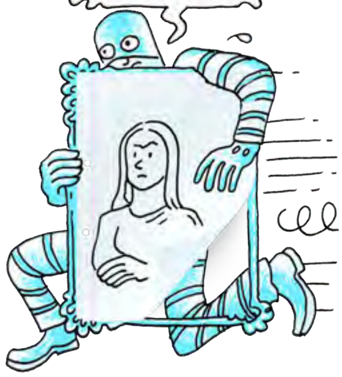
TAKE NOTE

When nuclei are broken apart, it is called **nuclear fission** and when two nuclei combine to form one nucleus, it is called **nuclear fusion**.



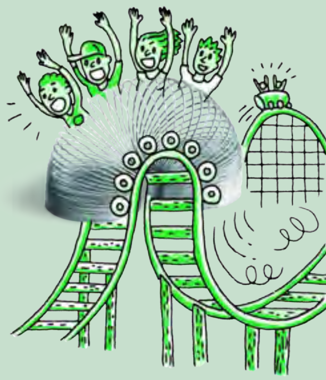
This is the international symbol for radioactivity.

DID YOU KNOW?

5% of South Africa's electricity is generated using nuclear fuels.

There is limited supply of uranium in the world, which is why we classify it as a non-renewable source. But there is enough uranium for nuclear energy to be used for a very long time because you need small amounts to produce lots of electricity. Therefore, many people see nuclear fuels as an alternative to fossil fuels. But there is a huge debate about this and many people also disagree about the use of nuclear fuels. Let's find out why.

ACTIVITY: Nuclear fuels - a debate



INSTRUCTIONS:

1. You will need to do some research and extra reading to answer these questions.
2. Then you will have a class discussion about the topic.

QUESTIONS:

1. What are some of the advantages of using nuclear fuels instead of fossil fuels? Write down your own findings below and then add to it when you have a class discussion.

DID YOU KNOW?

There is only one nuclear power station in South Africa. It is the Koeberg power station near Cape Town. The majority of the power stations in South Africa are coal-powered and some others use hydropower, for example the Gariep Hydroelectric Plant on the Orange River near the Gariep Dam.

2. Find out why many people, especially environmental activists are opposed to nuclear power. In other words, what are the disadvantages?

3. Although there are many disadvantages to nuclear fuels and power plants, many environmentalists and other people are now starting to change their minds and think that the advantages outweigh the disadvantages. This is happening as concern about climate change is increasing. Some people think the nuclear fuel is a more realistic alternative to fossil fuels than renewable energy sources, such as solar and wind power, which will not provide us with the energy to replace coal and oil. What do you think? Which side of the debate do you support? Discuss this with your class and then write down your thoughts below.

Renewable sources

Let's now take a closer look at some of the renewable energy sources that we have mentioned so far.

Wind is moving air and it can be used as a source of energy. The energy from moving air particles is used to turn large turbines. The turbines are connected to a generator which produces electrical energy.

Wind turbines use wind to generate electricity.

VISIT

Read more about renewable energy in South Africa.

bit.ly/15VuZ4n

You need a steady, strong wind blowing in order to produce a large, consistent amount of electricity. This means that wind farms cannot be put up in areas where there is not a lot of wind. Wind farms are noisy and many people do not like the look of them.

Water can also be used as an energy source. This is called **hydropower**. The energy from falling water is used to drive turbines in a power station. Unlike coal power stations, the water does not need to be heated and the water can be reused. These power stations must be at waterfalls or dams because there needs to be a strong flow of water to harness the energy.

VISIT

How does hydroelectricity work?

bit.ly/15G1FAJ

Hydropower - A large hydroelectric power station.

Explain why you think we can classify wind and hydropower as renewable energy sources.

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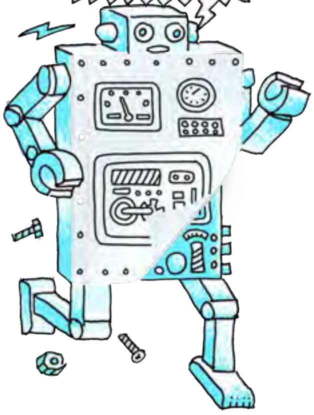
TAKE NOTE

You will learn more about the Sun and its relationship to the Earth later in the year.



There is a lot of energy in sunlight. Solar panels are used to absorb the radiant energy from the Sun and to transform the energy from the Sun into stored potential energy. The Sun is a star and the lifetime of a star is measured in billions of years. This means that our Sun can provide energy to the Earth for millions of years to come. Sunlight is considered a renewable energy source because it will not run out in the foreseeable future.

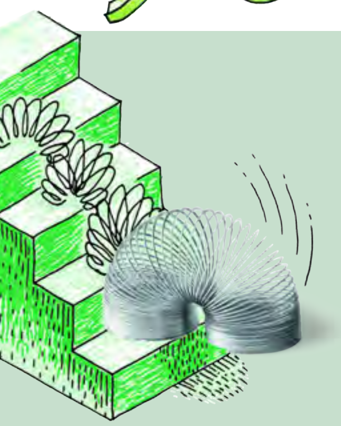
Solar panels on a rooftop. [1]

VISIT

Solar technology (video).

bit.ly/1hh2L5Y

A **biofuel** is any fuel which is produced from plant or animal waste. Methane can be produced by decomposing plants and animal waste. This is useful for farms as they can produce enough methane gas to help run their farms. The most common biofuels are made from maize, sugarcane and sorghum. The biofuels that are made can be used in vehicles or heating and cooling systems.



ACTIVITY: A case study on biofuels

INSTRUCTIONS:

Read the following article about biofuels and answer the questions that follow.

Dairy finds a way to let cows power trucks

27 March 2013

A large dairy farm, Fair Oaks Farms, in the United States of America has found a way to use the endless supply of manure from the cows to generate electricity. This electricity is in turn used to run the equipment that milks about 30 000 cows, three times a day.

For several years, the farm had been using the waste from the cows to create natural gas. The cow manure is swept up from the barn floors each day. The manure is then allowed to decompose in a digester and as it does so, it releases methane gas. The gas is collected and stored and used to power their buildings and barns. This gas is enough to power 10 barns, a cheese factory, a small restaurant, a gift shop and even a 4D movie theatre in the kids entertainment area.

Fair Oaks Farms was doing all of this, but only using about half of the manure they swept up from the cows each day. But, they have now become even more energy efficient.

Fair Oaks Farms is now using the rest of the manure and turning it into fuel to power its delivery trucks and tractors. This is the largest group of vehicles on the roads in the US using livestock waste to power them. This is a huge saving in the amount of diesel which would otherwise be used. Gary Corbett at Fair Oaks said "We are taking about half a million litres of diesel off the roads each year." Another advantage is that natural gas is about half the price of diesel fuel for the same amount of power.

Mike McCloskey, a co-owner of Fair Oaks, said he first started looking into renewable energy options for the farm more than a decade ago. This was a way to become more energy efficient, save money and he also said the smell of the manure, used as fertilizer on the fields, started to make some neighbours complain! The leftover byproducts from producing the natural gas is still spread over the fields as fertilizer, but it has much less of a smell. This shows that nothing goes to waste.

Other farmers, landfill management companies and other large industries that produce large amounts of methane-rich material are now also starting to take interest. If used, this could provide an endless supply of 'biogas', a cleaner, safer, sustainable alternative which also reduces greenhouse gas emissions.

A digester used to decompose manure to produce methane gas.

This has been adapted from an article which appeared in the New York Times on 27 March 2013.

VISIT

Find out more about how a digester works to produce biogas.

bit.ly/184BGkj

QUESTIONS:

1. What is the name of the farm in the article and in which country is it based?

2. What made the owners of Fair Oaks Farm decide to use manure as a form of energy?

3. In the article, the renewable energy source referred to is an example of a biofuel. What is this renewable energy source and why can we call it a biofuel?

4. How does the farm harvest methane from manure?

5. Why is it a good thing that the farm is taking "about half a million litres of diesel off the roads each year"?

6. What is another advantages of using the biogas to power the delivery trucks and tractors?

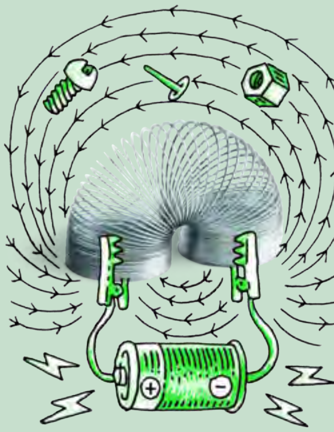
7. Do you think that South Africa could benefit from a setup such as the one at Fair Oaks Farms? Explain your answer.

DID YOU KNOW?

Biofuels have been around as long as cars have. At the beginning of the 20th century, Henry Ford planned to fuel his cars with ethanol. But then the discoveries of huge oil deposits kept fossil fuels cheap for decades, and biofuels were mostly forgotten.

Now that we have looked at non-renewable and renewable energy sources, let's summarise the disadvantages and advantages of each.

ACTIVITY: What are the advantages and disadvantages?



INSTRUCTIONS

1. Sit in groups of 3 or 4.
   Discuss, in your groups, the advantages and disadvantages of using non-renewable energy sources.

2. Discuss, in your groups, the advantages and disadvantages of using renewable energy sources.

3. Why do you believe that fossil fuels are still burnt as a source of energy? Write your own answer below.

4. Choose a spokesperson for your group and share your ideas with the rest of the class.
   Choose two of the sources of energy discussed so far in this chapter. Use your school library or the internet to find more information about how they are used to generate electricity in South Africa.

VISIT
You can make your own house more efficient in its use of waste. Have a look at this website.
bit.ly/1dL9CEQ

VISIT
Six myths about renewable energy sources.
bit.ly/1bmufX1

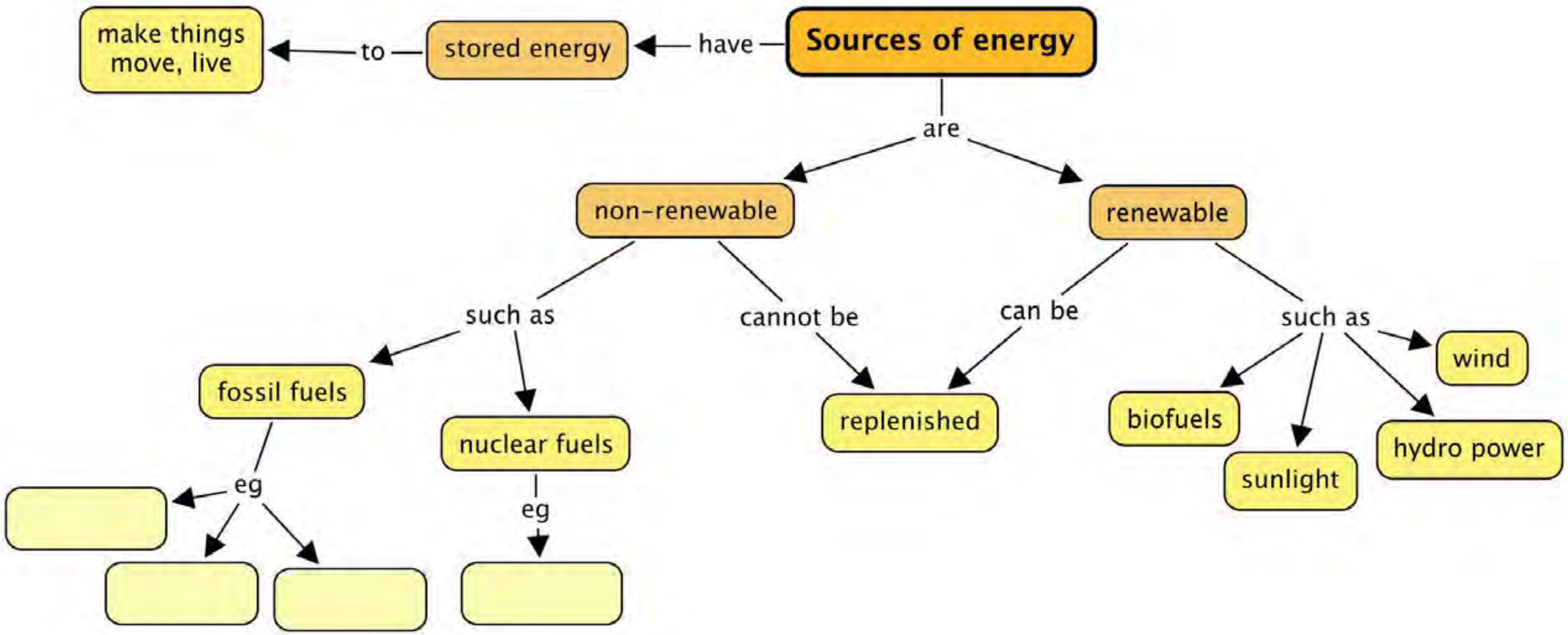
SUMMARY:

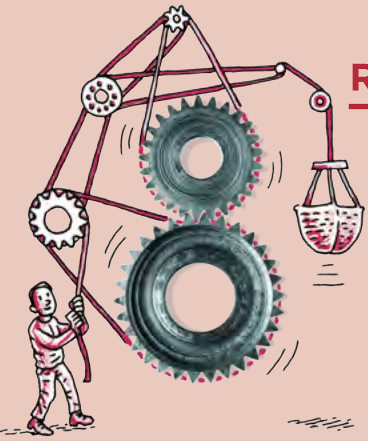
Key Concepts

- Energy is one of the requirements for life on Earth.
- Energy is needed to make things move.
- Sources of energy have energy stored within them that is used make something happen.
- Non-renewable energy sources cannot be recycled or reused. There is a limited supply.
- Examples of non-renewable energy sources are fossil fuels (coal, oil and natural gas) and nuclear fuels.
- Burning of fossil fuels releases greenhouse gases into our atmosphere.
- Renewable energy sources can be recycled or reused. There is an unlimited supply.
- Examples of renewable energy sources are wind, hydropower, solar power and biofuels.

Concept Map

This is our first concept map for Energy and Change. Complete it by filling in the three types of fossil fuels, and give an example of a nuclear fuel which was discussed in this chapter.


Sources of energy
have
stored energy
to
make things move, live
are
non-renewable
renewable
such as
fossil fuels
nuclear fuels
eg
eg
cannot be
can be
replenished
such as
wind
biofuels
sunlight
hydro power



REVISION:

1. What do we need to make things move? [1 mark]

2. What does it mean when we say something is 'a source of energy'? [1 mark]

3. Which of the following are sources of energy? [1 mark]
   a) Sun
   b) waves
   c) wind
   d) coal
   e) all of them

4. What does it mean if something is a non-renewable source of energy? [2 marks]

5. Which of these are renewable energy sources. [1 mark]
   a) coal
   b) natural gas
   c) sunlight
   d) wind
   e) crude oil

6. Which type of renewable energy uses the movement of air to generate electricity? [1 mark]

7. Complete the following sentences. Write them out in full on the lines provided and underline your answers. [5 marks]

   Coal, natural gas and oil are all examples of __________ (renewable/non-renewable) energy resources. When they are burned, they release __________ (energy/electricity). Coal, natural gas and oil are also known as __________ (nuclear fuels/fossil fuels). Wind and solar energy are examples of __________ (renewable/non-renewable) energy sources because they __________ (can/cannot) be replaced.

8. How does the burning of fossil fuels contribute to global warming? [2 marks]

9. Complete the following table. [18 marks]

Energy source	Renewable or non-renewable	Disadvantage	Advantage
Wind			
Coal			
Uranium			
Water (Hydroelectric)			
Sunshine			
Biofuels			

Total [30 marks]

2 Potential and kinetic energy

KEY QUESTIONS:

- What is potential energy?
- What is kinetic energy?
- Where do we get energy from?
- How much energy do I need?
- Can energy be created or destroyed?
- What is a system?

Renewable and non-renewable sources are where we get our energy **from** but what **types** of energy do we find in the world?

All energy can be placed into two main groups:

1. Potential energy
2. Kinetic energy

So what are these different types of energy and what does it mean if an object has potential energy or kinetic energy? Let's investigate!

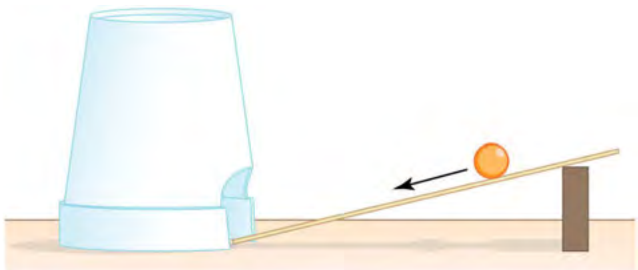
2.1 Potential energy

NEW WORDS

- joule
- potential energy
- system

Throughout our investigation and learning about the concepts surrounding energy, we will be talking about systems and how energy is transferred within a system. A system is a set of parts that work together as a whole. A change in one part of the system will affect the other parts. This will become more clear as we see some examples throughout this term.

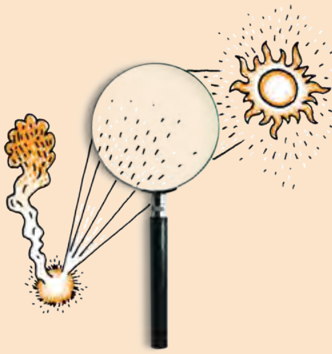
We are going to find the difference between potential and kinetic energy. Look at the following diagram which shows a ramp with a marble rolling down into a foam cup. The marble will knock the cup and make it move.



A marble rolling down a ramp.

When the marble is released, it rolls down the ramp and transfers some of its energy to the cup. This transfer of energy is what makes the cup move. But where did the marble get energy from? Do you think you can make the cup move more or less depending on how far up the ramp you start the marble? Let's do an investigation to find out.

INVESTIGATION: How can we make the foam cup move further?



INVESTIGATIVE QUESTION: If we roll a marble down a ramp and into a cup, how does the starting position of the marble affect how far the cup moves?

VARIABLES:

1. What will we change when performing this investigation?

2. What will we be measuring in this investigation?

3. Which things must stay the same?

HYPOTHESIS:

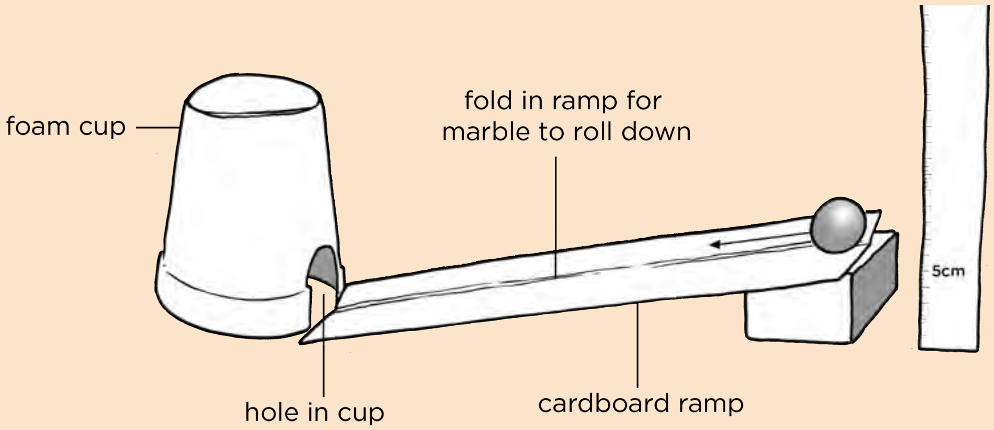
Write a hypothesis for this investigation. When you do this, you need to write what you expect to observe. It does not have to be the correct answer to the investigative question.

MATERIALS AND APPARATUS:

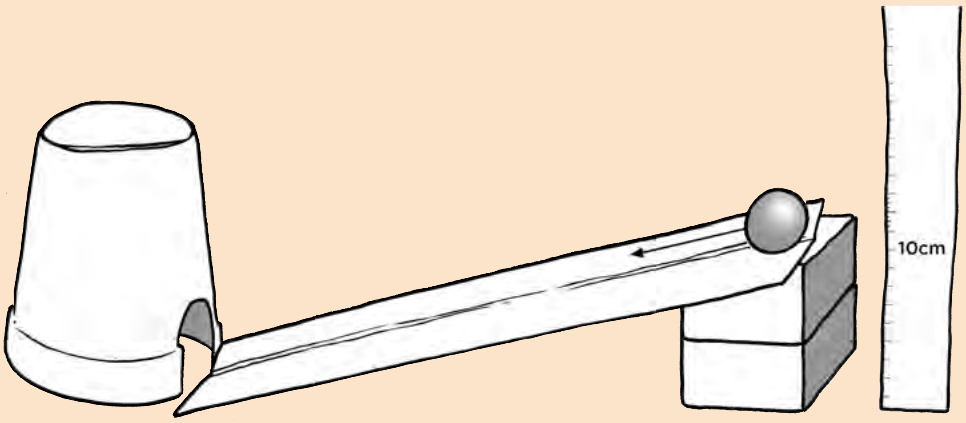
- a styrofoam cup
- a marble
- a pair of scissors
- a ramp (this can be a plank of wood or stiff card)
- books or wooden blocks to prop up the ramp
- rulers

METHOD:

1. Work in groups of 3 or 4.
2. Cut a hole in the lip of the cup so that when you turn it over on a table, there is a hole which a marble can now fit through, as shown in the previous diagram.
3. Build the setup as shown in the following diagram. Place the cup upside down on the table surface. Place the ramp so that it ends at the hole in the cup. Prop up the ramp with blocks or books. You will adjust the height of the ramp using different books or wooden blocks. Otherwise you can just hold the top of the ramp at the specified height.



4. Practice rolling the marble down the ramp and into the cup. You can use two rulers to create a path down the ramp to guide the marble into the hole so that it does not roll off the side of the ramp. Or else you can bend the cardboard so that the marble rolls down the middle on the fold. You can also try a cardboard tube like a roller towel inner. You will need to practice to see what works best with the materials that you have available.
5. Once you have found the best way to do this, you can start the measurements.
6. First set up the ramp so that the top of the ramp is at a height of 5cm. Roll the marble from a height of 5 cm and then measure how far the styrofoam cup moves.
7. Next adjust the height of the ramp by increasing by 5 cm each time. Each time place the marble at the top of the ramp and roll it down, measuring how far the cup moves.



8. Repeat the measurements until you have at least 6 recordings.
9. Record your measurements in the table and draw a graph with a line of best fit.

RESULTS AND OBSERVATIONS:

Record your results in this table.

Height of marble up the ramp (cm)	Distance the cup moves (cm)

Use the information in your table to draw a graph of the height of the marble up the ramp versus the distance the cup moves. Before you draw the graph, answer the following:

1. Which is the independent variable? This is the value which you changed in the investigation. The independent variable is written on the x-axis (horizontal axis).

---

2. Which is the dependent variable? This is the variable you measured. The dependent variable is written on the y-axis (vertical axis).

CONCLUSION:

1. Write a conclusion for this investigation. Remember to refer to your graph and hypothesis when writing your conclusion.

___

___

2. Was your hypothesis shown to be true or false?

___

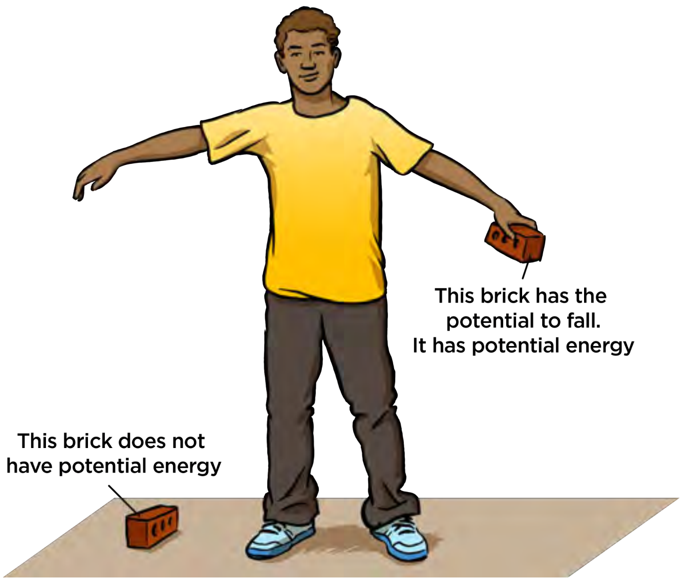
When you hold the marble at a distance up the ramp, you are preventing it from rolling down the ramp. This means that the marble has the potential to roll down and knock the cup. So, YOU gave the marble **potential energy** by picking it up and holding it at the top of the ramp. When the marble hits the cup, the marble transfers energy to the cup which then moves. The cup then comes to a stop after a while. Do you have any guesses about why the cup stops after a while?

___

___

Your investigation will have shown you that the greater the vertical height of the marble, the further the cup moved. This tells us that lifting the marble to a higher position means that it has more potential energy than if it was released from a lower position.

So the higher an object is above a surface, the more potential energy it has. Think of another example of picking up a brick, as shown in the diagram. Here we are looking at a system consisting of: the arm, the brick and the Earth that pulls on the brick.



When the brick was on the floor, it had no potential energy. But when it is lifted up, it has potential energy. Where did the potential energy come from?

The boy now lets go of the brick and it falls down to the ground and makes a hole in the sand. What received the energy of the falling brick?

Do you think the hole in the sand pit will be deeper if we drop the brick from a higher point? Why?

So what we have seen is that the energy is all still there within this system, but it is not easy to use anymore. The sand is warmer but we can not actually use that energy for anything because the temperature increase was so small. So the energy in the system has not been destroyed, but it is less available for us to use.

Let's look at another example of stored energy and energy transfers within a system.

ACTIVITY: Elastic bands

1. We are going to be shooting match boxes with elastic bands by stretching the bands and releasing them to hit the matchbox. What are the parts making up this system?

2. What is the energy input into this system?

Do you think there is a relationship between how far the matchbox travels and the energy that the hand puts in at each try? Let's find out.

MATERIALS:

- empty matchbox
- elastic band
- ruler

INSTRUCTIONS:

1. Place the empty match box on a desk, mark the spot with a piece of paper.
2. First, practice shooting the matchbox with the elastic band. Each time, place the elastic band and matchbox in the same starting position and distance from each other.
3. Once you feel comfortable doing this, stretch the elastic band by a different amount each time and measure how far the matchbox moves with each try.
4. Place a ruler next to your elastic band and first stretch it by a small amount. For example, if your elastic band is 5 cm long when held pulled tight, but not stretched, between your fingers, then stretch it to 8 cm.
5. Release the elastic band so that it hits the matchbox across the desk.
6. Measure the distance that the match box moves across the desk.
7. Record the distance in the table below.
8. Put the empty match box back in its original position on the desk.
9. Repeat the experiment several times but stretch the elastic band a bit more than before each time.

Record your measurements in the following table.

Elastic stretch (cm)	Distance moved (cm)

QUESTIONS:

1. Does the distance moved by the matchbox increase or decrease as you stretch the elastic band more? State the relationship between these two measurements.

___

___

2. What did you have to do in order to stretch the elastic band and keep it stretched?

___

3. Energy is transferred from the elastic band to the matchbox and the matchbox moves. But, then it comes to a stop after a while. Where did the matchbox transfer its energy to?

___

When the elastic band was stretched it gained potential energy. We know this because your hand had to do some work to stretch the elastic band, and now the elastic band can snap back and move the matchbox. The elastic band needs energy to make the matchbox move, and it got that energy from your hand.

The further we stretched the elastic, the further it could push the matchbox. This tells us that the more we stretch the elastic band, the more energy is transferred from the elastic band to the match box.

Energy transfers have taken place within this system: Energy is transferred from the hand, to the elastic band, to the matchbox, to the air and the table surface. The table ends up a little warmer than it was as it now has most of the energy and the air has the rest. The energy has not gone, but again it's not available to use.

*A **stretched** elastic band has potential energy.*

So did you notice that both the marble and the elastic band had potential energy? But we didn't do the same thing to give them that energy. We **lifted** the marble but we **stretched** the elastic. This means that there is more than one way to give something potential energy. **Potential energy is energy that is stored within a system.**

Now that you understand a bit more about potential energy, can you think of some more examples of things which contain potential energy? Think in terms of things which have the **potential or the ability to change something or make something move.**

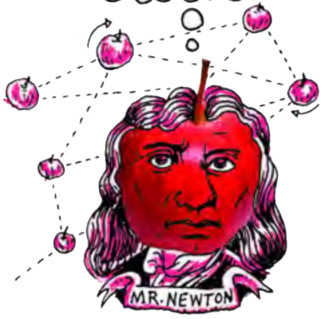
What about some of the fossil fuels that we discussed in the last chapter, such as coal and oil? Do you think these have potential energy? Yes they do. For example, coal is burned in power stations to generate electricity (you will learn more about this later on in the term). So, we can say the coal has stored energy which is used to generate electricity. Coal has potential energy. This is the same for other fuels as well.

Do you remember making electric circuits in Gr. 6 last year? Do you remember using batteries? The batteries are the source of energy for the circuit. The batteries store energy. In other words, they have potential energy.

Batteries are a source of potential energy for electric circuits.

DID YOU KNOW?

The joule was named after an English physicist, James Prescott *Joule* (1818-1889).



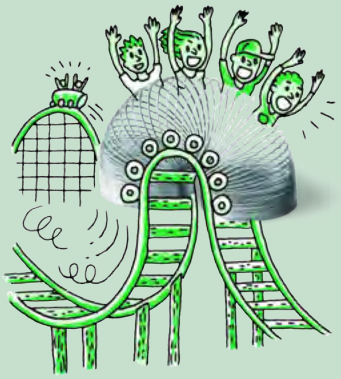
Where do we get our energy from? As we learnt in Life and Living, nutrition is one of the 7 life processes. We have to eat food. Food is the fuel for our bodies.

Have you ever had a look at all the small writing on food packaging? The information gives us nutritional information about the food. It also gives us the amount of **energy** stored in the food. Have you noticed that this is often given in **joules**?

So what is a joule? How do we measure energy?

We can measure energy, just as we can measure the mass of an object or how fast a car is going. The mass of an object is given in grams or kilograms, the speed of a car is given in kilometers per hour (km/h). In the same way, energy is measured in joules. There are 1000 joules in a kilojoule.

Let's have a look at the energy content for some of the cereals that we eat for breakfast.



ACTIVITY: Reading a cereal box

MATERIALS:

- cereal box
- pair of scissors
- calculator

INSTRUCTIONS:

1. Read the nutritional information on your cereal box.
2. Answer the questions that follow.

QUESTIONS

1. What is the amount of energy per 100 g for your cereal? Write your answer in kilojoules and in joules

___

2. The cereal boxes often indicate an amount per 100 g and then an amount per serving, which is normally less. What is the amount of energy per serving on your cereal box? Remember to include how many grams the serving is.

___

3. Look at the following table which gives the recommended daily amount of energy for an individual depending on your age and level of activity. This is a guideline as to how much energy you should consume in food in one day.

Gender	Age (years)	Sedentary (kJ)	Moderately Active (kJ)	Active (kJ)
Female	9 - 13 14 - 18	8 000 8 500	8 000 - 9 000 8 500 - 10 000	8 500 - 9 500 9 500 - 10 500
Male	9 - 13 14 - 18	8 500 10 000	8 500 - 10 000 10 000 - 11 500	9 500 - 11 000 11 000 - 13 000

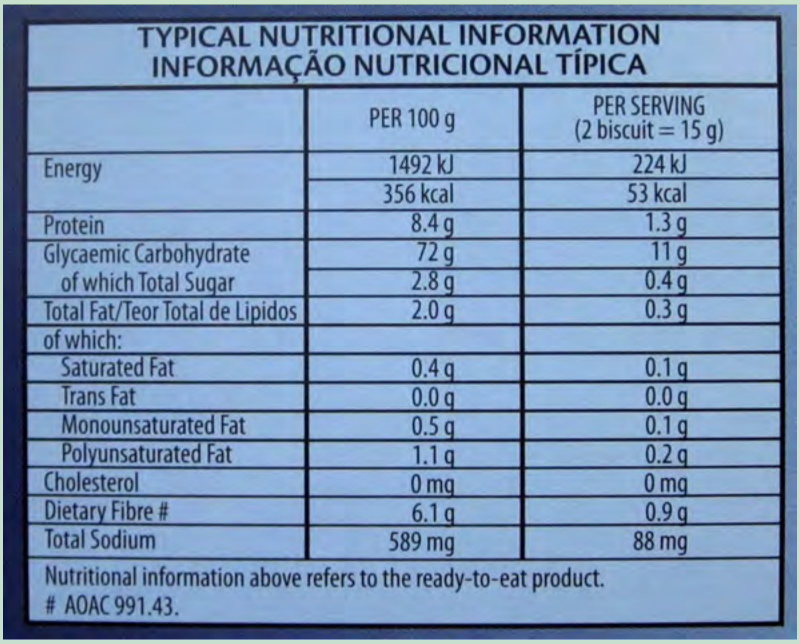
According to the table, what is the recommended daily amount of energy for your age and level of activity?

TAKE NOTE

Sedentary means that you lead an inactive lifestyle and do not do any exercise.

4. What percentage of your recommended daily energy is being supplied by one serving of your cereal? Show your calculations below.

5. The following photograph shows the nutritional information on a box of cracker biscuits. Study it and then answer the questions that follow.



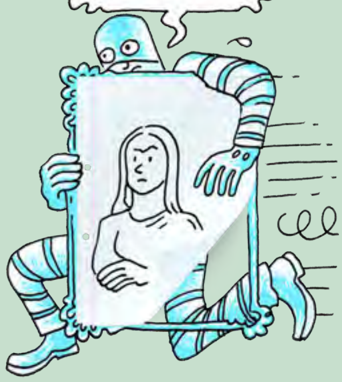
TYPICAL NUTRITIONAL INFORMATION
INFORMAÇÃO NUTRICIONAL TÍPICA

	PER 100 g	PER SERVING (2 biscuit = 15 g)
Energy	1492 kJ	224 kJ
	356 kcal	53 kcal
Protein	8.4 g	1.3 g
Glycaemic Carbohydrate	72 g	11 g
of which Total Sugar	2.8 g	0.4 g
Total Fat/Teor Total de Lipidos	2.0 g	0.3 g
of which:		
Saturated Fat	0.4 g	0.1 g
Trans Fat	0.0 g	0.0 g
Monounsaturated Fat	0.5 g	0.1 g
Polyunsaturated Fat	1.1 g	0.2 g
Cholesterol	0 mg	0 mg
Dietary Fibre #	6.1 g	0.9 g
Total Sodium	589 mg	88 mg

Nutritional information above refers to the ready-to-eat product.
AOAC 991.43.

TAKE NOTE

The joule is a measure of energy. A food joule is not different to an electrical joule, nor different to a joule that heats water, nor a joule that comes from the Sun.



a) What is the energy content per 100g in **joules**?

b) What is the mass of **one** biscuit?

c) The nutritional information gives the serving size of 2 biscuits, but you want to know what the energy content will be if you only eat one biscuit. Write down the answer below.

d) You now decide that you want to eat 5 biscuits. What is the energy content for this serving of 5 biscuits?

Do you now see why we can say that food has potential energy? We need energy to make our bodies function. We get our energy from the food we eat. The molecules which make up our food have energy stored inside them. We eat the food and use the stored energy to move our muscles and perform all our bodily functions. This stored energy is potential energy.

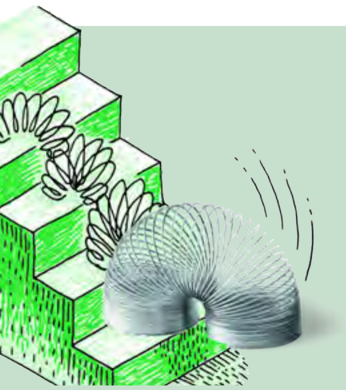
NEW WORDS

- kinetic energy
- transfer

2.2 Kinetic energy

Think back to the last activity where we used elastic bands to move matchboxes. The stretched elastic band had potential energy. When the elastic band was released, it moved and snapped back and then hit the matchbox and caused it to move. So what do we call this energy that the moving elastic band and moving matchbox have? We call it **kinetic** energy.

Kinetic energy is the energy that an object or system has because it is moving.



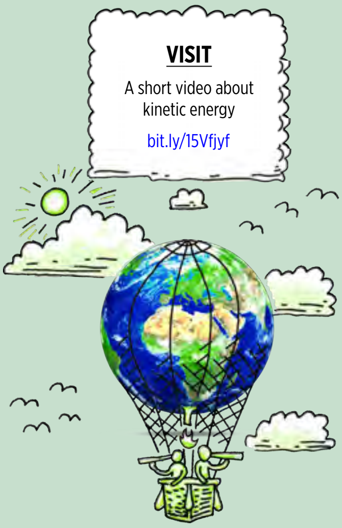
ACTIVITY: Which objects have kinetic energy?

INSTRUCTIONS:

1. Think about the definition of kinetic energy
2. Decide which of the objects in the following table have kinetic energy.
3. Give a reason for your answer.

Object	Does it have kinetic energy? (Yes or no)	Give a reason for your answer.
 A lady running.		
 A bird in flight.		
 A stop street sign.		
 A roller coaster.		

Object	Does it have kinetic energy? (Yes or no)	Give a reason for your answer.
 Two chairs.		
 An apple.		
 A helicopter.		



QUESTIONS:

1. Which bucket has more potential energy, the one sitting on the bottom step of a ladder, or the one sitting on the top step of the ladder?

2. Does a car travelling at 100 km/h or at 200 km/h have more kinetic energy?

3. When the wind blows, it is actually the air particles moving. What type of energy do the air particles have? Why?

4. You have a bucket full of water and you are about to tip the water out. What type of energy does the water have at this point? Explain why.

---

5. When you tip the water out and it falls to the ground, what type of energy does it have now?

NEW WORDS

- law
- theory
- conservation

What have we learnt so far?

- Potential energy is the energy that an object has because of its position in a system. In the brick activity, the brick had potential energy when it was lifted away from the surface of the Earth. The brick and the Earth attract each other so they are a system. The higher you lift the brick, the more potential energy you give it.
- We know that moving objects also have energy, we call the energy of moving objects kinetic energy.

But, we have also seen something else. Think again of the marble activity:

- The marble at the top of the ramp has potential energy.
- When the marble was released, it rolled down the ramp and knocked the cup causing it to move.
- The marble therefore **transferred** energy to the cup.

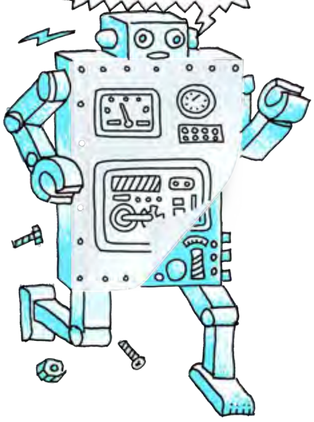
We also saw this in the match box activity:

- The stretched elastic band had potential energy.
- When the elastic band was released, it moved and snapped back and then hit the matchbox and caused it to move. This means that the match box now has energy.
- Energy was therefore transferred from the stretched elastic band to the matchbox.

So, the potential energy in the elastic band is not lost. It is transferred to the matchbox. This brings us to our next section.

TAKE NOTE

Scientific laws and theories are not set in stone, they are just the best explanation for how the world works based on the information we have now. Scientific knowledge is constantly growing and changing as new discoveries are made.



2.3 Law of conservation of energy

The **Law of Conservation of Energy** states that energy cannot be created or destroyed, it can only be transferred from transferred from one part of the system to other parts. This means that we keep recycling all the energy in the universe all the time!

Why are we talking about laws in science? Did you think laws were just for lawyers? Well, you would be wrong. In science we talk about **laws** and **theories**.

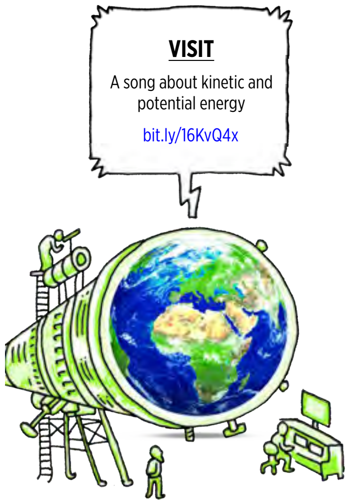
Scientific laws predict **what** will happen in a particular situation. The law has been tested repeatedly (often) and the results do not change. A law does not explain **why** something happens, it just says what **should** happen. Theories explain **how** or **why** things happen. Theories are also tested over and over again to make sure that they are valid.

Now that we know about the Law of Conservation of Energy, this matches our own observation that the energy in the elastic and matchbox example was not lost, rather it was transferred from the elastic to the matchbox. We can say that the elastic band and matchbox form a system. This is also true for the marble and cup example. Remember, a **system** is made up of different parts that work together or affect each other. Let's now look at some more examples of how energy is transferred within systems.

2.4 Potential and kinetic energy in systems

Remember, energy cannot be created or destroyed. It is transferred from one part of the system to other parts. When it is transferred it can be stored or used to make something move and so potential energy can be transferred to kinetic energy in a system.

We can look at how energy is transferred within different systems to show that energy is conserved. There are many different types of systems that we can look at to see how energy is transferred through the systems.

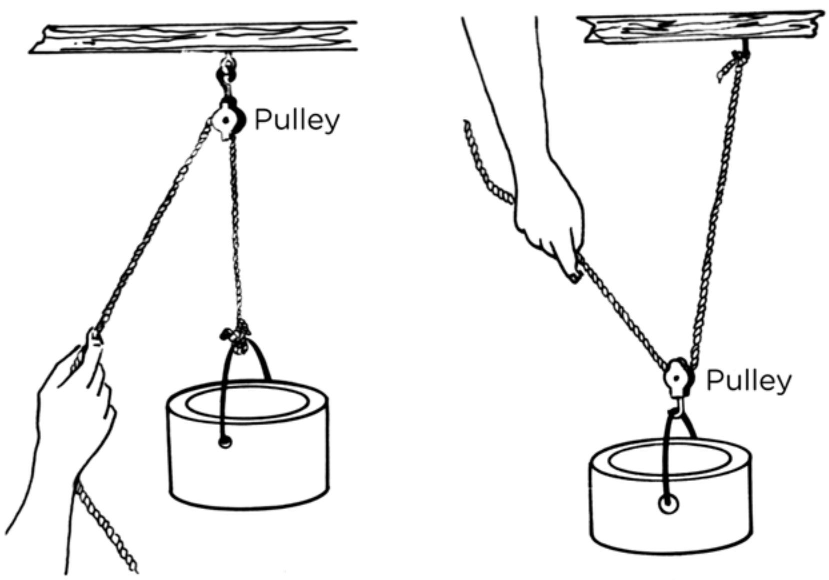


Mechanical systems

A mechanical system is one which is based on mechanical principles and the different parts interact in a mechanism. A mechanical system usually involves movement of some kind. It is often a group of simple machines working together.

Do you remember the elastic bands pushing the matchboxes? Do you think that was a system? You are right. It is a mechanical system. The hand, elastic band and matchbox all form part of a mechanical system. Your hand transfers potential energy to the elastic band, this is the input energy. The potential energy of the elastic band was transferred to the matchbox as kinetic energy. No energy was created or destroyed. We experienced the Law of Conservation of Energy without even realising it.

Another simple example if a pulley and rope system, such as at a construction site where the builders want to lift heavy objects up to a higher floor. The construction worker will pull on the rope which goes up over a pulley and to lift the heavy object higher.



A pulley system is an example of a mechanical system.

What is the input energy in this system?

What are the different parts making up this mechanical system?

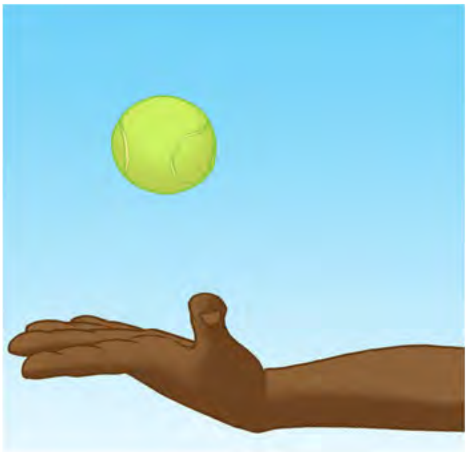
What is the input energy transferred to within this system?

A swing or a seesaw are examples of mechanical systems.

A swing is a simple mechanical system.

Did you realise that when you were swinging on the park swings that you were a part of a mechanical system? When you are at the top of the swing's arc, you and the swing have potential energy because the Earth is pulling you and you are going to start moving down. The **potential energy** becomes **kinetic energy** as you swing through the arc.

What about when you throw a ball up into the air? Do you think this is a mechanical system?



When you throw a ball upward it slows down as it moves upwards, stops for an instant and then speeds up as it falls back down to your hand. Your hand moves to throw the ball and transfers energy to the ball which allows it to move upwards. Does this also follow the Law of Conservation of Energy? Yes, it does. No energy was created or destroyed. The kinetic energy was transferred from your hand to the ball which then starts to move. As the ball moves upwards, kinetic energy is transferred to potential energy as it moves further away from the ground.

As the ball moves back down again, the potential energy is transferred to kinetic energy.

What are the parts involved in this mechanical system?

____

What is the input energy in this mechanical system?

____

When does the ball have the most potential energy?

____

When does the ball have kinetic energy?

____

Let's have a look at some more examples.

ACTIVITY: Identifying energy transfers in mechanical systems

MATERIALS:

- a piece of wire

We are first going to perform a simple demonstration to identify the energy transfers within mechanical systems. Take a length of wire and touch it to your lips. How does it feel?

____

Then, bend the wire into a U-shape and bend it back and forth 10 times quickly. Now, feel the temperature again at the bend. How does it feel?

____

This is an example of a mechanical system. We can describe the transfer of energy as the potential energy within your arms is transferred to kinetic energy as you move them back and forth. This is transferred to kinetic energy in the wire which is then transferred to the lips as heat.

INSTRUCTIONS:

1. Look at the following pictures of different mechanical systems.
2. Identify the different parts in the system and then how energy is transferred from one part to another. You can discuss this with your partner.

3. Then write a few sentences to describe the energy transfers within each system.

QUESTIONS:

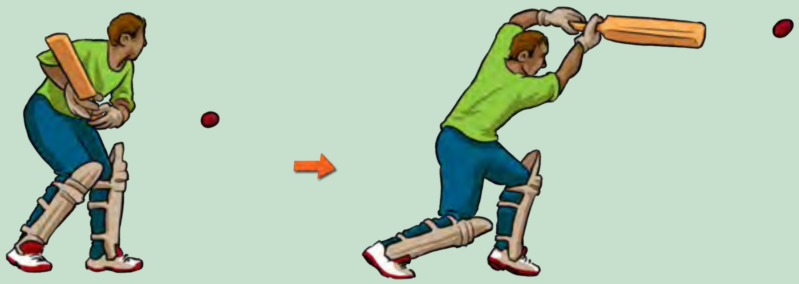
1. The girl uses the energy in her muscles and pulls her leg back. When her leg is at its highest point, what energy does it have?

---

2. As she swings her leg back down towards the ball, describe the transfer of energy.

---

3. When her foot hits the ball, and the ball moves off, describe the transfer of energy in the system.



4. The muscles in the cricketer's arm pull the cricket bat upward. Describe the transfer of energy.

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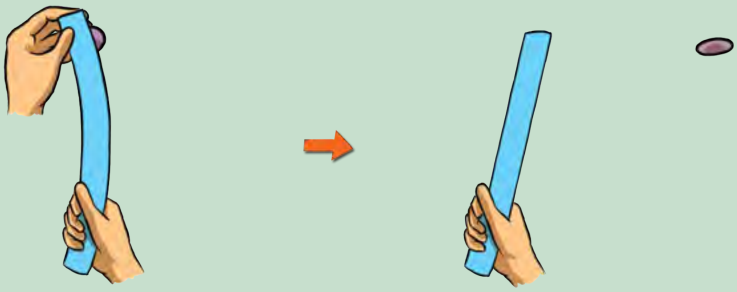
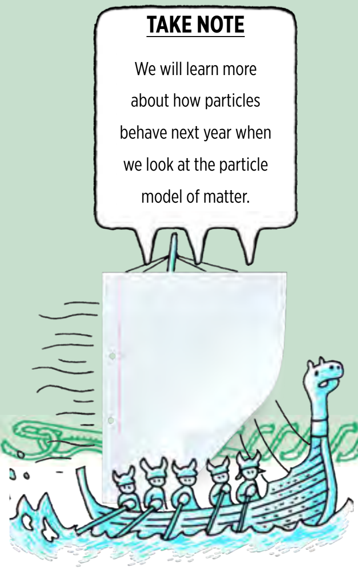
5. Describe the transfer of energy as the bat swings down and then hits the moving ball.



6. Now that you have had practice with the other examples, use the following space to describe the transfer of energy within the above system as a ruler is pulled back and then flicks a pellet across the room.



Thermal systems

Did you know that the particles that make up a substance or object, such as atoms or molecules, also have kinetic energy? Particles which have more kinetic energy will move faster than particles which have less kinetic energy. When the particles are moving very fast, we feel the substance and say "That's hot!". This is because the temperature of a substance depends on the kinetic energy of the particles.

The thermal energy can be transferred from one object to another in a thermal system. When thermal energy is transferred, this is called heat. We will look more at this in the next chapter, but for now let's look at some simple examples of energy transfers within thermal systems (heating).

INVESTIGATION: The energy transfers when boiling water

INVESTIGATIVE QUESTION:

What happens to the temperature of water when it is heated over a flame?

VARIABLES:

We will be measuring the change in the water temperature over time.

1. Which quantity/variable are you in control of? This is the independent variable.

2. Which variable are you measuring in response to the independent variable? This is the dependent variable.

3. Which variable are you keeping constant?

HYPOTHESIS:

Write a hypothesis for this investigation. (Hint: What do you think will happen to the temperature of the water. Will it go up or down?)

MATERIALS AND APPARATUS:

- 150 ml or 250 ml beaker
- tripod
- gauze
- Bunsen burner
- matches
- thermometer
- stopwatch
- retort stand
- clamp

METHOD:

1. Pour 200 ml of water into a beaker.
2. Place the beaker onto the wire gauze on the tripod.
3. Carefully place the thermometer into the water. When you take the readings, the thermometer should not be touching the sides of the beaker. Alternatively, if you have a retort stand and clamp, the thermometer can be clamped in the stand with the bulb in the water.
4. Light the Bunsen burner.
5. Measure the temperature of the water every 30 seconds until the water starts to boil.
6. Once the water starts to boil, take 3 to 5 more readings.
7. Write down your observations in the table.
8. Once finished, turn off the Bunsen burner and leave the beaker of water to stand.
9. Plot a graph showing the relationship between the time and the temperature.

RESULTS AND OBSERVATIONS:

A table to record your observations:

Time (seconds)	Temperature (°C)
30	
60	
90	
120	
150	
180	

Use the following space to draw a line graph for your results.

1. First, think about what will go on your horizontal, x-axis? This is what you changed.

___

2. What will go on the vertical, y-axis? This is what you measured.

___

3. The temperature of the water kept increasing, until it started to boil. What temperature did the water boil at?

4. What did you observe in the temperature when the water started to boil?

CONCLUSION:

1. What can you conclude from your results?

2. Can you accept or reject your hypothesis?

QUESTIONS:

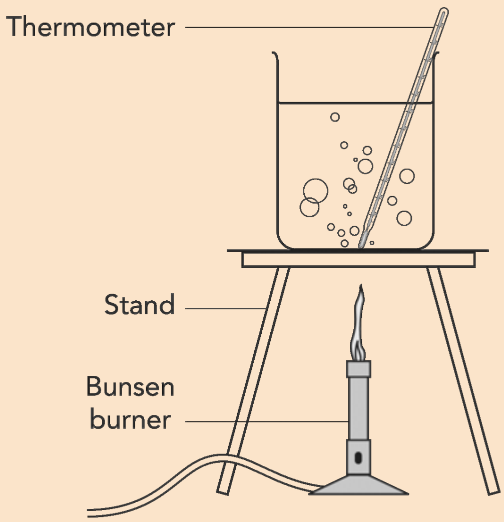
1. In order for the water to boil, the thermal energy of the water must increase. Where do you think the energy came from to make the water boil?

2. Describe the transfer of energy within this thermal system as the water is heated.

3. After the water has boiled, and you then turn off the Bunsen burner, what happened to the water in the beaker?

4. What do you think happened to the thermal energy of the water? Describe the transfer of energy.

5. A Gr. 7 learner is conducting the investigation and read the temperature off the thermometer as it is set up in the diagram below. What is wrong with this set-up? What is your advice to the learner?



So, what have we discovered? The temperature of the water increased. This means that the water particles must have been given more **kinetic energy**. The energy must have come from the Bunsen burner flame. The flame is there because we are burning gas so the energy must have been stored in the gas. If it is stored energy then it is **potential energy**.

So, we have discovered that the potential energy stored in the gas has been transferred to the water particles as kinetic energy. No energy has been **created**, it has been **transferred** from the gas to the water. The energy of the system has been **conserved**.

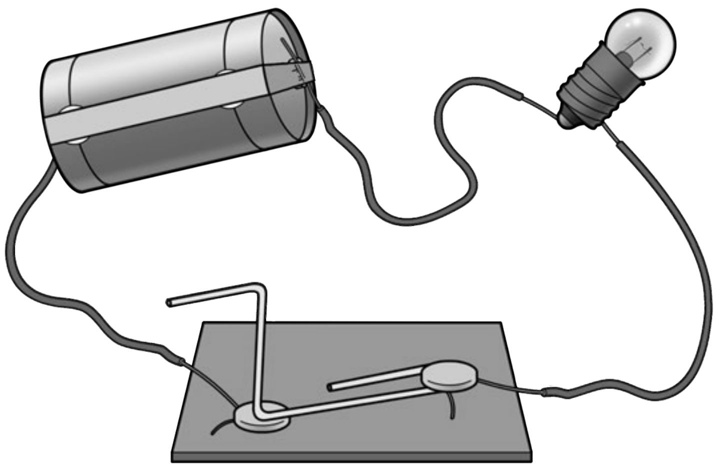
VISIT

Build your own skate park with this simulation and see what happens to the potential, kinetic, and thermal energy of the skateboarder.

bit.ly/18qYcmq

Electrical systems

Do you think an electric circuit is a system? Look at the following image and discuss this with your partner. Write down whether you think it is a system or not and why.



___

___

What is the source of energy is this electric circuit? In other words, what is the input energy in this system?

___

What is the result of the energy transfer in the system? In other words, what is the energy output?

___

Let's look at another example of an electrical circuit which makes a motor turn to see the different energy transfers within the system.

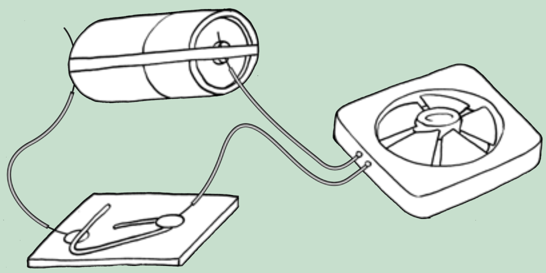
ACTIVITY: An electric fan system

MATERIALS:

- small electric fan or motor
- conducting wires
- battery
- switch

INSTRUCTIONS:

1. If possible, make the following circuit in class. However, if you do not make the actual circuit, study the image and answer the questions.
2. To make the circuit, attach a small fan or motor to a battery using the conducting wires.
3. Attach a switch in the circuit as shown in the image. You can make your own switch using a piece of board and pressing two metal pins into it. Then, bend a metal paper clip and attach it to the one drawing pin as shown below.
4. Close the switch and observe what happens to the fan.



QUESTIONS:

1. What are the parts making up this electrical system?

___

2. Which part of the system provides the input energy to the system?

___

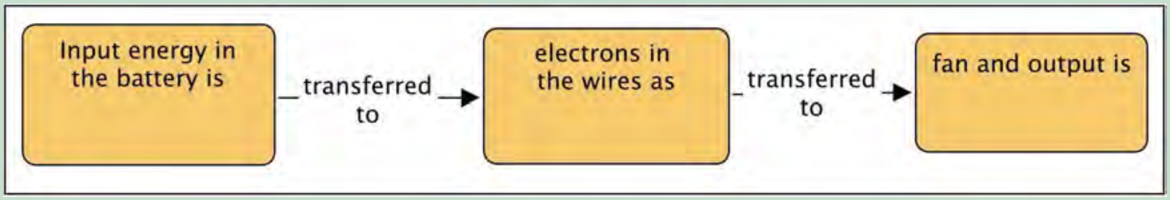
3. What happens to the fan or motor when you close the switch?

___

4. What type of energy does the fan now have?

___

5. Using your answers to the previous questions, complete the following flow diagram which describes the energy transfers within this electrical system. You need to fill in the type of energy at each step.

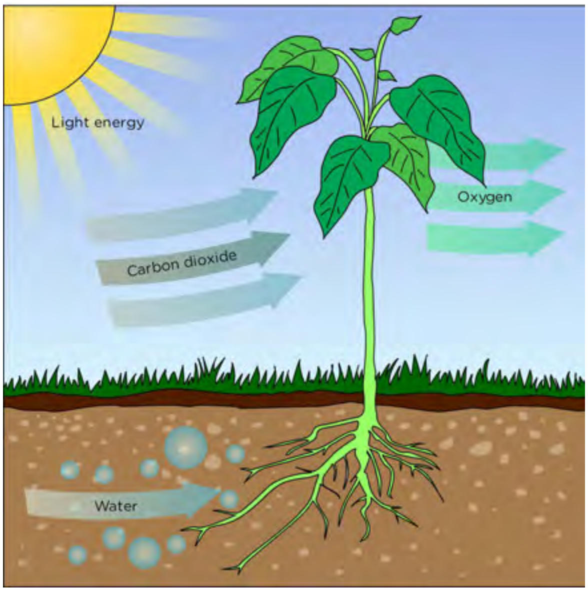


Biological systems

Do you know that we also get biological systems? You have come across these types of systems before in Life and Living, but now we are going to talk about them in terms of how the energy is transferred within these systems, and conserved.

Do you remember learning about photosynthesis and food chains in Life and Living? This is an example of a biological system. Let's find out why.

A plant uses the radiant energy from the Sun to make its own food through the process of photosynthesis. The energy from the Sun is stored as potential energy in plants, mainly as starch. Have a look at the following image to remind you.



What process is being shown in the diagram? Write a sentence to describe the requirements for this process.

___

___

___

When an animal eats the plant it uses the potential energy in the food which is released during respiration. This is then used by the animal to move and for all its life processes. So the potential energy in the food which the animal eats is transferred to kinetic energy. Energy has been transferred from the Sun to the plant to the animal.

An impala eats the grass and stores the energy in its muscles. When the impala runs, the stored energy becomes kinetic energy.

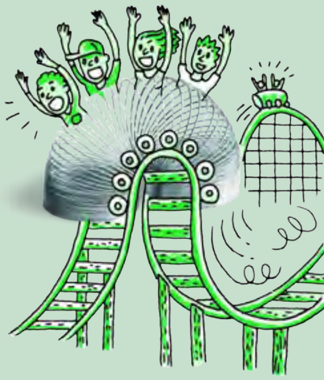
When we eat plants or animals we are able to use the stored potential energy to make our bodies function.

Our food provides the input energy for our bodies to work and move. The food contains potential energy.

Is the energy conserved in a biological system? Yes, it is! The plants change the Sun's energy into **potential** energy which it stores inside itself. Animals then eat the plants and the stored potential energy is transferred to them. The animals use the stored energy to enable them to move. This means the potential energy within the animal has been transferred kinetic energy. As the animal moves and performs its functions, this kinetic energy is transferred to the surroundings. No energy has been created or destroyed, just transferred from the Sun to the plant to the animal.

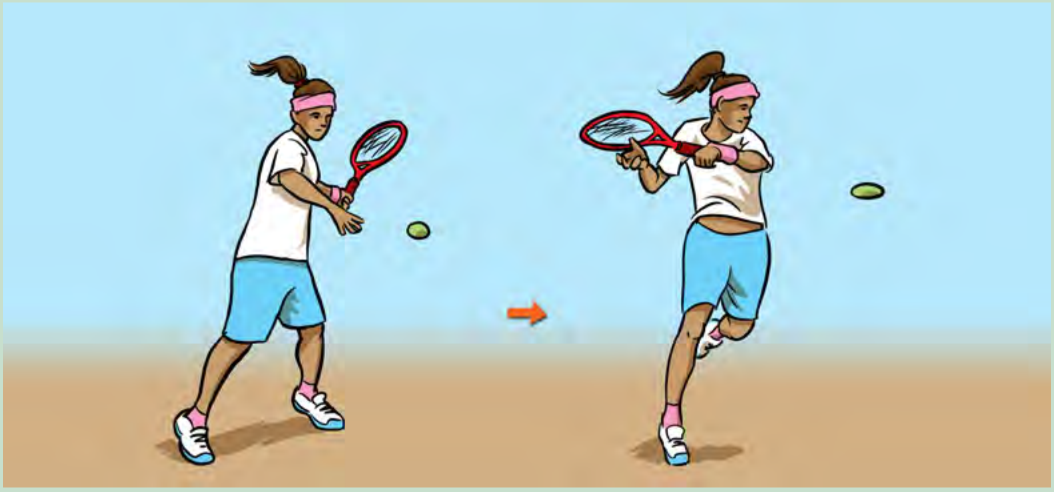
Let's revise the energy transfers within some systems by studying and drawing flow diagrams.

ACTIVITY: Flow diagrams for energy transfers



INSTRUCTIONS:

1. Study each of the following diagrams which show different systems.
2. Draw a flow diagram, similar to the one you did for the electric fan in the space provided.
3. Then write a few sentences underneath on the lines to describe how energy is transferred between the different parts in each of these systems.
4. The first one has been done for you.



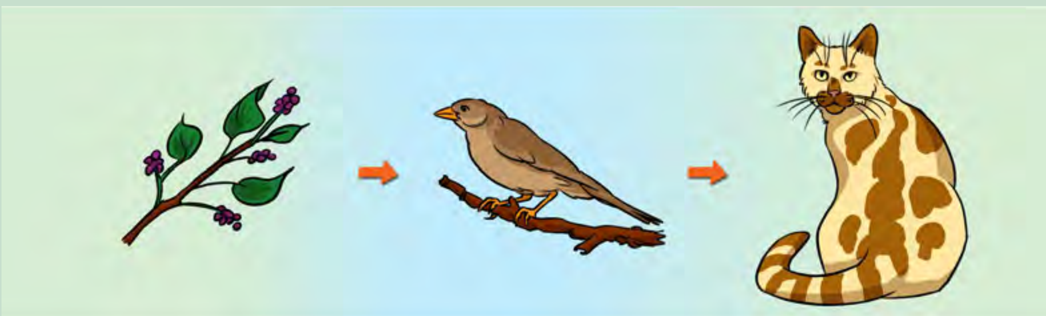
This flow diagram describes the transfers of energy.

potential energy in raised arm and racket → transferred to → ***kinetic energy*** in girls arm as she swings → transferred to → ***kinetic energy*** in tennis racket → transferred to → ***kinetic energy*** in ball

The tennis player's arm and racket have potential energy as they are raised. As the girl swings her arm, this potential energy is transferred to the tennis racket as kinetic energy. The tennis racket transfers energy to the ball as kinetic energy which enables the ball to move through the air.

QUESTIONS:

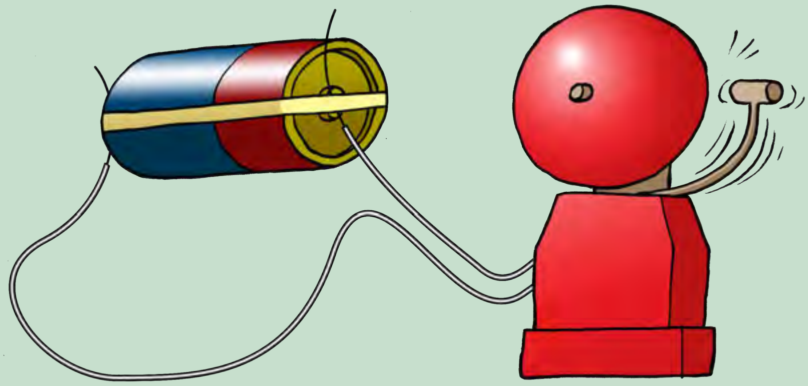
1. This drawing shows a food chain.



Draw a diagram showing the energy transfers in this biological system.

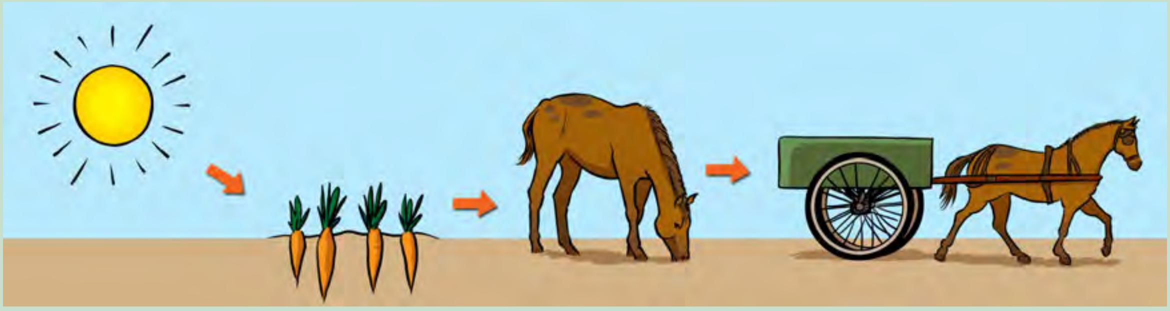
2. Write a description of the energy transfers below.

3. Draw a diagram showing the energy transfers in this electrical system.



4. Write a description of the energy transfers below.

5. In the previous example showing the berries, the bird and the cat, we saw an example of a food chain. Do you remember learning about food chains in Gr. 6? A food chain only shows the transfer of energy between organisms, and does not include the Sun. So, it always starts with a producer. Is the image below an example of a food chain? Why or why not?



6. We can rather call this an energy transfer sequence. Draw a flow diagram to explain the energy transfers in this biological and mechanical system.

7. Write a description of the energy transfers below.

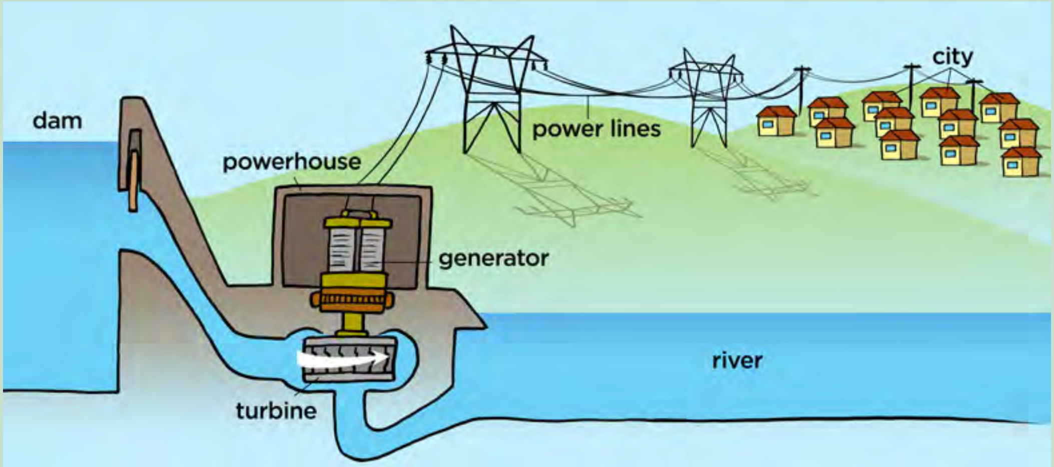
8. Let's now look at a more complex system which involves many different parts working together. Do you remember learning about hydropower as an source? Is it renewable or non-renewable?

____

TAKE NOTE

We will learn more about food chains and the interactions between organisms next year in Gr. 8 Life and Living.

9. Study the following diagram which shows a hydropower plant at the edge of a dam. Then answer the questions that follow.



a) The water in the dam on the left is high up. It has the ability to fall down. What kind of energy does the water have?

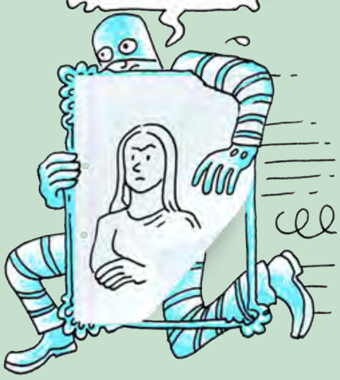
____

b) As the water flows down the outlet from the dam, describe the transfer of energy.

____

TAKE NOTE

We will study the national electricity grid in more detail at the end of the term.



c) The flowing water then turns the turbine. This is a mechanical system. What energy does the turbine have?

____

d) The generator then transfers the energy between two systems. The kinetic energy in the mechanical system is transferred to kinetic energy in the electrical system as it generates electricity. What parts make up the electrical system in the diagram?

____

____

e) What is the output from this whole system? In other words, what does the city get?

____

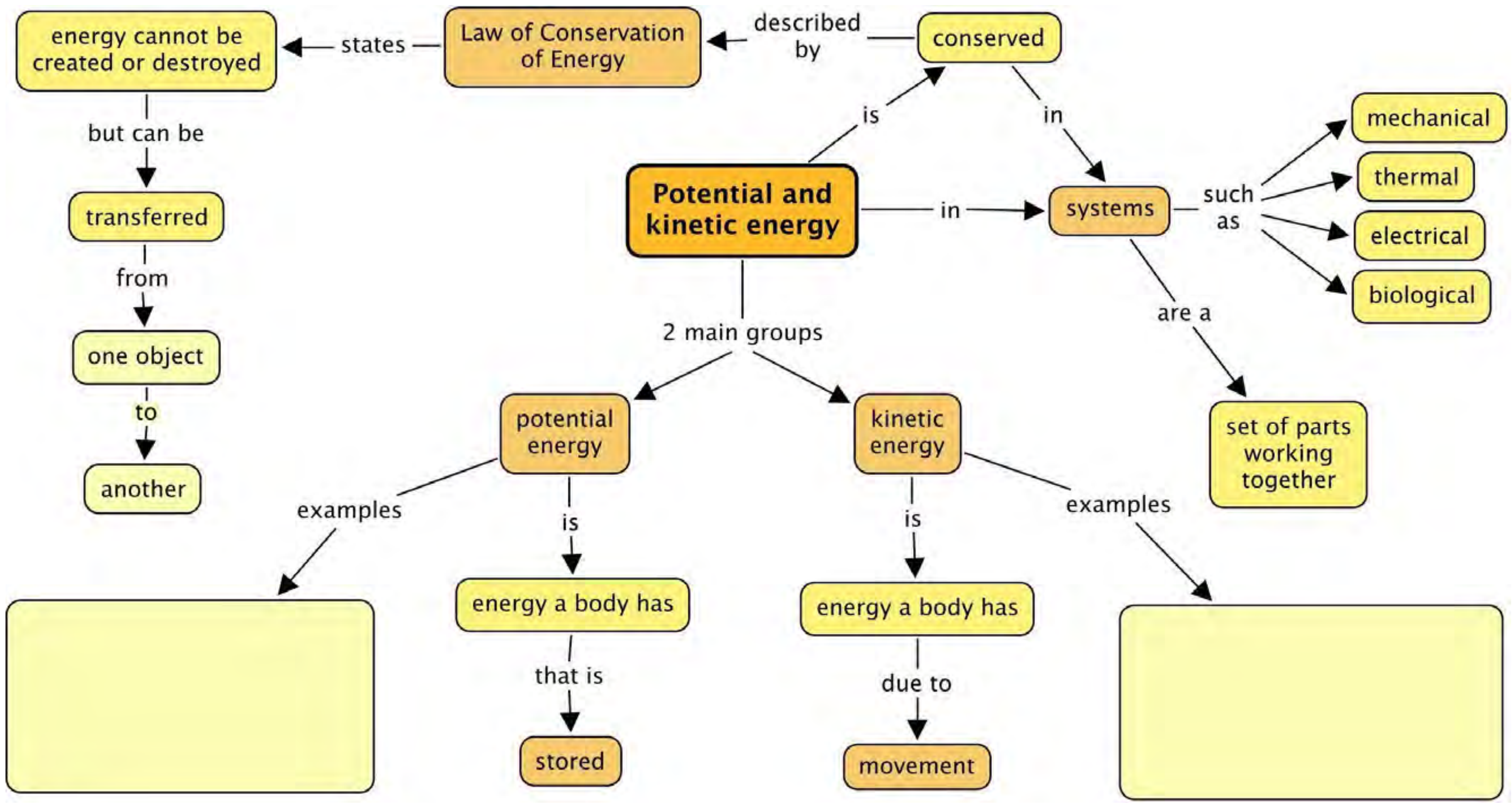
SUMMARY:

Key Concepts

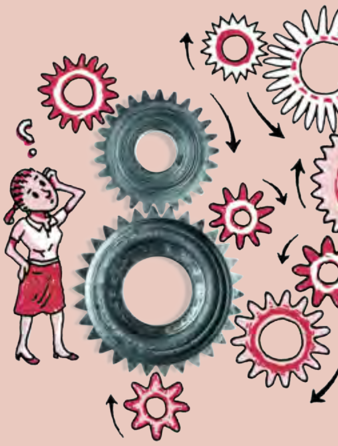
- Potential energy is energy which is stored in a system.
- Kinetic energy is energy which an object has because it is moving.
- Energy is measured in joules (J).
- Energy cannot be created or destroyed. It can only be transferred from one part of a system to another. This is the Law of Conservation of Energy.
- Energy is transferred within systems. The input energy is transferred through the system and energy is conserved.
- There are various energy systems, such as:
  - mechanical systems
  - thermal systems
  - electrical systems
  - biological systems
- Energy is also transferred between different systems.

Concept Map

Complete the concept map below by filling in some examples of objects with either potential energy or kinetic energy that you learnt about in this chapter.


Potential and kinetic energy
is
conserved
described by
Law of Conservation of Energy
states
energy cannot be created or destroyed
but can be
transferred
from
one object
to
another
in
systems
such as
mechanical
thermal
electrical
biological
are a
set of parts working together
2 main groups
potential energy
is
energy a body has
that is
stored
examples
kinetic energy
is
energy a body has
due to
movement
examples

REVISION:

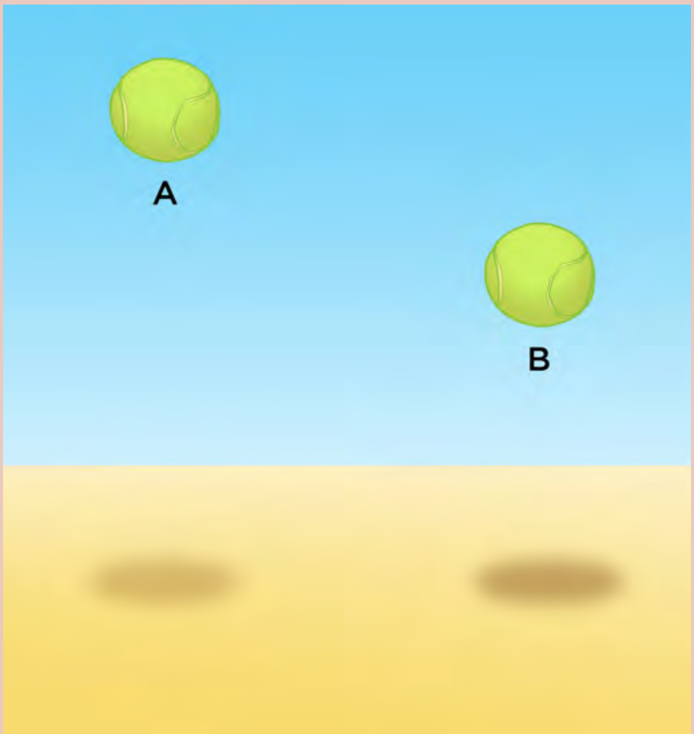


1. What is potential energy? Give two examples of systems which have potential energy [3 marks]

2. What is kinetic energy? Give two examples of systems which have kinetic energy? [3 marks]

3. What does the Law of Conservation of Energy state? [1 mark]

4. Look at the picture below.



a) Which ball has the most potential energy? [1 mark]

b) Explain your choice. [1 mark]

5. Complete the sentences by filling in the missing words. Write the sentence out in full and underline your answers.

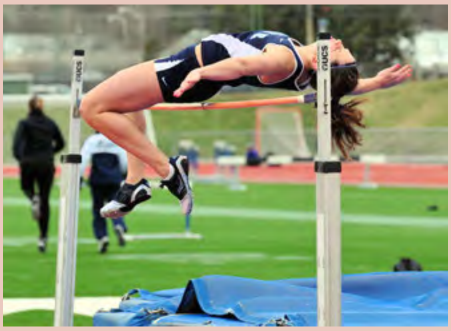
   a) A plant receives energy from __________ and uses the energy to make __________. The plant then changes some of the sugar into __________ and stores it in leaves, fruit and other parts. The plant has __________ energy which you can get when you eat the plant. [4 marks]

   b) When a plane carries skydivers high into the sky, it is giving them __________ energy. When they jump out and free-fall, they have __________ energy. [2 marks]

These army skydivers have just jumped out the back of a plane.

6. Draw an energy transfer flow diagram to show how energy gets from the Sun into your food and then to you. [3 marks]

7. A high jumper starts running. As she approaches the bar, she pushes off the ground and lifts her body off the ground and flies over the bar. She then falls down into a large padding on the ground.



A high jumper going over the bar.

Think about her jumping, from the moment her feet leave the ground. She goes up in the air, she almost stops as she goes over the bar, and then she comes down again.

a) Where does she have the most potential energy? [1 mark]

---

b) Where does she have the most kinetic energy? [1 mark]

---

c) Does she have some potential energy and some kinetic energy at any point in her jump? If you say yes, name one point where it is true. [2 marks]

---

8. Which type of energy do each of the following systems contain (kinetic or potential or both types)? [6 marks]

a) A mountain biker at the top of the mountain.

---

b) Petrol in a storage tank.

---

c) A race-car travelling at its maximum speed.

---

d) Water flowing down a waterfall before it hits the pond below.

---

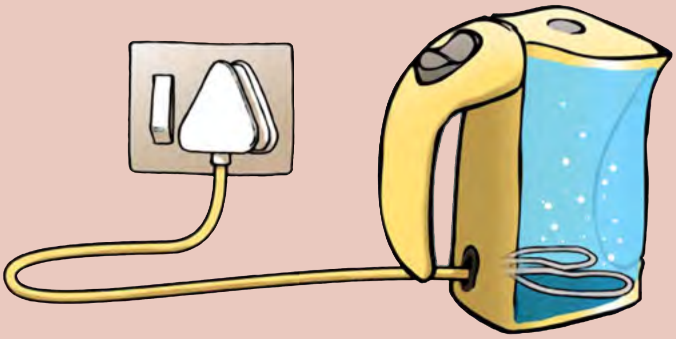
e) A spring in a pinball machine before it is released.

---

f) A running refrigerator motor.

---

9. Study the following image and answer the questions.



a) There are two systems involved in this image of heating water in a kettle that is plugged in. What are they? [2 marks]

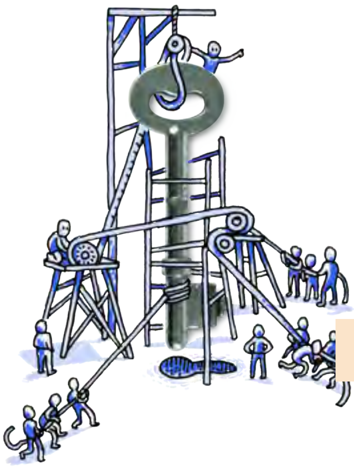
---

b) Describe the energy transfers within and between these two systems. [2 marks]

Total [32 marks]

Got another idea for the apple? Discover the possibilities here.

3 Heat: Energy transfer



KEY QUESTIONS:

- What is the difference between heat and temperature?
- How does a heater warm up a cold room?
- Why can the Sun make us warm?
- Why does my cold drink become warm?

3.1 Heating as a transfer of energy

In the last chapter we looked at thermal systems. The thermal energy of an object is the amount of energy it has inside of it, in other words, its internal energy. In a thermal system, thermal energy is transferred from one object to another. Heat is the transfer of thermal energy from a system to its surroundings or from one object to another. This transfer of energy is from the object at a higher temperature to the object at a lower temperature.

It is very important to know that, in science, heat and temperature are not the same thing.

- **Heat** is the transfer of thermal energy from a system to its surroundings or from one object to another as a result of a difference in temperature. Heat is measured in joules (J). This is because heat is a transfer of energy.
- **Temperature** is a measure of how hot or cold a substance feels and it is measured in degrees Celsius (°C). Temperature is a measure of the average kinetic energy of the particles in an object or system. We use a thermometer to measure the temperature of an object or substance.

NEW WORDS

- thermal
- heat
- temperature

Complete the following table to summarise the differences between heat and temperature

	Heat	**Temperature**
Definition		
Unit of measurement		
Symbol for unit		

Heat is the transfer of energy. During energy transfer, the energy moves from the hotter object to the colder object. This means that the hotter object will cool down and the colder object will warm up. The energy transfer will continue until both objects are at the same temperature.

There are 3 ways in which thermal energy can be transferred from one object/substance to another, or from a system to its surroundings:

1. Conduction
2. Convection
3. Radiation

Let's have a look at these in more detail.

VISIT

A rap song to introduce you to (and help you remember!) conduction, convection and radiation.

bit.ly/1h3PIok

3.2 Conduction

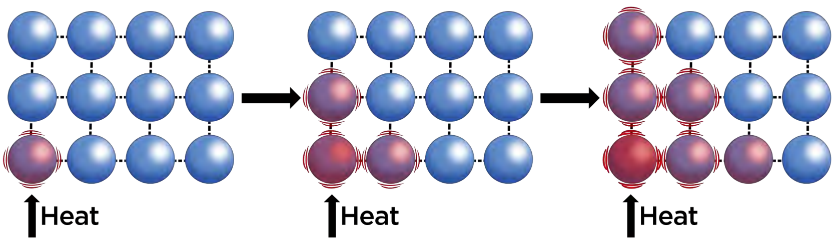
Have you noticed that when you put a cold, metal teaspoon into your hot cup of tea, the teaspoon handle also warms up after a while? Have you ever wondered how this warmth "moved" from the hot tea to the cold teaspoon and warmed it up? This is one way in which energy is transferred and this is called **conduction**. Let's find out how it works.

How does the handle of the metal teaspoon become hot when in a cup of tea?

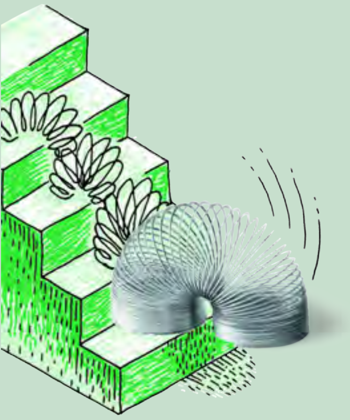
NEW WORDS

- conduction
- conductor
- insulator

When energy is transferred to an object, the energy of the particles increases. This means the particles have more kinetic energy and they start to move and vibrate faster. As the particles are moving faster they "bump" into other particles and transfer some of their energy to those neighbouring particles. In this way, the energy is transferred through the substance to the other end. This process is called **conduction**. The particles conduct the energy through the substance, as shown in the diagram.



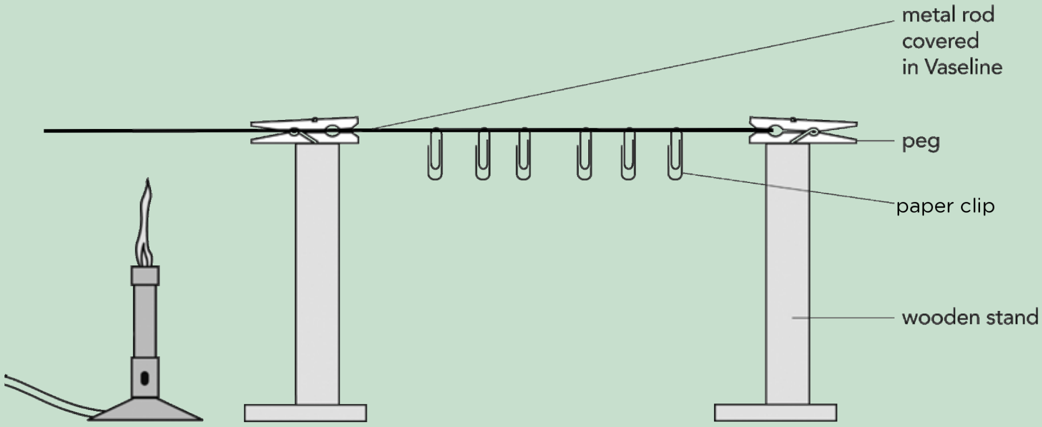
Let's demonstrate this practically.



ACTIVITY: Conduction through a metal rod

INSTRUCTIONS:

1. Your teacher will set up the demonstration as in the diagram below.
2. Observe what happens to the pins or paper clips as the Bunsen burner is lit and heat is applied to one end of the metal rod.



QUESTIONS:

1. When the Bunsen burner is lit, what happens to the rod just above it?

2. Which pin or paperclip dropped off the metal rod first? The one closest to or furthest from the Bunsen burner?

3. What does this tell us about the way in which heat is conducted along the rod?

Let's think about the teaspoon in the tea again. The tea is hot and the metal spoon is cold. When you put the metal teaspoon into the hot tea some of the thermal energy from the tea is transferred to the metal particles. The metal particles start to vibrate faster and collide with their neighbouring particles. These collisions spread the thermal energy up through the teaspoon. This makes the handle of the teaspoon feel hot.

Conduction is the transfer of thermal energy between objects that are touching. In the teaspoon example, the particles of the tea are touching the particles of the metal spoon, which in turn are touching each other, and this is how heat is conducted from one object to the other.

Do all materials conduct heat in the same way? Let's find out.

INVESTIGATION: Do all materials conduct heat in the same way?

AIM: To investigate which materials are the best conductors of heat.

In this investigation, we will be placing an ice cube on a plastic block and on an aluminium block and observing which ice cube melts the fastest.

HYPOTHESIS:

Write a hypothesis for this investigation. Which block do you think will melt the ice cube the fastest?

____

____

MATERIALS AND APPARATUS:

- a plastic block
- an aluminium block
- ice cubes
- a plastic ring to keep the ice cube in place on the block

METHOD:

1. First feel the plastic block and the aluminium block. Describe how they feel.

____

____

2. Place an ice cube onto each block and observe what happens.

OBSERVATIONS:

1. Which ice cube starts to melt first and the fastest?

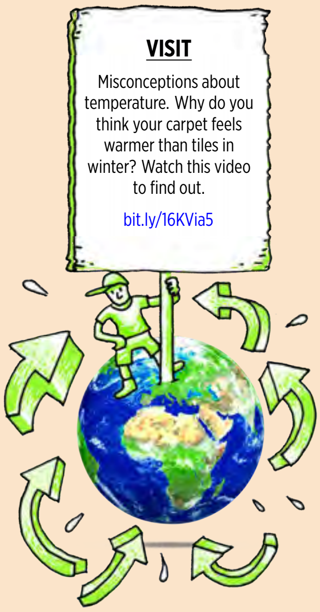
____

2. Is this what you thought would happen? Refer back to your hypothesis.

____

____

____



CONCLUSIONS:

What can you conclude about which material (the plastic or the metal) is the best conductor of heat?

VISIT

Misconceptions about heat: Why is a cake tin more likely to burn you than the actual cake?

bit.ly/GL81CW

So how does this work? This is to do with **thermal conductivity**, the rate at which heat is conducted from one object to another.

When you originally felt the blocks, you felt that the plastic block was warmer. But, what we observed is that the aluminium or metal block melted the ice cube faster. This is because the metal block is conducting the heat faster to the ice cube. The plastic block is a worse thermal conductor so less heat is being transferred to the ice cube and so it does not melt as fast.

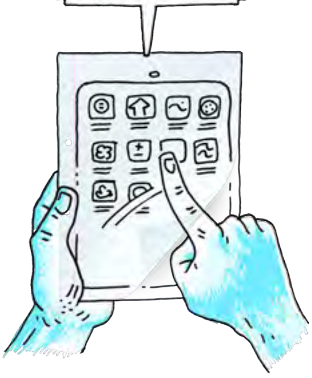
Why then does the aluminium block feel colder than the plastic block?

This is because the aluminium conducts heat faster away from your hand than the plastic does. Therefore the aluminium block feels colder and the plastic block feels warmer. When you touch something, you do not actually feel the temperature. Rather you feel the rate at which heat is either conducted away from or towards you.

Let's think of another example of baking a cake. Imagine you have just finished baking a cake in the oven at 180 °C.

TAKE NOTE

Remember, just because a material **feels** colder, does not mean it has a lower temperature. It may just be that it is conducting heat faster away from your hand.



A cake baking in the oven in a metal tin.

When you remove the cake from the oven, which is more likely to burn you more, the metal cake tin, or the cake?

Do you think the cake and the tin are at the same temperature when you remove them from the oven? Why?

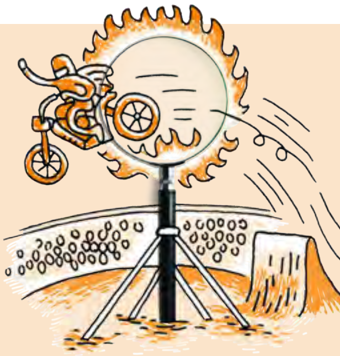
What we have seen here is another example of thermal conductivity. The tin will conduct heat much faster to your hand than the cake, so the tin will burn you, but the cake will not. The tin and the cake are at the same temperature.

So what have we learnt? Metals conduct heat better than non-metals.

- There are substances that allow thermal energy to be conducted through them and so they are called **conductors**.
- There are substances that do not allow thermal energy to be conducted through them and so they are called **insulators**.

Now that we know that metals are good conductors of heat, do you think all metals conduct heat equally well? Let's investigate which metals are better conductors.

INVESTIGATION: Which metals are the best conductors of heat?



We are going to see which metal is the better conductor of thermal energy. To do this we will see which metal becomes hot first.

AIM: To identify whether some metals are better conductors of heat than other metals.

IDENTIFY VARIABLES:

Read through the method and look carefully at the diagram for the investigation to identify the different variables required.

1. Which variable are you going to change?

____

2. What do we call the variable that you are going to change?

____

3. Which variable are you going to measure?

____

4. What do we call the variable that you are going to measure?

____

5. Which variables must be kept the same?

____

____

6. What do we call the variables which must be kept the same?

HYPOTHESIS:

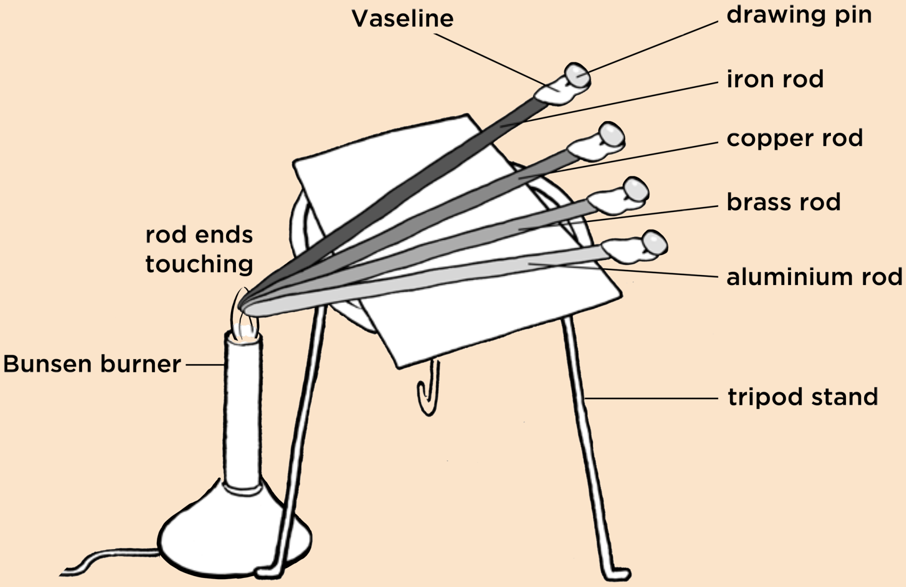
Write a hypothesis for this investigation.

MATERIALS AND APPARATUS:

- Bunsen burner
- Vaseline
- copper, iron, brass and aluminium rod
- stopwatch
- drawing pins
- tripod
- cardboard or paper
- matches

METHOD:

1. Stick the flat end of a drawing pin to the end of each of the metal rods using the Vaseline. Try to use the same amount of Vaseline for each drawing pin.
2. Place the cardboard on the tripod.
3. Balance the metal rods on the cardboard so that one end of each is over the Bunsen burner.
4. Light the Bunsen burner.
5. Using a stopwatch, measure how long it takes for each of the pins to drop off.
6. Record your results in the table.
7. Draw a bar graph to illustrate your results.



RESULTS AND OBSERVATIONS:

Record your results in the following table.

Type of metal	Time taken for pin to drop off (seconds)
iron	
copper	
brass	
aluminium	

Now draw a bar graph to show your results. Do not forget to give your graph a heading to describe what it represents.

1. Which variable should be on the horizontal x-axis?

___

2. Which variable should be on the vertical axis?

___

3. Why do you think that a bar graph is suitable for this investigation?

___

___

ANALYSIS:

1. Which bar on your graph is the longest?

2. Which bar is the shortest?

3. Write down the materials in order of how fast they conducted heat from the quickest to the slowest.

4. Why does the Vaseline melt?

5. Why do you think it was necessary to place the piece of cardboard or paper on the tripod stand underneath the metal rods. Hint: The tripod stand is also made of metal.

6. Why do you think it is necessary to use the same amount of Vaseline on the ends of each rod?

7. Do you think we could have performed this investigation if our rods were of different lengths? Why?

EVALUATION:

It is always important to evaluate our investigations to see if there is anything we would change or improve on.

1. Is there anything that went wrong in your investigation that you could have prevented?

2. If you were to repeat this investigation, what would you change?

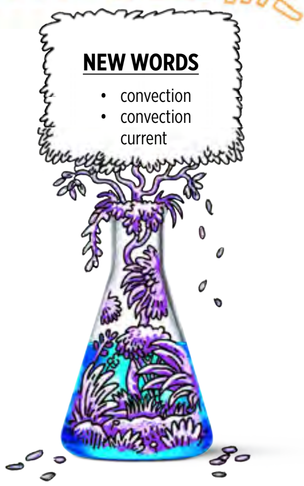
CONCLUSIONS:

1. Write a conclusion for this investigation about which metal is the best conductor of heat.

____

____

____



In this section we looked at how heat is conducted through metal rods and other objects. These were all *solid* objects. How is energy transferred through liquids or gases? Let's find out in the next section.

3.3 Convection

Think of a pot of water on a stove. Only the bottom of the pot touches the stove plate, but all of the water inside the pot, even the water not touching the sides, becomes warmer. How does the energy transfer throughout the water in the pot? The transfer of energy is because of **convection**.

Let's do an activity that will help us to visualise how convection occurs.

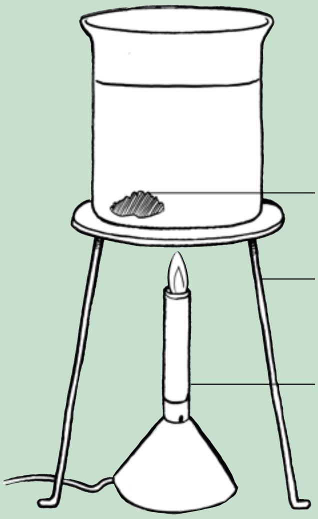
ACTIVITY: Convection in water

MATERIALS:

- 200 ml glass beaker
- potassium permanganate
- Bunsen or spirit burner, tripod stand, wire gauze

INSTRUCTIONS:

1. Half fill the beaker with cold tap water.
2. Carefully put a small amount of potassium permanganate on one side of the beaker. DO NOT STIR.
3. Heat the water directly under the side of the beaker with potassium permanganate with a Bunsen/spirit burner and observe what happens.
4. Set up a control experiment and place a few grains of potassium permanganate into the bottom of a beaker filled with water. Do not heat this beaker and observe what happens.



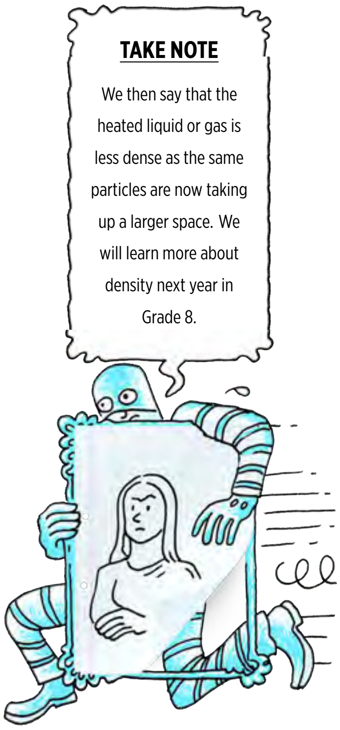
QUESTIONS:

1. What did you see as the water started to warm up in the beaker that was heated? Draw a picture to show what you see.

2. What is happening to the potassium permanganate in this beaker?

3. Can you explain the pattern you saw?

4. Compare this to the beaker which was not heated. What did you observe in this beaker?

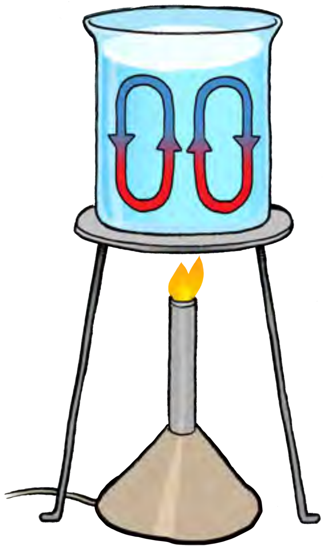


Let's now explain what we observed in the last activity. Convection is the transfer of thermal energy from one place to another by the movement of gas or liquid particles. How does this happen?

As a gas or liquid is heated, the substance expands. This is because the particles in liquids and gases gain kinetic energy when they are heated and start to move faster. They therefore take up more space as the particles move further apart. This causes the heated liquid or gas to move upwards and the colder liquid or gas moves downwards. When the warm liquid or gas reaches the top it cools down again and therefore moves back down again.

In the last activity, the water particles gained kinetic energy and moved apart from each other, therefore taking up more space. This water then moves upwards as it is less dense than the cold water, meaning it it lighter than the cold water. We were able to observe this as the potassium permanganate dissolved in the water and moved with the water particles, and then moved downwards again as the water cooled.

This movement of liquid or gas, is called a **convection current**, and energy is transferred from one area in the liquid or gas to another. Have a look at the diagram which shows a convection current.



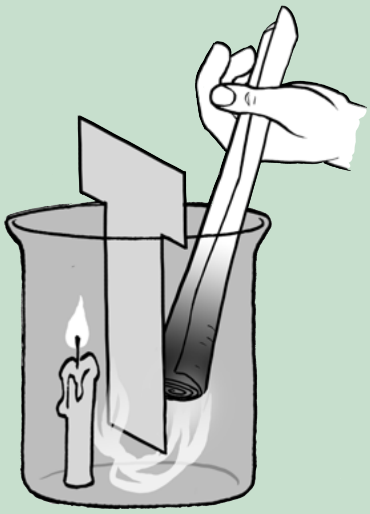
ACTIVITY: Does smoke move up or down?

MATERIALS:

- T-shaped cardboard
- candle
- twist of paper or splint
- beaker
- box of matches

INSTRUCTIONS:

1. Light the candle and place it inside the beaker, to the side of the beaker.
2. Put the T-shaped cardboard into the beaker so that there is a small gap between the bottom of the beaker and the cardboard.
3. Light the twisted roll of paper and hold it in the beaker on the opposite side to the candle as shown in the diagram.
4. Observe what happens to the smoke.



QUESTIONS:

1. What happens to the smoke from the paper?

___

2. Why do you think the smoke moves in this way?

___

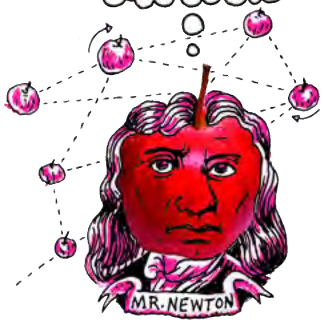
___

___

In the last two activities, we have observed convection currents in a liquid and in a gas. Convection currents can only form in gases and liquids as these particles are free to move around. They are not held in fixed positions like in a solid. Solid particles are held together too tightly for them to move when heated. Solid particles will only vibrate faster when heated but will not move from their positions.

DID YOU KNOW?

The blobs in a lava lamp move up and down in the lamp as they first heat and expand and then reach the surface and cool so they move back down again.



The blobs in a lava lamp move up and down showing us the convection currents as the lamp provides the source of heat at the bottom.

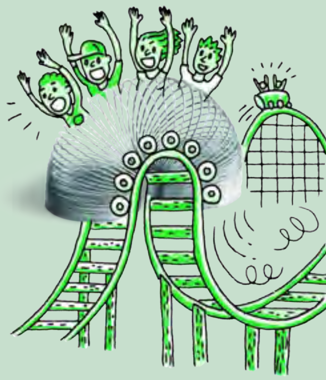
VISIT

How does a lava lamp work? (video)

bit.ly/16sqFMw

Now that we have learned about convection, how can we apply this in the world around us? It is interesting to learn about concepts and theories in science, but it is even more interesting when we discover how this has an influence in our daily lives.

ACTIVITY: Installation of air heating and cooling systems



This is an photo of an air conditioner.

Imagine that your teacher has been given a heater and an air-conditioning unit for your classroom. The heater will warm your classroom in winter and the air-conditioner will keep you cool in summer. You need to help you teacher decide where each item should go in the classroom. Should they go on the wall near the ceiling or near the floor? Should they go next to a window?

INSTRUCTIONS:

1. Get into groups of 2 or 3.
2. Discuss where in your classroom you would place a heater so that it can effectively heat up the room. Draw a diagram to explain your choice.

3. Discuss where in your classroom you would install the air-conditioner so that it can effectively cool the room. Draw a diagram to explain your choice.

Try to find an air-conditioner or heating specialist who you can interview. Ask them to explain the best way to install the air-conditioner and a heater.

We have now looked at how energy is transferred through different materials, whether they are solids (conduction) or liquids and gases (convection). But, what about if there are no particles to transfer the thermal energy? Is there still a way for energy to be transferred?

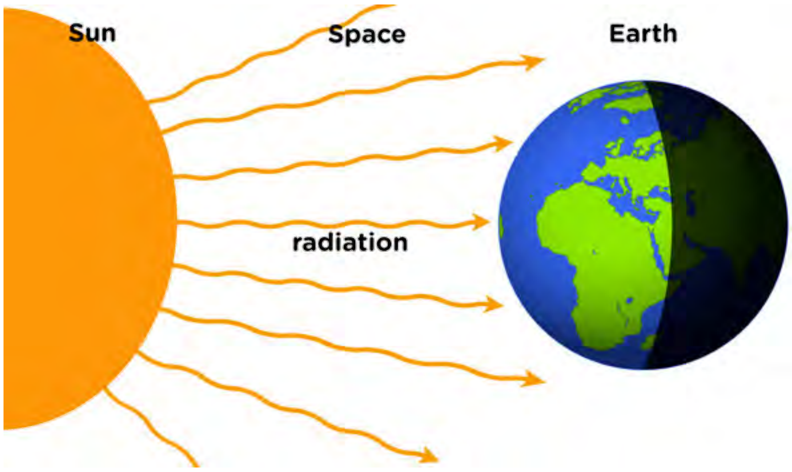
NEW WORDS

- radiation
- matt
- reflect
- absorb

3.4 Radiation

Have you ever wondered how the Sun is able to warm us even though it is so far away? The energy is transferred from the Sun to everything on the Earth. The Sun does not need to be touching the Earth for the energy to be transferred. Also, there is space in between the Earth and the Sun. The energy from the Sun is able to warm us without the Sun ever touching us.

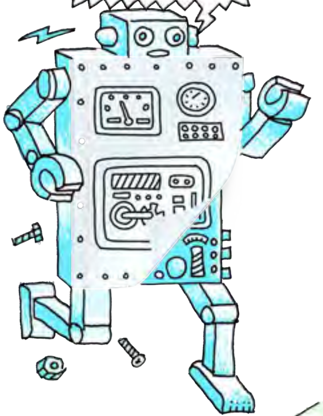
This transfer of energy is called **radiation**. It is different to conduction or convection as it does not require objects to be touching each other or the movement of particles.



The Sun radiates heat in all directions. Energy is transferred through space to Earth

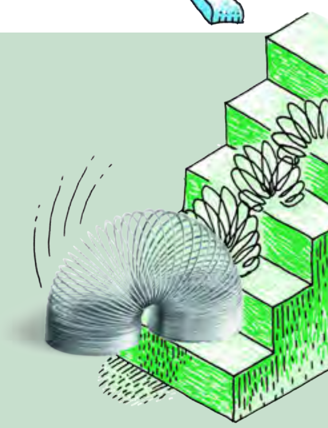
TAKE NOTE

Radiation comes from the Greek word *radius*, meaning a beam of light.



We can also see how heat is transferred by radiation here on Earth, and not just between the Sun and the Earth. Let's demonstrate the difference between radiation and convection using a candle.

ACTIVITY: Radiation from a candle



MATERIALS:

- candle in a holder
- metal spoon or metal rod
- matches

INSTRUCTIONS:

1. Light a candle and place it in a holder. Your teacher might do this and get groups of you to come up at a time to the demonstration.
2. First hold you hand above the candle.
3. Then hold your hand on the side of the candle.
4. Answer the following questions.

QUESTIONS:

1. We know now that heat from a candle will be transferred to the air around it. These will warm up. Where will this air move to?

2. What is this called?

3. So, when you hold your hand above the candle, what do you feel and why?

4. But, what about when you hold your hand on the side of the candle? Could you also feel warmth from the candle?

5. This is not convection as the air particles do not travel sideways when they warm up from the flame. So, how is energy transferred to your hand when you feel the warmth on the side of the candle?

6. Lastly, if your teacher placed a metal spoon in the candle flame and you felt the end, how would it feel after a little while?

7. How was the energy transferred from the flame to the end of the spoon?

8. This photo shows all three forms of how heat is transferred.

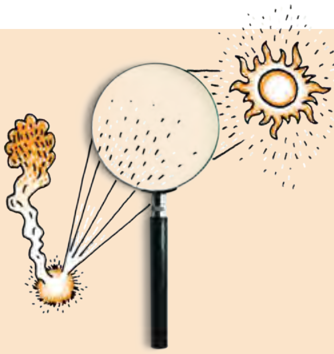
   Explain which type of heat transfer is represented by each hand.

Energy is transferred in three ways.

As we saw in the last activity, energy is transferred from the candle to your hand by convection and by radiation. Have you ever stood next to a huge fire? You will feel the radiating heat even though the air might be very cold. This is because the energy is transferred to you by radiation through the spaces between the particles in air.

What about if you touch a black wall or a white wall? Do you think there is a difference in how different surfaces **absorb** and **reflect** radiation? Let's find out by doing an investigation.

INVESTIGATION: Which surfaces absorb the most radiation?



We are going to investigate which surfaces absorb the most heat, using dark coloured paper, light coloured paper and shiny paper, such as aluminium foil. We will use the temperature inside an envelope made from each kind of paper as a measure of the amount of heat the paper absorbed. Why do you think we can do this?

INVESTIGATIVE QUESTION:

Which surfaces will absorb the most radiation from the Sun and therefore increase in temperature the fastest?

VARIABLES:

1. Which variable are you going to measure?

---

2. What do we call the variable you have measured?

---

3. Which variable are you going to change?

---

4. What do we call this variable?

---

5. What must be kept the same for all the different materials?

HYPOTHESIS:

Write a hypothesis for this investigation.

____

____

MATERIALS AND APPARATUS:

- matt black paper
- white paper
- aluminium foil
- 3 alcohol thermometers
- stopwatch or timer
- glue or adhesive tape

METHOD:

1. Fold each piece of paper and aluminium foil into the shape of an envelope.
2. Put a thermometer into each of the envelopes and record the starting temperature.
3. Put all the envelopes outside in the Sun.
4. Check the temperature on the thermometers every 2 minutes for 16 minutes.
5. Record your results in the table.
6. Draw a line graph for each envelope on the same set of axes.

RESULTS AND OBSERVATIONS:

Record your results in the following table.

Time (minutes)	Temperature in black paper envelope (°C)	Temperature in white paper envelope (°C)	Temperature in aluminium foil envelope (°C)
0			
2			
4			
6			
8			
10			
12			
14			
16			

Draw a line graph for each of the envelopes in the space below. Do not forget to give your graph a heading.

ANALYSIS:

1. What do you notice about the shapes of the graphs you drew? Are the graphs straight lines or curves?

2. Which line on your graph is the steepest? What does this tell us?

3. Compare your results for the white paper and the shiny surface. What does this tell you.

EVALUATION:

1. Did the investigation run smoothly? Or is there anything you would change?

2. Did you get any results which did not seem to fit the overall pattern?

CONCLUSION:

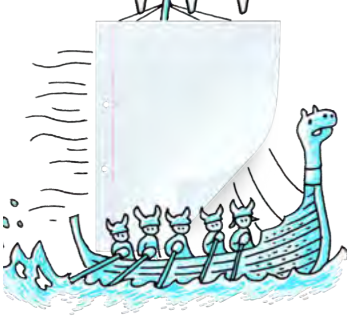
Write a conclusion for your investigation. Remember to refer back to the investigative question that we wanted to answer.

The investigation showed that the dark envelope showed the biggest increase in temperature. The lighter coloured envelope showed a smaller increase in temperature. The envelope made out of a shiny material showed the smallest increase in temperature.

So what have we learnt? Dark colours seem to absorb more of the Sun's radiation than light or reflective colours. So, if you want to stay warm on a cold day, dark clothing will absorb more of the available warmth from the Sun's radiation than light colours.

TAKE NOTE

Radiation from the Sun is essential to life on Earth, but ultraviolet radiation from the Sun can also be very damaging our skin. Remember to wear suncream and a hat when outside and avoid being in direct sunlight between 11am and 2pm.



The average summer temperature in Hotazel, a town in the Northern Cape is about 34 °C. If you lived in Hotazel and needed to buy a new car, would you buy a light or dark-coloured car? Explain why.

You have the option of getting the car sprayed to make the surface more shiny. Do you think this will help keep the car cool in hot, summer months? Explain why.

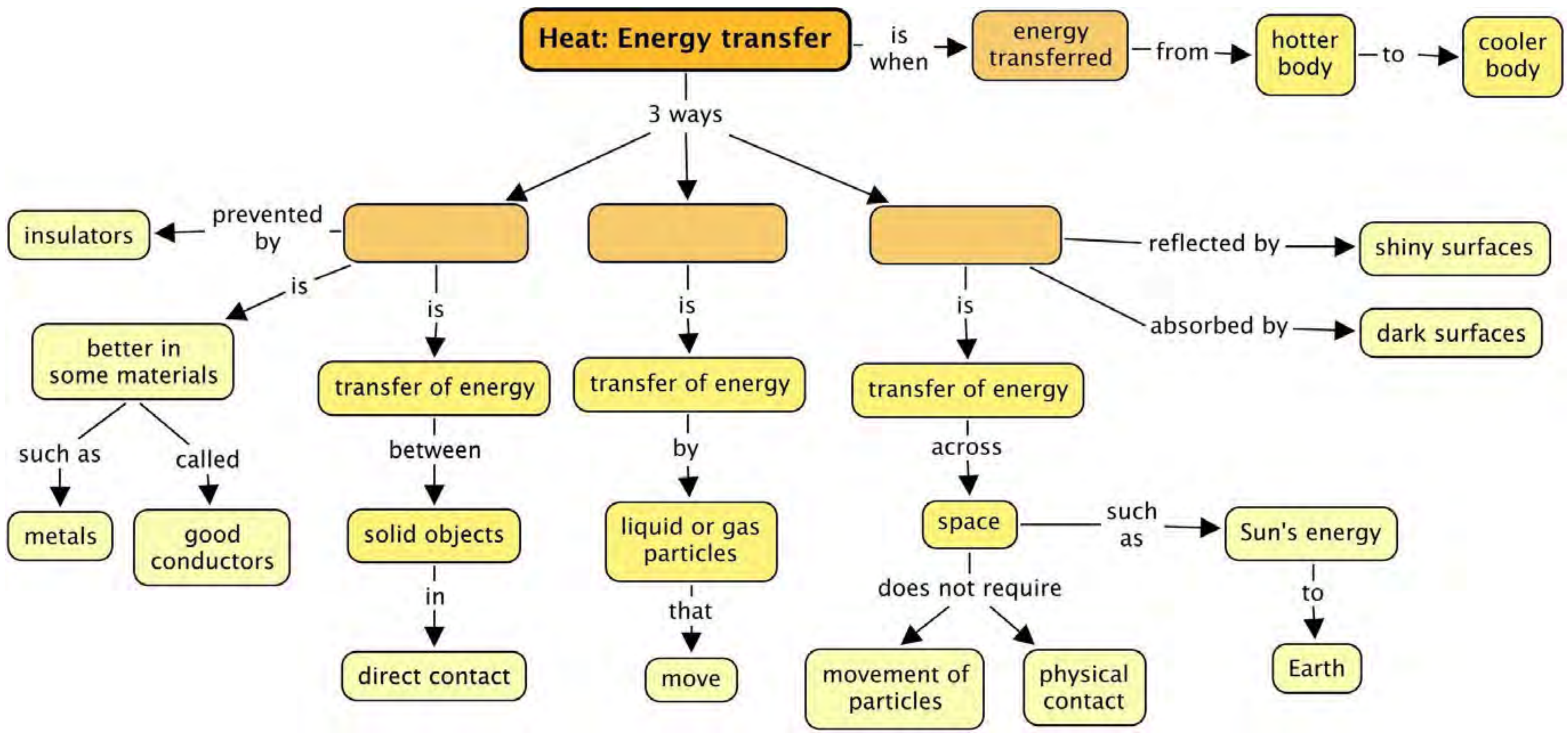
SUMMARY:

Key Concepts

- Heat is energy that is transferred from a hotter to a cooler object.
- Temperature is a measure of how hot or cold a substance feels.
- Heat (energy transfer) occurs in three ways: conduction, convection or radiation.
- During conduction, the objects must be touching each other for energy transfer to take place.
- Some materials, such as metals, conduct heat well. They are called conductors of heat.
- Some materials, such as plastics and wood, slow down or prevent conduction. They are called insulators.
- Convection is the transfer of energy within liquids or gases.
- A convection current refers to the movement of a liquid or gas during energy transfer. The liquid or gas moves upwards from the heat source (as it expands) and then downwards when the liquid or gas cools (as it contracts).
- Radiation is the transfer of energy where objects do not have to be physically touching. Radiation does not require a medium and can take place through empty space.
- The Sun's energy is transferred to Earth by radiation.
- Dark, matt surfaces are good absorbers of radiant heat
- Light and shiny surfaces are poor absorbers of radiant heat. Light, shiny surfaces reflect more radiant heat than they absorb.

Concept Map

Below is a concept map showing how the different topics about heat together. You need to fill in the three different ways that energy can be transferred, as discussed in this chapter, but you cannot just put anyone into any box. You need to study the concepts which come after and explain each way of transferring energy during heating.


Heat: Energy transfer
is when
energy transferred
from
hotter body
to
cooler body
3 ways
prevented by
insulators
is
better in some materials
such as
metals
called
good conductors
is
transfer of energy
between
solid objects
in
direct contact
is
transfer of energy
by
liquid or gas particles
that
move
reflected by
shiny surfaces
absorbed by
dark surfaces
is
transfer of energy
across
space
such as
Sun's energy
to
Earth
does not require
movement of particles
physical contact

REVISION:

1. How is energy being transferred in the following photos showing different heating processes? Write down conduction, convection or radiation. Some illustrations may show more than one form. [4 marks]

 The heat from the Sun travels to Earth.	 Cooking food on a braai or fire.
 Boiling water in a metal pot.	 A heater in a room.

2. In each of the following situations, identify the method of energy transfer taking place (conduction, convection, radiation).

   a) A fireplace has a glass screen in front of it. The person sitting in a chair next to the fireplace chair feels hot due to _______________. [1 mark]

   ___

   b) When you stir your tea with a metal spoon the handle gets hot because of _______________. [1 mark]

   ___

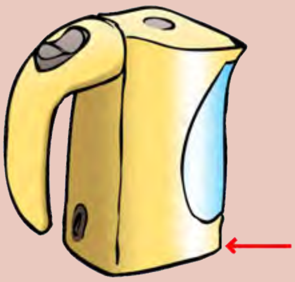
   c) When you are lying on the beach your skin feels hot because of _____________. [1 mark]

   ___

3. Draw energy transfer flow charts for the following: You buy a cup of hot chocolate and hold it in your hands on a cold winter day. [2 marks]

4. Your parents have a metal hot water geyser and they are complaining about the amount of energy needed to keep the water hot. What can you recommend your parents could do to prevent energy loss from the geyser? Explain your answer. [4 marks]

5. Explain why the heating element for a kettle is at the bottom and not at the top. [3 marks]



6. Explain why you think the water boils throughout the kettle pot and not just at the bottom? [2 marks]

7. Explain why you think take-away coffee is sold in styrofoam cups rather than ceramic cups. [2 marks]

8. Explain why you think two thin blankets can sometimes be warmer than one thick blanket. [2 marks]

9. Explain why birds fluff up their feathers to stay warm, especially in winter. [2 marks]

10. Why should you place an air conditioner at the top of a room, near the ceiling, rather than at the bottom near the floor? [2 marks]

11. Imagine you want to build a small enclosure for some chickens on your property. You have an outside area for them that is made from barbed wire, and you have made a small inside, covered enclosure for them out of bricks and cement which you would like to paint. You know that it can get quite cold in winter in your area so you want the house to be as warm as possible for the chickens. What colour paint are you going to choose to paint the outside of chicken house? Will it be a dark-coloured paint, such as brown or black, or a light-coloured paint, such as white or yellow? Explain your choice. [4 marks]

Total [30 marks]

4 Heat insulation and energy saving

KEY QUESTIONS:

- How can you keep your tea warm?
- Can you use the same materials to keep your house warm in winter and cool in summer?
- How do insulating materials assist with saving energy?

4.1 Why do we need insulating materials?

NEW WORDS

- insulator
- conductor

Heat is the transfer of energy by conduction, convection or radiation, as we learnt in the previous chapter. Often, we want this energy to be transferred for heating. For example, when you place a heater in a room, you want the energy to be transferred through convection and radiation to the room so that the room becomes warmer.

In other situations, you want to prevent energy transfer. For example, on a cold winter's day, we need to minimize heat loss from the house, so that it stays warm. Other objects, such as electric geysers, need to prevent energy transfer to the surroundings so that the water inside stays warm. Materials which are insulators can slow down or prevent energy transfer.

An example of where we want the transfer of energy to take place in some parts of the system but prevent it in other parts, is in a solar water heater. The use of a solar water heater helps to save energy. This is not only because the system is efficient at warming water, but we also use solar power which is free, whereas we pay for electricity from the national grid and it puts demands on the national demand for electricity.

We use different materials in different situations depending on whether or not we want energy transfer to take place. Let's find out why, and discover how a solar water heater works.

ACTIVITY: How do solar water heaters work?

INSTRUCTIONS:

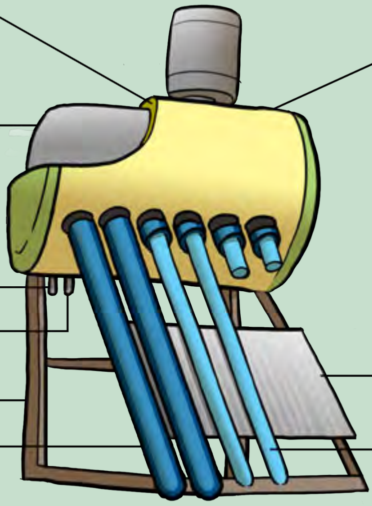
1. Study the following diagrams which show how a solar water system works.
2. Answer the questions which follow.

There are several different types of solar water heaters. We will be looking at the most efficient heater, which uses evacuated tubes.

A solar water heater on top of a corrugated iron house.

A close up photo of a solar water heater.

The following diagram shows the different parts of the solar water heater to which we will be referring. Cold water flows in the cold water intake pipe and then down the long tubes, called **evacuated tubes**. The water warms up due to energy transfer from the Sun and it then flows into the storage tank at the top. When someone wants hot water in the house, the hot water flows out of the hot water output and down into the house.



VISIT
A simple demonstration showing how a solar water heater works.
bit.ly/1h3TNbU

QUESTIONS:

1. Is solar power an example of a renewable or non-renewable energy source?

---

2. When the cold water flows down the tubes, energy is transferred to the water from the Sun. What type of heating is this?

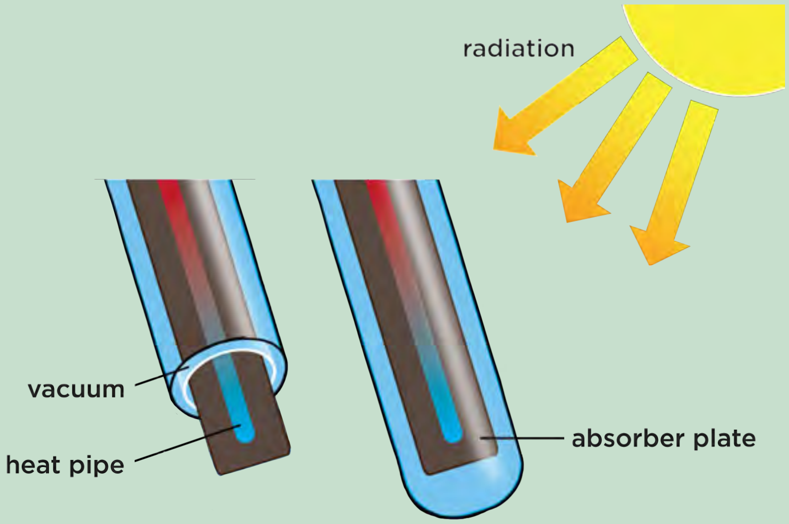
---

3. In the tubes part of the system, we want energy transfer to take place, so specific materials are used to make energy transfer as efficient as possible. There is a shiny surface underneath the tubes called a **reflector**. How does this help to increase the amount of energy that the water in the tubes receive?

4. Do you see that there is a tank at the top to store the hot water? In this part of the system we want to prevent energy transfer to the outside. This tank consists of an inner tank and an outer case. If there were just these two layers, made of metal, how could heat loss from the hot water to the external environment occur?

5. However, something has been done to help prevent this transfer of energy. What have they done to help keep the water warm while it is stored?

6. Let's now take a closer look at the evacuated tubes in a solar water heater. Study the following diagram. The water runs down the central **heat pipe**. There is an absorber plate below each pipe and this is enclosed within two layers of tube.



Can you see that there is an inner and an outer tube? Between these tubes there is a **vacuum**. This means that the Sun's energy can still pass through to warm the water. However, when the energy is transferred to the water, and it warms up, the vacuum prevents energy from transferring back out by conduction or convection. Why is this so?

7. Underneath the heat pipe there is a plate which helps to absorb radiant energy from the Sun and transfer it to the heat pipe. Why is it made of a dark material and not a light material?

---

8. Do you see that the water at the bottom is cooler, indicated by the blue colour, and the water at the top of the tube is warmer, indicated by the red colour? When the cooler water moves to the bottom and the warmer water moves to the top, what is this called?

---

9. This movement of water helps to move the hot water out of the tubes and into the tank so that cold water can replace it.
10. Do you think the solar water heater is an energy efficient system? Why?

Now that we have looked at how different materials are used in different situations depending on whether we want to prevent energy transfer or allow it to take place, we are going to take a closer look at how we use those materials that prevent energy transfer.

4.2 Using insulating materials

Before we start, write down your own definition for an insulator of heat.

Which materials work well as insulators of heat? Let's first do a fun activity.

ACTIVITY: Keep your coffee hot and your cold-drink cold

MATERIALS:

- kettle
- 2 identical mugs, metal or ceramic
- tea or coffee
- alcohol thermometer
- various insulating materials
- timer or stopwatch

INSTRUCTIONS:

1. Get into groups of 3 or 4.
2. Design a method to keep a cup of tea warm for as long as possible. You may use any materials that you have at home or provided by your teacher.
3. Make your design.
4. Write a hypothesis for your planned design.
5. Fill your insulated cup with boiling hot tea.
6. Measure the temperature with a thermometer.
7. Keep the thermometer in the cup and time how long it takes to reach room temperature (approximately 25 °C)
8. Fill the uninsulated cup with boiling hot tea and time how long it takes to reach room temperature.
9. Repeat this activity using a cold drink in the cups.

QUESTIONS:

1. What materials did you use to keep your tea warm?

___

___

2. Why did you choose those particular materials?

___

___

3. How did you attach the materials to the mug?

___

4. Draw a labelled diagram of your design to keep your tea warm.

5. How long did it take your tea to reach room temperature (25 °C)?

6. What materials did you use to keep your cold drink cold?

7. Why did you choose those particular materials?

8. How did you attach the materials to the mug?

9. Draw a labelled diagram of your design to keep your cold drink cold.

10. How long did it take your cold drink to warm up to room temperature (25 °C)?

11. Why did you also time the uninsulated cups?

12. Was your hypothesis shown to be true or false?

____

____

What have you learnt from your attempts at keeping your hot drink warm and your cold drink cool? Some materials trap heat really well and others do not. Let's now do a more formal investigation of some of the different materials to find out which is the best insulating material.

INVESTIGATION: Which is the best insulating material?

AIM: Write down an aim for this investigation.

____

____

____

MATERIALS AND APPARATUS:

- 4 beakers or tins
- 4 alcohol thermometers
- aluminium foil
- fabric
- newspaper
- plastic
- kettle
- timer or stopwatch

METHOD:

1. Wrap one beaker with newspaper, one beaker with plastic, one beaker with aluminium foil and the fourth beaker with fabric.
2. Boil water in a kettle.
3. Pour 250 ml of boiling water into each beaker.
4. Put a thermometer in each beaker.
5. Measure the starting temperature of the water and then measure the temperature of the water every 5 minutes for half an hour.
6. Write the measurements in the table in the results section.
7. Draw a graph representing the data you have collected.

RESULTS AND OBSERVATIONS:

Record your results in the following table.

Time (minutes)	Temperature of aluminium foil beaker (°C)	Temperature of newspaper (°C)	Temperature of plastic (°C)	Temperature of fabric (°C)
0				
5				
10				
15				
20				
25				
30				

Use the following space to draw a line graph for each type of material. You must plot each graph on the same set of axes.

First, we need to think about which data is put on each axis.

1. What will you plot on the horizontal x-axis? This is the independent variable.

---

2. What will you plot on the vertical y-axis? This is the dependent variable.

---

3. How are you going to show a difference between the lines for each type of material on one graph?

ANALYSIS:

1. Which of your graphs has the steepest curve?

2. What does the steepness of the curve tell you about how quickly the material allows heat to leave the water?

3. Arrange the materials in order from very good insulator to poor insulators of heat.

4. Which material was the best conductor of heat? Explain your choice.

5. Which material was the best insulator of heat? Explain your choice.

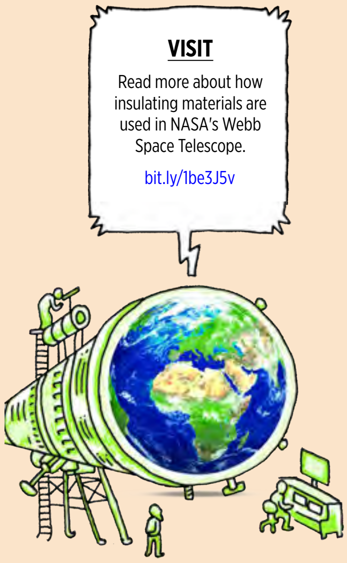
____

____

6. If you had to keep a bottle of water cold for as long as possible, which of the 4 materials would you choose? Explain your choice.

____

____



CONCLUSION:

Write a conclusion for this investigation.

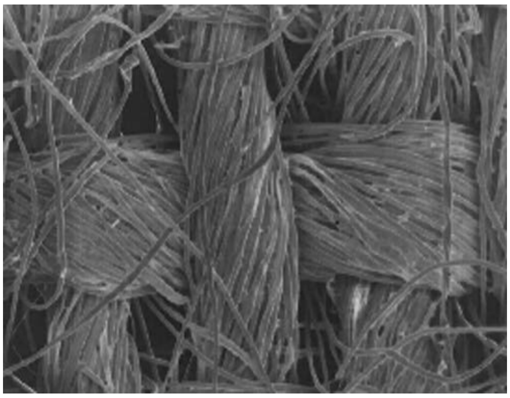
____

____

____

Why is fabric a good insulator? The woven fibres of the fabric trap air between them. Air is a poor conductor of heat and so it slows heat loss through the fabric.

Here are some different fabrics.



And here is a close up of the fibres making up the fabric.

Fabric is not generally used to keep our hot drinks warm. In fact, most take-away cups are made from styrofoam. Styrofoam is a good insulator of heat. It is made from polystyrene which has had air pumped through it. This makes styrofoam extremely light and the air pockets make it a very good insulator.

A very useful application of the use of insulating materials is the cooler box and hot box. Look at the following photo of a cooler box.

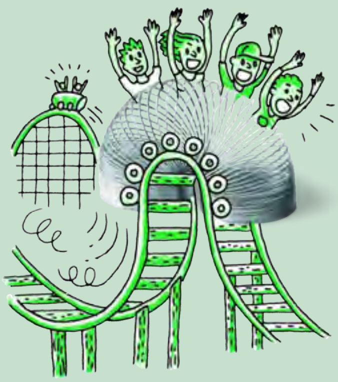
A cooler box.

Cooler boxes are used to keep food cold. You need to put ice blocks in with the food to do so. The cooler box is made from a thick layer of plastic. How does this help to keep the contents cool inside?

___

___

A hot box works in a similar way, but can be used to keep food warm for long periods of time. There are many ways to construct a hot box.



ACTIVITY: Building a hot box

INSTRUCTIONS:

1. Depending on your teacher, he or she will either make a hot box as a demonstration in class, or else you are required to design and make your own hot box.
2. The hot box needs to keep a pot of rice and water brought to boiling point hot enough so it finishes cooking.
3. If you are designing and making the hot box yourself or in a group, you need to think about which materials will be the best insulators for the hot box.

QUESTIONS:

1. Draw a labelled diagram of the hot box design that either you, your group or your teacher made.

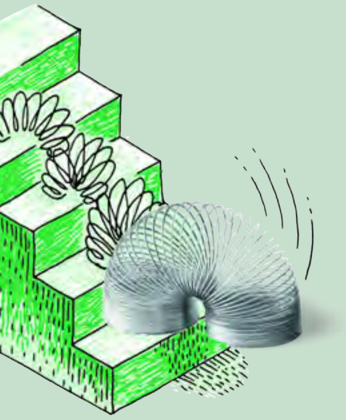
2. Why did you or your teacher use the specific materials to make the hot box?

3. Why did you put rice with the water boiling, instead of cold water, in the hotbox?

VISIT
A video on solar cooking
bit.ly/GzvzLr

4. If you had something cold and you wanted to keep it cold, could you use your hotbox? Explain your answer.

Keeping our homes warm in winter is also very important and there are different ways to do this. Let's look at how our homes are insulated.



ACTIVITY: Keeping our homes warm

The following image shows how heat is lost from a house, using a colour scale to represent how much heat is lost. Red represents areas of high energy transfer, yellow is medium and green and blue are areas of low energy transfer.

1. Which parts of the house lose the most heat?

---

2. How is heat lost through these places?

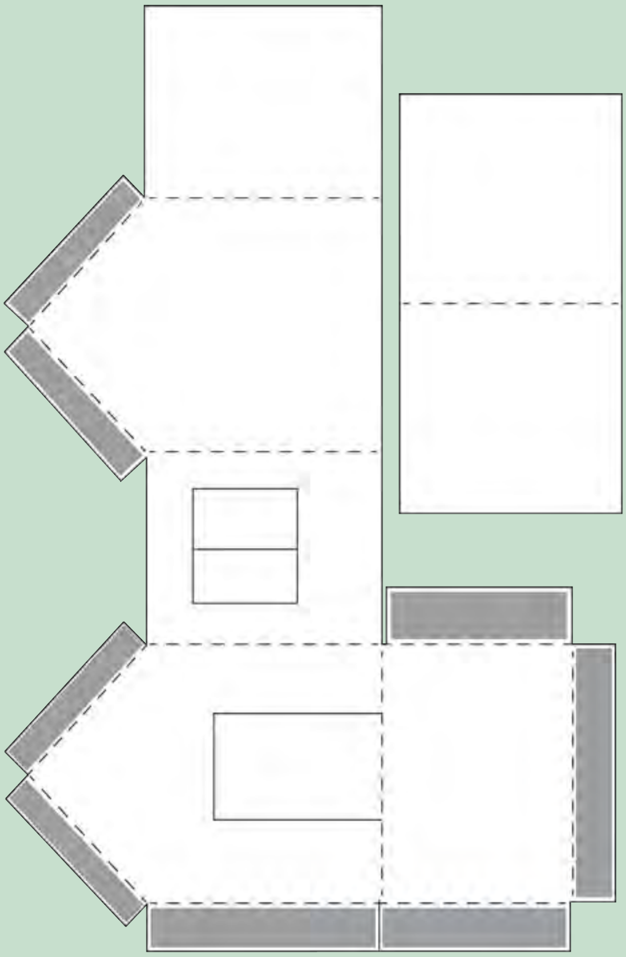
Convection also cools down a house, cold air is drawn in through gaps in doors and windows and is circulated through the house. Some of the heat is lost by radiation through the walls, roof and windows. Let's now make our own model houses to see how we can prevent heat loss.

MATERIALS:

- model house template
- paper and cardboard
- glue
- sellotape
- pieces of fabric or cotton wool
- hole punch
- pair of scissors
- thermometer
- lamp (to simulate sunlight)
- timer or stopwatch

INSTRUCTIONS:

1. Your teacher might provide you with a large model house template for you to cut out. If not, copy the following template onto a large piece of cardboard or design your own template for making a house.



1. Cut a small hole in the roof using the hole punch. This is for the thermometer.
2. Choose the number of windows you would like your house to have.
3. Cut out the windows. Use sellotape across the hole to act as glass.
4. Cut out a piece of fabric for the floor.
5. Glue the fabric to the floor of your model house.
6. Fold along the dotted lines and then glue the shaded flaps together to make the house. Place the roof on top.
7. Insert the thermometer through the roof.
8. Set up the lamp so that it is shining directly onto your model house. An alternative is to put the houses in a sunny place. This will depend on the weather.
9. Take temperature readings every 5 minutes for half an hour.
10. Switch off the lamp, or bring your model out of the Sun, and measure the temperature as the house cools down, measure every 5 minutes for half an hour.

Time (minutes)	Temperature (°C)
0	
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	
55	
60	

Draw a line graph of temperature versus time. Do not forget to include a heading for your graph.

QUESTIONS:

1. Why did your model house warm up when the lamp was shining on it, or when it is placed in the Sun? Use your knowledge of radiation, conduction and convection in your explanation.

2. Why did your model house cool down when the lamp was switched off, or you brought your model back inside out of of the Sun? Use your knowledge of radiation, conduction and convection in your explanation.

3. What could you have changed in your model house in order to slow down the energy transfer so that the house is not too hot or too cold?

4. Think about your own home. What do you think you could do to improve the insulation of your home in winter?

5. Will the suggestions you made in the previous question also work for summer? Explain your answer.

In the previous chapter you learnt that dark, matt surfaces are good absorbers of radiation. Light, shiny surfaces are poor absorbers and they can reflect some radiation. These properties are very important when choosing an insulating material. In extremely hot climates, such as Greece, the local people paint their houses white because the walls do not absorb as much heat during the day and therefore stay cooler inside. The position of the house in relation to the rising and setting of the Sun is also considered. For example, people will build their houses facing away from direct sunlight if they live in very hot areas.

Houses painted white in Greece to keep them cool in the hot summers.

Let's look at how some of the indigenous houses in Southern Africa make use of insulating materials in the house structure.

Indigenous homes

The indigenous people of South Africa have many different ways of insulating their homes. Here are some pictures of different homes from different indigenous groups.

A thatched Zulu house.

An Ndebele house.

Did you notice that the houses do not have windows, or the windows are very small? Windows allow a lot of heat to escape a building and so these designs rather leave those out. The roofs are made from thatch which is a poor conductor of heat. We know that most of the heat of a home is lost through the roof and so by using an insulating material in the roof it helps to minimise the heat loss in cold weather and heat gain in hot weather.

The roofs also extend further over the walls creating an overhang. The overhang helps to shade the walls in summer but the winter sun can still reach under the overhang. The walls are also very thick. How do you think this helps?

We have now seen how our knowledge of insulating materials can be applied in the world around us to come up with solutions for preventing heat loss. Remember, be curious to discover the possibilities.

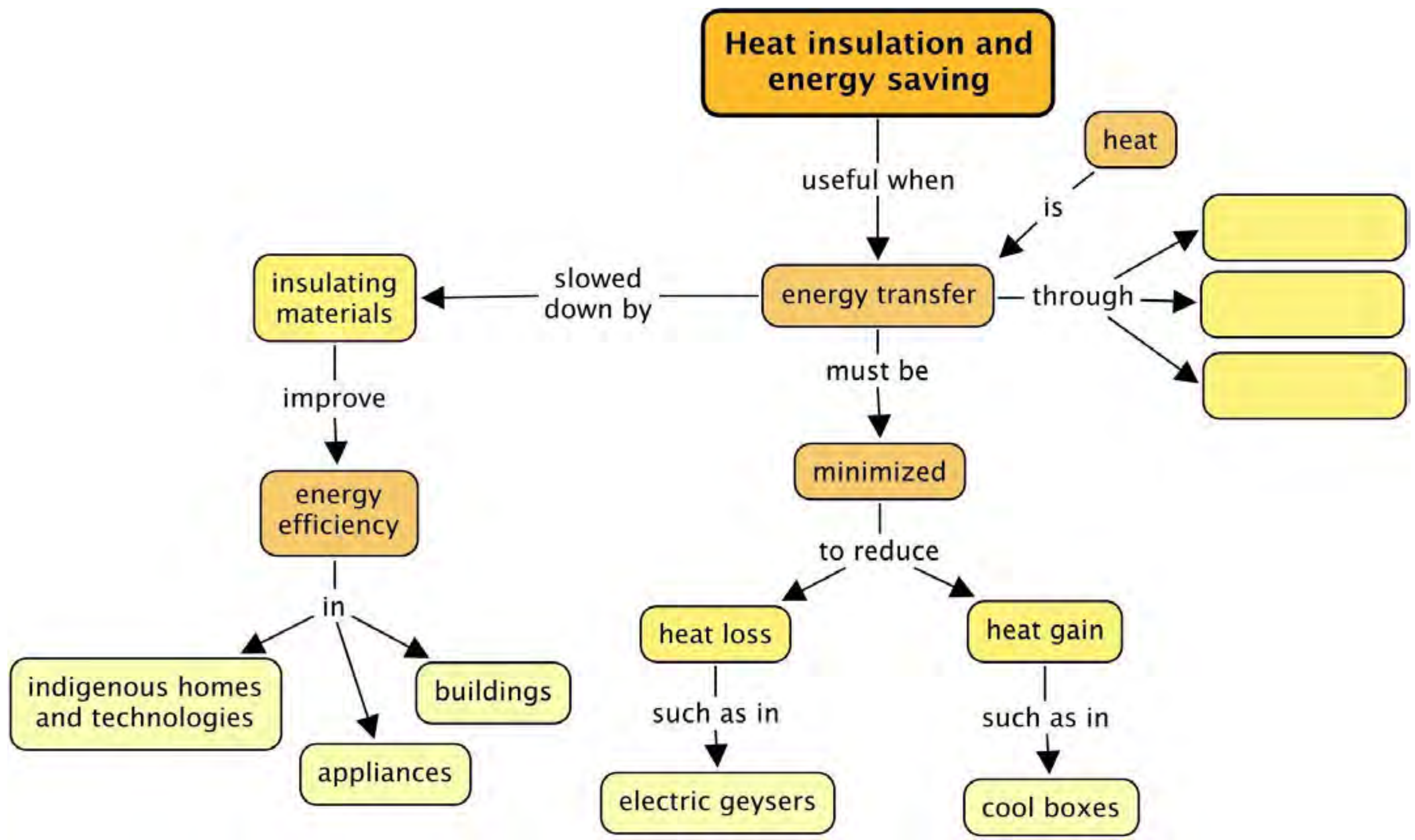
SUMMARY:

Key Concepts

- Heat is transferred by conduction, convection and radiation
- In some cases, heat transfer is advantageous, for example from a heater to the air in a room.
- In other systems, heat transfer needs to be minimised or prevented.
- Insulating materials are used to minimise heat loss or gain from systems.
- Metals are good conductors of heat. Non-metal materials are good insulators of heat. Non-metals are used as insulating materials.
- We use insulators to keep our homes warm in winter and cool in summer. This helps to conserve energy and electricity.
- Indigenous homes in Southern Africa make use of insulating materials to be energy efficient in our climate.

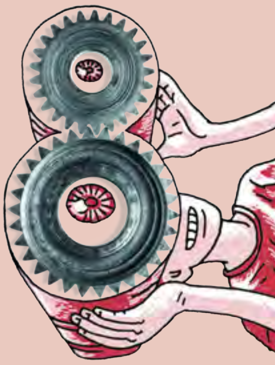
Concept Map

Complete the following concept map by identifying the three ways in which energy is transferred.



Heat insulation and energy saving
useful when
heat
is
energy transfer
through
slowed down by
insulating materials
improve
energy efficiency
in
indigenous homes and technologies
appliances
buildings
must be
minimized
to reduce
heat loss
such as in
electric geysers
heat gain
such as in
cool boxes

REVISION:



1. What is an insulator? [1 mark]

2. Are the following statements true or false? If they are false, explain why:

   a) A tea cosy keeps the cold out. [2 marks]

   b) Space is empty and so it is impossible for energy to transfer between the Earth and the Sun. [2 marks]

   c) On a cold day, insulating clothing reduces the energy transfer from your body to the surroundings. [2 marks]

3. A man is building a wooden house. He lives in a very cold area, especially in winter. He has space for one window. He has two choices. He can put in a large window with a single pane of glass or he can put in a smaller window which has 2 panes of glass separated by a small air space trapped in between them. Which window do you think he should use? Why did you choose that window? [3 marks]

4. Take away coffee is often served in paper cups with a corrugated cardboard layer on the outside. Why are these materials used? [4 marks]

5. You have designed a new material for insulating coffee cups. You're hoping to make money from this new material but you have to test that it works better than other materials. You arrange a blind test to convince a group of people who might invest in your new company so you can develop it.

The scientist who is performing the test is given 4 different materials, labelled A, B, C and D. One of the 4 materials is your new material you have developed, but she does not know which one it is. This is called a blind test. She takes 4 beakers and wraps each one in a different material. She pours hot water into each beaker. She measures the temperature of the water at the start of the experiment and again 30 minutes later.
The following table shows the results of her experiment.

Time (minutes)	**Material A (°C)**	**Material B (°C)**	**Material C (°C)**	**Material D (°C)**
0	70	70	70	70
30	34	30	50	48

a) What is the independent variable for this experiment? [1 mark]

---

b) What is the dependent variable for this experiment? [1 mark]

---

c) Draw a bar graph of the material collected. Show the starting temperature and end temperature for each material as separate bars. [8 marks]

d) After the experiment the results show that your material is the best insulator. Based on the results, which material (A,B,C or D) is yours? [2 marks]

e) How do you know? [2 marks]

6. How does a thick woollen jersey help to prevent heat loss? [2 marks]

7. Look at the following photo showing the inside of a ceiling in a house being constructed. Do you see the pink material?

The ceiling in a new house being built.

a) What do you think this is for? [1 marks]

b) How will it work? [2 marks]

c) What type of climate do you think this house is being built in? Why? [2 marks]

8. Marathon runners are often given thermal blankets at the end of a long race which are made from plastic and have a shiny surface. This very thin, light blanket does not look very warm at all.

    a) How do you think it works? [2 marks]

____

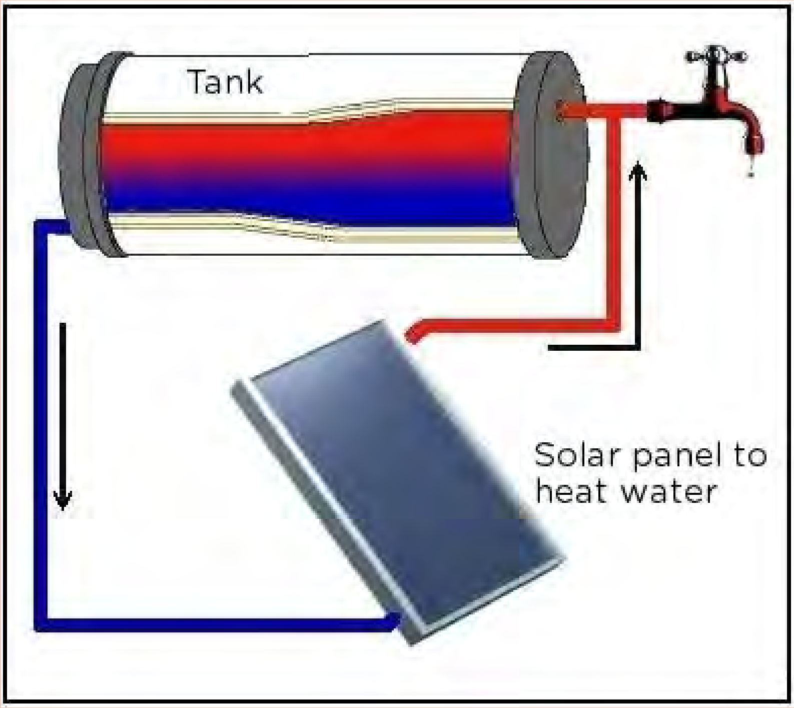
____

    b) You might think that a wool blanket would be better for this purpose. why do you think the race organizers rather use these plastic blankets? [2 marks]

____

____

9. Study the following diagram showing the parts that make up a solar water heating system. This is a different type to the one we looked at in the beginning of the chapter. In this solar water heater, instead of evacuated tubes, there is a flat solar panel, called a collector.



    a) What are the parts that make up this system? [3 marks]

____

    b) Why does it make sense to have the outlet pipe for the tank to go to the solar panel at the bottom of the tank? [2 mark]

____

____

c) Why do you think the tap is at the top of the tank? [2 marks]

d) What sort of covering do you think this tank should have to make it the most efficient system? [2 marks]

Total [48 marks]

Imagine the possibilities of a plain piece of paper. They are endless!

Energy transfer to surroundings

KEY QUESTIONS:

- What sort of useful energy output do some systems produce?
- What is meant by "wasted" energy?
- What is a Sankey diagram?
- How do we draw Sankey diagrams?

5.1 Useful and wasted energy

This term we have been looking at energy transfers within systems. Systems have an input energy and an output energy. Systems such as appliances, tools, vehicles and machines provide us with a useful output. Let's look at some examples to identify what these outputs are in some systems.

ACTIVITY: Useful outputs from energy systems

INSTRUCTIONS:

Look at each of the photos and identify what is useful to use from this system.

System	What useful output does it provide us with?
 *A light bulb.*	
 *An electric fan.*	

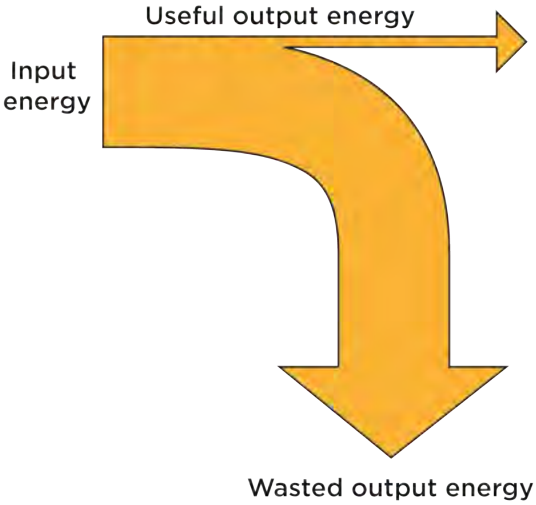
 *An electric iron.*	

> **VISIT**
> Watch how this chocolate rabbit melts beneath an energy-inefficient light bulb.
> bit.ly/16s7AtK

What was the input for each of these systems?

Whenever we use an appliance or a machine we are transferring energy from one object to another. Not all the energy is transferred where we want it, a lot of it is transferred to the surroundings where it does not help us achieve our aims. The energy which is transferred to the surroundings is "**wasted**".

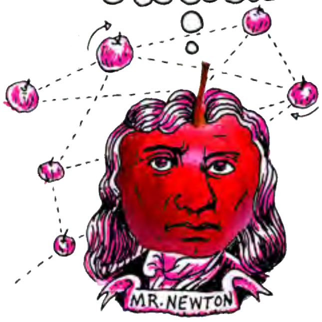
We can use a **Sankey diagram** to show how the energy is transferred in a system. This gives us a picture of what is happening and shows the input energy and how the output energy is made up of useful energy (arrow at the top) and wasted energy (arrow going to the bottom). Have a look at the following general example.



The width of the arrows tell us something in these diagrams. The input energy is the width of the original arrow. The width of both the output energy arrows (useful and wasted) add up to the width of the input arrow. Why do you think this is so? Think back to what you learned about energy within systems in Chapter 2.

DID YOU KNOW?

Sankey diagrams are named after the Irish Captain Matthew Sankey, who first used this type of diagram in 1898 in a publication on the energy efficiency of a steam engine.



Sankey diagrams are drawn to scale so that the width of the arrows gives us a visual idea of how much energy is useful and how much is wasted. In the diagram above, you can see that only a small part of the input energy was useful and a large amount of the input was wasted by being transferred to the surroundings. An efficient system is one where the useful output energy is only slightly smaller than the input energy. An inefficient system has a lot of wasted energy. Do you think this is an efficient energy system? Why?

____

____

This brings us to our next point of how efficient an energy system is. If the wasted energy is much larger than the useful energy output, then the system is not energy efficient. The above Sankey diagram actually shows the energy transfers for a light bulb. You identified the useful energy output as light in the last activity. What do you think the wasted energy output is? Where does it go?

____

Do you see that an incandescent light bulb is actually not a very efficient system? This is because a lot of the energy is lost as heat as energy is transferred to the surroundings. Is there something more efficient? Look at the photo of a fluorescent light bulb.

A fluorescent light bulb.

A fluorescent light bulb is much more efficient than incandescent light bulbs which use a heated wire to produce light. Most of the energy is lost as it is transferred to the surrounding air from the metal filament.

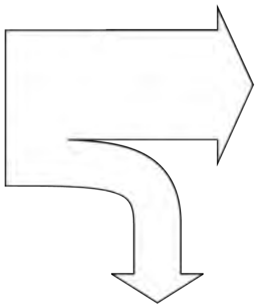
In a fluorescent light bulb, less energy is lost to the surroundings and more energy is transferred to useful light energy. Use this information to draw a Sankey diagram for a fluorescent light bulb in the space below.

Let's look at another example.

Look at the lady in the photo using an electric drill. The electrical energy from the drill is transferred to the drill bit as kinetic energy. The drill bit turns and drills into the metal. But the drill also makes a lot of noise. Energy is used to make sound and the drill bits get hot, so some of the energy is converted into thermal energy. This means that some of the electrical energy has been transferred to the surroundings as sound and thermal energy. This is energy that has been "wasted" because the sound and thermal energy are not useful to us.

A lady using an electric drill to make a hole in an aeroplane part.

Complete the following Sankey diagram by writing in what the energy input is, and then the energy outputs.

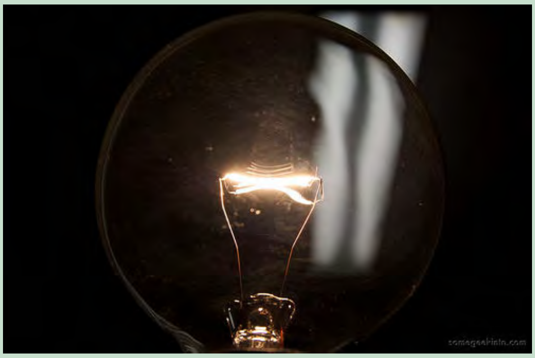


In order to draw a Sankey diagram you need to think carefully about the input energy and how the input energy is transferred to the surroundings. Let's practice this a bit more in the following activity.

ACTIVITY: Energy transfers in systems

INSTRUCTIONS :

1. Look at the following diagrams/photos of appliances.
2. Complete the tables showing the energy transfers for each diagram/photo. The first one has been completed for you.



Filament in a light bulb.

Energy INPUT	Useful Energy OUTPUT	Wasted energy OUTPUT

Burning candles.

Energy INPUT	Useful Energy OUTPUT	Wasted energy OUTPUT

An electric beater.

Energy INPUT	Useful Energy OUTPUT	Wasted energy OUTPUT

A car engine.

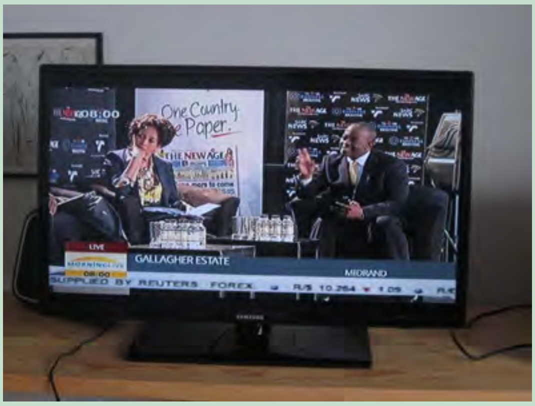
Energy INPUT	Useful Energy OUTPUT	Wasted energy OUTPUT

Welding metal together.

Energy INPUT	Useful Energy OUTPUT	Wasted energy OUTPUT

Athletes running.

Energy INPUT	Useful Energy OUTPUT	Wasted energy OUTPUT



A television.

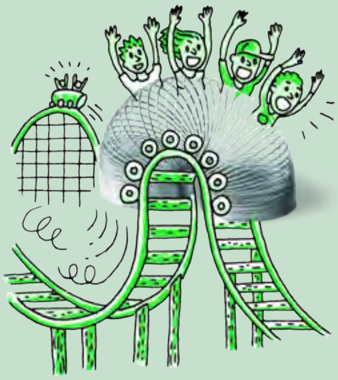
VISIT

Video on drawing a basic Sankey diagram.

bit.ly/19jAwi4

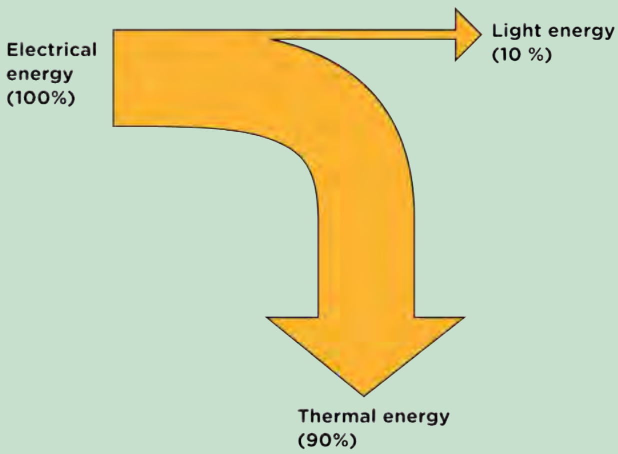
Energy INPUT	Useful Energy OUTPUT	Wasted energy OUTPUT

Now that we have identified the energy transfers in each system and the input and output energy, let's practice drawing some more Sankey diagrams.



ACTIVITY: Drawing Sankey diagrams

Let's look at the example of a filament light bulb to draw a Sankey diagram. A filament light bulb only uses about 10% of the input energy to generate light, the rest is "wasted" because it warms up the surrounding air without producing any light. This means that our Sankey diagram must split into two parts: one for the light and one for the thermal energy which is transferred to the surroundings (heat). The thermal energy arrow must be 90% of the width of the input arrow and the light arrow must be 10% of the width of the input arrow.



INSTRUCTIONS:

1. Now draw a Sankey diagram for some of the appliances from the last activity, which are listed below.
2. A description of the energy transfers has been provided for each appliance.
3. Concentrate on showing how the input energy is split between useful energy and wasted energy. Remember that the width of the arrow must show how much energy is transferred. A thick arrow means a large amount of energy, a thin arrow means a small amount of energy.
4. Show the various input and output energies and the percentages.

Electric beater:

The electric beater transfers 70% of the input energy to kinetic energy to beat the food and 30% is wasted output energy in the form of thermal energy and sound.

Car engine:

The car engine transfers only 30% of the input energy to move the car and 70% is wasted as sound and thermal energy.

Television:

The television uses 80% of the input energy to create the images on the screen and sound and 20% is wasted as thermal energy.

QUESTIONS:

1. Which is the most efficient system in the above three examples? Why?

____

____

____

2. Which is the least efficient system in the above three examples? Why?

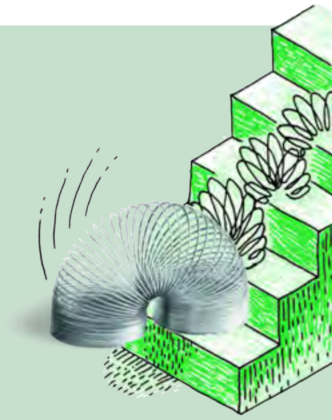
____

____

____

Most of our everyday activities require some form of electrical energy. Electricity is produced by burning fuels and transforming the chemical potential energy into kinetic energy to generate electricity. Fossil fuels, such as coal, store huge amounts of energy but we can only harness a small percentage of that energy. A lot of the energy is transferred to the surroundings in the form of heat, sound and light.

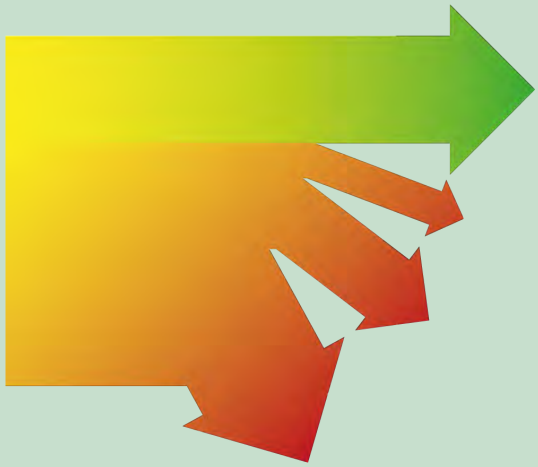
ACTIVITY: Researching energy transfers



In the last activity we looked at the energy transfers in a car engine. However, we only used one arrow to represent the wasted energy. We can show a difference between the ways in which energy is wasted in a Sankey diagram.

Use the following information to label the Sankey diagram:

- The input energy in a car engine is supplied by the combustion of petrol.
- Only 30% of the energy is transferred to useful output energy as movement.
- About 70% of the energy is transferred to the surroundings in the form of thermal energy and sound. Some of the energy is lost in cooling down the engine.
  - 40% is lost as thermal to the surroundings.
  - 20% is lost in cooling the engine.
  - 10% is lost as sound.



TAKE NOTE

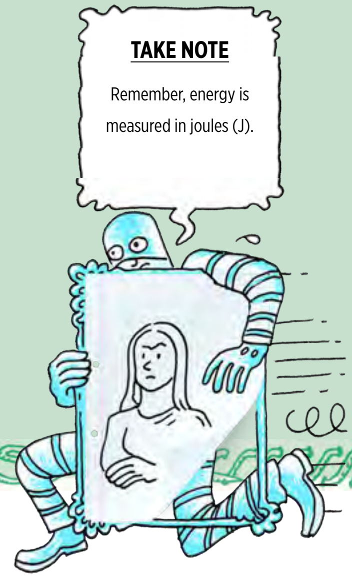
In our previous Sankey diagrams, we just had one arrow for wasted energy output, but it can split into more than one arrow to represent the different ways in which energy is wasted. There could also be more than one arrow for the useful energy, for example in the TV diagram above, light and sound are both useful and could be represented by two arrows.

In a power station, energy is transferred through the system in order to produce electricity. During the transfer of energy through the system, some of the energy is wasted.

Use the internet or other resources to find the different ways in which energy is transferred to the surroundings as wasted energy during the production of electricity in a power plant.

Write a short paragraph to explain the energy transfers. How is the input energy transferred through the system and where is the wasted energy lost?

Draw a Sankey diagram for the energy transfers.

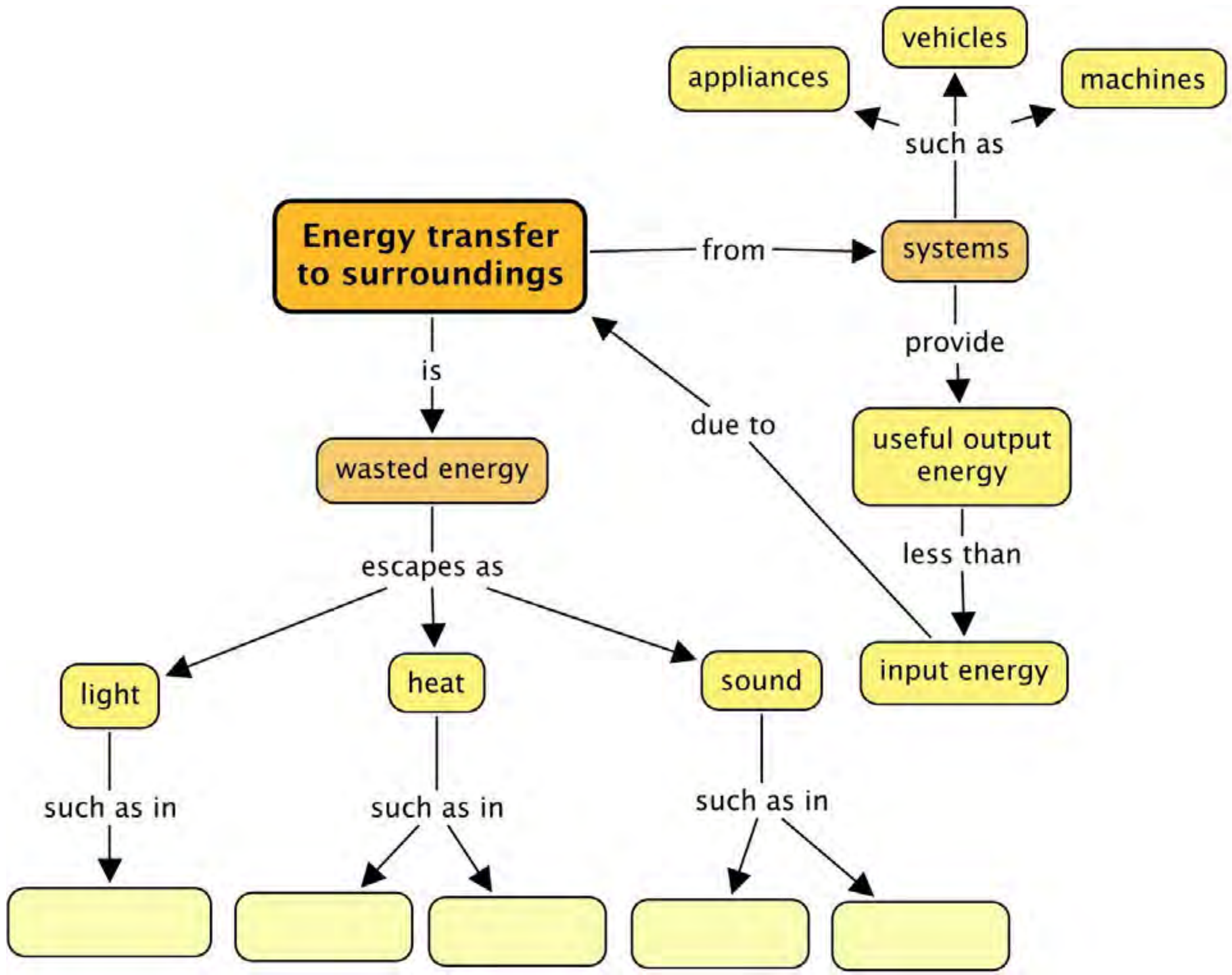


SUMMARY:

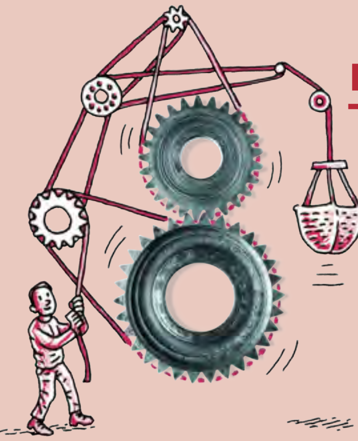
- Energy entering a system is called the input energy.
- The energy is transferred in a system to provide a useful output energy.
- Tools, appliances, vehicles and machines all provide useful energy outputs.
- Not all of the input energy is transferred to a useful output. Some of the energy is wasted or lost. The useful output is therefore less than the input energy as some of the output energy is wasted.
- An example is a light bulb where the input is electricity and the useful output is light. However, a large amount of the energy is lost to the surroundings as thermal energy.
- The efficiency of a system is determined by how much of the input energy is transferred to useful output energy. The greater the wasted output energy, the less efficient the system.
- A Sankey diagram is used to show the energy transfers in a system.
- In a Sankey diagram, the arrows represent the portion of the input energy which is transferred to useful energy output and the portion which is transferred to the surroundings and wasted.

Concept Map

Complete the concept map by giving two examples of systems where energy is transferred to the surroundings and "wasted" as sound and thermal energy, and one example of where the wasted energy output is light.



Energy transfer to surroundings
from
systems
such as
appliances
vehicles
machines
provide
useful output energy
less than
input energy
due to
is
wasted energy
escapes as
light
heat
sound
such as in
such as in
such as in



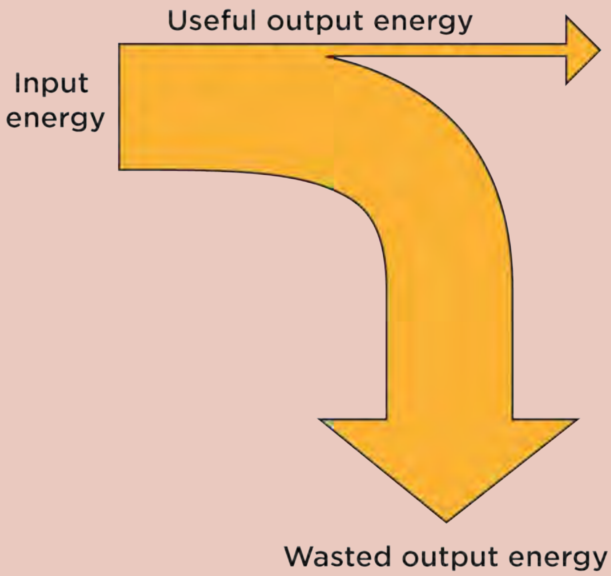
REVISION:

1. What is meant by "wasted" energy? [2 marks]

____

____

2. Draw a simple Sankey diagram to show the energy transfers in a system where the wasted energy output is more than the useful energy output. [4 marks]



3. For each of the following situations, draw a labelled Sankey diagram to show the amount of input energy, useful energy and wasted energy.

a) An electrical torch converts 100 joules (J) of electrical energy to 10 J of light energy and 90 J of thermal energy. [3 marks]

An electric torch.

b) A television has an energy output of 500 J. 400 J is in the form of light. 50 J is in the form of sound and 50 J is thermal energy. [3 marks]

A television set.

c) A hair dryer converts 300 J of energy into 150 J of kinetic energy, 100 J of thermal energy and 50 J of sound energy. [3 marks]

A hair dryer.

4. Write a description of the energy transfers in each of the situations in question 2. [6 marks]

5. What is the difference between a filament light bulb and an energy saving light bulb? [2 marks]

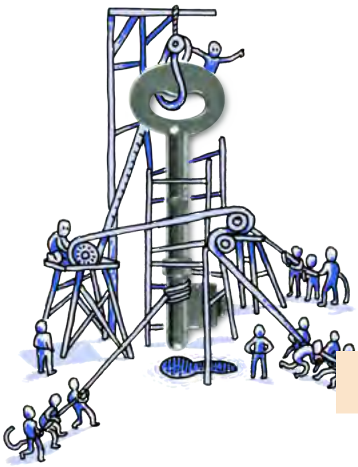
6. Why is an energy saving light bulb better at saving energy than a filament light bulb? [3 marks]

7. In the last chapter we looked at insulating materials and how they help reduce energy transfer. Use this knowledge, and what you have learned in this chapter about input energy, useful output energy and wasted energy, to explain why an electric geyser should have an insulating layer on the outside. [4 marks]

8. In the electric geyser, the heating element is placed near the bottom of the geyser. Why is this? [2 marks]

Total [32 marks]

6 The national electricity supply system



KEY QUESTIONS:

- How does Eskom produce electricity?
- What energy is transferred during electricity generation?
- How does the electricity reach our homes?
- Can we use as much electricity as we like?
- How can we save electricity?

6.1 Energy transfers in the national grid

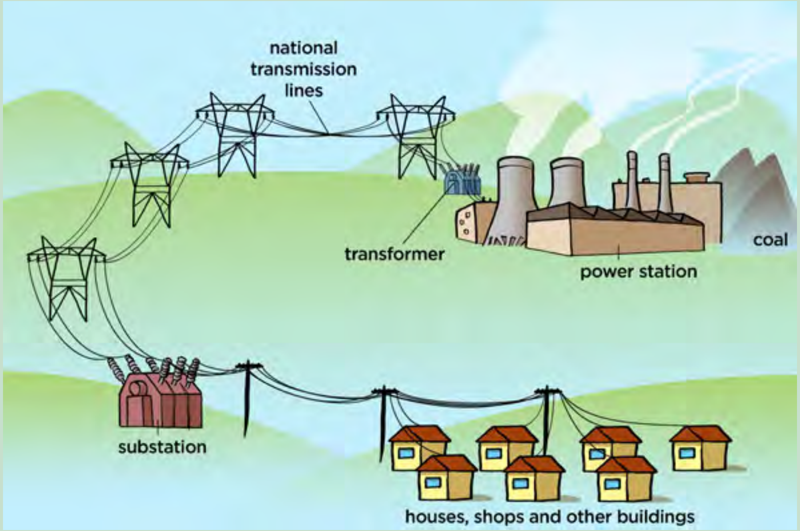
Do you remember learning about the mains electricity supply in Gr. 6 Energy and Change? We learnt that the electricity that is used to power our homes, schools, shops and other buildings is generated in power stations and delivered to us in the **national electricity grid**. In this chapter we are going to be looking in more detail at how electricity is generated and delivered to the consumers.

The national grid is a system

Let's look at the different parts of the national electricity grid.

ACTIVITY: Overview of the national electricity grid

The following is a diagram of the national electricity grid. This gives you an overview of the process and different steps that we will be discussing.



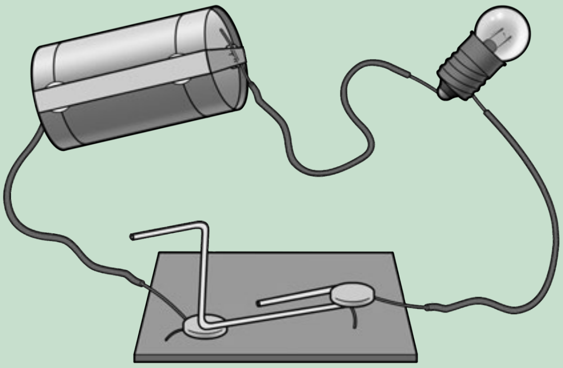
QUESTIONS:

1. Write your own definition of a system.

2. What does the Law of Conservation of energy tell us about the energy in a system?

3. Look at the diagram of the national electricity grid. Do you think it is a system? Why?

4. The national electricity grid is actually a big electrical circuit. Look at the following diagram of a simple electric circuit that you might have made in class and the diagram of the national grid. We can draw similarities between this circuit and the national electricity grid to understand it.



TAKE NOTE

In the simple circuit, the circuit is completed as the wire goes from the bulb back to the battery. We cannot see this in the national electricity grid, but there are also power lines which connect back to the station to complete the circuit.

5. The battery is the source of potential energy in the simple circuit. What generates electricity in the national electricity grid?

6. In the simple circuit, the conducting wires transmit the electricity in the circuit. What does this job in the national electricity grid?

7. In the simple circuit, the useful output energy is to make the light bulb light up. What are some of the useful outputs in the buildings where the electricity is delivered to in the national electricity grid.

VISIT

Great video that provides a comprehensive overview of where energy comes from and how it is distributed via the national grid.

bit.ly/16s7EtM

8. In Chapter 1 of this term, we discussed sources of energy. What is the source of energy for the power station in the diagram?

9. Is this a renewable or non-renewable energy source? Why?

10. We can divide the national electricity grid up into 4 main stages. These are:

    - **A: Generation** (this is where electricity is generated)
    - **B: Transmission** (the electricity enters the power lines of the national grids and is transmitted)
    - **C: Distribution** (the electricity is distributed at substations to various towns and areas)
    - **D: Consumers** (this is where the electricity is transferred to useful energy outputs)

    Use this information to write the letters A, B, C and D on the diagram of the national electricity grid to label these stages.

NEW WORDS

- national electricity grid
- Eskom
- turbine
- generator
- dynamo
- solenoid
- geyser
- transformer
- pylon
- consumption

Let's now take a closer look at the first stage in the national electricity grid, namely how electricity is generated.

How electricity is generated and supplied

Do you remember that in Chapter 2 we looked at another renewable way that electricity is generated using a hydropower plant. The water in the dam was used to turn the **turbine** to generate electricity. What energy did the water have when it was at the top in the dam?

What was this energy transferred to as the water fell and turned the turbine?

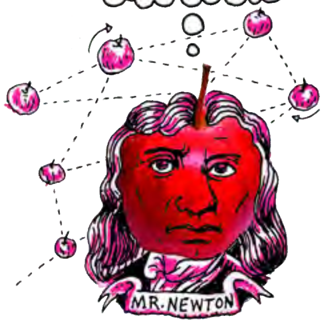
In South Africa most of the power stations use coal for fuel. We are therefore going to learn more about how coal-powered power stations work. The coal is mined out of the earth. The coal is transported to the power station in large trucks or trains.

This is the Orlando Power Station in Soweto which served Johannesburg for 50 years from 1951. It is not used anymore. The painted cooling towers are seen most prominently, but the building to the right is also part of the power station.

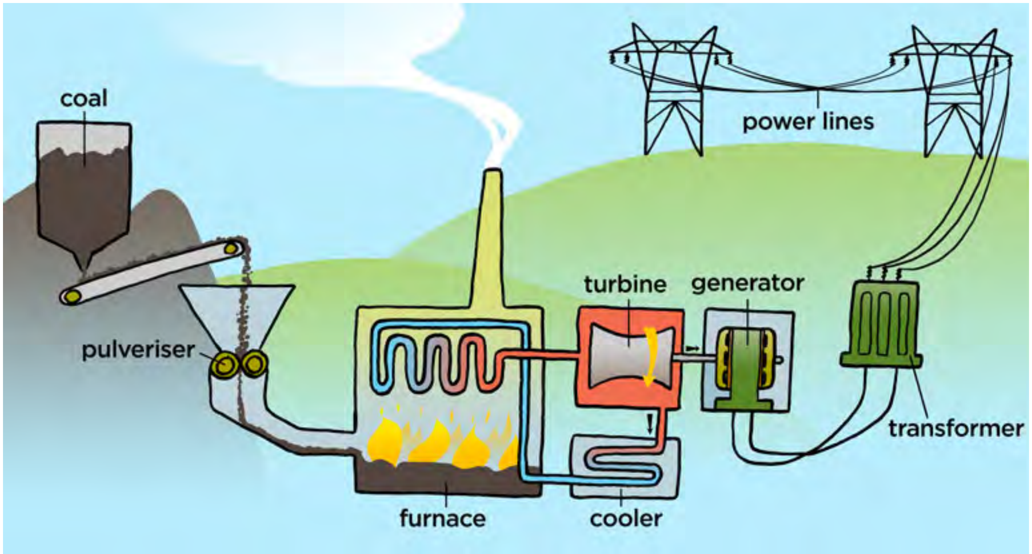
A coal-powered power station.

DID YOU KNOW?

The cooling tower on the left in the photo is covered in the largest mural painting in South Africa.



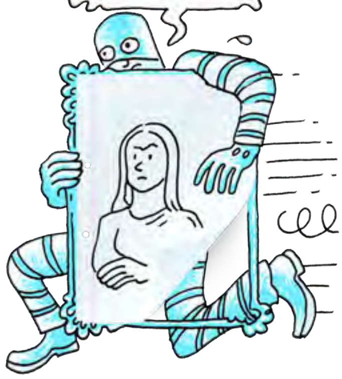
Let's take a closer look at what happens inside a power station. Have a look at the following diagram.



1. The large chunks of coal are first crushed into a fine powder. This is called **pulverisation**.
2. The coal is then transported to a **furnace** where it is burnt.
3. The thermal energy from the burning coal is used to boil water and generate **steam**.
4. The steam pushes the blades of the **turbine** and so the turbine spins.
5. The turbine is connected to the shaft of the **generator** which then turns large magnets within wire coils, which generates electricity.
6. The **electric current** is sent through the **power lines** to businesses and homes.

TAKE NOTE

We will learn about how coal is formed next term in Planet Earth and Beyond.



Now that we know the basic process for producing electricity, let's look more closely at how energy is transferred from one part to another in the system.

Energy transfers in the national grid

In a coal-powered power station, the potential energy stored in the coal is used to boil water to produce steam.

The thermal energy in the steam is transferred to a turbine. This allows the turbine to turn which means that the turbine now has kinetic energy. Can you see how energy is transferred from a thermal system to a mechanical system?

A steam turbine with the outer case removed.

How does the steam make the turbine turn? Let's make a simple turbine (pinwheel) and see how it works.

ACTIVITY: Turning a pinwheel

MATERIALS:

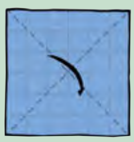
- A5 stiff cardboard
- pair of scissors
- straw
- pin
- kettle

INSTRUCTIONS:

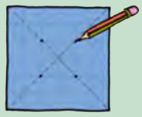
1. Start with a piece of paper. Fold the rectangular A5 page into a square.

2. Use the scissors to cut off any excess paper.

3. Fold the square corner to corner and then unfold so that you have diagonal crease marks.



4. Make a pencil mark about a third of the way from the centre along each diagonal line.



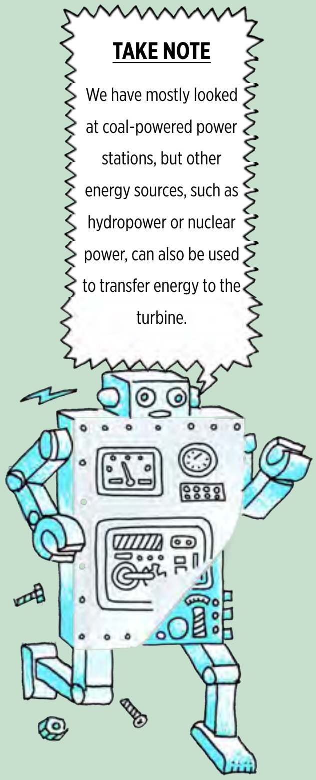
5. Use the scissors to cut along the fold lines and stop at the pencil mark.

6. Bring each point to the centre of the square and stick a pin through all four points.

7. The head of the pin forms the centre of the pinwheel.

8. Turn the pin wheel over and make sure your pin goes through the exact centre.

9. Stick the pin into a thin stick or straw. Make sure that the pinwheel is free to turn. You can also place a small bead in between the pinwheel and the stick to make sure it spins easily.



10. Boil a kettle. The kettle must be full and boiling rapidly.

11. Hold the pinwheel over the spout of the boiling kettle and watch it.

QUESTIONS:

1. What happened to the pinwheel when it was held in the steam from the boiling kettle?

___

2. Why did the pinwheel turn? Explain the energy transfers which are taking place.

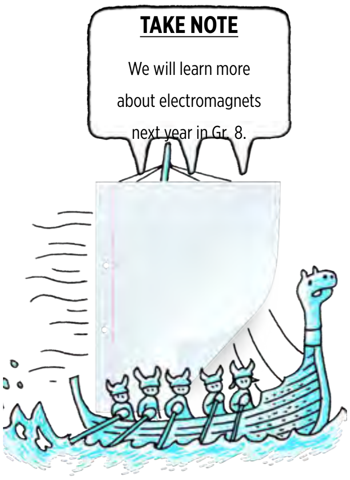
___

___

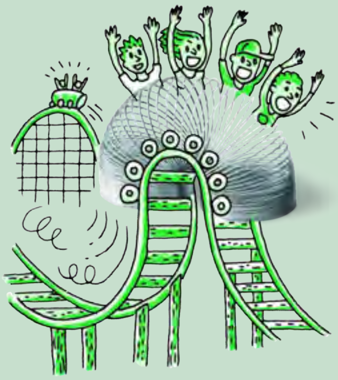
___

The turning turbine is attached to the axle of a generator. The turning turbine turns the generator. So the turbine transfers its kinetic energy to the generator.

A generator consists of a very large **solenoid** with a large rotating magnet. The solenoid is made up of thousands of coils of conducting wire. When the magnet is turned inside the coil, the generator produces electricity. The electricity is then sent to our homes through the national grid power lines. We use the energy in our homes to make our appliances work.



The national power lines transmit electricity across the country from the power stations.



ACTIVITY: Energy transfers

INSTRUCTIONS:

1. Use the information given in this chapter about how electricity is produced to draw a flow diagram of the energy transfers which take place in the production of electricity in a coal power station.
2. Start with the burning of coal and end with the transmission of electricity in the power lines.

Dynamos

Eskom produces electricity by using large generators but we can produce electricity on a smaller scale using a **dynamo**. A dynamo is a type of generator and they are considered to be the device that came before and led to the development of the modern day electrical generators that are used now all over the world. However, dynamos are still used in some places where a low current is needed.

A bicycle light is powered by a small dynamo. A bicycle dynamo has a small magnet which is turned inside a metal coil. The magnet is turned by the motion of the bicycle wheel.

TAKE NOTE

A dynamo is a type of generator, but a generator is not necessarily a dynamo.

A dynamo on the wheel of a bicycle.

Do you see the cog which turns at the top as the wheel goes around? This turns the magnet enclosed in the dynamo. Explain the transfer of energy in this system.

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What is the advantage of having a dynamo on the bicycle, rather than a battery for example?

___

___

VISIT

How a coal power station works (video)

bit.ly/18qGMbl

Dynamos are also used in mining helmets and wind-up torches and radios. If a miner's light on his helmet goes out, he can just wind up the dynamo again to generate electricity for the light. This is very useful when miners are deep underground and they cannot afford to have no light. A battery-powered light has the risk of running out and there is no way to recharge it when underground.

Electricity is very expensive to produce and, in South Africa, we rely heavily on non-renewable sources of energy such as coal. The burning of fossil fuels releases greenhouse gases into the atmosphere, causing damage to our environment. We therefore need to conserve electricity.

NEW WORDS
- conserve

6.2 Conserving electricity in the home

In South Africa, electricity is produced by Eskom and sent to our homes through the wires of the national grid. Eskom charges us for the electricity we use. In order to save money and to preserve our environment we need to make sure that we use as little electricity as possible.

There are many ways to cut down on the amount of electricity we use in our homes. Simple things such as switching off lights when you leave a room or using extra blankets to keep warm rather than a heater. Air conditioners also use a lot of electricity so using them only when really necessary will also help to save electricity.

An electric oven.

There are several common household appliances which use a lot of electricity. The element of an electric stove and ovens use a lot of electricity in order to stay hot enough to cook food. Electricity can be saved by making sure that the oven is switched off as soon as the food has been cooked.

An electric stove usually has several different sizes of heating elements. In the photo there are two large plates and two smaller ones. It is important to use small pots on small elements and large pots on larger elements. Why do you think this is?

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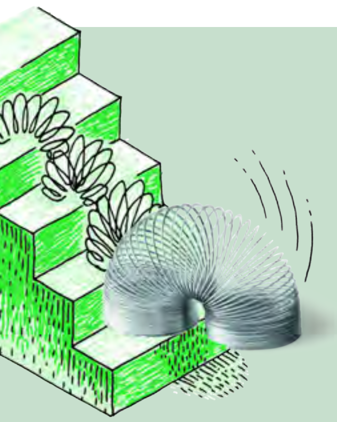


ACTIVITY: Geyser blankets and solar geysers

Any appliance that produces heat requires a lot of electricity. A **geyser** is an appliance which uses a lot of electricity. A geyser is a cylindrical tank which is used to warm and store hot water for people to use in their homes. It takes a lot of energy to warm the water and so a lot of electricity is needed. A lot of the energy transferred to the water is wasted because the air around the geyser gets warmed up as energy leaves the water and is transferred to the air. The geyser has to keep warming the water to keep the temperature constant.

One way to help reduce the energy loss to the surrounding air is to use a geyser blanket. Geyser blankets are usually between 50 mm and 150 mm thick and are often made from fibreglass and other insulating materials. They are covered with a reflective aluminium layer.

Solar geysers do not use electricity from the national grid for their energy needs. We have already learnt about how they work.

QUESTIONS:

1. Use your knowledge of insulating materials to explain how a geyser blanket could help reduce energy loss from the water to the surroundings, and therefore conserve electricity.

____

____

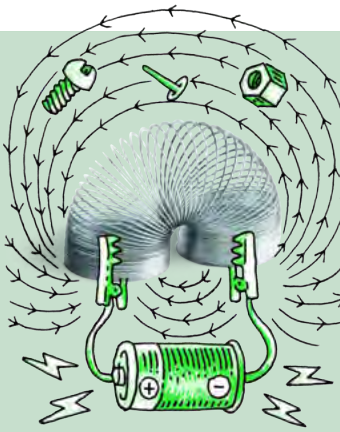
2. How does installing a solar geyser contribute to relieving demand placed on the national grid?

____

____

Let's look at some more ways to conserve electricity.

ACTIVITY: Conserving electricity



INSTRUCTIONS:

Look at the grid below. If the instruction helps to SAVE electricity, colour it in BLUE. If the statement WASTES electricity, colour it in RED.

Turning off appliances when on holiday	Leaving lights on in an empty room	Using an electric blanket	Using fluorescent lights	Using filament lights
Wearing jerseys and warm clothes in winter	Leaving outside lights on during the day	Using an electric toothbrush	Running full loads in the washing machine	Switching off the geyser during the day
Boiling a full kettle	Using a gas heater	Hanging clothes outside to dry	Turning the TV off when no one is watching	Using a geyser blanket
Running half loads in a dishwasher	Leaving the oven on when nothing is cooking	Using an electric can opener	Running an air conditioner with the windows open	Using a tumble dryer

Look at all of your red blocks. Rewrite each statement so that it changes from a waste of electricity to a method of saving electricity.

QUESTIONS:

1. Make a list of the electrical appliances in your home. Walk through your home and make sure to count every item. What could you do, in your home, to help your family conserve electricity?

2. Our country relies heavily on fossil fuels for our energy supply. Eskom power stations use coal, which is a non-renewable energy source. How can saving electricity in our homes help to reduce our negative impact on the environment?

3. What renewable energy alternatives could your family use in your house to reduce your use of electricity supplied by coal-powered stations through the national electricity grid?

____

____

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ACTIVITY: Writing a letter to your local newspaper

You have just found out that there are plans to build a new coal-powered power station just outside your home town. Your local community is upset about this due to the effects of the pollution on the environment. Your community also feels that greater measures are needed to change the way we rely so heavily on non-renewable sources. We should rather be looking at alternative ways of generating electricity. You decide to do some research about the best possible solution for a power station, other than one which uses fossil fuels.

INSTRUCTIONS:

1. You decide to write a letter to your local newspaper explaining your findings, your community's concerns and your alternative suggestion.
2. Use your knowledge from this term's work and think about the best possible solution for your area. For example, perhaps there is a dam nearby which could be used for a hydroelectric power plant? Perhaps there is a wind power farm close by which could be expanded?
3. You need to think critically and present a constructive solution to the problem.
4. Use the following space to write your letter.
5. Reference any sources which you use.

DID YOU KNOW?

'Citizen science' is when the general public takes part in and conducts scientific research.

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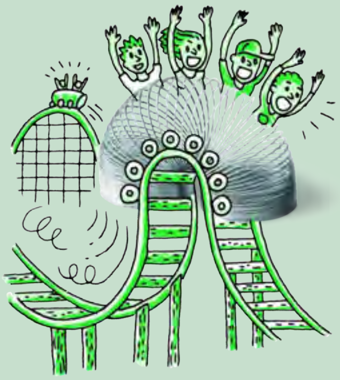
VISIT

Want to take part in some real science research? Check out these citizen science projects to easily get involved.

bit.ly/15VgBsY

Careers in electricity

There are many different careers in the field of electricity generation. Engineers, both mechanical and electrical, are needed to help design and run the processes of electricity generation. Technicians and artisans are needed to build and maintain the power generators. Research scientists are also needed to help test and develop new technologies.



ACTIVITY: Career research

INSTRUCTIONS:

Choose an electricity related career which you find interesting and research the career. You can do this by searching on the internet or in books. Some careers to find out about are those in the field of electricity generation, including engineers, scientists, artisans and technicians.

What does a day in the life of this career involve?

Remember to discover more online by visiting `http://www.curious.org.za` and by typing the links in the Visit margin boxes into your Internet browser to watch any videos, play with simulations or read an interesting article.

Type the bit.ly link for the video or site that you want to visit into the address bar of your browser on your computer, tablet or mobile phone.

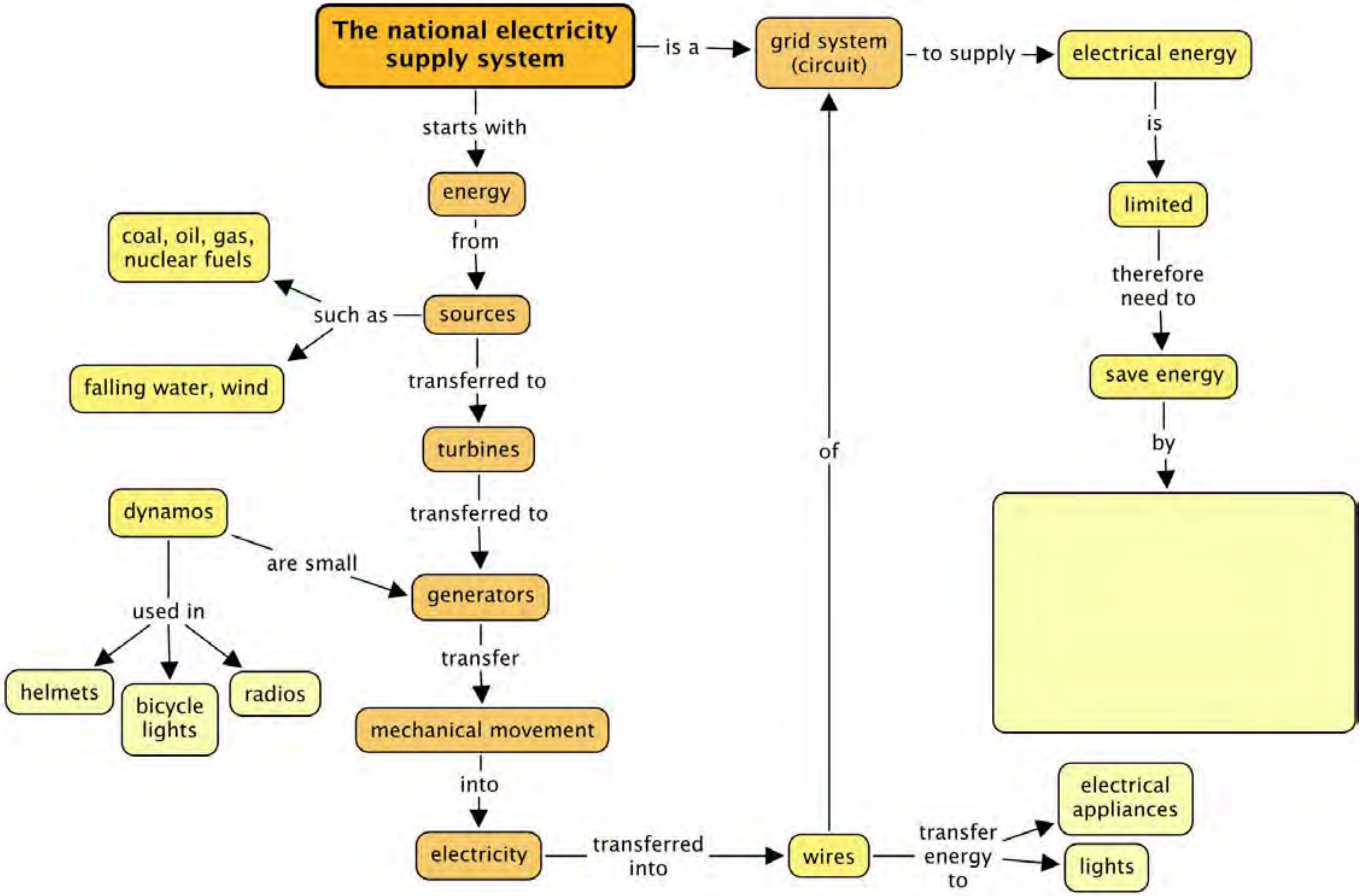
SUMMARY:

Key Concepts

- The national electricity grid is a system in which the energy is conserved. It makes a complete circuit.
- In a coal power station, the coal is burned and steam is produced. The steam turns a turbine. The turbine turns a generator which produces electricity. This is transferred to the powerlines in the national grid.
- Eskom uses coal powered stations and generates electricity using generators.
- Dynamos are a type of generator that can be used to produce small amounts of electricity, such as a for a bicycle lamp.
- Electricity is expensive and we need to conserve electricity to reduce our household costs.
- Fossil fuels are burnt to generate electricity. When fossil fuels are burnt they release greenhouse gases into the atmosphere. We need to reduce our electricity consumption in order to reduce pollution.
- There are many practical ways to conserve electricity within our homes.

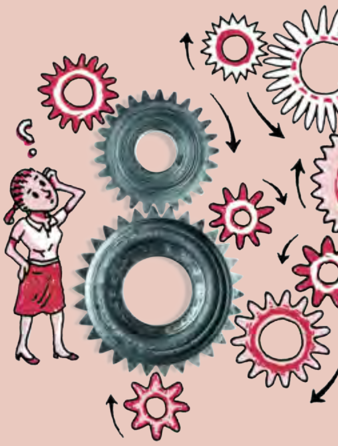
Concept Map

Complete the concept map below by filling in some of the ways to save energy.



The national electricity supply system
is a
grid system (circuit)
to supply
electrical energy
is
limited
therefore need to
save energy
by
starts with
energy
from
sources
such as
coal, oil, gas, nuclear fuels
falling water, wind
transferred to
turbines
transferred to
generators
dynamos
are small
used in
helmets
bicycle lights
radios
transfer
mechanical movement
into
electricity
transferred into
wires
of
transfer energy to
electrical appliances
lights

REVISION:

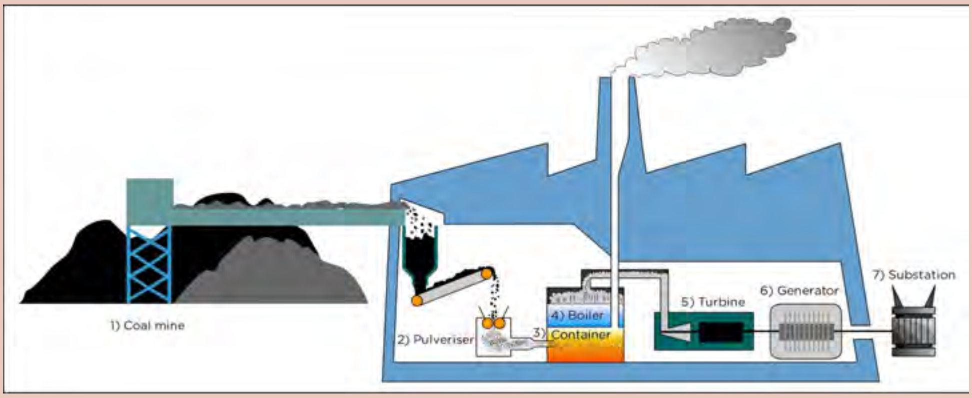


1. Why do you think we can refer to the national electricity supply as a **grid**? [2 marks]

2. What is the main source of energy for power stations in South Africa? [1 mark]

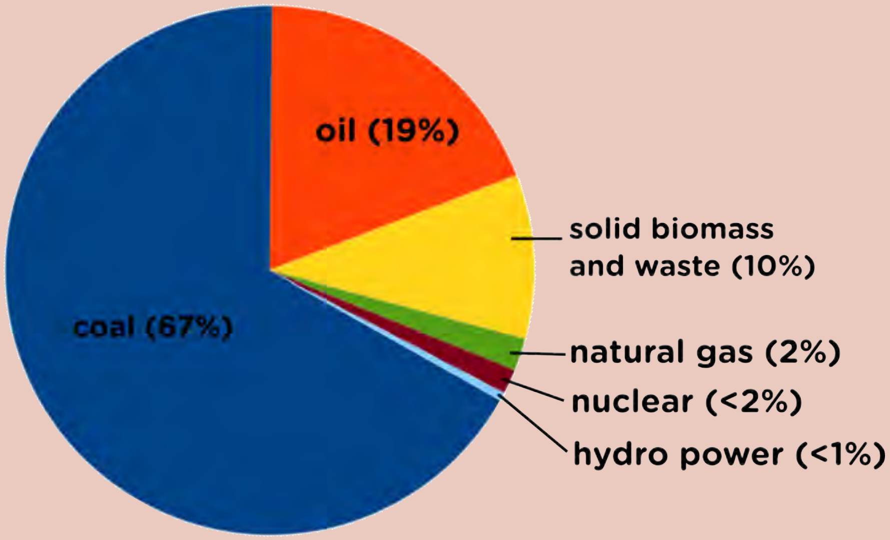
3. What is Eskom? [1 mark]

4. Look at the diagram of a power station. Write a paragraph to describe the process by which electricity is produced in a coal power station. [7 marks]



5. We have mostly looked at coal power stations and how energy from coal is transferred to the turbine. What other energy sources can be used? [3 marks]

6. The following graph shows the energy supply in South Africa from the various sources of energy. These percentages include the electricity production, consumption and export for each source in 2010. Answer the questions that follow.



a) What type of graph is this? [1 mark]

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b) What do all the percentages add up to in this type of graph? [1 mark]

---

c) What percentage of our energy supply comes from coal, as shown in 2010? [1 mark]

---

d) What percentage of our energy supply came from fossil fuels in total in 2010? [2 marks]

---

e) Does South Africa rely more on renewable or non-renewable energy supply? [1 mark]

---

f) What energy source is the smallest supply in South Africa, as in 2010? [1 mark]

---

g) What is the impact of our country's reliance on non-renewable energy sources? [3 marks]

7. Use the chart to draw a table showing this data in the space below. [6 marks]

8. Why does a miner need a dynamo instead of a battery for his helmet light? [2 marks]

9. List 3 ways in which you could save electricity in your home. [3 marks]

10. The following table shows the amount of energy used by some kitchen appliances in one hour.

Appliance	**Kilojoules**
Coffee machine	2 400
Electric stove	10 800
Electrical frying pan	4 500
Hot plate - large	8 600
Hot plate - small	4 600
Kettle	6 800
Microwave oven	4 400
Toaster	3 600
Snackwich	4 300
Food processor	600

a) Use the table to draw a bar graph. [5 marks]

b) Which appliance uses the most electricity? [1 mark]

c) How could you conserve electricity by continuing to cook your food in another system, once it has warmed up? Hint: You might have made one of these in a previous activity! [1 mark]

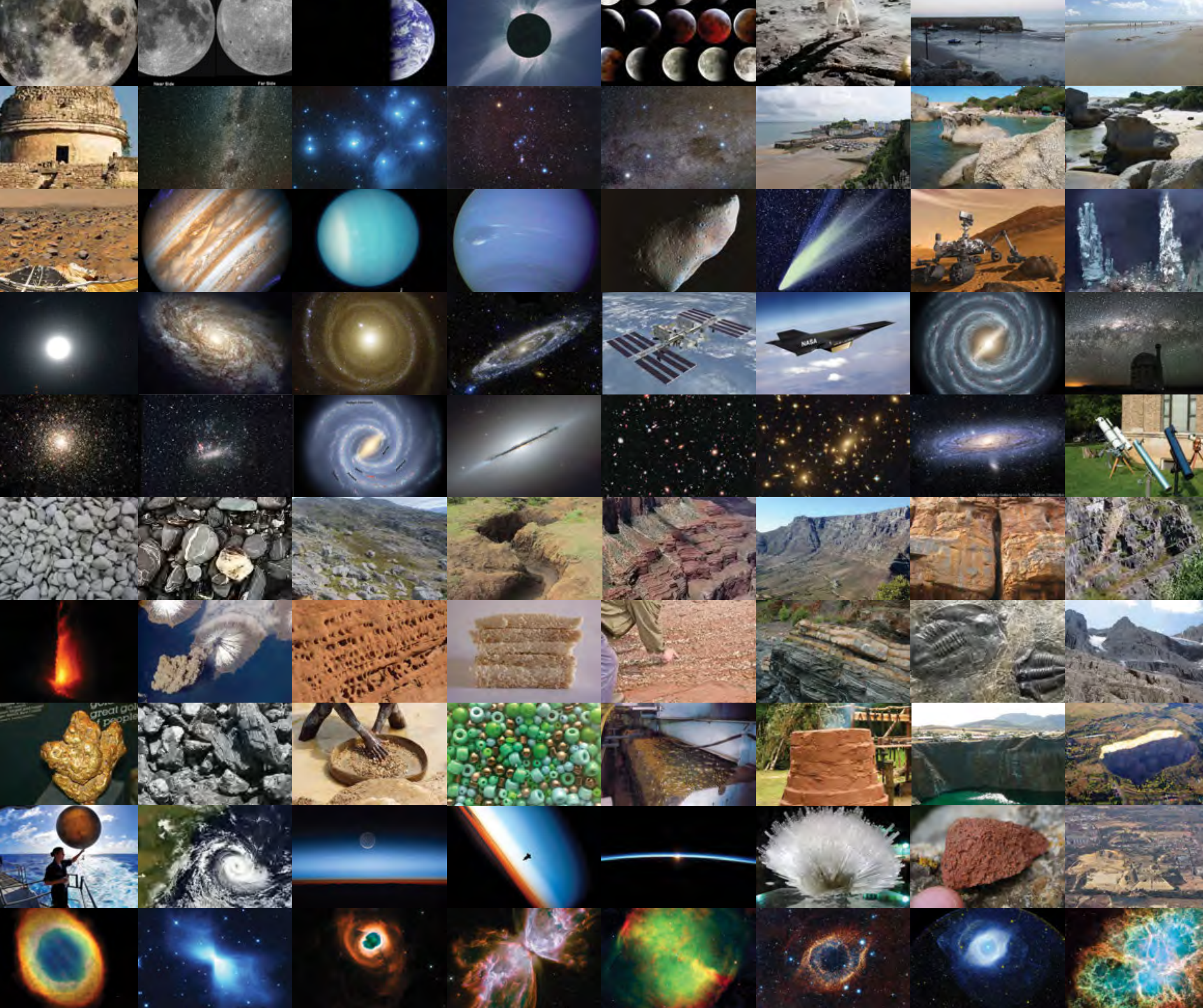
Total [42 marks]

The possibilities for cogs are endless. Discover more!

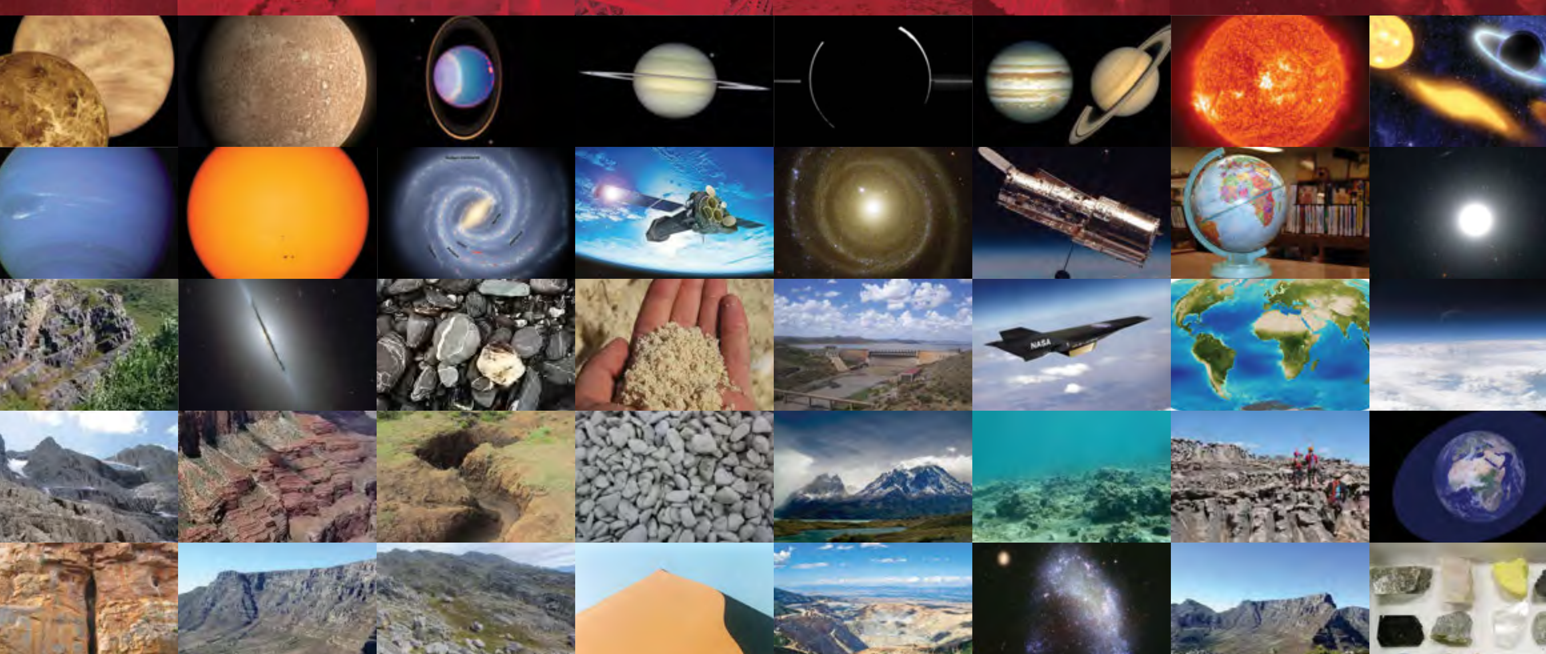
GLOSSARY

absorb:	to take in
biofuel:	a fuel made from biological materials such as soya, maize or sugar cane; examples of these fuels are biodiesel and methanol
conduction:	the transfer of energy between objects that are in direct contact with each other
conductor:	a substance which allows heat, sound or electric charge to pass through it easily; a good conductor alls free passage whilst a poor conductor allows partial passage
conservation:	a quantity stays constant; something is not lost or destroyed
conserve:	to make something last longer by using it carefully
consistent:	reliable and predictable
consumption:	using up a resource
convection current:	the movement of liquid and gas particles as the substance warms up and rises and then cools and moves down again to form a current
convection:	transfer of energy through a liquid or gas by the movement of liquid or gas particles
dynamo:	a small generator that can be used for powering a bicycle light, a mine helmet or a wind up torch
fossil fuel:	non-renewable energy sources, namely coal, oil and natural gas
generator:	a machine used to convert mechanical energy into electrical energy
geyser:	a cylindrical tank that is used to warm and store hot water
greenhouse gases:	gases in the atmosphere that contribute to the greenhouse effect; these gases include carbon dioxide and methane
heat:	heat is the energy transferred between two objects as a result of the temperature difference between them; it is also when energy is transferred between a system and the environment as a result of the temperature difference between them; it is measured in joules (J).
hydrocarbon:	a molecule which consists of hydrogen and carbon atoms bonded together
hydropower:	the energy harnessed from a moving water source, like a river or a waterfall
input:	something that enters a system and is altered by the system to produce an output
insulator:	a substance which resists the movement of heat, sound or electric charge through it
joule:	the standard, international unit of measurement for energy

kinetic energy:	energy that a body has when it is moving
law:	in science, a law is a statement of what happens and it is based on repeated experiments and observations
matt:	not glossy or shiny
methane:	a colourless, odourless gas which is often called natural gas
national electricity grid:	the network of cables, pylons and transformers which transfer electricity throughout the country
non-renewable:	a resource, such as coal, that can not be replenished or there is a limited supply of it
nuclear:	the type of energy released when a large atomic nucleus breaks up or two smaller ones combine
output:	the end result of a process
potential energy:	energy that is stored in a system
pylon:	a large vertical steel tower which supports electrical power cables
radiation:	the transfer of energy from a source that does not require physical contact or movement of particles
reflect:	to throw back heat light or sound without absorbing it
renewable:	something which is continuously replenished or there is an unlimited supply of it
reservoir:	a large container or space in which a gas or liquid can be stored
Sankey diagram:	a Sankey diagram is used to show the difference between input and output energy
solenoid:	a current carrying coil or coils of conducting wire
system:	a system is any set of parts working together to carry out a particular function
temperature:	a measure of how hot or cold a substance feels; it is measured in degrees Celsius (°C).
theory:	in science, a theory is an explanation of why or how something happens
thermal:	relating to heat
transfer:	to move from one object or place to another; in an energy system, we say energy is transferred from one object to another
transformer:	an electrical device to transfer energy between two parts of the circuit in the national electricity grid
turbine:	a set of curved blades on a central, rotating spire



PLANET EARTH AND BEYOND



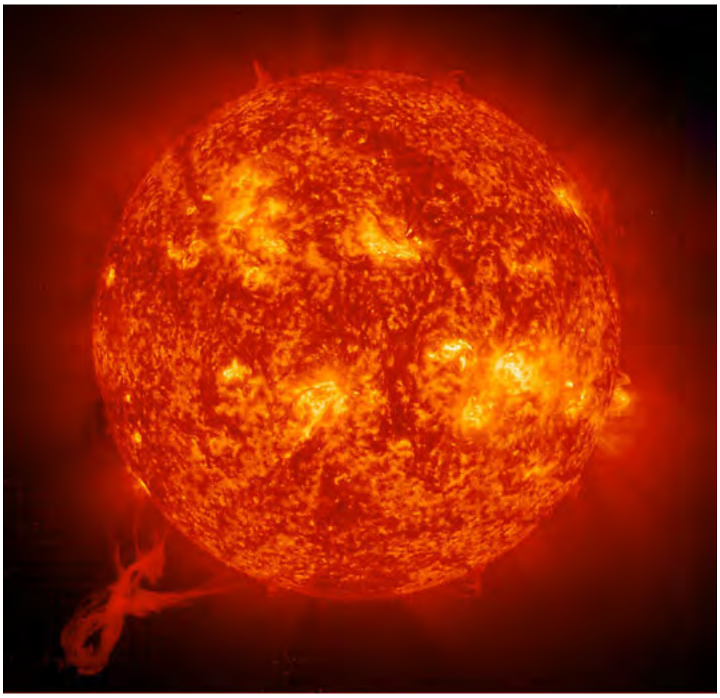
KEY QUESTIONS:

- Why do we have night and day?
- Why do we experience seasons on Earth?
- Do other planets have seasons too?
- How does the Sun influence life on Earth?

The Sun is our closest star. It is a huge ball of very hot gas in space which radiates heat and light in all directions. All the planets, including our home, the Earth, travel around the Sun in orbits. As we will see in this chapter, the Sun is incredibly important: it provides us with light and warmth and its apparent motion across our sky causes day and night and the passage of the seasons.

NEW WORDS

- sphere
- axis
- rotation
- revolution
- day
- orbit



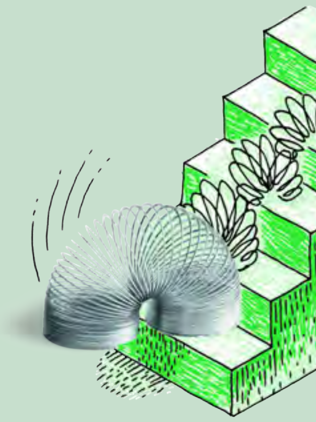
Our Sun.

1.1 Solar energy and the Earth's seasons

Earth's rotation

Let's start off with seeing what you can remember learning about **day** and night in Grade 6.

ACTIVITY: Day and night revision exercise



INSTRUCTIONS:

1. Answer the questions in the table below.

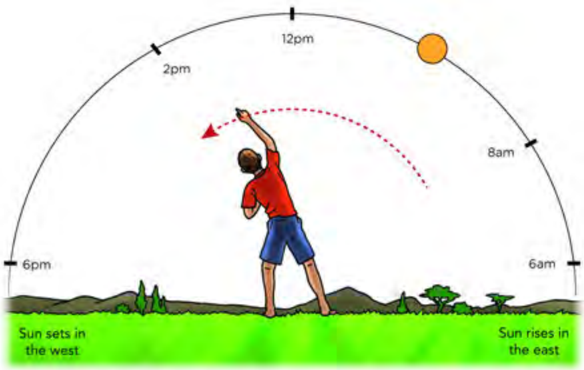
QUESTIONS:

In which direction would you have to look to see the Sun rising?	
In which direction would you look to see the Sun setting?	
At what time is the Sun at its highest point in the sky?	
At midnight, where is the Sun in relation to your position on the Earth?	
How long does it take the Earth to complete one rotation on its axis?	

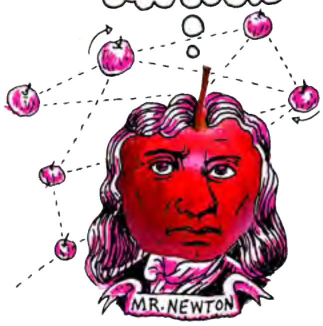
If you follow the path of the Sun during the day you will see that it rises in the east and sets in the west. The Sun reaches its highest point at noon (midday). Why do you think it looks as though the Sun moves across the sky during the day?

DID YOU KNOW?

Different planets take different amounts of time to make one complete rotation on their axis and so they have different lengths of days. Venus is the most sluggish rotator of all the planets in our solar system and takes 243 Earth days to complete one rotation. A Venus day lasts longer than 200 days on Earth!



The Sun is at different positions in the sky during the day. But is it the Sun that is moving?



Let's do an activity to find out!

ACTIVITY: Movement of a classroom Sun

MATERIALS:

- yellow round balloon or ball which can be hung from the ceiling
- string for hanging the ball or balloon

INSTRUCTIONS:

1. Hang up the balloon or ball from the ceiling using the string close to one of the corners in your classroom. Make sure that the balloon/ball is high up and visible from the back of the classroom. The balloon/ball represents the Sun.
2. Stand up in your classroom and face the balloon/ball.
3. Now slowly turn on the spot in a clockwise direction keeping your head still, completing two or three turns.
4. Repeat the activity but this time turn in an anti-clockwise direction.

VISIT
The story of our planet (video)
bit.ly/1bLAXbE

QUESTIONS:

1. As you turned clockwise what direction did the hanging balloon/ball appear to move?

___

2. As you turned anti-clockwise what direction did the hanging balloon/ball appear to move?

___

3. Did the hanging Sun actually move?

___

4. Why do you think we see the Sun move across the sky?

___

As you can see the hanging Sun is not really moving, it just appears to move because you are turning. This is also true for the real Sun in the sky. The Sun does not really move, it just appears to move because the Earth is turning on its **axis**. So, it is the Earth's **rotation** that causes the apparent movement of the Sun across the sky during the day.

ACTIVITY: Daytime and nighttime

MATERIALS:

- a globe (or a ball/balloon with the shapes of the continents drawn on it) which can be hung from the ceiling
- string for hanging the globe
- non-permanent marker or sticker
- desk lamp or torch
- black bin bags or curtains to darken the room

INSTRUCTIONS:

1. If you do not have a globe, you can make a model of the Earth yourself in class. Use any ball. Draw the Equator and mark the North and South Poles.
2. Mark with a dot/sticker your position on the globe.
3. Hang the globe from the ceiling near the middle of the class. It should be at about eye level height. The globe represents the Earth.
4. Darken the room.
5. Shine a desk lamp or torch on the globe facing Africa and keep the lamp/torch steady in this position. The torch represents the Sun.
6. Walk around the globe so that you can see all of it. Is it all lit up by the torch? How much of it is lit and how much is dark?

7. The lit area represents daytime and the dark area represents nighttime. Is your dot/sticker in daytime or nighttime?

8. Now turn the globe anti-clockwise, half a turn. Is your dot/sticker in daytime or nighttime?

9. Where is it now daytime?

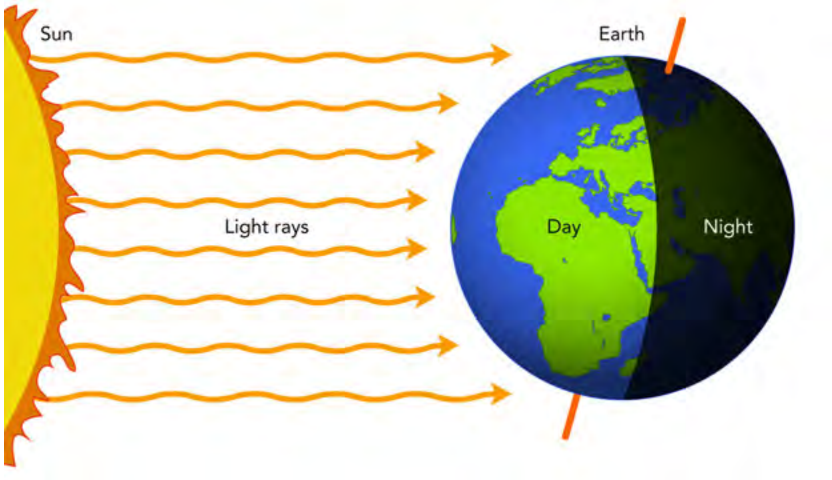
10. Keep turning the globe anti-clockwise until your dot/sticker is back in its original position and lit again. How long would it take on the real Earth for the dot to complete one rotation like this?

TAKE NOTE

It is incorrect to talk about the Sun 'burning'. The Sun is not 'burning' in the way a fire does. Remember, a fire burning on Earth requires oxygen and there is no oxygen in space. Rather, the gas is very hot and glowing as a result.

VISIT
Video of the Earth spinning on its axis causing day and night.
bit.ly/1h8mMeM

So, now you can see how the Earth's rotation about its axis causes day and night. When one half of the Earth is lit up by the Sun, the other half is in darkness. It is daytime in the lit half and nighttime in the dark half. As the Earth spins you move from light to shadow and back to light again over the course of one day (24 hours).



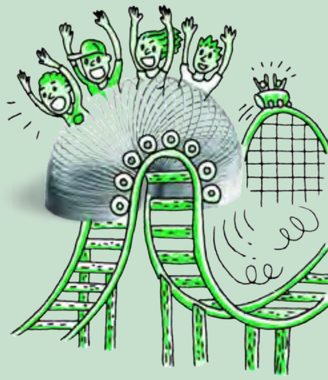
During the night you cannot see the Sun move across the sky, but if you look carefully you will notice that the stars move across the sky, just like the Sun does. It takes the Earth 24 hours to make one complete turn (called a rotation) on its axis, so an Earth day is 24 hours long.

This picture of the SALT telescope near Sutherland was taken at night with the camera shutter left open. You can see the star trails due to the Earth's rotation.

VISIT
Why does the Earth spin? (video)
bit.ly/16ORlvF

You now know that the Earth rotates on its axis completing one turn every 24 hours. But which way does it turn? Let's see if you can figure it out.

ACTIVITY: Which way does the Earth rotate?



MATERIALS:

- a ball or balloon
- string for hanging the ball

INSTRUCTIONS:

1. Hang up the balloon or ball from the ceiling using the string close to one of the corners in your classroom. Make sure that the balloon/ball is high up and visible from the back of the classroom. The ball represents the Sun.
2. Stand up in your classroom and face the balloon/ball.
3. Now slowly turn on the spot in a clockwise direction keeping your head still, completing two or three turns. Are you turning to your left or right? Note what happens to the hanging balloon or ball.

---

4. Now repeat the activity but this time turn in an anti-clockwise direction. Are you turning to your left or right? Note what happens to the hanging balloon or ball.

---

5. What do you notice about the direction that you turn (left or right) and the direction that the hanging Sun appears to move?

---

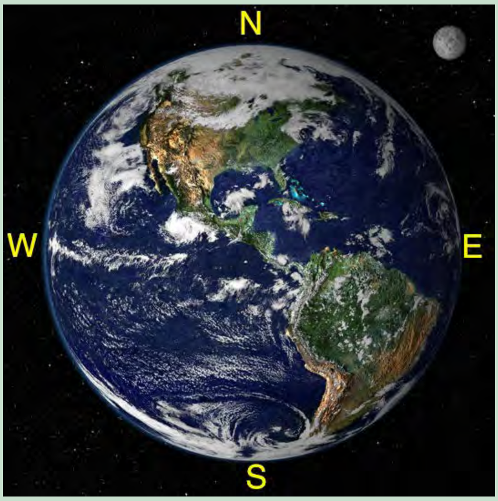
6. Which direction does the Sun appear to move across the sky, east to west or west to east? Given your answer to question 5 which way do you think the Earth is really turning?

---

7. Look at the following picture showing the Earth from space. Using your answer to question 6, is the Earth spinning in a clockwise or anti-clockwise direction? Draw the direction on the picture below.

DID YOU KNOW?

The only planet that rotates on its side like a barrel is Uranus. The only planet that spins backwards relative to the others is Venus.



This colour image shows North and South America (green and brown continents) as they would appear from space.

Earth's revolution

The Earth revolves around the Sun in an almost perfect circle, completing one **revolution** (**orbit**) around the Sun per year (or 365 $\frac{1}{4}$ days to be precise). As the Earth revolves around the Sun it also rotates (spins) on its axis at the same time. Having two words both beginning with "r" relating to movement can be confusing! Let's check now that you know what they mean before we continue.

In your own words explain what is meant by the Earth's **rotation**.

____

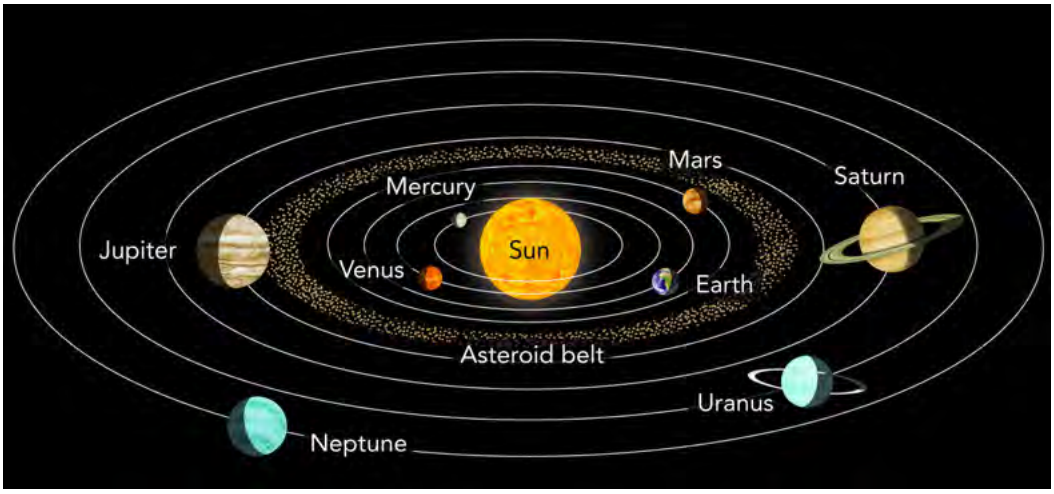
____

In your own words explain what is meant by the Earth **revolving**.

____

____

Different planets take different amounts of time to make one complete revolution around the Sun and so their years have different lengths. The planets further from the Sun will have bigger orbits, as shown in the diagram, and therefore take longer to revolve around the Sun.



Our solar system.

NEW WORDS

- solar energy
- intensity
- oblique
- direct
- indirect
- equator
- equinox
- hemisphere
- tilt
- season
- solstice

Why do we have seasons?

As the Earth travels around the Sun it receives **solar energy** in the form of light and heat, emitted from the Sun. Do you remember that in Energy and Change last term, we spoke about how heat is transferred from the Sun through space, to Earth? What is this called?

___

We are very lucky to have our Sun! if the Earth did not receive any energy from the Sun the Earth would be cold and lifeless. Have you noticed that the average temperature is not the same all year round? We experience the **seasons**: winter, spring, summer and autumn. It is generally much warmer in summer and cooler in winter, why do you think that is?

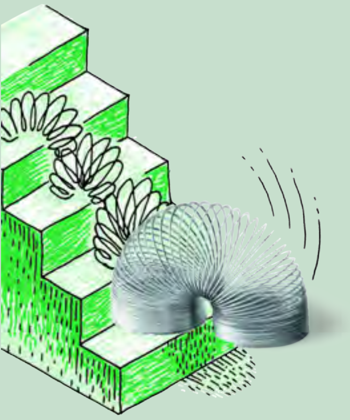
___

___

DID YOU KNOW?

Mercury has a year of just 88 Earth days, and Neptune has a year of 164 Earth years.

Let's first make sure that we know some of the terminology about Earth before continuing.



ACTIVITY: Label the Earth

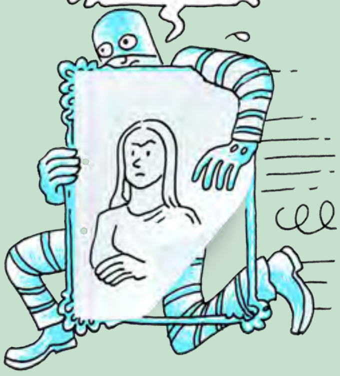
INSTRUCTIONS:

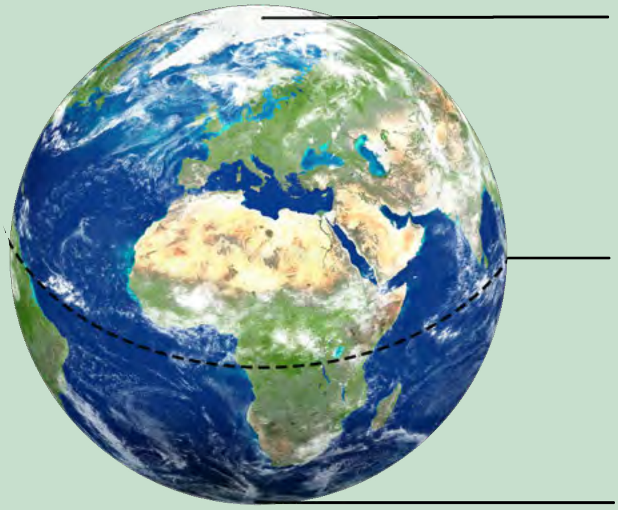
Using the word bank, label the diagram of the Earth below.

Word bank:
- Northern Hemisphere
- Southern Hemisphere
- Equator
- North Pole
- South Pole

TAKE NOTE

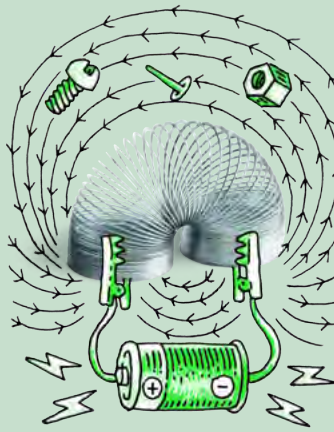
The amount of solar energy the Earth receives is called **insolation** which comes from the words: **in**coming **sol**ar r**a**diat**ion**





You might already have some thoughts about why we get different seasons throughout the year.

ACTIVITY: What causes the seasons? Guesses!

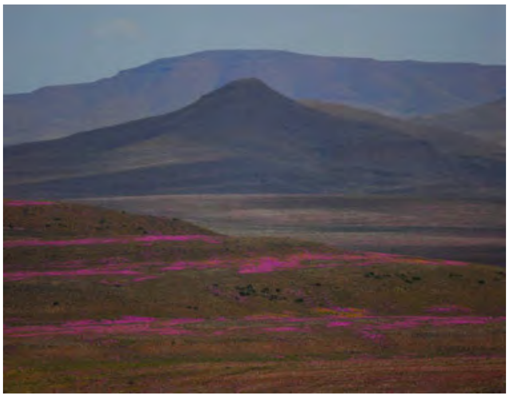


INSTRUCTIONS:

1. Which of the statements in the table do you think are true and which do you think are false? Put your answers in the right hand column.

Statement	True or False
We experience winter because the Sun emits less energy in winter.	
We experience summer because we are closer to the Sun during summer.	
If it is winter in the Northern Hemisphere it is winter in the Southern Hemisphere too.	
Daytime is longer in the summer because the Earth spins more slowly in the summer months.	

ALL the statements in the "What causes the seasons?" activity are false! The amount of energy emitted by the Sun is the same all year round. Also the Earth spins on its axis at the same rate all year. When it is summer in Cape Town it is winter in Paris and when it is spring in London it is autumn in South Africa. The seasons are reversed in the Northern and Southern **Hemispheres**. If it can both be winter and summer on different parts of the Earth at the same time, the seasons cannot be caused by our distance to the Sun. If that were the case, then the whole of the Earth would experience summer and winter at the same time.

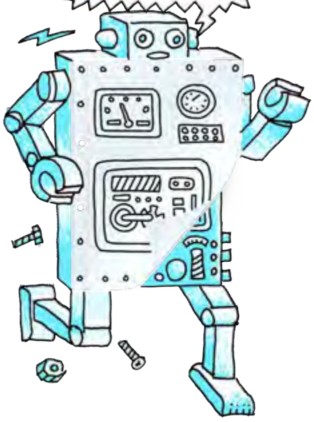


Springtime in the Northern Cape, the flowers are out in bloom.

Winter time in the Northern Cape. In Sutherland, temperatures can go below 0°C and it often snows.

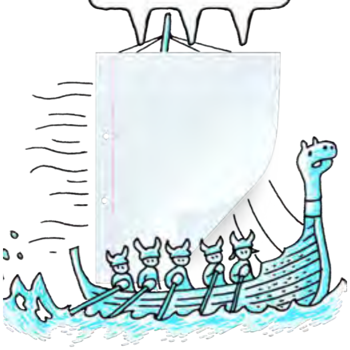
TAKE NOTE

The relative position of the Earth around the Sun is not drawn to scale. If it was drawn to scale, the Earth would not fit on this page!

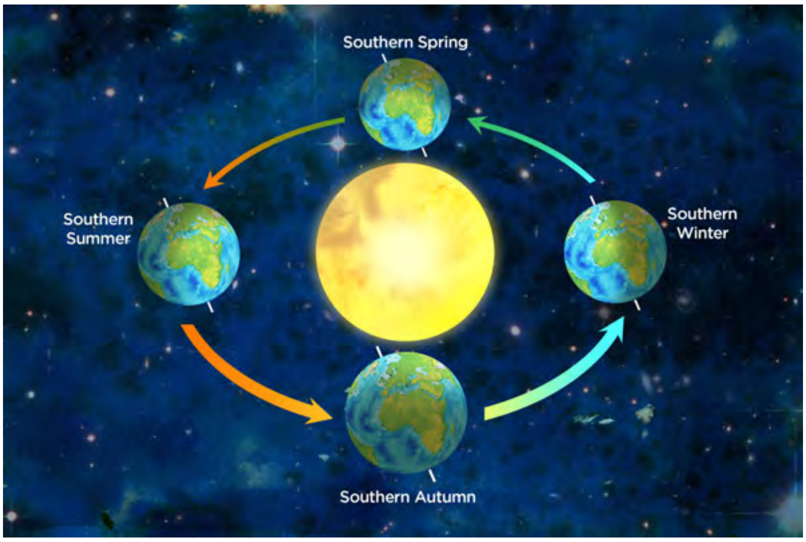


TAKE NOTE

The Earth's orbit is actually very slightly elongated but very close to a circle, called an ellipse.



Let us now find out what causes the seasons. The seasons don't just divide up the year into quarters, they tell us where the Earth is in its path around the Sun. Have a look at the following diagram which shows how the Earth revolves (orbits) around the Sun and the different seasons experienced by the Southern Hemisphere.



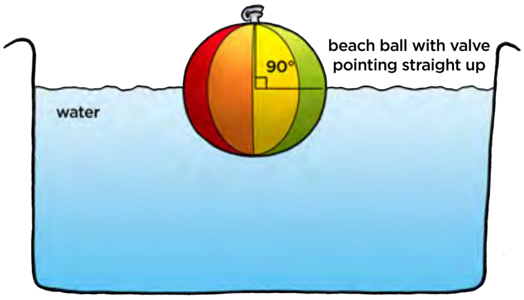
The relative positions of the Earth and Sun during the course of a year. It takes one complete year for the Earth to revolve (orbit) around the Sun. It takes six months for the Earth to travel halfway around the Sun.

Look at the picture showing the position of the Earth as it orbits the Sun during a year. The Earth travels around the Sun in an almost perfect circle. If you look closely, you can see that the Earth's axis is not pointing straight up, but is slanted, or tilted in the picture. This is because the Earth is actually tipped over slightly relative to the plane of its orbit. The Earth's axis always tilts in the same direction in space: the North Pole points towards the star Polaris.

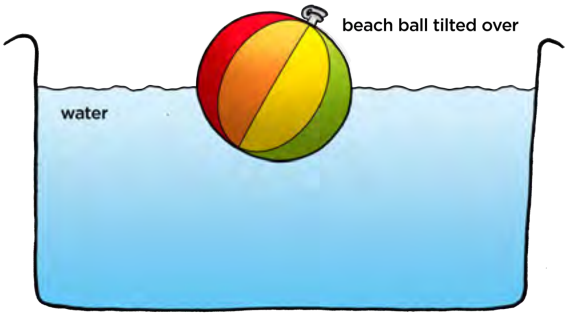
What do we mean when we say that the Earth's axis is tilted relative to the **plane** of its orbit? A plane is a flat surface, for example a flat piece of card or the surface of still water. The plane of the Earth's orbit is an imaginary flat surface that contains the Earth as it revolves around the Sun.

Imagine that the Earth is a beach ball floating on the surface of water in a swimming pool with half the ball submerged so that you can only see the top half of the ball poking out of the water. Now imagine that the ball is moving around in a circle on the surface of the water but it is not moving up or down. This is what we mean when we say that the Earth travels in a circle in a plane. In this example the Earth's orbital plane is the surface of the water. In space there is no surface of water, the plane is just an imaginary flat surface!

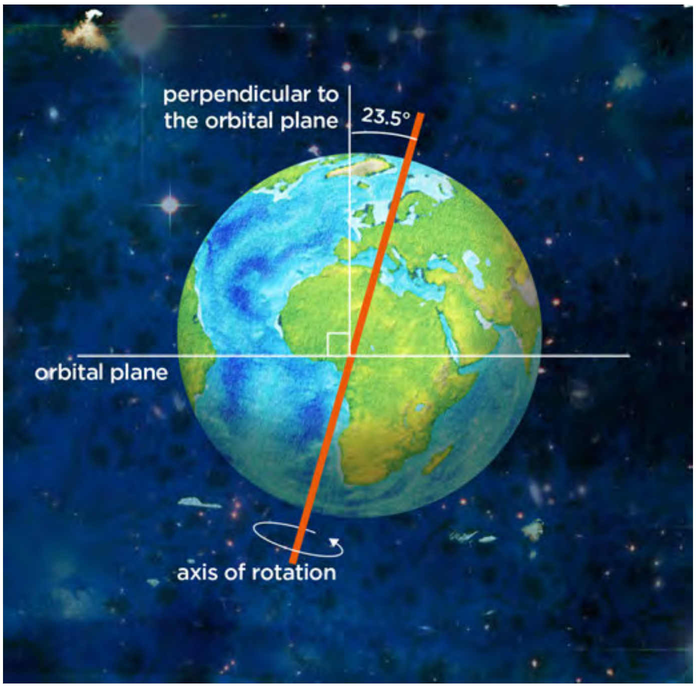
Now imagine that the valve where you blow up the beach ball is pointing straight up towards the sky. This valve represents the Earth's North Pole. In this case the valve and the plane are **perpendicular** to each other and the angle between them is 90 degrees.



However, if you push the ball over slightly so that the valve no longer points straight up, then the valve (representing the Earth's North Pole) and the water surface will not be perpendicular to each other.



The Earth's rotation axis is tilted over by an angle of 23.5 degrees (23.5°) from the vertical. As the Earth travels around the Sun its North and South Poles constantly point in the same direction in space.



The Earth's rotation axis is tilted by 23. 5° from the vertical as it orbits the Sun.

DID YOU KNOW?

By pure luck, in the Northern Hemisphere the North Pole points to the star Polaris, which allows astronomers to find north easily! Unfortunately, there is no "south star" in the Southern Hemisphere.

Let's model the Earth's tilt.

ACTIVITY: The Earth's tilt

MATERIALS:

- globe or ball/balloon
- non-permanent marker or stickers
- card and tin foil to make a star
- string
- scissors
- glue

INSTRUCTIONS:

1. Mark on the globe the position of the North and South Pole with a marker or stickers. If using a ball or balloon mark the positions of two points directly opposite each other on the surface of the ball/balloon which will be used to represent the North and South Poles of the ball/balloon.
2. Using the scissors, cut the card into the shape of a star.
3. Cover the star in foil, using the glue if necessary to stick it to the card.
4. Hang the star up from the ceiling using the string. Make sure it is high up and clearly visible from the whole of the class.
5. Sit in a circle with the rest of your class, your class teacher should sit or stand in the middle of the circle representing the Sun.
6. Select one member of your class in the circle to start the activity and pass the globe to them.
7. Tilt the globe away from the vertical, pointing the North Pole towards the hanging star.
8. Pass the globe around the circle keeping the North Pole pointed in the same direction towards the hanging star. *Remember to keep the globe spinning on its axis as it is passed around!*
9. Note how as the globe moves around the circle, sometimes the Northern Hemisphere is tilted more towards the Sun, sometimes the Southern Hemisphere is pointed more towards the Sun and sometimes neither hemispheres are tilted towards the Sun.

QUESTIONS:

1. For roughly what fraction of the orbit did the Southern Hemisphere point towards the Sun?

---

2. For roughly what fraction of the orbit did the Northern Hemisphere point towards the Sun?

---

3. What length of time do these fractions correspond to for the real Earth's orbit around the Sun?

Let's see now what effect this tilt has on the Earth.

ACTIVITY: Direct and indirect light

MATERIALS:

- A4 sized or larger piece of black card, one per pair
- torch, one per pair
- bin bags to darken the room if necessary
- pencil or pen, one per pair

INSTRUCTIONS:

1. You will need to work in a pair for this activity.
2. Place the card flat on a desktop or table.
3. Darken the room using curtains or bin bags.
4. One person should hold the torch about 25 cm above the card pointing straight down onto the card. Shine the light onto the card.
5. Look at the beam shining on the black card and note its size. The person in the pair not holding the torch should draw around the edge of the beam with a pen or pencil.
6. Swap places and point the torch towards the card at an angle of 45°, keeping it at the same distance from the card as before. Shine the light onto the card.
7. Look at the beam shining on to the card, draw around the edge of the beam with a pen or pencil.

QUESTIONS:

1. In which case is the light more concentrated? (direct or indirect)

____

2. In which case is the light more spread out? (direct or indirect)

____

3. If the light is more concentrated, does this mean that the energy from the torch is more concentrated or spread out?

____

4. In which case did the light look brighter? Why is this?

____

____

The energy is spread out over a larger surface area when the light is shone at a slanting (**oblique**) angle relative to the card than when it is shone **directly** onto the card. Similarly, when light from the Sun hits the Earth directly, the solar energy is spread over a smaller surface area and is more **intense** (concentrated) than when light hits the Earth **indirectly**. Do you think this has an effect on the temperature? Let's investigate.

INVESTIGATION: Direct and indirect light and its effects on temperature

Scientists often use models to recreate the real world in a laboratory. In this investigation, you will use a model to simulate how sunlight strikes the surface of the Earth. You will use a torch to represent the Sun. You will change the angle at which light strikes a flat surface and see what effect this has on the heating of the surface. This will model how sunlight strikes the surface of the Earth at different angles.

INVESTIGATIVE QUESTION:

Does direct light heat an area more quickly or slowly than indirect light?

HYPOTHESIS:

What do you think will happen?

___

IDENTIFY VARIABLES:

1. What are you keeping constant in this experiment?

___

___

2. What are you changing in this experiment?

___

3. What are you going to be measuring in this investigation?

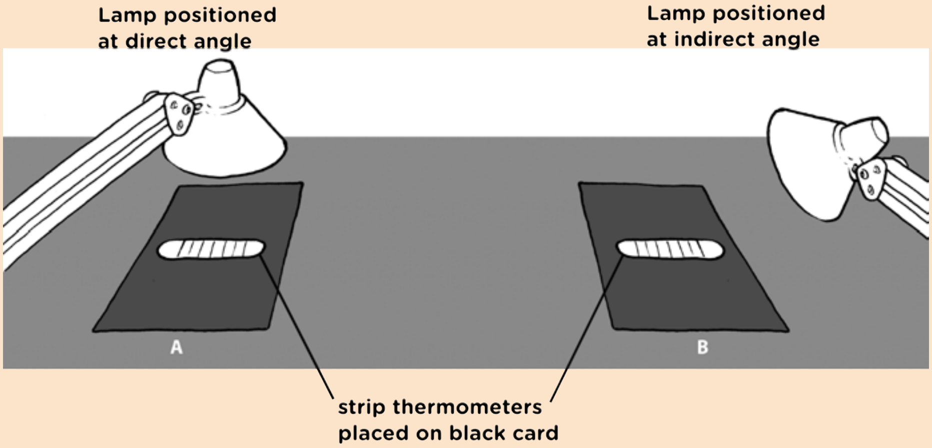
___

MATERIALS AND APPARATUS:

- two desk lamps
- two pieces of black card/paper
- two strip thermometers
- watch or clock
- marker pen and/or sticker to label the cards

METHOD:

1. Place the two desk lamps on a table or desk about 1 metre apart from each other.
2. Point one of the desk lamps directly downwards towards the table, at a height of about 30 cm.
3. Place the black card under the light and label it "A".
4. Place the thermometer strip in the centre of the black card. The light bulb should be directly above the thermometer strip.
5. Adjust the second desk lamp so that it is at the same height as the first one, but instead of pointing it directly down at the table, tilt it slightly to one side (left-right direction).
6. Place the second piece of black card under this lamp and label it "B".
7. Place the second thermometer strip in the centre of the black paper. This light should shine indirectly over the thermometer.
8. Record the temperature of both thermometers in the table below.
9. Turn on both lights at the same time. Wait for about 30 seconds and then record the temperatures of the thermometers in the table below.



RESULTS AND OBSERVATIONS:

Card	Initial temperature(°C)	Final temperature (°C)	Temperature difference (°C)
Card A (direct light)			
Card B (indirect light)			

1. Is light hitting the card from lamp A direct or indirect light?

____

2. Is light hitting the card from lamp B direct or indirect light?

____

3. Which card has the hottest final temperature? Why is this?

____

EVALUATION:

How could you have improved this experiment?

CONCLUSION:

What do you conclude about the heating effects of direct and indirect light? Why do you think this is the case?

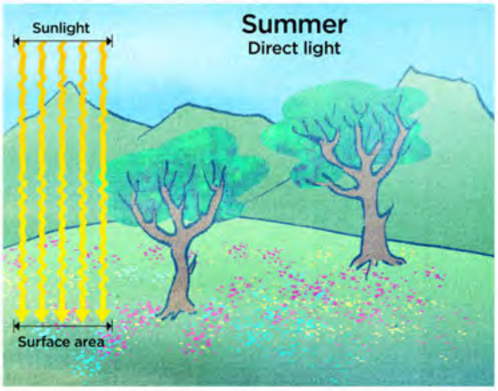
QUESTIONS:

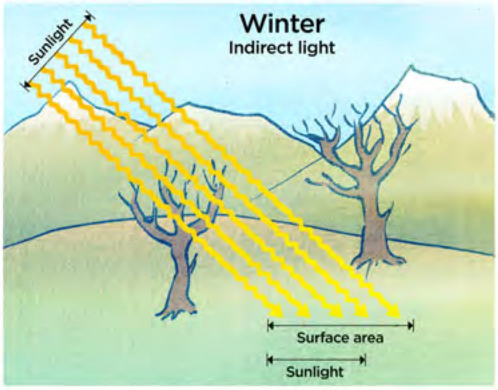
Imagine that the lamps represent sunlight and the cards represent the surface of the Earth.

1. What season on Earth do you think corresponds to case A, and why do you think this?

2. What season on Earth do you think corresponds to case B, and why do you think this?

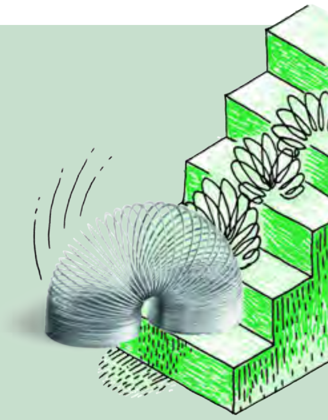
Areas of the Earth that are hit by direct sunlight are therefore warmer than areas that are hit by indirect sunlight. In the summer, the Sun is high in the sky and we receive more direct sunlight than in winter when the Sun is lower in the sky and we receive more indirect sunlight. This explains why summer is warmer than winter.





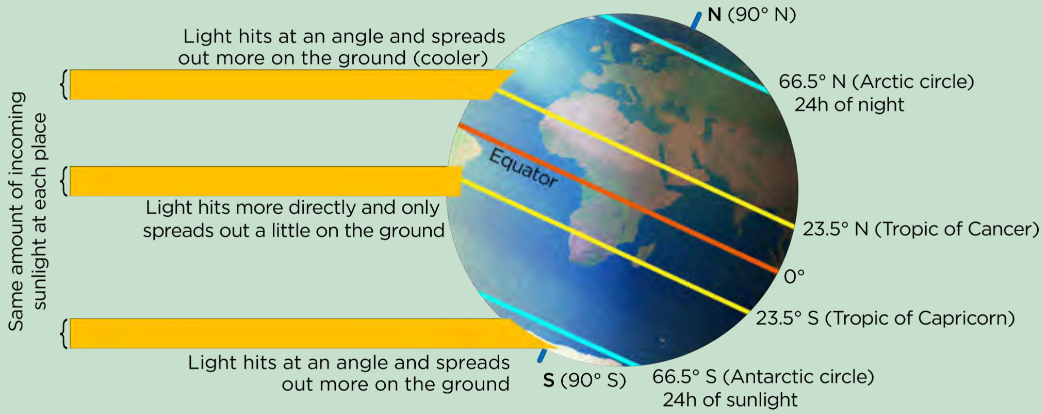
But why do we receive more direct light in summer? And why is it always warmer at the equator than at the North and South Poles? Let's do an activity to find out.

ACTIVITY: Looking at sunlight hitting the Earth



INSTRUCTIONS:

1. Look at the example picture below. It shows sunlight hitting the Earth.
2. Look at the Sun's rays and see how the angle at which they hit the Earth's surface changes at different points along the surface of the Earth because of its curved shape.
3. Answer the questions below.



QUESTIONS:

1. Does the equator receive more or less direct light than the poles?

2. Which hemisphere receives more direct light in the picture? Why is this?

3. Which hemisphere in this diagram receives more indirect light? Why is this?

4. Why do you think it is warmer at the equator than at the poles?

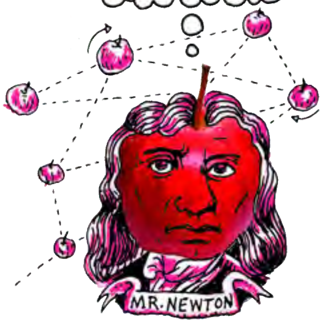
5. Is it summer or winter in the Southern Hemisphere in this example?

6. Is it summer or winter in the Northern Hemisphere in this example?

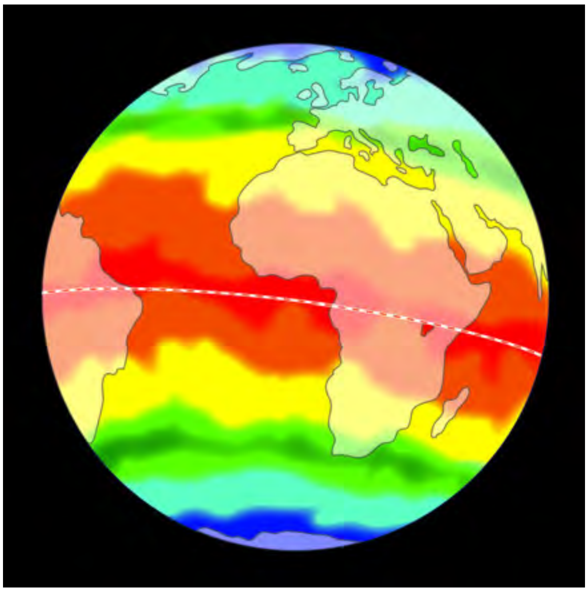
7. What would happen to the seasons if the Earth was tilted in the opposite direction, with the Northern Hemisphere tilted towards the Sun instead?

DID YOU KNOW?

Different cultures around the world have various celebrations and holidays around the winter and summer solstices, the equinoxes, and the midpoints between them.



The light falling on the Equator always hits at angles very close to 90° (almost direct), so it stays almost the same temperature all year round.



The areas around the Equator are warmer than at the poles throughout the year, as light falls almost directly on the Earth's surface between the Tropic of Cancer and Tropic of Capricorn.

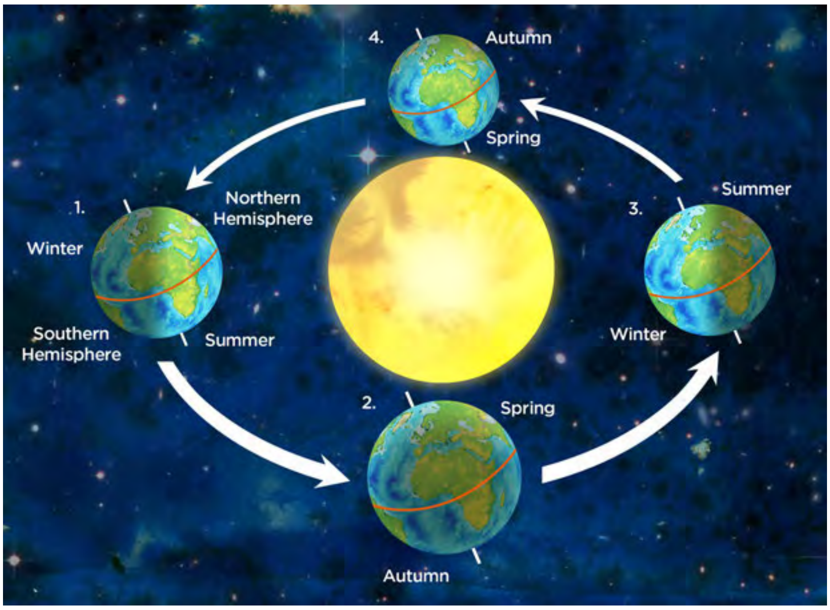
Areas that are hit by indirect sunlight are cooler because the Sun's energy is spread out over a larger area than at the equator. The poles are always hit by indirect sunlight which explains why it is cold at the North and South Poles.

We experience the different seasons because of the varying amount of direct and indirect sunlight we receive. When the Southern Hemisphere is tilted towards the Sun it receives more direct sunlight (more radiant energy) and temperatures increase: it is summer in the Southern Hemisphere.

The opposite hemisphere is tilted away from the Sun and receives less direct sunlight, it receives less energy and temperatures decrease, so it is winter in the Northern Hemisphere. When the Northern Hemisphere is tilted towards the Sun we have the opposite case and it is summer in the Northern Hemisphere and winter in the Southern Hemisphere.

TAKE NOTE

Another way to say that the light falls indirectly is to say **obliquely.** Oblique means it is not at a right angle (90°), but slanted.



The seasons as the Earth revolves around the Sun.

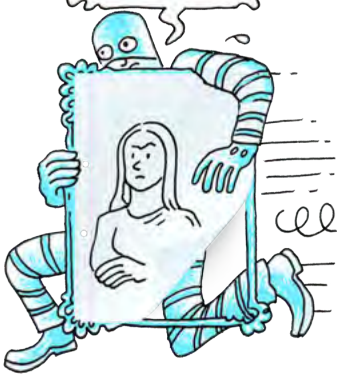
In the picture above you can see the Earth travelling around the Sun in its orbit. The Earth's axis always points in the same direction in space. Because of this, sometimes the Southern Hemisphere is tilted towards the Sun and sometimes it is tilted away from the Sun. Let's follow the path of the Earth around the Sun as it completes one revolution from points 1 to 4.

At position 1 the light falls directly on the Tropic of Capricorn (23.5° S). This occurs when we, in the Southern Hemisphere, are having summer, and is called a **solstice**. The day of the summer solstice is the longest day in the year. In the Southern Hemisphere, this is usually around 21 December. At position 3, the light falls directly on the Tropic of Cancer (23.5° N). This occurs during our winter, whilst the Northern Hemisphere is having summer. This is called the winter solstice in the Southern Hemisphere and occurs around the 21 June. The winter solstice is the shortest day of the year.

At position 2 and 4, the equator receives direct sunlight. This is called an **equinox**. An equinox occurs twice a year, around 20 March (when our autumn equinox occurs at position 2) and 22 September (when our spring equinox occurs at position 4).

TAKE NOTE

The term 'equinox' comes from the Latin words *aequus* (equal) and *nox* (night), because around the equinox, night and day are about the same length.



ACTIVITY: Earth's seasons summary

INSTRUCTIONS:

1. Refer to the previous diagram showing the Earth's seasons.
2. Fill in the blanks in the sentences below.
3. Write out the paragraph in full and underline your answers.

QUESTIONS:

1. At position 1, the Southern Hemisphere is tilted towards the Sun and experiences summer. This is called the summer __________ in the Southern Hemisphere and occurs around the date, __________. The Northern Hemisphere is tilted __________ from the Sun and experiences winter. This is called the winter __________ in the Northern Hemisphere.

2. At position 2, __________ months later, neither hemisphere is tilted more toward the Sun. Direct sunlight only hits the Earth near the __________ and indirect sunlight hits nearly everywhere else. This is called an __________. This causes mild temperatures in the north and south away from the equator.

3. Six months later, the Southern Hemisphere is tilted __________ from the Sun and experiences __________. This is called the winter __________ in the Southern Hemisphere and occurs around the date, __________. The Northern Hemisphere is tilted __________ the Sun and experiences __________. This is called the summer __________ in the Northern Hemisphere.

4. Nine months later, neither hemisphere is tilted more toward the Sun. Direct

light only hits the Earth near the _________ and indirect light hits nearly everywhere else. This causes mild temperatures in the north and south away from the equator.

5. The Earth is now back to its starting point again, having completed one revolution of the Sun in _________ months.

6. Why do you think it is important to know about the seasons? Think about how people used the knowledge of the seasons to organise their lives and mark the passage of time. Discuss this with your class and take some notes below.

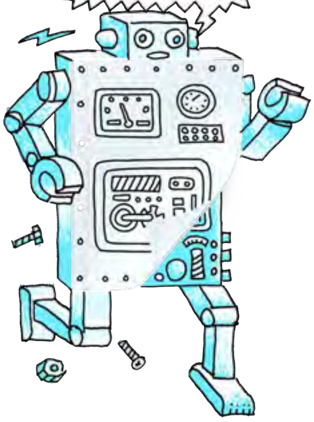
So you now know that temperatures (and therefore the seasons) on Earth are determined by the angle at which sunlight hits the Earth. In summer, the Sun is high in the sky and sunlight hits the Earth directly. In winter, the Sun is low in the sky and the Sun's rays strike the Earth indirectly at an oblique (shallow) angle. The seasons occur because *the Earth's axis is tilted relative to the path of its orbit around the Sun* and not because the distance between the Earth and the Sun vary as the Earth revolves around the Sun.

Viewed from the Earth's surface, the Sun appears higher in the sky in summer. As the

Sun travels higher in the sky it takes more time to travel across the sky from sunrise to sunset. Therefore, daytime is longer in summer than in winter. The change in the length of daytime during the year also occurs because of the tilt of the Earth's rotation axis in space.

TAKE NOTE

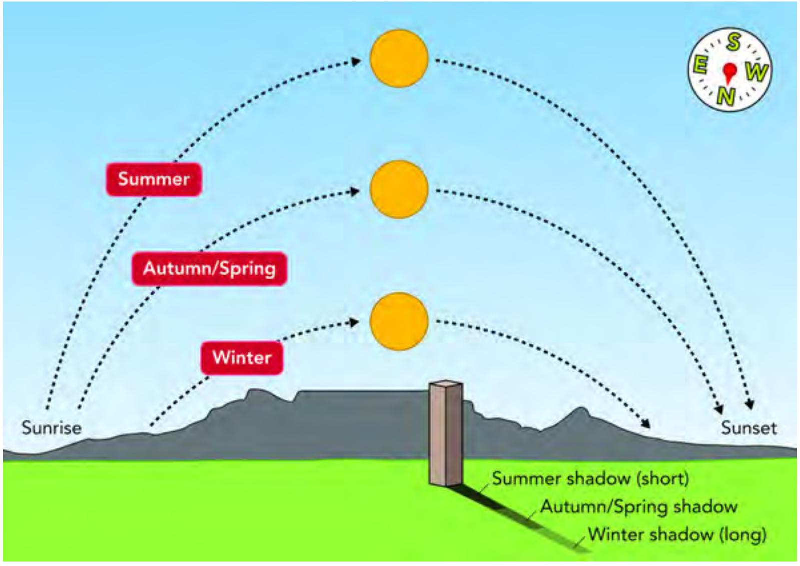
Remember that it is NOT actually the Sun that moves, but Earth's rotation which makes it look as though the Sun moves across the sky.



VISIT

A year of the sky on Earth (video)

bit.ly/16vU8Fr



The apparent path of the Sun across the sky in winter and summer. The Sun travels higher and further across the sky in summer, and so days are longer.

What do you think would happen to the seasons if the Earth were not tilted by 23.5°, but instead were pointed straight up relative to the path of its orbit?

____

____

____

The Southern Hemisphere receives the greatest amount of solar energy around the 21st of December each year. However, the hottest days of the year are generally a month or so afterwards. Why do you think this is?

____

____

Seasons on other planets

Do you think that other planets experience seasons too?

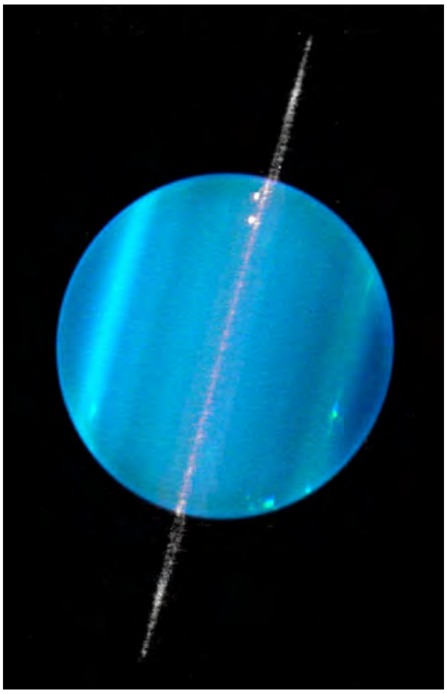
Yes they do! Every planet in the solar system has seasons, but they are nothing like the seasons we experience on Earth. Seasons pass very quickly on some planets like Venus, yet last decades on others like Uranus. Unlike the Earth's seasons, which are caused *only* by the tilt of the Earth's axis in space, seasons on other planets can be caused by:

1. The tilt of the planet's rotation axis.
2. The variable distance of the planet from the Sun during its orbit. This is because some planets have extremely oval shaped orbits around the Sun unlike Earth.

The planets Venus and Jupiter have very small tilts compared with Earth. Their rotation axes are only tilted by 3° compared with the Earth's 23.5° tilt and so Venus' and Jupiter's seasons are hardly noticeable. Venus does have interesting weather however! Venus's surface is a whopping 460 °C all year round because

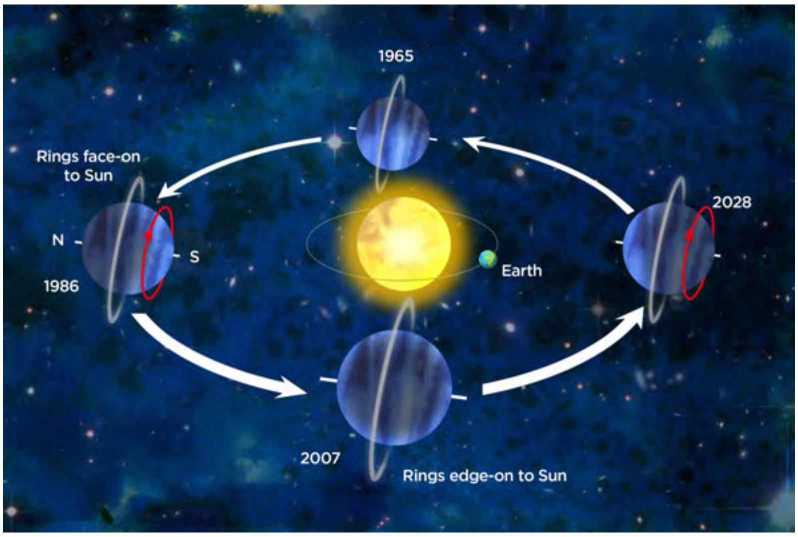
Venus has an atmosphere made of dense acidic clouds which trap sunlight leading to a runaway greenhouse effect.

Mars' tilt is 25°, very close to the Earth's 23.5°. Because of this tilt, Mars has seasons, just like the Earth. As Mars takes two Earth years to orbit the Sun, the seasons on Mars are twice as long. The rotation axis of Mars does not point toward Polaris, our North Star, but points towards the star Alpha Cygni. Because of this, Martian seasons are out of step with the seasons on Earth. Mars also has a distinctly oval-shaped orbit. When Mars is further away from the Sun in its orbit it is cooler, which leads to long, extreme southern winters. The northern winters are not so long and extreme because they occur when the planet is closer to the Sun.



Uranus.

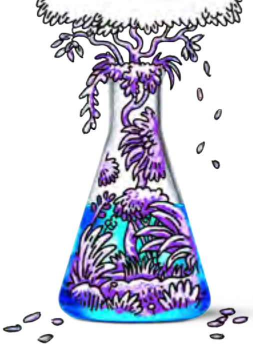
The planet with the most extreme seasons in the solar system is Uranus. Like Earth, the orbit of Uranus is nearly circular, however, Uranus's rotation axis is tilted by a massive 98°. Uranus is on its side! Uranus completes one revolution around the Sun every 84 Earth years, giving rise to seasons which last 21 years each! For two of the seasons, one pole is pointed directly at the Sun and the opposite hemisphere does not see the Sun because Uranus spins on its side. The hemisphere facing away from the Sun experiences a long (around 21 years!) dark, bitterly cold winter and doesn't see the Sun until the planet has travelled on in its orbit, to a point in its orbit where Uranus's rotation axis no longer points directly at the Sun.



The seasons on Uranus: In 1986 the south pole was facing the Sun and so its Northern Hemisphere was in total darkness. In 2028 the North Pole of Uranus will face the Sun and the Southern Hemisphere will be in total darkness. Presently, neither pole is facing the Sun directly.

NEW WORDS

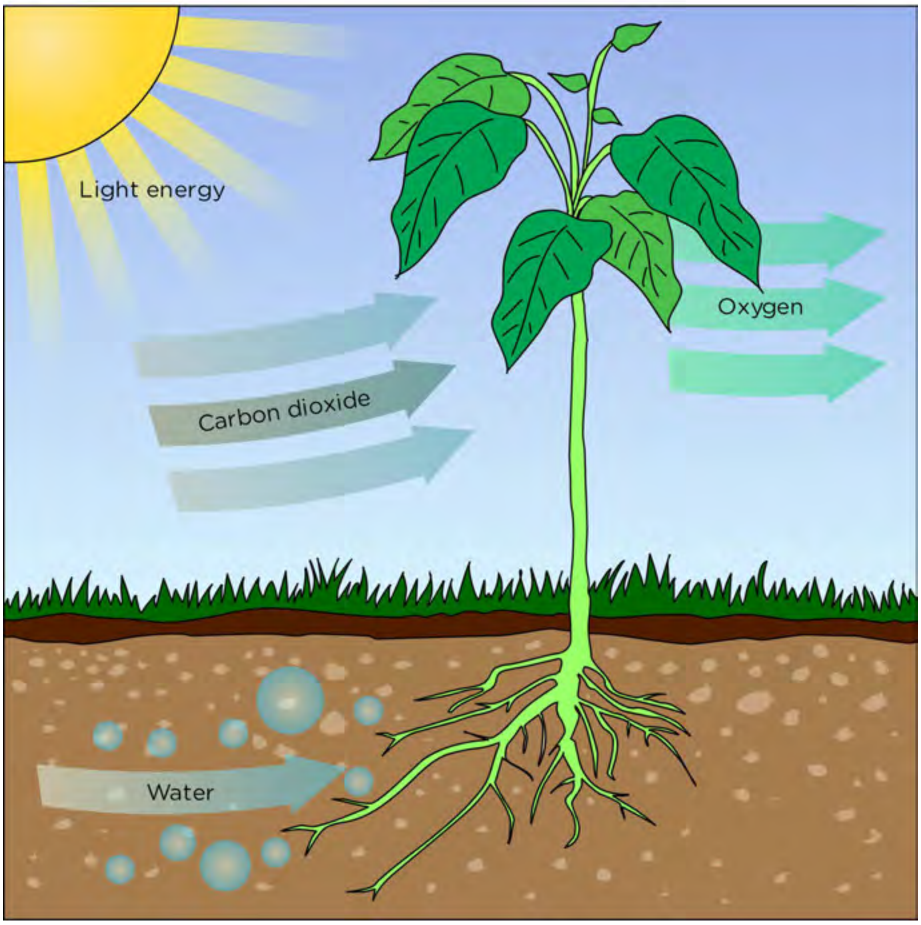
- solar energy
- photosynthesis
- cellulose
- glucose
- starch



1.2 Solar energy and life on Earth

So far this term you learnt about how the Sun and Earth interact to form day and night, and the seasons. In this section we are going to look further at how important the Sun is for us on Earth, and more specifically at how the energy from the Sun is essential for life on Earth.

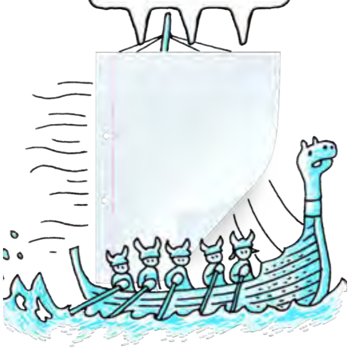
In Grade 6 you learnt how plants produce food through the process of **photosynthesis**. Plants absorb light energy from the Sun and use the energy to make food. In this way the Sun's energy is captured and stored so that it can be used later on.



The process of photosynthesis to produce carbohydrates which are stored in the plant.

TAKE NOTE

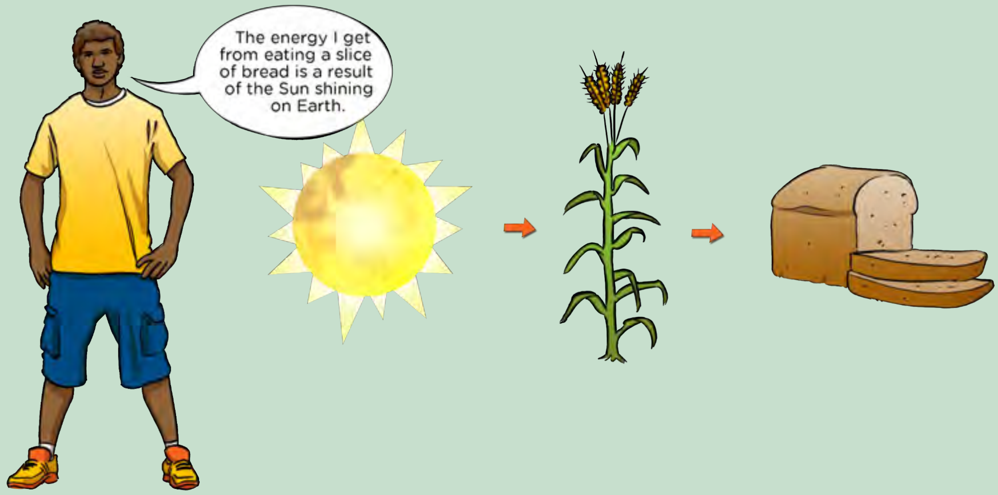
Plants also take up minerals from the soil, which are necessary for their functioning.



In photosynthesis the energy from the Sun is to used to change carbon dioxide and water into **carbohydrates** (for example **cellulose**, **starch** or **glucose**). The carbohydrates are stored in fruits, leaves, wood or bark. When we eat the plant, for example an apple, our bodies are able to release the energy stored in carbohydrates. In the same way animals, for example cows, use the Sun's energy when they eat the grass.

ACTIVITY: Capturing the Sun's energy

Study the following flow diagram and answer the question below.



QUESTION:

A boy says: 'The energy I get from eating a slice of bread is a result of the Sun shining on Earth.' Do you agree with this statement? Use the flow diagram provided, and write a paragraph to explain why you agree or disagree with the statement. Use the words in the word bank in your explanation.

Word bank:
- capture
- release
- store
- energy
- photosynthesis
- Sun
- wheat
- bread

____

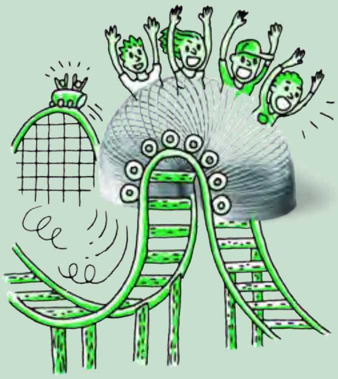
____

____

____

____

All plants and animals depend on photosynthesis for their energy. In previous grades, you learnt about energy transfer between producers, for example grass, and consumers, for example a buck or lion. You used food chains and food webs to show how energy is transferred. Plants play a vital role in life on Earth as they form the basis of food chains. Without plants, life on Earth would not survive. Plants are completely dependant upon the Sun for survival and would die out without its energy which allows them to photosynthesise. Let's investigate this in the following activity:



ACTIVITY: What would happen if the Sun's rays are blocked from reaching Earth?

Imagine a world without the Sun. How can this happen? It has happened before in Earth's history.

Dinosaurs lived on Earth millions of years ago. They were the dominant terrestrial vertebrates until about 65 million years ago, when there was a massive extinction. There are several theories about what caused this mass extinction. The most supported theory is that a massive asteroid hit Earth. It entered Earth's atmosphere with a brilliant flash of light and crashed into a shallow sea. Huge pieces of red-hot rock and steam exploded into the sky, causing raging fires which destroyed everything in their path. The asteroid's impact also caused giant waves, called tsunamis which swept across the coastal lands. Scientists think that the impact could have started a series of volcanic eruptions. This sent huge clouds of ash and dust into the atmosphere, blocking the sunlight. These huge clouds of ash, dust and steam quickly spread all over Earth and blocked the warm rays of the Sun. Scientists hypothesise that this cold, dark environment could have lasted for months, or even years.

An artist's depiction of the asteroid impact 65 millions years ago, which scientists think is the most direct cause of the dinosaur's sudden, mass extinction.

Much more recently in Earth's history, there was a supervolcanic eruption at the present site of Lake Toba in Indonesia. This occurred about 70 000 years ago when Mount Toba erupted and sent a huge volcanic ash cloud into the atmosphere. The eruption was followed by a six year long volcanic winter as the ash blocked out the sun's rays, and a 1000-year-long Ice Age. Following the eruption, mount Toba collapsed inwards and today the site can be seen at Lake Toba.

A satellite image of Earth's largest caldera (30 x 100 km), partially filled by Lake Toba, formed during the super volcano eruption about 70 000 years ago.

Let's now pretend that another event occurs in present day, blocking the Sun's rays from reaching Earth. What would happen to the people, animals and plants on Earth? Discuss this with a friend and then complete the table by writing down the things that you think would happen if the Sun's rays are blocked from reaching Earth for an extended period.

TAKE NOTE

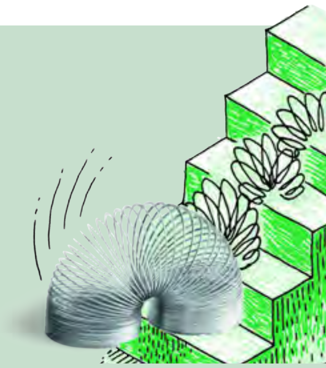
A caldera, meaning*cooking pot* in Latin, is a large volcanic feature usually formed by the collapse of land after a volcanic eruption.

	What do you think would happen?
On the first day	
One week later	
One month later	
One year later	

1.3 Stored solar energy

Earlier this year you learnt about **renewable** and **non-renewable** energy sources. **Fossil fuels** are examples of non-renewable energy sources. In this section we are looking at the relationship between the Earth and the Sun and how solar energy is stored on Earth. We have learnt that plants store the Sun's energy and we are able to use that energy later on. But what happens to the stored energy when plants die? To answer this question we need to go back in time. Millions of years back in time...

ACTIVITY: Going back in time



The following video tells the story of how fossil fuels were formed millions of years ago and how we are able today to use the energy captured at the time: bit.ly/19FdvrQ.

Watch the video and answer the questions below.

QUESTIONS:

1. What are fossil fuels?

2. Are fossil fuels renewable or non-renewable? Give a reason for your answer.

3. What conditions are needed for fossil fuels to form?

4. How were each of these conditions met at the time when fossil fuels were formed?

5. Why are fossil fuels important?

6. Why can't we make fossil fuels today?

NEW WORDS

- fossil fuels
- coal
- crude oil
- natural gas
- renewable
- non-renewable
- vegetation

Fossil fuels were formed millions of years ago. **Coal, crude oil** and **natural gas** are examples of fossil fuels. The different fossil fuels were all formed in slightly different ways. Let's look at how they were formed.

Formation of coal

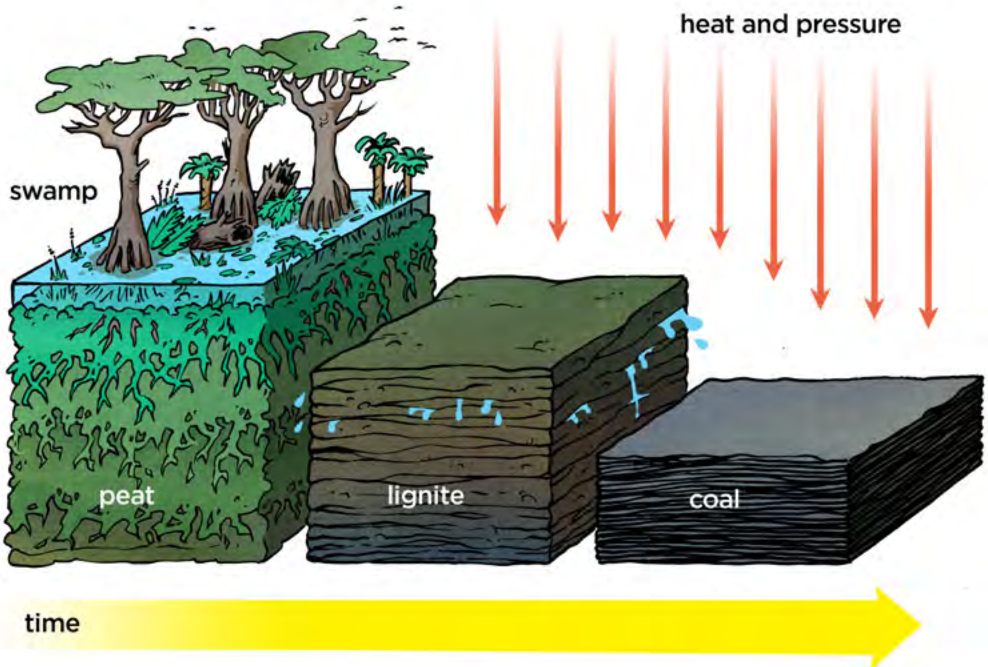
Millions of years ago the Earth was covered with fern-like plants. The plants captured the Sun's energy and manufactured carbohydrates through the process of photosynthesis, just like plants do today. Through changes in the conditions on Earth, the land was increasingly covered by water, forming swamps. Over time the plants died, forming a thick layer of dead **vegetation** on swamp bottoms.

As more water covered the land, sand and silt were washed in and covered the dead vegetation, enabling more and more plants to grow. These plants eventually died as well and more layers of plant material formed. Again they were was covered with water, sand and soil. This process repeated itself for millions of years building up massive layers of dead plant material, called **peat**. The peat layers eventually became buried and compressed by further layers of sediment forming above them.

Deep in the Earth the peat was subjected to pressure and heat, and turned into **lignite**, a porous type of coal. Upon further pressurisation and heating, more moisture was squeezed out of the lignite until it became soft, bituminous coal and eventually anthracite, the hardest type of coal available.

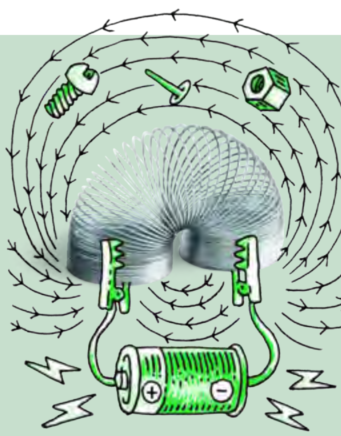
TAKE NOTE

Bituminous coal is a soft coal, containing bitumen, a sticky, black tar-like substance. Bituminous coal is of a lower quality than **anthracite** coal, which is a hard, compact coal with the highest carbon content out of all the coal types.



Coal was formed from the remains of ancient plants over millions of years.

ACTIVITY: Coal formation flow diagram



INSTRUCTIONS:

1. Read the above section on the formation of coal and summarise it in a flow diagram.
2. The following tips will help you draw your flow diagram:
   a) Underline the most important key words.
   b) Write a short sentence on each event.
   c) Identify the order in which events took place.
   d) Link the sentences using arrows.

DID YOU KNOW?

92% of the coal consumed in Africa, is mined in South Africa.

Coal is found in a number of different areas in South Africa. Study the map to see where the coal deposits are located in South Africa. Millions of years ago the interior of South Africa was a large swamp where many plants grew and died, eventually forming coal.

DID YOU KNOW?

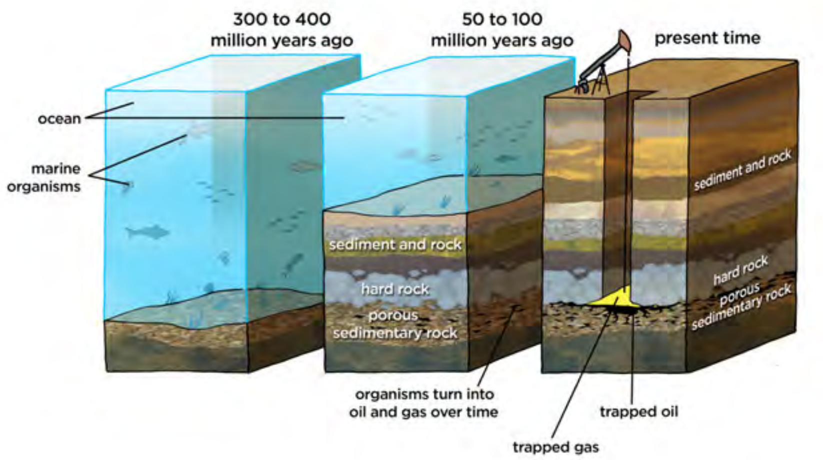
South Africa is one of the seven largest coal producing countries in the world. A quarter of the coal mined in South Africa is exported, mostly from Richards Bay.

Coal deposits in South Africa.

Formation of crude oil and natural gas

Oil, also known as crude oil, and natural gas were also formed millions of years ago by processes similar to those leading to the formation of coal. Sea animals and plants died in the oceans and were deposited on the ocean floor. Over millions of years, layer upon layer of marine deposits formed and were covered by sand and silt.

Through the actions of temperature and pressure, the deposits were changed into crude oil and natural gas. Today, oil and gas are trapped under layers of rocks and sediment and have to be drilled and pumped out of the Earth. South Africa has some gas fields off the coast of Mossel Bay, but we do not have any oil reserves.



Crude oil and gas were formed millions of years ago.

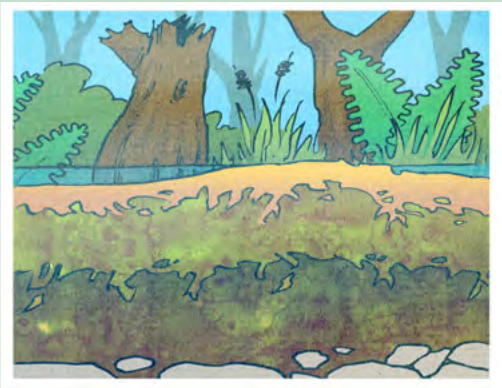
Crude oil is a thick, dark, sticky substance when it comes out of the ground. Crude oil has many uses, but has to be refined first to obtain different a number of different products. These different products have different boiling points, which is how they can be separated from each other. Do you remember that we learnt about this in Matter and Materials when looking at how to separate mixtures? What is the name of this technique where different components, which have different boiling points, are separated by evaporating and collecting them?

Crude oil is refined to make a number of different products such as motor oil, petrol, lighter fuel, aeroplane fuel, diesel and tar, Vaseline and other waxes. The components of crude oil are evaporated at different temperatures, starting with lighter fuel (which has the lowest boiling point), then jet fuel, then petroleum, then motor car oil, until only tar is left. When crude oil is refined, some of the raw materials extracted from this process are then used to make plastics and various chemicals.

ACTIVITY: Forming coal

INSTRUCTIONS:

1. The following pictures explain the formation of coal. The pictures are not in the correct order.
2. Study the pictures and order them in the correct order to show how coal is formed.
3. Write a paragraph explaining the formation of coal.



Picture 1.

Picture 2.

Picture 3.

Picture 4.

Fossil fuels store and transfer solar energy

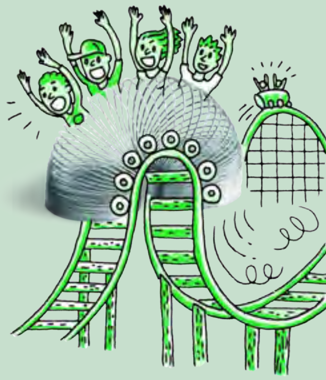
What type of energy is stored in fossil fuels?

___

VISIT
The formation of coal (video).
bit.ly/188KxS7

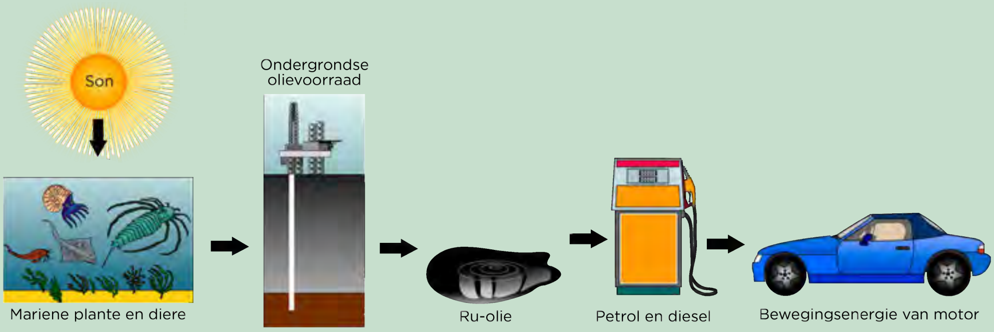
When we use fossil fuels, the stored energy is transferred to another part in the system, for example as kinetic energy. We already saw this in Energy and Change last term when looking at how a coal-powered power station works to generate electricity. In a coal-powered station, coal is burned and used to boil water. The steam produced then turns the turbine, which in turn causes the generator to turn to produce electricity. In the next activity we will investigate how the Sun's energy is transferred through fossil fuels.

ACTIVITY: Explaining the flow of energy



INSTRUCTIONS:

Petrol is made from crude oil, a fossil fuel. Use the diagram below to answer the questions about how the Sun's energy is captured in petrol and how this helps life on Earth.



QUESTIONS:

1. Using the diagram, explain how the Sun's energy is captured in petrol and used in cars.

___

___

___

___

___

___

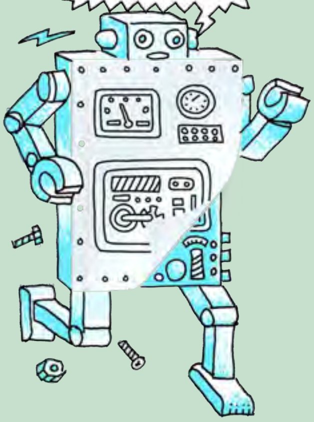
2. What transfer of energy takes place within the system?

3. Why is petrol important in our lives?

4. Draw a labelled flow diagram to show the transfer of energy from the Sun to a fire made from burning anthracite, a type of coal.

TAKE NOTE

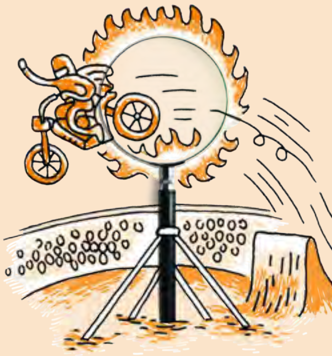
We also rely on crude oil for many products besides as a source of energy, such as producing plastics, lubricating waxes and oils and other materials and chemicals.



5. For each label write a sentence explaining how the energy is transferred. Also give an example of how this energy can be used in human activity.

This stored energy is not in limitless supply. It will run out at some point so we need to be very careful how we use it, and we need to find alternatives to using fossil fuels for our energy supply. Do you think that people on Earth are using our fossil fuels wisely? Let's investigate how fossil fuels are used in our homes.

INVESTIGATION: The use of fossil fuels in your home



For this task, you need to find out how much your household makes use of fossil fuels in one month.

INSTRUCTIONS:

1. Make up a question that you would like to answer. You teacher will help you formulate this. Write your question below.

___

___

2. Think about what information you need and design a table where you will gather this information.
3. Research information about fossil fuels and their uses.
4. Report the information in the format that your teacher specified (either a written report, a poster or a project):
   a) Do a write-up which clearly shows how your findings are linked to fossil fuels, and how you collected your data.
   b) What have you found? Write a paragraph on your findings.
   c) Write a conclusion. Answer the question you posed in step 1.
   d) Make some recommendations on what you have found. Does your family use a lot of fossil fuels? Is this good or bad? Why do you think so? Give your own opinion here.

SUMMARY:

Key Concepts

- The Earth revolves around the Sun completing one orbit every $365\frac{1}{4}$ days. As the Earth revolves around the Sun it also spins on its axis completing one rotation in 24 hours.
- The Earth's rotation axis is tilted in space. The North Pole points towards the star Polaris and the axis is offset from the vertical by 23.5°.
- The tilt of the Earth's rotation axis is responsible for the seasons on Earth.
- Areas near the equator are warmer than areas near the poles because they receive more direct sunlight.
- The Sun's energy is captured and used by plants to produce carbohydrates, which the plant uses and stores. Plants form the basis of food chains.
- The energy stored by plants millions of years ago is available to us today in fossil fuels. The energy however is non-renewable.
- Coal, crude oil and natural gas was formed millions of years ago from the remains of dead animals and plants.
- Life on Earth depends on the Sun's stored energy in fossil fuels.

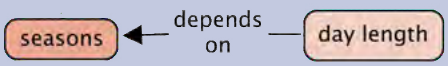
Concept Map

Look at the concept map below which shows what we have learnt in this chapter about the relationship between the Sun and the Earth.

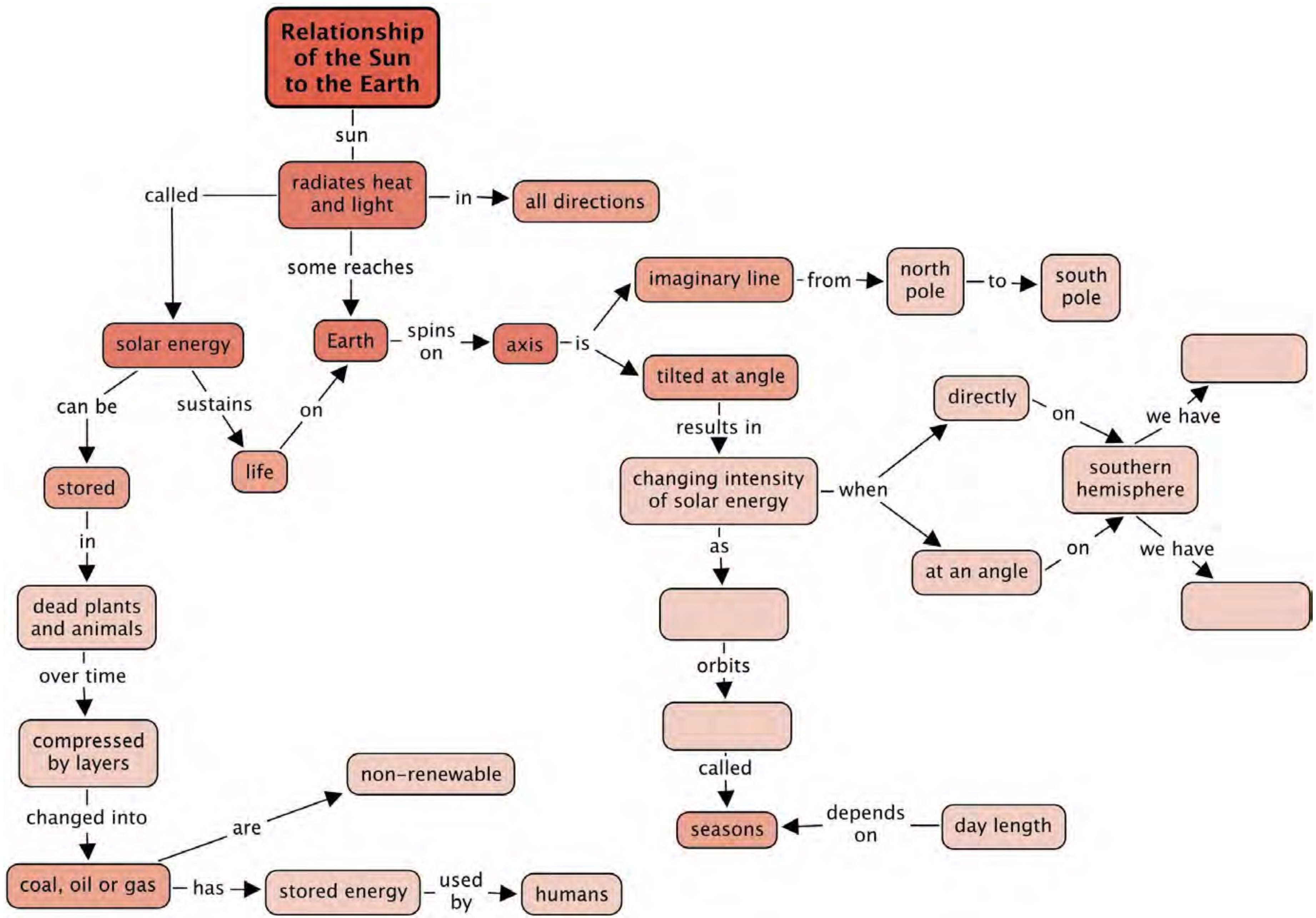
Fill in the blank spaces to complete the concept map. You need to fill in two of the seasons. To do this, read the concept map and complete the sentence. For example 'when **solar energy** falls **directly** on the **Southern Hemisphere**, we have __________'.

There are also two blank spaces to fill in about what orbits what in terms of the Sun and the Earth.

It is important to take note of which direction the arrows are pointing in a concept map so that you know which way to read it. For example, below where we have:



The arrow is pointing to the left so this reads, 'Day length depends on seasons' and NOT the other way around 'seasons depends on day length'.


Relationship of the Sun to the Earth
sun
radiates heat and light
in
all directions
called
solar energy
some reaches
Earth
spins on
axis
is
imaginary line
from
north pole
to
south pole
tilted at angle
results in
changing intensity of solar energy
when
directly
at an angle
on
southern hemisphere
we have
as
orbits
called
seasons
depends on
day length
can be
sustains
life
on
stored
in
dead plants and animals
over time
compressed by layers
changed into
coal, oil or gas
are
non-renewable
has
stored energy
used by
humans

REVISION:

1. What causes day and night? [2 marks]

2. The Sun appears to move across the sky during the day moving from east to west. What is really happening? [2 marks]

3. What is the difference between rotation and revolution? [2 marks]

4. How long does it take the Earth to complete one rotation? [1 mark]

5. How many days does it take for the Earth to complete one revolution around the Sun? [1 mark]

6. Why do you think we have leap years every 4 years, when there is an 'extra day', 29 February? [1 mark]

7. What does sunlight do for the Earth? [2 marks]

8. Why is it hotter at the equator than at the poles? [4 marks]

9. What causes the seasons on Earth? [5 marks]

10. Explain why the seasons cannot be caused by the change in the Earth's distance from the Sun as it travels along its slightly oval (elliptical) orbit. [2 marks]

11. Where does crude oil come from? [2 marks]

12. Why are the coal deposits found mostly in the same area in South Africa? [1 mark]

13. Compare the formation of natural gas, crude oil and coal by completing the following table. [5 marks]

	When was it formed?	**What was it formed from?**	**What conditions were need for its formation?**	**Does South Africa have this natural resource?**	**Renewable or non-renewable resource?**
Coal					
Oil					
Natural Gas					

14. Explain how fossil fuels are able to store the Sun's energy. [4 marks]

15. The Sun's energy is essential for life on Earth. Draw a flow diagram to show how the Sun's energy is transferred through natural gas and used in gas cooker in a household. Use appropriate labels to explain the diagram. [4 marks]

Total [38 marks]

Just a plain flask from an experiment? What are the possibilities? Be curious here.

2 Relationship of the Moon to the Earth

KEY QUESTIONS:

- How long does it take for the Moon to orbit the Earth?
- What keeps the Moon in orbit around the Earth?
- What causes tides on Earth?

NEW WORDS

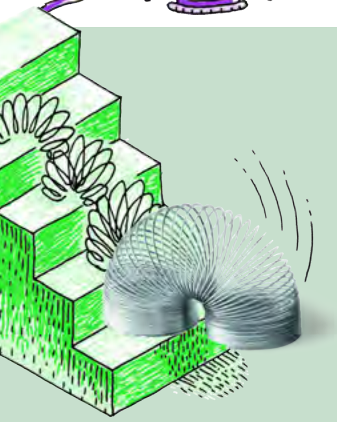
- moon
- lunar
- eclipse

The Moon is the most obvious feature in our night sky and has captivated people for thousands of years. Ancient cultures recorded the apparent motion of the Moon through the sky and made calendars which used the phases of the Moon to mark the months. In fact some religious calendars still use a lunar (Moon) based calendar rather than the official solar (Sun) based calendar used today in South Africa and most of the Western world (called the Gregorian calendar). The Moon's influence on the Earth is also important to us in other ways as you will discover in this chapter.

Our Moon.

2.1 Relative positions

You learnt about the Moon in Grades 4 and 6. Lets see what you can remember!



ACTIVITY: Moon revision quiz

INSTRUCTIONS:

1. Fill in the gaps in the Earth-Moon comparison table below using the word bank.

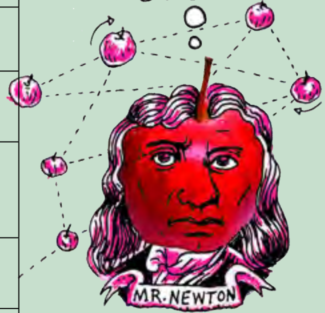
Word bank:

- rock, soil and water
- rock and lunar soil
- reflects
- absorbs
- Sun
- Earth
- an
- no
- larger
- smaller
- 24
- 27.3

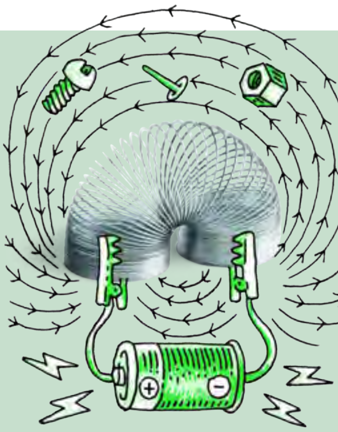
The Earth	The Moon
Surface consists of __________.	Surface consists of __________.
Is __________ than the Moon.	Is __________ than the Earth.
Is visible because it __________ light from the Sun hitting it.	Is visible because it __________ light from the Sun hitting it.
Is in orbit around the __________.	Is in orbit around the __________.
Spins on its axis once every __________ hours.	Spins on its axis once every __________ days.
Has __________ atmosphere.	Has __________ atmosphere.

DID YOU KNOW?

The Moon is actually covered in a layer of lunar 'soil' called regolith. This is why you can see astronauts' footprints on the Moon. Lunar 'soil' has different properties to soil on Earth, most significant is that terrestrial soil has organic matter in it.



Let's now take a closer look at the surface of the Moon.



ACTIVITY: Observe the Moon!

Images of the near side and far side of the Moon taken with NASA's Clementine spacecraft. Look at the difference between the two images, what do you notice?

DID YOU KNOW?

Humanity got its first view of the far side of the Moon in 1959 when the Soviet Union launched the small spacecraft *Luna 3*. This was the first probe to get to the far side of the Moon and photograph it.

INSTRUCTIONS:

1. Study the images of the Moon.
2. Answer the questions below.

QUESTIONS:

1. Does the Moon's surface have any oceans or lakes?

____

2. What do you notice covering much of the Moon's surface?

____

3. Some areas look dark and others look lighter, the dark areas are called maria (singular mare) meaning seas, as astronomers initially thought that these areas were seas on the surface. The bright areas are called highlands as they are higher than the maria. On what side of the Moon (near or far) are there more dark areas (maria)?

____

TAKE NOTE

The time that it takes an object to make one complete orbit around another object, relative to the stars, is called the orbital period or synodic period.

The Earth, just like all the other planets in the solar system, travels around the Sun, completing one revolution every year. As the Earth travels around the Sun it has a companion in space: our Moon!

The Moon orbits around the Earth completing one revolution every 27.3 days. Our Moon rotates on its own axis and experiences daytime and dark nighttime just like the Earth does. However, the Moon spins much more slowly than the Earth does and completes one rotation on its axis once every 27.3 days. Did you notice that the Moon takes the same amount of time to spin on its axis as it does to orbit completely around Earth? This means that from the Earth, we always see the same side of the Moon (called the 'nearside'). The side we do not see from Earth, called the 'farside', has been mapped during space missions to the Moon.

Viewed from above, the Moon moves in an anti-clockwise direction around the Earth. The Moon's orbit is not a perfect circle, it is elliptical, so its distance from Earth varies as it revolves around the Earth. The average distance is about 385 000 km, which is about 60 times the radius of the Earth itself. For comparison, the Earth's average distance from the Sun is 149 597 871 km, or about 23 481 times the radius of the Earth. You can see now why the Moon is called Earth's close companion!

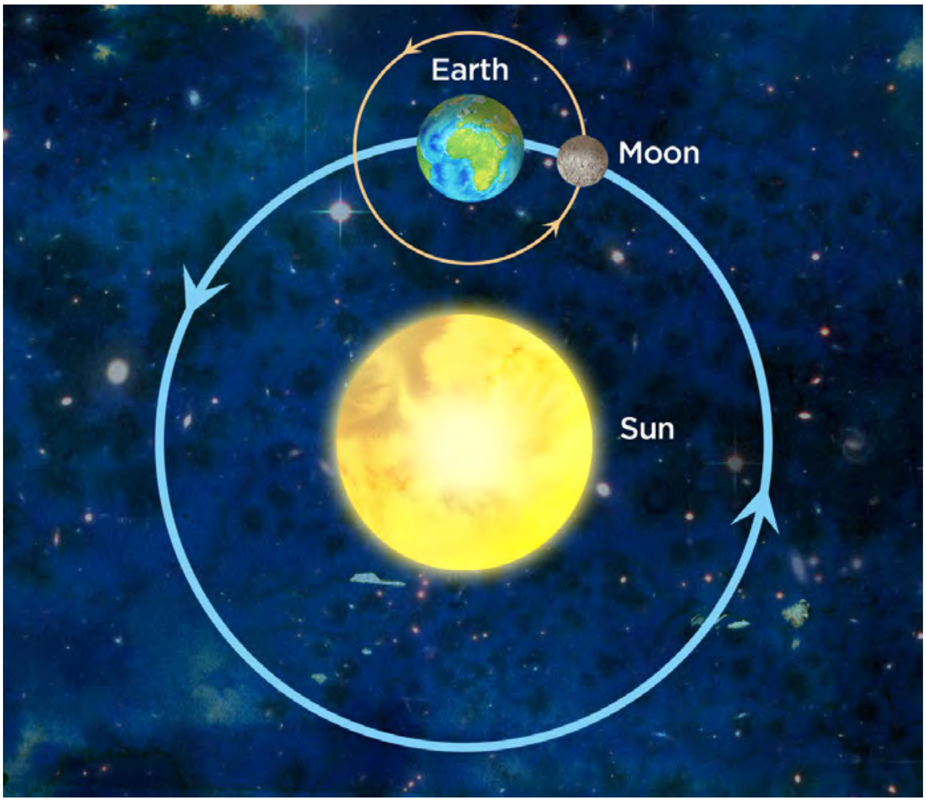
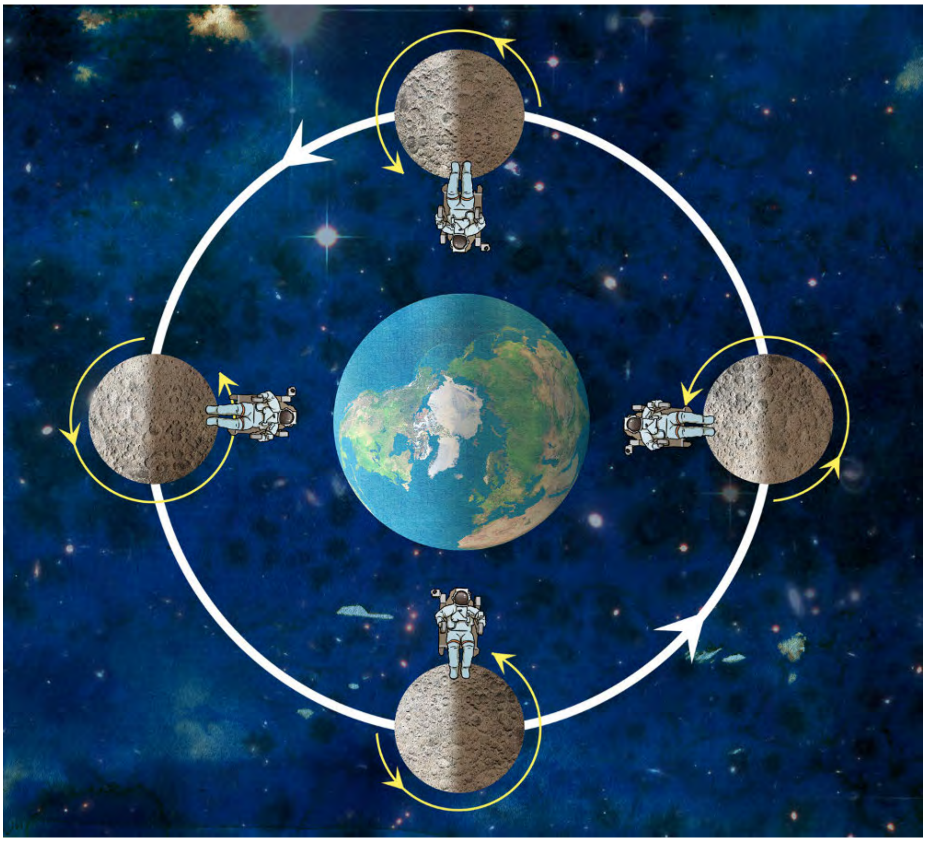


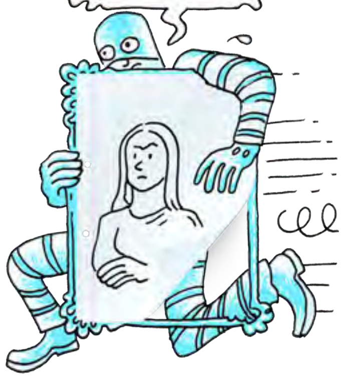
Diagram showing the Earth's motion around the Sun and the Moon's motion around the Earth.



The Moon spins on its own axis at the same rate that it revolves around the Earth. As it completes one quarter turn on its axis it also completes one quarter of its orbit. This results in the same side of the Moon always facing Earth.

TAKE NOTE

In the diagram, the Sun and Sun-Earth distance are not drawn to scale, the Sun would be MUCH larger than in this image and the distance between the Sun and Earth would also be MUCH larger.



VISIT

Why do we only see one side of the Moon? (video)

bit.ly/1eJOmCj

VISIT

Read more about exploring the far side of the Moon.

bit.ly/14L9X7S

VISIT

A spacecraft, called Ladee, was launched in 2013 to orbit the Moon to gather information about the lunar environment. Have a look at this infographic detailing the mission.
bit.ly/16C6HZ0

An image of the Earth and Moon taken from the Galileo satellite on its way to Jupiter over 6 million km away. The Moon's diameter is just under a third of the Earth's diameter. You can see the sunlit sides of the Earth and Moon. On what side do you think the Sun is?

The following table summarises some useful information about the Sun, Earth and Moon.

Characteristic	Sun	Earth	Moon
Relative position	Is at the centre of our solar system	Orbits the Sun once every 365.25 days	Orbits the Earth once every 27.3 days
Rotation	Spins on its own axis roughly once every 28 days	Spins on its own axis once every 24 hours	Spins on its own axis once every 27.3 days
Distance from orbited body	-	23 481 Earth radii from the Sun	60 Earth radii from Earth
Size	Diameter is roughly 100 times the Earth's diameter	-	Diameter is roughly times the Earth's diameter

VISIT

Did the Earth have two Moons?
bit.ly/1bvHqlx

We have now looked at the relative positions and movement of the Earth, Moon and Sun. Let's extend this knowledge to learn about a solar eclipse.

ACTIVITY: Total Solar Eclipse

INSTRUCTIONS:

Look at the image below. It shows a total solar eclipse which you learnt about in Gr. 6. This happens when the Moon passes directly in front of the Sun and blocks the Sun's light. The bright light from the Sun is blocked, allowing us to see the very faint outer edge of the Sun's atmosphere, called the corona. We normally cannot see the corona as it is swamped by the bright light from the

Sun. When you look at the size of the Moon in the sky compared with the size of the Sun in the sky you see that they are very similar. We call this the **angular size**. This is because the Moon is much closer than the Sun. The Moon appears large enough from Earth to totally block out the Sun's light.

A total solar eclipse. The Moon is in front of the Sun allowing us a rare glimpse of the Sun's outer corona, with thin wisps of atmosphere extending into space.

QUESTIONS:

1. Which in reality is larger, the Moon or the Sun?

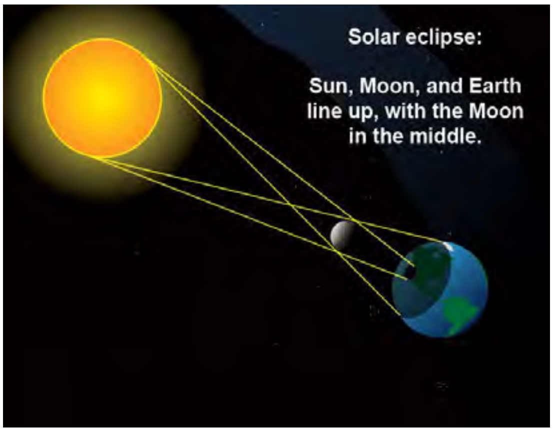
2. Which is further away, the Moon or the Sun?

3. How do the angular sizes of the Moon and the Sun compare when viewed from the Earth's surface?

4. Why is this the case?

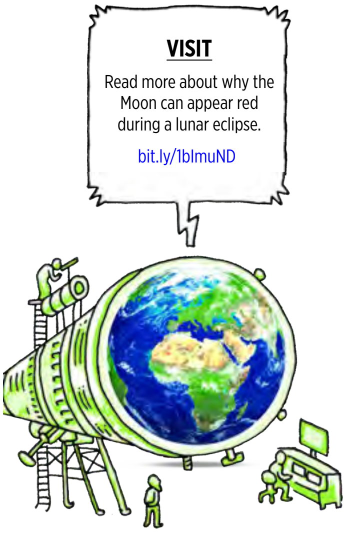
A total solar eclipse occurs when the Earth, Moon and Sun are aligned in a straight line with the Moon placed in between the Earth and the Sun. Just by chance, the Sun and Moon are currently at distances where they have the same angular size viewed from the Earth's surface. If the angular size of the Moon were smaller, it would not be large enough to completely block the Sun and we

wouldn't have total solar eclipses! The picture below shows the relative alignment of the Sun, Earth and Moon during a solar eclipse.



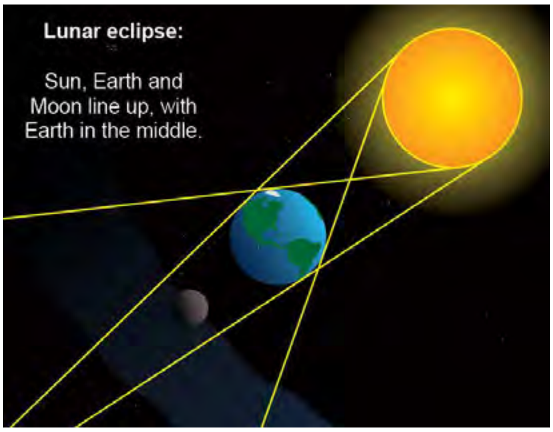
The Sun, Moon, and Earth all lined up during a solar eclipse. The black spot on Earth shows the location from where a total solar eclipse would be visible. This area is in the Moon's shadow. The grey area on Earth's surface indicates the location from where a partial eclipse would be visible.

We can also get a lunar eclipse. This is when the Sun, Earth and Moon line up with the Earth in the middle.



A series of images showing the Moon during a full lunar eclipse.

See how a lunar eclipse compares to a solar eclipse in the diagram. In this case, the Earth blocks the sunlight from reaching the Moon's surface, making the Moon appear dark in the night sky.



Sun, Earth and Moon line up to form a lunar eclipse.

2.2 Gravity

The word **gravity** is used to describe the **gravitational pull (force)** an object experiences on or near the surface of a planet or moon. The gravitational force is a force that attracts objects with mass towards each other. *Any object with mass exerts a gravitational force on any other object with mass.* So, the Earth exerts a gravitational pull on you, the desks in your classroom and the chairs in your classroom, holding you on the surface and stopping you from drifting off into space.

NEW WORDS

- gravity
- mass
- weight
- acceleration due to gravity
- gravitational force

The Earth's gravity pulls everything down towards the centre of the Earth and so when you drop an object like a book or an apple it falls to the ground. However, do you know that you, your desk, your chair, and the falling apple and book exert an equal but opposite pull on the Earth? Why do you think that these pulls don't cause the Earth to move noticeably?

___

___

The arrows show the direction of the force of gravity by the Earth on all other objects with mass. The arrows all point towards the centre of the Earth because the gravitational force is always attractive.

VISIT

Interact with this simulation to see the relationship between gravity and the masses of the object and distance between them.

bit.ly/1dLLZMn

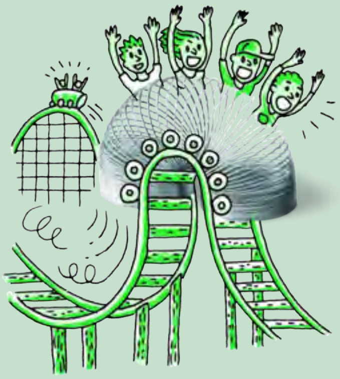
The gravitational force between two objects decreases as the objects move further apart. If you double the distance between two objects the gravitational force between them decreases by a factor of four. Similarly if you triple the distance between them, the gravitational force between them decreases by a factor of nine. This explains why we are stuck to the Earth rather than the Sun. The Sun is 333 000 times more massive than the Earth and its gravity is much stronger than the Earth's. However, we are so far away from the Sun that the gravitational force the Sun exerts on us, is much smaller than the gravitational force the Earth exerts on us.

The Moon is held in orbit around the Earth by the gravitational force between the Earth and the Moon. Similarly, the Sun's gravity holds the Earth in orbit around the Sun. Lets do an activity to demonstrate the Moon's orbit around the Earth.

VISIT

Watch Felix Baumgartner's supersonic freefall back to Earth.

bit.ly/15wRxKr



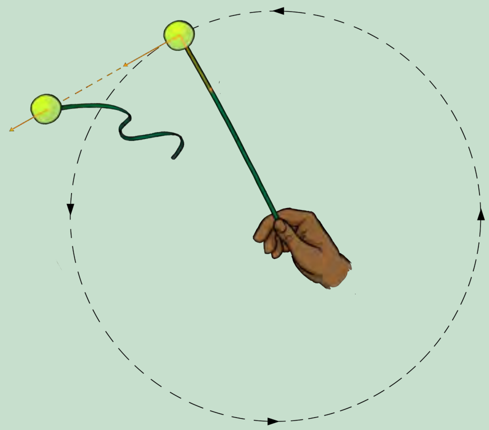
ACTIVITY: Demonstrating the Moon's orbit around the Earth

MATERIALS

- rope
- ball (tennis balls are ideal)

INSTRUCTIONS

1. Tie a ball to the end of a piece of rope. You may have to wrap the rope around the ball a few times to do this.
2. Hold the rope up high above your head and swing the rope around in a horizontal circle.
3. Let go of the rope and observe what happens.



Looking down at a ball swung in a circle after it is released.

DID YOU KNOW?

The Moon is slowly moving away from the Earth at a rate of 3.8 cm per year (the Moon's orbit is getting larger). In about 563 million years time its angular size on the sky will have decreased so much that it will no longer be large enough to produce total solar eclipses!

QUESTIONS:

1. How can you describe the movement of the ball as you swing it around?

___

2. The rope pulls the ball inwards towards the centre of the circle keeping the ball moving in a circle. What force holds the Moon in orbit around the Earth?

___

3. What happens to be ball when you let the rope go?

___

4. What does this represent in terms of the Earth and the Moon?

___

All the components in our Universe are held together by gravity. In summary we can say:

- The greater the mass of the objects, the stronger the gravitational pull between them.
- The closer objects are, the stronger the gravitational pull between them.

VISIT

Move the Sun, Earth, Moon and space station to see how it affects their gravitational forces and orbital paths.

bit.ly/1fZGRGi

Weight

The weight of an object is the force acting on it due to gravity. Weight is not the same as mass although the two words are often confused in everyday language.

The **mass** of an object is the amount of matter in the object, it tells you how many particles you have. Do you remember that we briefly spoke about atoms in Matter and Materials? So, for example, the mass of a wooden block tells us how many atoms there are. Mass is measured in kilograms (kg) and is independent of where you measure it. A wooden block with a mass of 10 kg on Earth also has a mass of 10 kg on the Moon.

However, an object's **weight** can change as it depends on the mass of the object and also the strength of gravity acting on it. Weight is measured in Newtons (N). For example the Earth exerts a gravitational force of about 10 Newtons for every kilogram of mass on its surface. So, a person with a mass of 50 kg has a weight of 500 N on the surface of the Earth.

DID YOU KNOW?

The Moon's gravity affects humans on Earth. The tug of the Moon's gravity decreases a person's weight by the equivalent of a few grams on the surface of the Earth!

The Moon also has its own gravity. The strength of gravity on the surface of the Moon is one-sixth that of the Earth, and so you would weigh one-sixth of what you do on Earth on the Moon. On Jupiter you would weigh 2.5 times more than you do on Earth as Jupiter's gravity is 2.5 times that of the Earth's. Even though you would weigh different amounts (and feel lighter on the Moon and heavier on Jupiter) your actual mass would stay the same in both cases.

An astronaut's mass remains the same wherever it is measured. The astronaut's weight however depends on where you measure it, as you can see the astronaut weighs 1200 N on Earth but only 200 N on the Moon.

Check your understanding of mass and weight with the following questions.

1. Lindiwe has a mass of 50 kg on Earth. What is her mass on the Moon?

___

2. Andrew has a mass of 60 kg on Earth, what is his weight in Newtons on Earth?

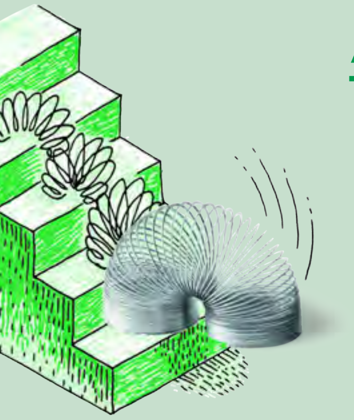
___

3. How much would Andrew weigh on the Moon?

___

4. Would Lindiwe feel heavier or lighter on the Moon?

___



ACTIVITY: How much would you weigh on other planets?

MATERIALS:

- weighing scales
- calculator

INSTRUCTIONS:

1. Measure your mass in kilograms using weighing scales. Record the value in the table below.
2. Look at the table below, it shows how strong the gravity is on each of the planets in our solar system.
3. Calculate your weight on each of the planets and enter it into the table below.

Hint: On Earth each kilogram weighs 10 Newtons. So if your mass is 50 kg then you weigh 50 x 10 = 500 N on Earth. If the strength of gravity on a planet is half the strength of the Earth's gravity then you would weigh half of what you weigh on Earth on that planet.

Planet	Your mass (kilograms)	Strength of gravity relative to Earth	Your weight (Newtons)
Earth		1	
Mercury		0.378	
Venus		0.907	
Mars		0.377	
Jupiter		2.36	
Saturn		0.916	
Uranus		0.889	
Neptune		1.12	

QUESTIONS:

1. On which planets would you feel heavier than you do on Earth?

---

2. On which planets would you feel lighter than you do on Earth?

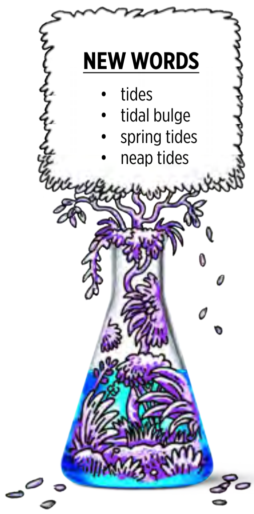
The Moon's gravity

As you have already discovered, the Moon, like any other planet or moon, has its own gravity. The strength of gravity on the surface of the Moon is one-sixth that of the Earth, and so on the Moon you would weigh one-sixth of what you do on Earth. Due to the weak gravity on the Moon, you would be able to jump six times higher than usual! The astronauts had to learn to walk in strange ways (such as leaping or hopping) to move about on the surface of the Moon.

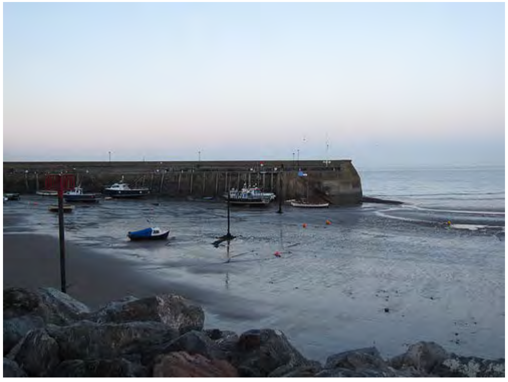
Neil Armstrong, the first man on the Moon.

As we will find out in the next section, the Moon's gravity not only affects humans walking on the Moon, but also influences the Earth.

2.3 Tides



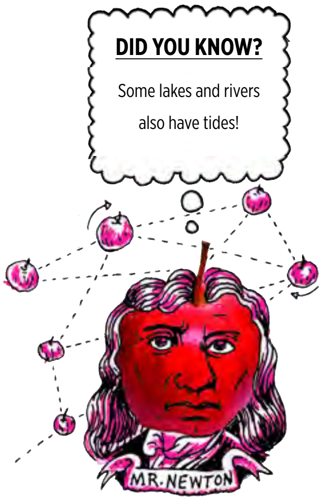
Tides are the predictable, repeated rise and fall of sea levels on Earth. If you look closely you will notice that the height of the surf at any beach varies slowly with time. When the sea is far out and there is lots of sand exposed, it is called low tide. You can see an example of low tide in the photo.



At low tide, the water is far out and the boats are resting on the sand.

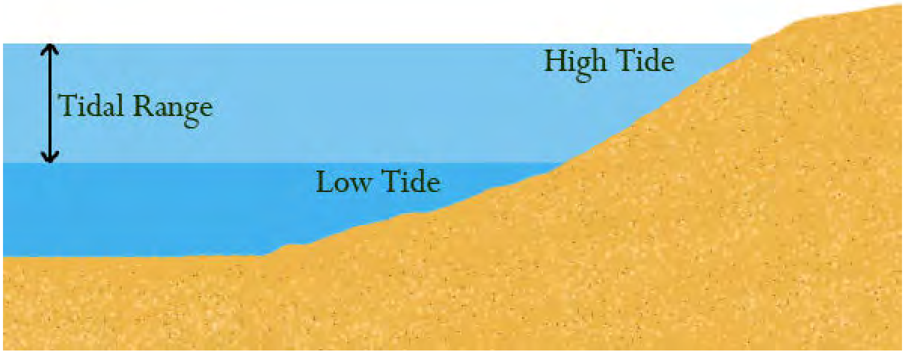
Following low tide, the water gradually comes further up on the beach until it reaches its highest level, this is called high tide. After high tide the water level gradually drops again until it goes back to low tide. This pattern repeats over and over again. You can see an example of low and high tide at the same beach in the pictures below.

The same beach photographed at low tide (top) and high tide (bottom).



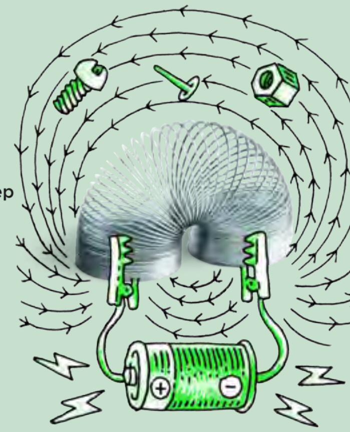
In general there are are two low and two high tides per day on the sea, which can be observed on the beaches or even in estuaries. The times of high and low tides are not exactly the same every day, they occur roughly one hour later each day.

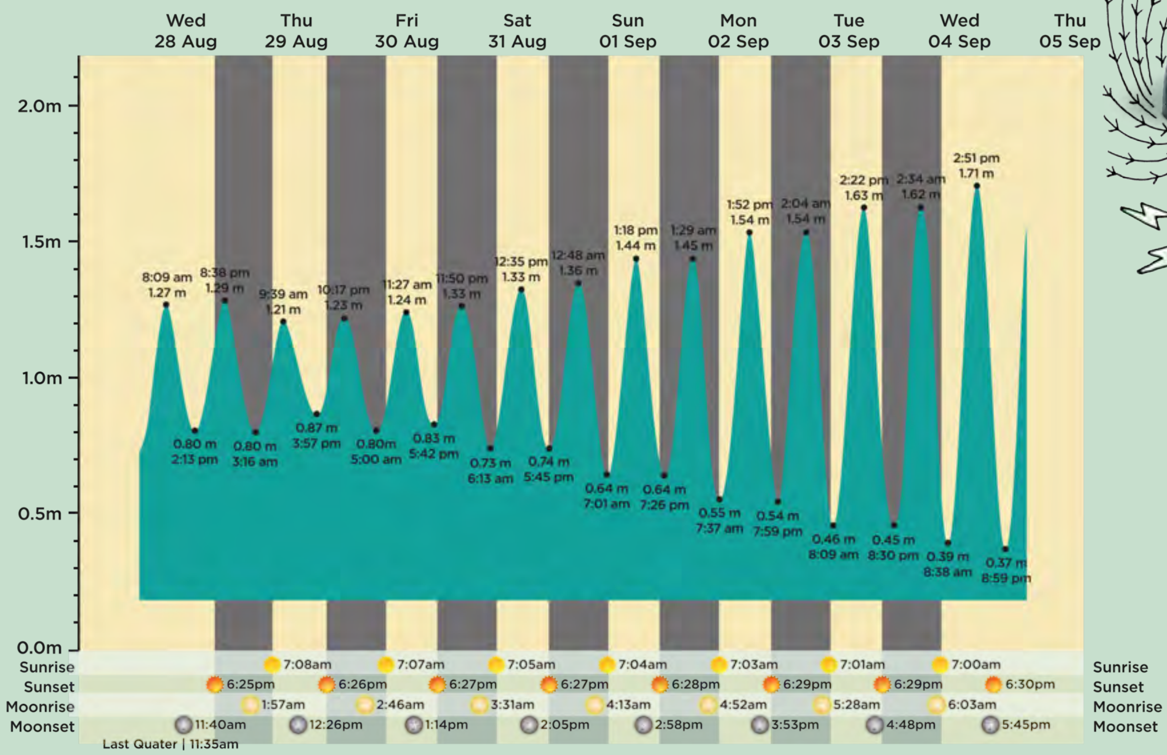
Tides can be predicted and low and high tide times are published in tide tables. Fishermen use this information to plan when they will fish. Surfers also use this information so they can plan the best times to go surfing as each beach has a particular time when the sea level is just right for producing excellent surfing waves.



This diagram shows how the sea level differs at low and high tide at a beach. The vertical difference between low and high tide is called the tidal range.

ACTIVITY: Reading a tide chart





This graph shows the predicted tides for a period of one week in Cape Town. Although the graph only includes data for one week, the actual pattern of high and low tides repeats every day throughout the year.

INSTRUCTIONS:

1. Look at the chart above, it shows the predicted times of low and high tide for one week in Cape Town.
2. The peaks represent times of high tide and the heights are listed in metres along with the time of high tide. The troughs represent times of low tide.
3. Answer the following questions.

QUESTIONS:

1. How many peaks appear per day in the chart?

____

2. What do these correspond to? High or low tide?

____

3. How many troughs appear per day in the chart?

____

4. What do these correspond to? High or low tide?

____

5. What is the height in metres of the highest low tide during the week?

6. When does the lowest high tide occur? (date and time)

7. What height is the lowest high tide?

8. The following photo is of a small harbour in Cape Town with a boat moored. These photos were taken on Monday 29 April.

Boulders Beach in Cape Town at low tide.

The same view of Boulders Beach at high tide.

a) What time of day, was the photo taken of low tide?

b) What time of day was the photo taken of high tide?

VISIT

Timelapse of a shore from low to high tide.

bit.ly/1fHZYoi

This picture shows a small harbour at low tide. The tide is out and the boats are stuck on the sand banks. Once the tide comes back in the boats will float on the water again.

So you now know that all seas have tides, why do you think this is? Lets do an activity to find out.

ACTIVITY: Dance of the tides

MATERIALS:

- Four (ideally blue) scarves or strips of fabric per group, each one needs to be about a metre in length.

INSTRUCTIONS:

1. Work in groups of six, one learner represents the Earth, four learners represent the Earth's oceans and one learner represents the Moon.
2. The learner representing the Earth: stand in an open space.
3. The four learners representing the oceans: take one scarf each and stand in a circle around the learner representing Earth. (One behind, one in front and one on either side).
4. The four learners representing the oceans: link scarves with your neighbours.
5. Learner representing the Moon: stand outside the circle of "ocean" about 5 steps away from the "Earth" directly in front of one of the learners representing the ocean.
6. All learners apart from the Moon: turn to face the "Moon". You are now going to be "pulled" towards the Moon by the Moon's gravitational attraction! Remember that the gravitational pull exerted on an object by the Moon decreases with increasing distance to the Moon.
7. Which part of the Earth and ocean is being pulled the most by the Moon?

---

8. Which part of the Earth and oceans is being pulled least by the Moon?

---

9. Ocean learner closest to the Moon: take three large steps towards the Moon.
10. Two ocean learners standing beside the Earth and the Earth learner: take two large steps toward the Moon.
11. Ocean learner farthest from the Moon: take one large step towards the Moon. Why have you moved towards the Moon by varying amounts?

---

12. Note what happens to the shape the "oceans" now make, are you still in a circle or forming an oval shape?

---

13. Note which sides of "Earth's" body is experiencing high tide. (Front and back or left and right arms).

---

14. Earth: spin around on the spot a few times stopping in a random position not directly facing the Moon. Remember that the Earth is continually spinning on its axis!
15. Note which sides of the "Earth's" body is experiencing high tide.

---

16. Now imagine that there is no Moon, but only the Sun to exert a gravitational pull on the Earth. Because the Sun is much farther than the Moon, its gravitational pull is only one third of the Moon's pull. The team member representing the Moon must now represent the Sun instead.
17. Sun learner: take an additional 10 steps away from the Earth so that you are 15 steps away in total.
18. Ocean learners return to your starting circle positions.
19. All learners apart from the Sun: turn to face the "Sun". You are now ready to be pulled towards the Sun.
20. Ocean learner closest to the Sun: take one large step towards the Sun.
21. Two oceans learners standing beside the Earth *and* the Earth learner: take one normal step toward the Sun.
22. Ocean learner farthest from the Sun: take one small step towards the Sun.
23. Note what happens to the shape the "oceans" now make, are you still in a circle or forming an oval shape? How does the shape compare with that made when you were pulled by the Moon?

QUESTIONS

1. How many sides of the Earth experience high tide at the same time?

---

2. Where are they positioned in relation to the Moon?

---

3. As the Earth spins what happens to the position of high tides in relation to the Moon?

---

4. As the Earth spins what happens to the position of high and low tides on the surface of Earth?

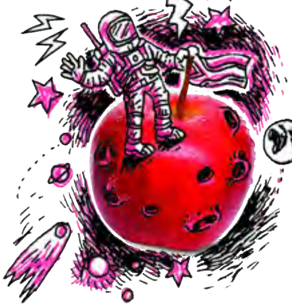
---

5. Besides the Moon, what pulls on the Earth?

6. If there were no Moon, would we still have tides?

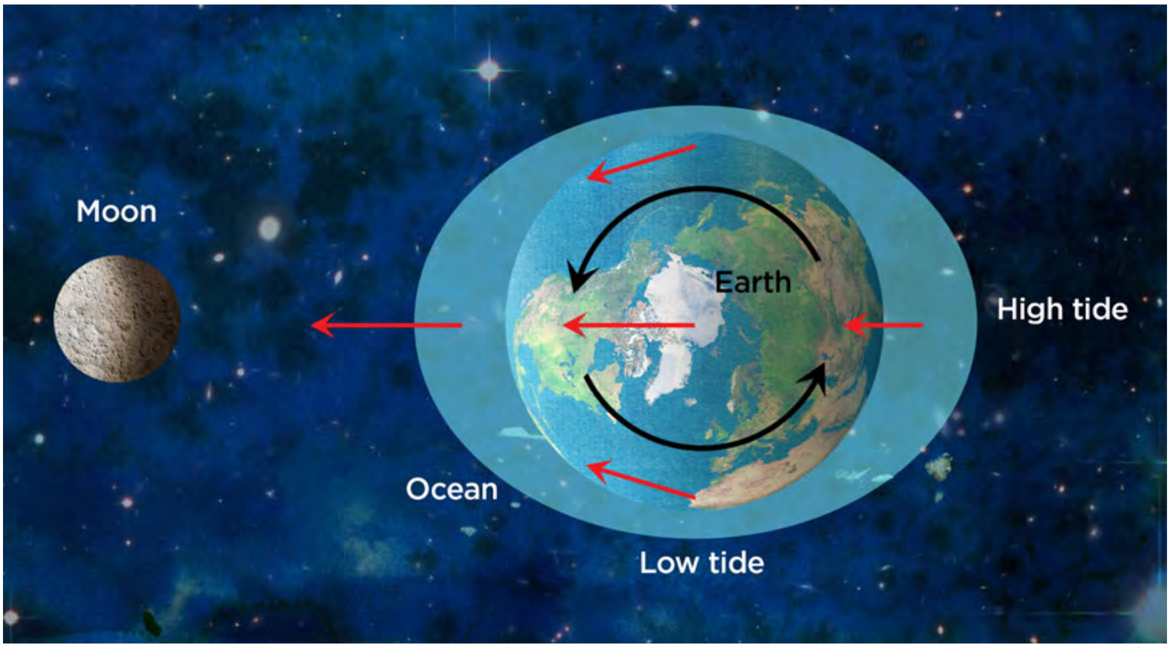
DID YOU KNOW?

As well as distorting the shape of the Earth's oceans, the Moon's gravitational pull also distorts the shape of the solid Earth. The solid Earth's bulge is about one hundred times smaller than the ocean bulge, but the Earth's crust closest to the Moon actually rises a few centimetres!



Look at the image below. It shows how the Moon's gravity distorts the shape of the Earth's oceans into an oval shape. Do you remember how the gravitational force depends on distance? The ocean on the side of the Earth closest to the Moon experiences a greater gravitational pull towards the Moon relative to the ocean on the far side of the Earth.

This difference in gravitational pulls stretches the Earth's oceans into an oval shape. Along the Earth-Moon direction the oceans form two *tidal bulges*. At places in line with the Moon, where the oceans are experiencing a tidal bulge we have high tide. At locations which are at right angles to the Moon we have low tide.



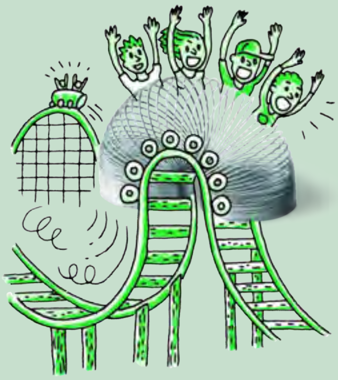
This picture shows the Earth and the Moon looking down from above. The gravitational pull experienced by different parts of the Earth towards the Moon are shown as arrows. The longer the arrow, the greater the pull. The ocean closest to the Moon experiences the greatest pull from the Moon and the ocean farthest from the Moon experiences the smallest pull towards the Moon. The differences result in the Earth's oceans being stretched to an oval shape.

DID YOU KNOW?

The highest tides in the world are at the Bay of Fundy in Canada. The bay is very narrow, so water rushing in from the ocean can rise and fall by up to 20 metres a day!

Why do you think there are two low tides and two high tides at a given beach per day? Look at the diagram above again. When the Moon is directly overhead your location you experience high tide. You also experience high tide when the Moon is directly opposite your location on Earth. Remember that the Earth spins on its axis once every 24 hours and so during one day you experience two high tides at a given location: one when the Moon is directly above your location and one when the Moon is directly opposite your location roughly twelve hours later. Similarly there are two low tides per day. This cycle continues as the Earth spins.

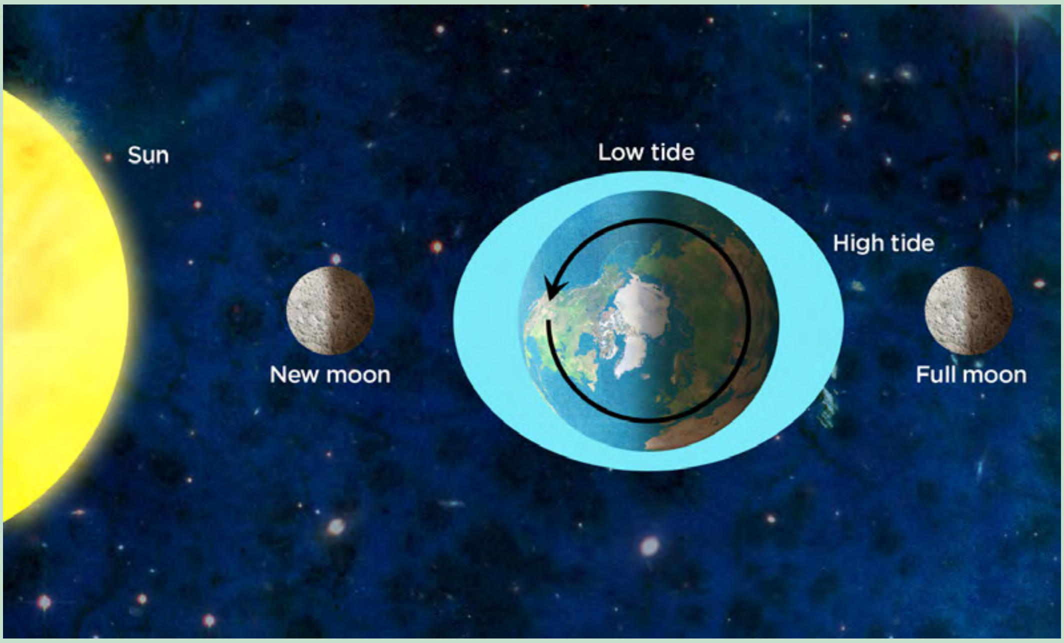
The height of the tides varies slightly with the phase of the Moon. This is *not* because the gravitational pull of the Moon is changing: the Moon has the same amount of mass and therefore exerts the same gravitational pull at all phases. Rather, the change in the heights is due to the relative alignment of the Sun and the Moon. Let's look at this further in the following activity.



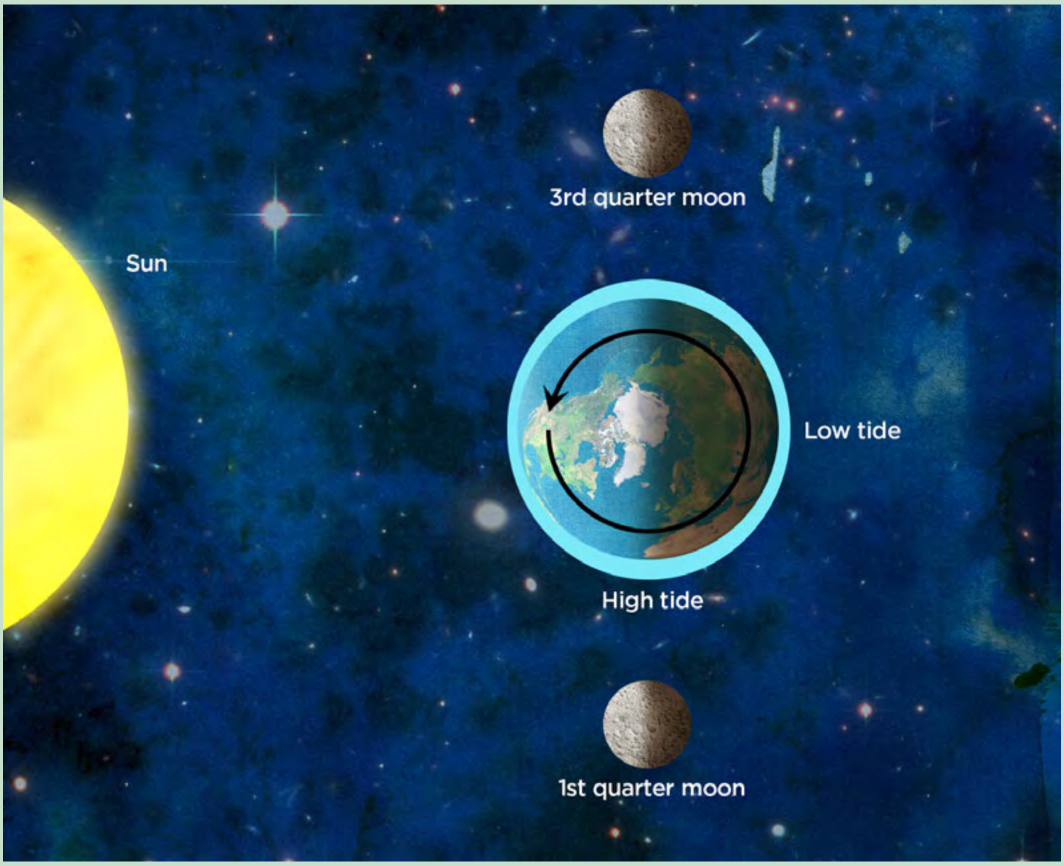
ACTIVITY: Spring and neap tides

INSTRUCTIONS

1. Look carefully at the following diagrams, it shows the size of the tides at Full and New Moon (top) and at the first and third quarter phase (bottom).
2. Answer the following questions.



Spring tide, showing the size of the tides at New moon and Full moon.



Neap tide, showing the size of the tides at first quarter and third quarter moon.

DID YOU KNOW?

Earth's only natural satellite is simply called the Moon because people didn't know other moons existed until Galileo Galilei discovered four moons orbiting Jupiter in 1610. Other moons in our solar system are given names so they won't be confused with each other.

QUESTIONS

1. When the Sun, Moon and Earth are in a straight line the Sun's gravitational pull adds to the Moon's gravitational pull. What Moon phases does this correspond to?

2. During what phases of the Moon do the Moon's and Sun's gravitational pulls partly cancel each other out?

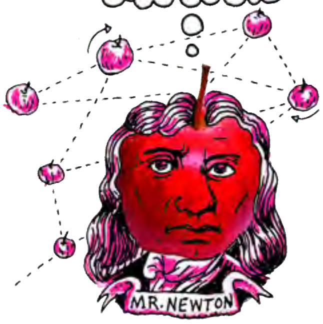
3. During what Moon phases would you expect the highest high tides and the lowest low tides?

When the Sun, Moon, and Earth are lined up in a straight line (at the time of New or Full Moon), the pull of the Sun's gravity adds to the pull of the Moon's gravity creating extra-high high tides, and very low low tides. The difference in height between low and high tide is at its maximum at this time. These are called *spring tides*. When the Sun and Moon are at right angles to each other (during first and third quarter), the Sun's gravitational pull partially cancels out the Moon's gravitational pull and produces less extreme tides. The difference in height between the low and high tide is at its minimum at this time. These are called *neap tides*. Overall the Moon contribution to the Earth's tides is bigger than the Sun's contribution because it is much closer to Earth. If there were no Moon, the Earth's tides would be about a third of their current height.

You can now see how important our closest neighbour the Moon is. The Moon's gravitational pull is responsible for the ocean tides!

DID YOU KNOW?

The Moon's orbit is gradually increasing, and the Moon is slowly moving away from the Earth. Due to this the tides used to be much higher than they are today, and they will continue to become smaller.



NEW WORDS

- ecosystem
- intertidal zone

The effects of tides on shoreline ecosystems

The intertidal zone can be seen here between the sea and the top of the sand.

The region of the beach between high tide and low tide levels is called the **intertidal zone**. The intertidal zone is a harsh environment for marine animals to live. During storms the surf can be very rough and plants and animals must be able to withstand the battering from big waves and not get washed away! Animals and plants that live here are underwater at high tide but are exposed to the air during low tide. Some organisms may stay underwater if they are in small rock pools which do not empty out when the tide goes out. Those that are exposed to air at low tide, face hot temperatures in summer and cold temperatures in winter so they must be able to adapt to different temperatures.

Animals exposed to the air at low tide may be soaked in fresh water when it rains and yet be soaked in salty sea water at high tide. Therefore, they must also be able to adapt to different salt concentrations as the tides come in and out.

Different animals have adapted to this tough environment in different ways. For example:

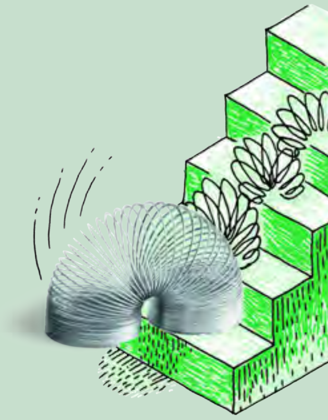
Crabs burrow into the sand to hide during low tide.

Kelp and other seaweeds are covered with thick slime to prevent them drying out.

Mussels and barnacles close their shells tightly to avoid drying out.

This oystercatcher takes advantage of low tide to feed.

ACTIVITY: The effects of tides on shoreline ecosystems



MATERIALS:

- Pictures and texts about shoreline animals. (Can be textbooks, library books or online materials as directed by your teacher).

Seaweed, starfish and mussels in a rock pool.

Birds feeding on the rocks.

Eggs on some seaweed.

Green anemones in a rock pool.

Mussels growing on the rocks.

A crab in the sand.

A mother seal and pup in the waves in the intertidal zone.

Mudskippers - fish that can walk on land!

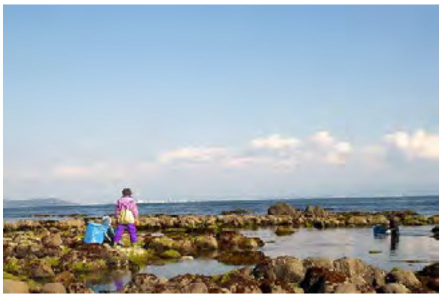
INSTRUCTIONS:

Study the pictures and texts and write a summary about how two different organisms are adapted to living in the intertidal zone. You can use the internet or other resources to do some more research.

DID YOU KNOW?

Sea anemones look like plants with flowers but they are actually animals. Their tentacles contain a poison which paralyses their food (small fish and shrimps) when touched.

High up in the intertidal zone water splashes only during high tide and the rest of the time it is dry. As you go lower down the intertidal zone, down the beach towards the sea, it gets progressively wetter for longer periods of time.

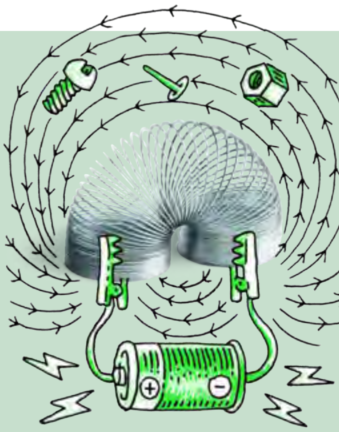


Harvesting seaweed during low tide.

Marine life in the intertidal zone have to adapt to the rise and fall of sea levels at the beach. But marine life is not the only kind of life that has to take note of the tides. Many people also use the low tide to collect seaweed. Seaweed has many uses, including being a food source for people. In some cultures seaweed is used for medicinal purposes and to make various woven products, such as rope, baskets and mats.

Fishermen looking for big catches time their fishing activities according to the tides too. Lets investigate this further.

ACTIVITY: How good a fisherman are you?



BACKGROUND:

Fish are easier to catch at times when they are feeding. The tides determine when most fish feed. When the tide is coming in or going out the moving water stimulates feeding. The fastest part of the tide is normally around two hours before and after low and high tides. These times are the best times to go fishing.

INSTRUCTIONS:

1. Look at the example tide table data for one day below and answer the following questions.

Durban - Thursday 29th August 2013

Time	Tide Height (m)	Comment
00:56		Moonrise
02:29	0.85	Low tide
06:14		Sunrise
08:41	1.26	High tide
11:42		Moonset
14:52	0.93	Low tide
17:39		Sunset
21:34	1.27	High tide

QUESTIONS:

1. Thembela wants to go fishing at the best time around the first low tide of the day. What times could she go fishing?

___

2. Josh wants to go fishing while the Sun has set. What would be the best possible times for him to choose from?

___

3. Faried wants to go fishing while the Sun is up. What would be the best possible times for him to choose from?

___

VISIT

Watch the original footage of Apollo 11 landing on the Moon in 1969.

bit.ly/185mzXG

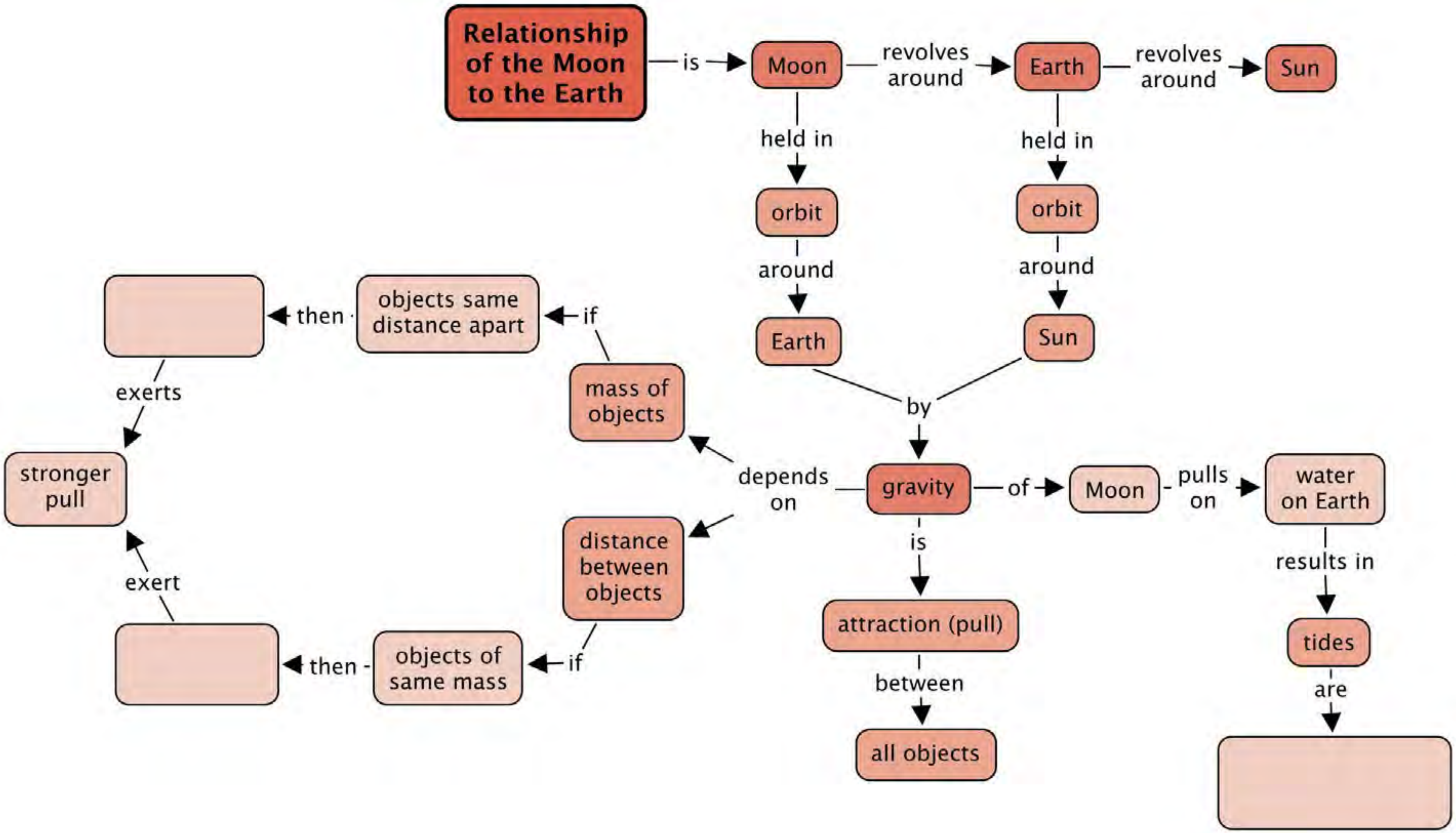
SUMMARY:

Key Concepts

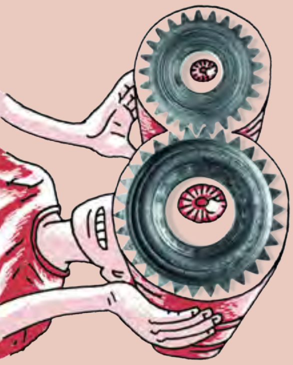
- The Moon orbits the Earth once every 27.3 days. The Moon also spins on its own axis once every 27.3 days. Due to both these time periods being the same, we only ever see one side of the Moon from Earth.
- Gravity is a force that acts between all objects with mass. The size of the force acting on the objects is proportional to their masses and inversely proportional to their distance from each other.
- The Earth's gravity is responsible for holding the Moon in orbit around the Earth.
- The Moon's gravitational pull is mainly responsible for the tides on Earth.
- Neap tides occur when the Sun and Moon are at 90 degrees to each other.
- Spring tides occur when the Sun and Moon are in line with each other.
- The rise and fall of the tides affects marine life living along shorelines. They have adapted to this harsh environment in many ways to prevent themselves from drying out and from being washed away by strong waves.

Concept Map

Complete the concept map by filling in the blank spaces. You can do this by reading the sentence that is made in the concept map. For example, "**Gravity** depends on **mass of objects**. If **objects same distance apart**, then ___________, exerts a **stronger pull**." What would the answer be? A 'bigger object' or a 'smaller object'? Fill the answer in. Also do this for the distance between objects. Would 'closer objects', or 'further away objects' exert a stronger pull? Then give a description of tides.



Relationship of the Moon to the Earth
is
Moon
revolves around
Earth
revolves around
Sun
held in
orbit
around
Earth
held in
orbit
around
Sun
by
gravity
of
Moon
pulls on
water on Earth
results in
tides
are
is
attraction (pull)
between
all objects
depends on
mass of objects
if
objects same distance apart
then
exerts
stronger pull
distance between objects
if
objects of same mass
then
exert



REVISION:

1. Why do we only see one side of the Moon from Earth? [2 marks]

2. What is gravity? [1 mark]

3. What holds the Moon in orbit around the Earth? [1 mark]

4. How does the gravitational force of attraction between two objects depend on their masses? [2 marks]

5. How does the gravitational force of attraction between two objects depend upon their distance? [2 marks]

6. If you were to stand on the surface of the Moon you would experience only 1/6th the strength of gravity that you experience standing on the surface of the Earth. Why is this? [2 marks]

7. What causes tides? [2 marks]

8. Look at the following photo of boats on the sand. Do you think it is a problem that they are stuck on the sand? How will people get them into the sea?

Boats on the sand.

9. What kind of tides occur when the Moon is inline with the Sun? [1 mark]

10. What kind of tides occur when the Sun, Earth and Moon are at right angles to each other? [1 mark]

11. At what phases of the Moon do spring tides occur? [2 marks]

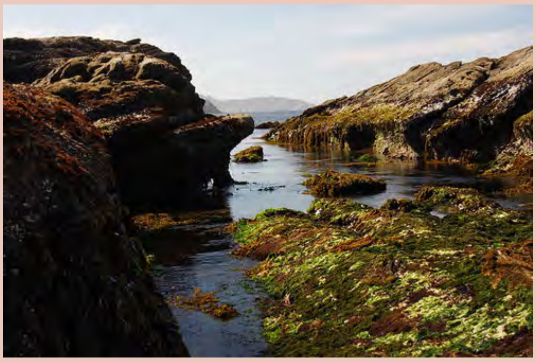
12. At what phases of the Moon do neap tides occur? [2 marks]

13. What would happen to the height of the tides if there were no Moon? [1 mark]

14. Draw a diagram to show the alignment of the Sun, Earth and Moon during neap and spring tides. [4 marks]

15. Explain why spring tides are more extreme than neap tides. [2 marks]

16. Look at the following photo and answer the questions.



A rocky shore.

a) Do you think it is low or high tide? Give a reason for your answer. [2 marks]

b) What is the name given to this zone on the shoreline where the tides move back and forth? [1 mark]

c) What are the main risks to marine life living in this region? [2 mark]

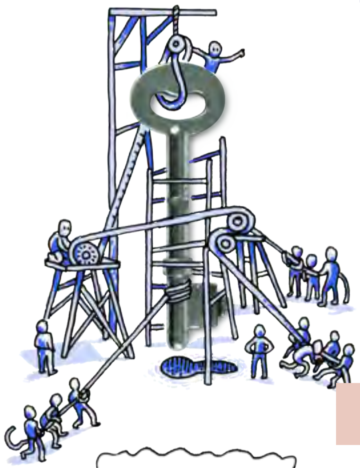
d) How is the seaweed adapted to not dry out? [1 mark]

e) What other types of animals do you think you would find in this region? Give 4 examples. [2 marks]

Total [33 marks]

Curious? Unlock more possibilites with this key.

3 Historical development of astronomy



KEY QUESTIONS:

- How did ancient astronomers use the motions of the Sun, Moon and stars for time keeping?
- How did ancient astronomers view our place in the solar system?
- Why did Copernicus think that the Earth and planets go around the Sun?
- What discoveries did Galileo make using his telescope?
- How did Newton explain Kepler's observations?

3.1 Early indigenous knowledge

NEW WORDS

- lunar calendar
- solar calendar
- constellation
- star lore

Astronomy is one of the oldest sciences. Ancient civilisations around the world watched the night skies, noting the patterns they saw in the sky. These patterns are called the constellations. A constellation is any group of stars, as seen from Earth, that seems to form a pattern or picture in the sky. Different nations, cultures and people have given different names for the different star patterns and how they interpreted the patterns.

A well known example is the Southern Cross. Have a look at the photos which show the stars in the night's sky and how to view the pattern making up the cross.

This pattern of stars is the Southern Cross.

The white lines show you how to view the Southern Cross.

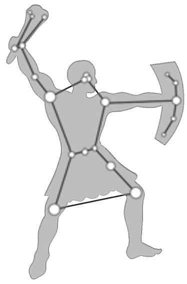
TAKE NOTE

To find south using the Southern Cross constellation, extend the long axis of the cross four times and go straight down to the horizon.

The Southern Cross, *Crux*, and the two bright Pointer stars were used by farmers to mark the beginning of the planting season. According to Sotho, Tswana and Venda traditions, these stars were called *Dithutlwa*, meaning "The Giraffes". The bright stars of *Crux* are male giraffes, and the two Pointers are female giraffes.

Another example is the constellation Orion. It is named after Orion, a supernaturally, strong hunter in Greek mythology. This is one of the most recognised constellations around the world and many cultures have identified with it, each forming their own myths, many around a strong man or hunter.

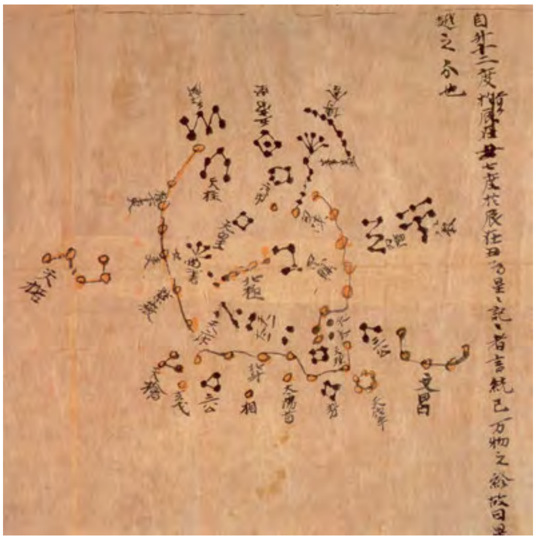
The Orion constellation, seen here as the three bright stars in the middle making up Orion's belt and the four stars in each corner.



This image shows how the pattern of stars in Orion make the image of the hunter.

People also watched the movement of the stars and planets across the sky marking the passage of time. Early cultures tended to identify the stars and planets they saw in the night sky with gods, spirits or animals. Ancient astronomers could tell the difference between stars and planets as the relative positions of the stars remain fixed in the sky whereas planets appear to move across the sky relative to the background stars. Not all the planets were known to the ancient people, rather only Mercury, Venus, Mars, Jupiter and Saturn. Uranus and Neptune were only discovered after telescopes were invented.

Ancient civilisations like the Sumerians, Babylonians and Egyptians were responsible for introducing many of the constellations that astronomers use in the West today.



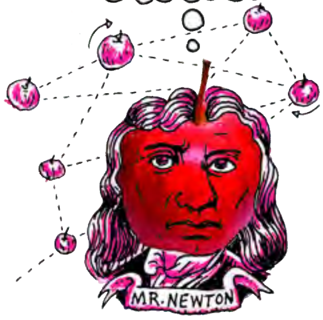
The Dunhuang Star Map from the Tang Dynasty in China (circa 700 AD) showing some of the constellations they observed.

Knowledge of these constellations were later passed on and added to by later civilisations like the ancient Greeks, Romans and Arabs. Native Americans, Aboriginal Australians, Mayans, Aztecs, Polynesians and ancient Chinese and Japanese peoples took a keen interest in the stars and had their own constellations and stories about the stars.

Astronomy played an important role in religion at the time, and the dates of festivals and holy days were fixed by the alignment of the stars or the phase of the Moon. In fact, the ancient Egyptian and Mayan pyramids and temples were designed in such a way that the Sun, Moon, stars and planets would be visible

DID YOU KNOW?

The name planet comes from the Greek word *planetes* which means wanderer. Planets were called wanderers by the ancient Greeks as they move across the sky relative to the background stars.



DID YOU KNOW?

We have seven days of the week due to the seven moving celestial bodies known to the ancient people, namely, the Sun, the Moon, Mercury, Venus, Mars, Jupiter and Saturn.

VISIT

About Chinese astronomy.

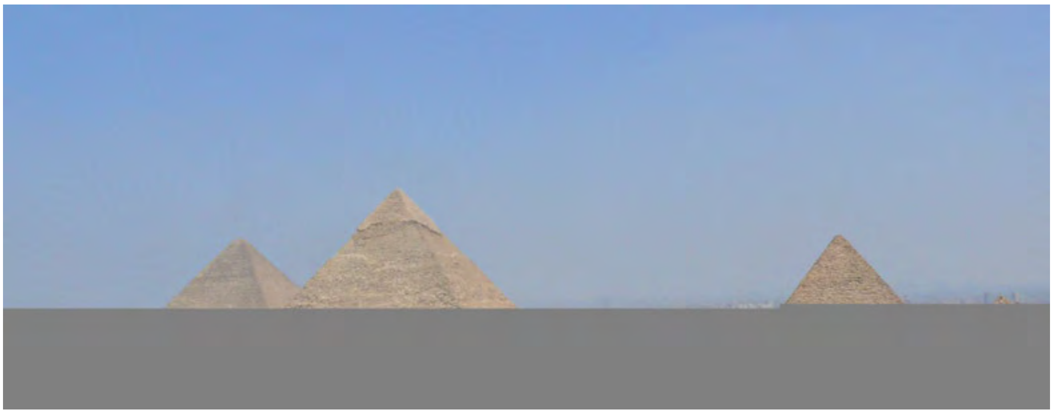
bit.ly/19BmxGp

VISIT

Ancient Egyptian Astronomy (video)

bit.ly/1bHFeNo

from the top or through certain windows at important times of the year, such as solstices or equinoxes.



The three Great Pyramids of Giza.

DID YOU KNOW?

Some people believe that the builders of the ancient pyramids of Giza in Egypt placed them specifically to look the same from above as the three "belt stars" of the constellation Orion look from Earth.

Here in South Africa, early cultures also had their own constellations and stories which were passed down from generation to generation.

Early cultures used the stars for navigation. When travelling to new areas or over water they would have been unable to use familiar landmarks. When viewed from a particular location, a star always rises and sets in the same direction and follows the same path across the sky. We are familiar with this idea as the Sun is a star and we see it rise and set in the same direction every day. Early navigators learnt to use the directions of rising and setting stars to find their way.

Ancient manuscripts from Timbuktu in Mali in central Africa, documenting astronomical observations.

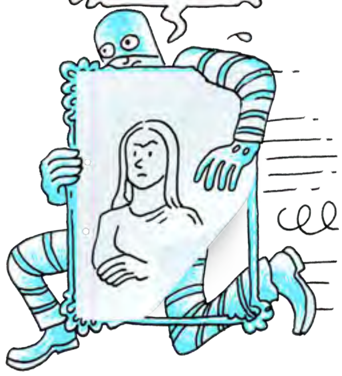
Early cultures also used the observed changes in the sky for timekeeping. A day was marked by the time between one sunrise and the next, just as it is today. The Moon's regular phases made it a very convenient "clock", and the time period between one New Moon and the next formed the basis of many of the oldest calendars.

The lunar cycle was useful because it was predictable in the same way as day and night, however, each Moon cycle was also connected to a slightly different season with its own name and activities.Tally sticks made of bones with notches etched into them have been found dating as far back as 20-30 000 years ago and are believed to mark the phases of the Moon. Today we use a **solar calendar**, a calendar in which a year is defined by the complete revolution of the

Earth around the Sun, but some religious calendars still use a lunar calendar. Accurate timekeeping was particularly important for farming communities because people needed to know when to plant their seeds and when to harvest their crops.

TAKE NOTE

In a *lunar calendar* the time between one New Moon and the next is called a *synodic month* and it is 29.5 days.



The Lebombo Bone was discovered in the Lebombo mountains between South Africa and Swaziland in the 1970s. It is a bone from a baboon used as a Tally Stick. It is roughly 35 000 years old. It is thought to have been used for tracking lunar cycles, due to the 29 marks on it.

The *Pleiades*, also called the *Seven Sisters,* is a bright cluster of stars. Traditional farming communities in South Africa used the Pleiades to help them plan their planting. Once the constellation was visible in the early morning in June they knew it was time to start planting their crops. The Khoikhoi call the Pleiades *Khuseti* or *Khunuseh* meaning "rain stars". They are called *Selemela* in Sotho and Tswana, *Shirimela* in Tsonga, *Tshilimela* in Venda, and *isiLimela* in Xhosa and Zulu. In Xhosa the stars are called the "digging stars". In East Africa and Zanzibar the Pleiades are called *Kilimia*, which also means "ploughing stars" or " digging stars". Not only were the Pleiades used in Africa to mark planting season, they were also used by the ancient Mayans in Mexico and Central America to mark the start of their rainy season too.

The Pleiades or Seven Sisters star cluster. Although the constellation is known as the seven sisters, the star cluster actually contains hundreds of stars although only about seven are easily visible to the human eye.

VISIT

Read more about traditional African star lore.

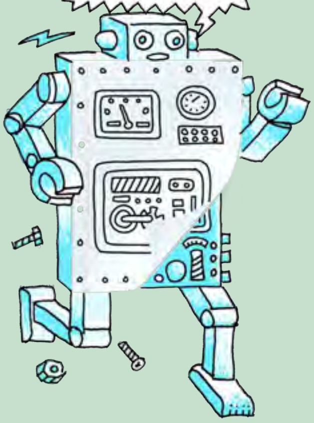
bit.ly/1dL83XI

ACTIVITY: The traditional and modern Xhosa calendar

In the Xhosa language, there are two ways of naming months, the modern and the traditional way. The modern names of the months are used in urban areas. However, in rural areas, in poetry, and particularly in the Eastern Cape the old names are still used. Look at the following table which shows these names.

TAKE NOTE

You do not need to know the names of the months in Xhosa. This activity is for interest.



English	Modern Xhosa	Traditional Xhosa	Meaning of traditional name
January	uJanuwari	EyoMqungu	month of the Tambuki Grass
February	uFebhuwari	EyoMdumba	month of the swelling grain
March	uMatshi	EyoKwindla	month of the first fruits
April	uApreli	UTshazimpuzi	month of the withering pumpkins
May	uMeyi	UCanzibe	month of Canopus (Canopus is a star)
June	uJuni	Isilimela	month of the Pleiades
July	uJulayi	EyeKhala / EyeNtlaba	month of the aloes
August	uAgasti	EyeThupha	month of the buds
September	uSeptemba	EyoMsintsi	month of the coast coral tree
October	uOktobha	EyeDwarha	month of the lilypad
November	uNovemba	EyeNkanga	month of the small yellow daisies
December	uDisemba	EyoMnga	month of the mimosa thorn tree and Simba (the lion)

QUESTIONS:

1. Do you see that the modern Xhosa names are derived from the English names. The traditional names for the months mostly come from the names of plants and flowers. Why do you think certain months are given specific plants or flower names?

___

___

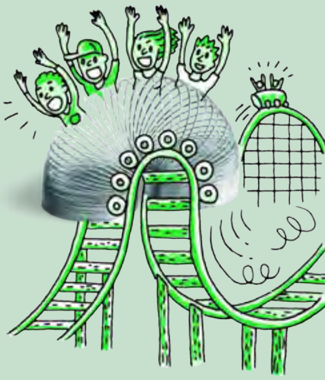
2. Why do you think August is called *EyeThupha*, the month of the buds?

3. Why is June called *Isilimela*? Hint: Read the preceding text in your workbook.

4. What time of year does *Isilimela* correspond to? What does this signal to traditional farmers?

5. What month are you born in? Write down the traditional Xhosa name below.

ACTIVITY: Class discussion about different calendars



The calendar the we use is the Gregorian calendar and is the most widely used around the world. It is also known as the "Western calendar" or "Christian calendar". It was named after the man who first introduced it in February 1582: Pope Gregory XIII. The term New Year's Day for the 1 January was adopted in Western Europe in the Middle Ages. Before this, the Roman Julian calendar (named after Julius Caesar) was used.

The Islamic year begins on the first day of the month of Muharram. It is counted from the year of the Hegira (Anno Hegirae), when Muhammad emigrated from Mecca to Medina (16 July 622 AD).

The Jewish calendar represents the number of years since they believed the world was created. This is calculated by adding up the ages of people in the Bible. So when someone of Jewish beliefs says that the year is 5763, it means 5763 years from the creation of Adam.

INSTRUCTIONS:

1. Around the world, and within South Africa, there are different calendars which are in use. Do you think it would just be easier to have one calendar?

2. Discuss this as a class.
3. You could do this as a class debate with teams debating the pros and cons of the concept.

DID YOU KNOW?

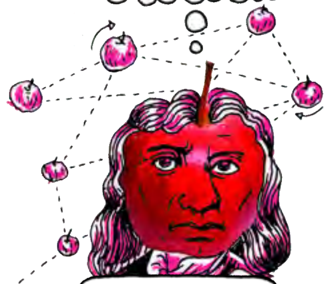
The Roman influence in the Gregorian calendar explains why the months of July (Julius) and August (Augustus) are named after Roman emperors.

As well as their practical uses in timekeeping, stories surrounding the Sun, Moon and constellations have been passed down from generation to generation. These mythical stories are called **star lore**. For example some believed that after sunset the Sun travelled back to the east over the top of the sky and that the stars are small holes which let the light through. Others said that the Sun is eaten each night by a crocodile and that it emerges from the crocodile each morning.

Being the most prominent object in the night sky, the Moon also has many stories and legends associated with it. If you look closely at the Moon you can see that it has lighter and darker patches. The pattern formed by the light and dark patches had been interpreted differently by different cultures: some see a rabbit, others a buffalo, others a "Man in the Moon". One urban legend that some people still incorrectly believe is that the the Full Moon is linked to insanity. There is no evidence to support the claims of increased birth rates, admissions to psychiatric hospitals, traffic accidents, homicides or suicides during a Full Moon.

DID YOU KNOW?

Lunacy and *lunatic* are derived from the Latin name for the Moon, *Luna*.



The Khoikhoi called the Moon *kham*, or *khab* meaning "the Returner". The Khoikhoi also considered the Moon to be "the Lord of Light and Life" and would sing and dance at times of New and Full Moon. In /Xam San star lore, there is the following story:

> The Moon is a man who has made the Sun angry. The Sun's sharp light cuts off pieces of the Moon until almost the whole of the Moon is gone, leaving only one small piece. The Moon then pleads for mercy and the Sun lets him go. From this small piece, the Moon gradually grows again until it becomes a Full Moon.

TAKE NOTE

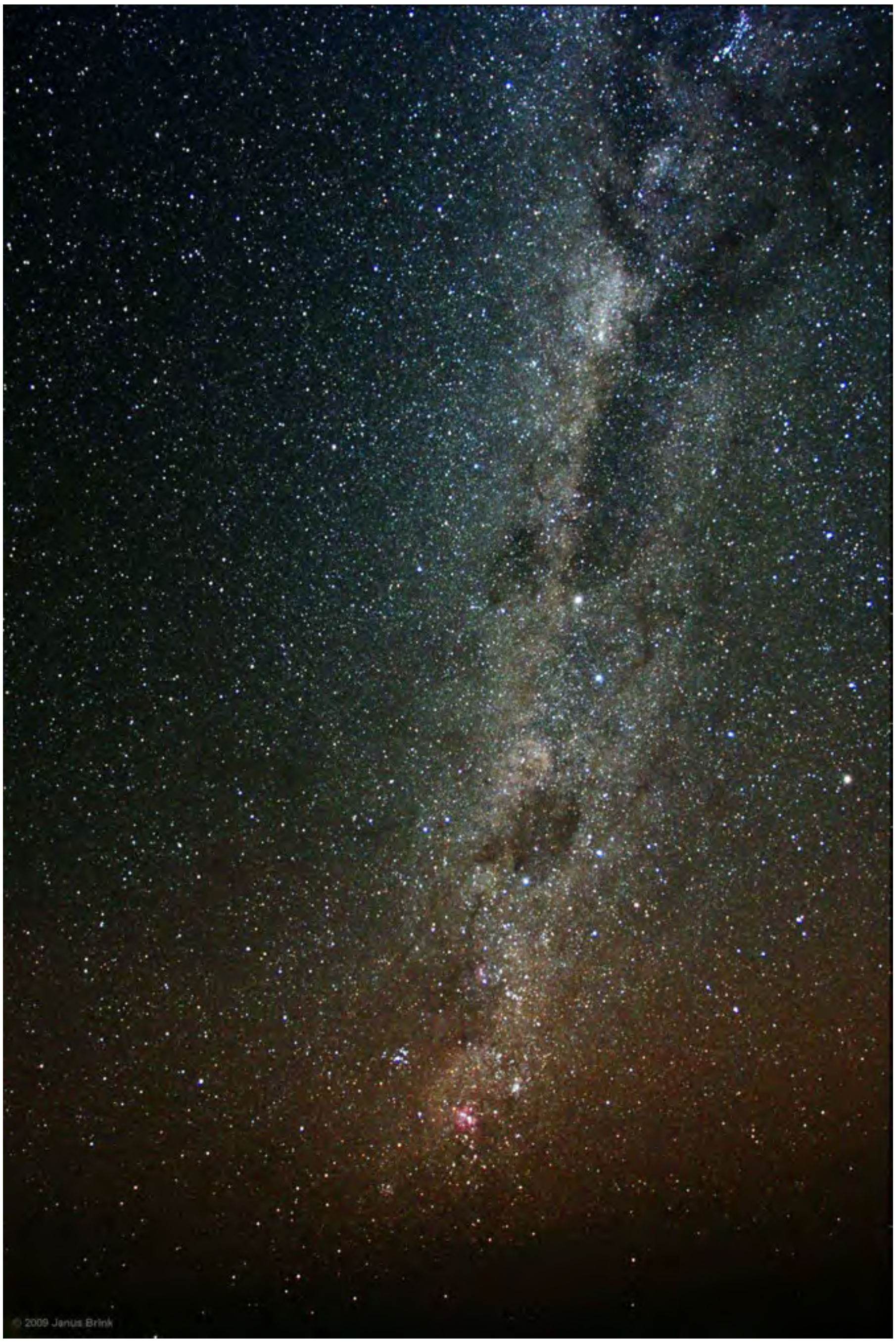
We will learn more about our galaxy, the Milky Way, and other galaxies, next year in Grade 8.

What do you think the San were observing which they explained with this story?

___

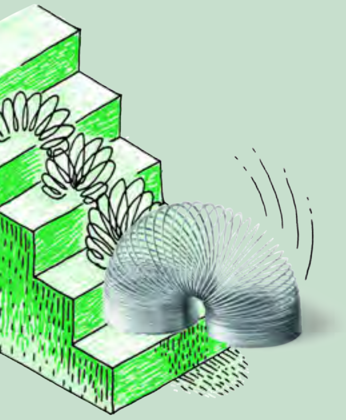
The Xhosa considered the time of New Moon to be a time of inaction. When it reappeared as a crescent in the evening sky, it was cause for celebration. Important events were scheduled to take place around the time of Full Moon.

The Milky Way is also a prominent feature of the South African nighttime sky visible away from cities. Ancient peoples in South Africa described the Milky Way as as a footpath across the sky, along which the ancestor spirits walked. In San starlore, the Milky Way was created by a girl who scooped up a handful of ashes from a fire and flung them into the sky. This made a glowing path along which people could see the route to return home at night.



The Milky Way seen from Sutherland, Northern Cape, by Janus Brink (SAAO/SALT).

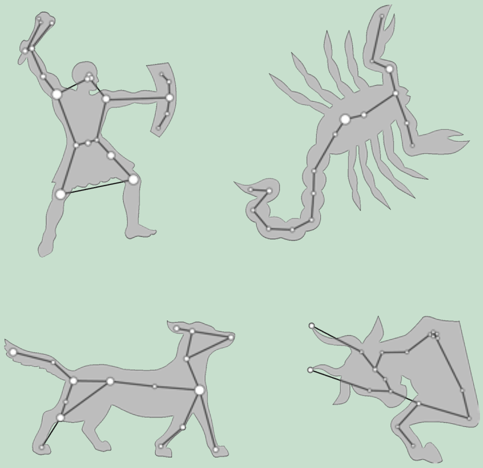
Meteors (also called shooting stars) and comets also feature heavily in starlore around the world. In most cultures meteors and comets were regarded as signs of important events. In Tswana starlore, a very bright meteor is an indication of a good season ahead. However, the .Xu San saw a meteor as an evil spirit racing across the sky to cause mischief among people. The /Xam San, thought that a meteor announced the death of one of them. In Xhosa starlore, a comet, *Uzatshoba,* is associated with bad luck, wars and death. There was also a strong belief that comets predicted the death of a chief. The Sothos called comets *naledi tsha mesela*, and the Zulus called them *inkanyezi enomsile*, which means "stars with tails".



ACTIVITY: Create your own legend

MATERIALS:

- pictures of famous constellations for inspiration



Some examples of constellations in the sky.

INSTRUCTIONS:

1. Make up your own pattern of stars and draw them in the box below.
2. Make up a legend (story) to go along with your new constellation.

Draw your new constellation pattern the box below.

Write your legend here.

VISIT

Curious about the universe, but don't know where to start? Have a look at this step-by-step guide to becoming an awesome amateur astronomer.

bit.ly/1aqKQHX

NEW WORDS

- telescope
- observatory
- prograde
- retrograde

3.2 Modern developments

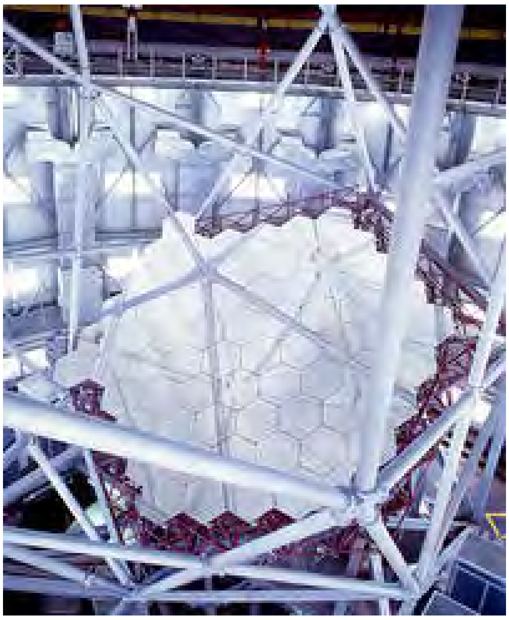
The earliest astronomers had no sophisticated observatories. They studied the stars and planets using just their eyes. This is called naked eye observing. The South American Mayans, ancient Egyptians and ancient Chinese built some of the first **observatories**. These are special buildings used for studying the stars. These ancient observatories had no telescopes inside.

Nowadays modern observatories contain large telescopes with extremely sensitive cameras and instruments mounted on the telescopes. Astronomers use computers to move the telescopes and operate the instruments. As technology has progressed, we have been able to see a lot more and have learnt a lot more about the Universe.

Chichen-Itza observatory in Mexico. This ancient observatory was used by the Mayans, although it had no telescope inside.

South Africa currently has the largest optical telescope in the Southern Hemisphere, the Southern African Large Telescope (SALT). SALT is located just outside Sutherland in the Karoo where the skies are clear and very dark. SALT's main mirror is a hexagon shape measuring 11 x 9 metres across and is made up of 91 individual smaller mirrors which are slotted together. Its mirror is so large so it can collect a lot of light from very faint and distant objects. SALT is used to study a variety of objects including asteroids, stars and galaxies.

The Southern African Large Telescope (SALT).



SALT's huge mirror collects light from faint distant objects.

South Africa will also be hosting part of the Square Kilometre Array (SKA), the world's largest radio telescope, scheduled to be completed in 2024. The SKA will be located in the Karoo near the town of Carnarvon, far away from big towns and cities where there is little radio interference. When complete the telescope array will be 50 times more sensitive than any other radio telescope to date. The array will contain 3000 radio dishes as well as other types of radio detectors.

What the SKA will look like in the Karoo.

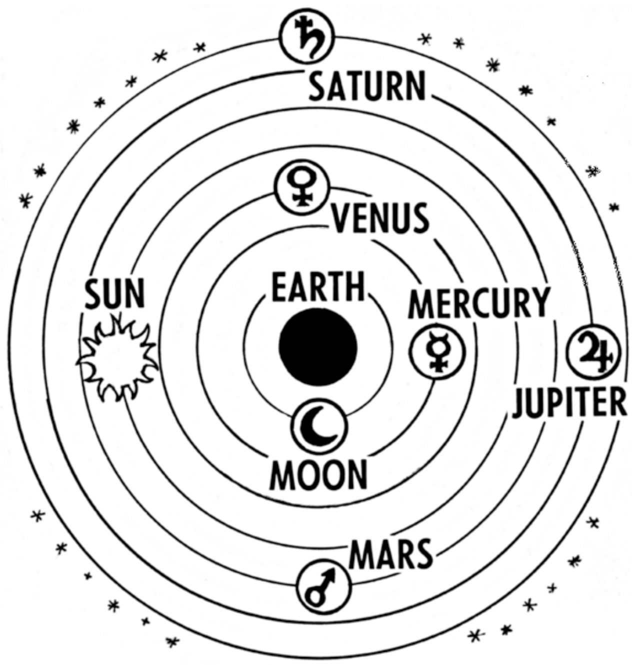
Astronomers plan to use the giant telescope to test the laws of gravity using black holes. They will also peer at some of the most distant clouds of gas in the Universe which formed before the first stars. Astronomers will also study how galaxies form, and change over time, and perhaps also detect life elsewhere in the Universe.

We still have so much to learn about our Universe, we only understand about 5% of the content of our Universe presently. SALT and SKA will help us understand far more about our Universe, so much is still to be discovered.

Let's look at some of the highlights in our journey of scientific discovery so far.

The discovery that the Sun is at the centre of the solar system and not the Earth

Early astronomers such as the ancient Greeks believed the Earth was at the centre of the Universe, with the stars and planets orbiting around the Earth.



The ancient Greeks thought that the Earth was at the centre of the universe and believed that the planets, Sun and background stars all orbited around the Earth.

TAKE NOTE

An array means a large number of the same items. For example, when the desks in your classroom are all lined up neatly, we can call that an array of desks.

VISIT

Two thirds of the SKA will be built in Africa (mostly in South Africa), while the remaining third will be built in Australia.
Find out more about SKA.
bit.ly/1eJ3JuG

VISIT

History of astronomy
bit.ly/15Vufw5 and
bit.ly/16sp7Cf

TAKE NOTE

Motion towards the east is called direct or*prograde* motion. Backwards motion is called *retrograde* motion.

By carefully watching the motions of the planets in the sky, the Greeks saw that most of the time the planets travelled west to east across the sky relative to the background stars. However, they occasionally reversed their direction and moved backwards, from east to west relative to the background stars. The ancient Greeks' ideas about the Earth-centred Universe worked when the planets were travelling in the same direction as the background stars, but could not account for the their retrograde (backwards) motion.

In 1543, Nicolaus Copernicus, a Polish mathematician and astronomer, published his book called *De revolutionibus orbium coelestium*, or in English, *On the Revolutions of the Celestial Spheres*. In it he correctly deduced that the Sun, rather than the Earth, was at the centre of the Solar system. He based his deductions on many of his own and other people's observations.

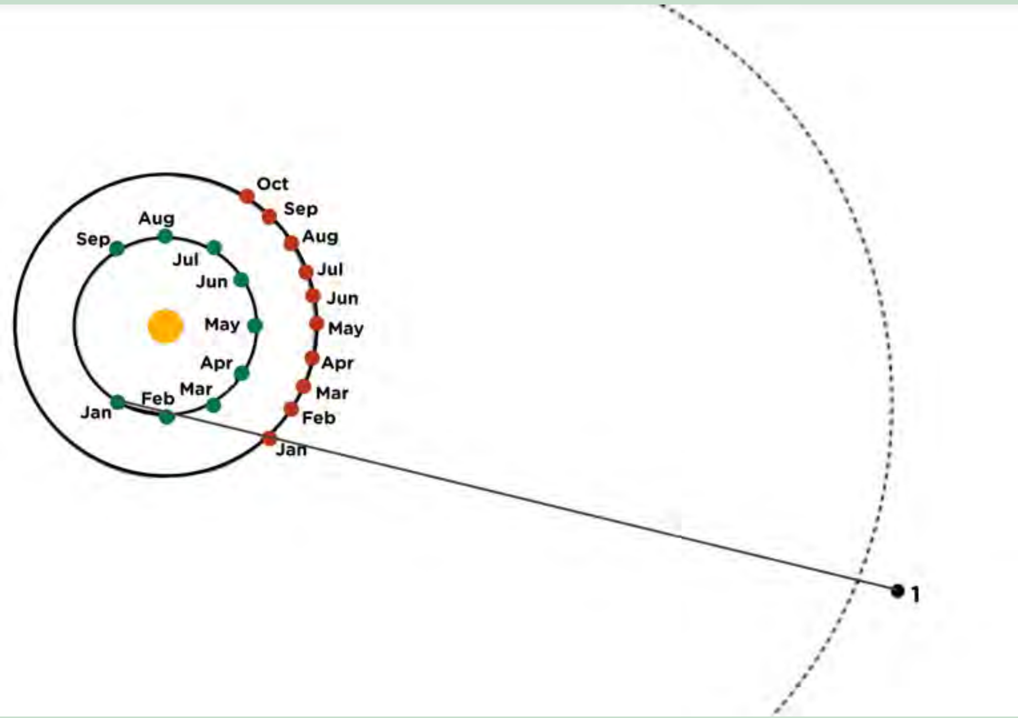
Copernicus correctly ordered all the planets known at the time in increasing distance from the Sun. In his model, all the orbits of the planets were circular, so in this way, it was similar to the model of the ancient Greeks. But how did Copernicus's new deduction solve the problem of Mars' backwards motion?

Let's do an activity to find out.

ACTIVITY: Explaining the motions of Mars

MATERIALS:

- pencil/pen
- ruler



Note that inner orbit is that of Earth (green) and outer is that of Mars (red). The dashed line are the background stars.

INSTRUCTIONS:

1. Draw a line from each Earth position through the Mars position for the same month. Extend the line approximately 1 cm past the dashed curve on the right which represents the background stars.
2. Place a dot at the end of the line and label the dots in order. If a new line crosses one already drawn, draw the new line slightly longer and place the dot slightly farther away than you did for the other lines. The line for January is already drawn as an example. The dots represent the positions where an observer on Earth would see Mars for the month indicated on the diagram.
3. Start with the dot number 1, and carefully connect the dots in order. This connecting line represents the path Mars appears to follow on the sky as viewed from Earth.
4. Answer the questions below.

QUESTIONS:

1. How does Mars move around the Sun between January and August?

___

___

2. To an observer on Earth, what movement does Mars appear to experience during that time period?

___

___

___

3. During which months does Mars appear to be moving backward in its orbit?

___

___

4. Carefully observe what is happening to Earth and Mars in their orbits when Mars seems to loop "backward." What causes Mars to seem to move backward in its orbit?

___

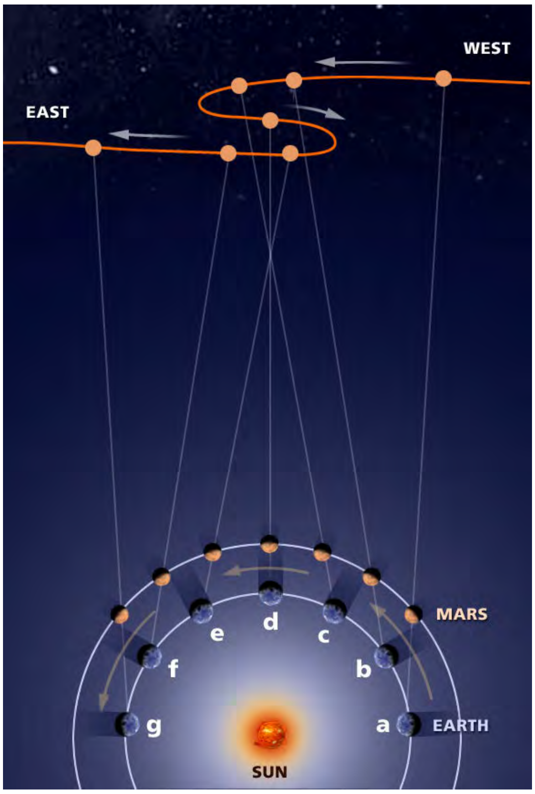
___

___

VISIT
Retrograde motion of Mars.
bit.ly/1732x0x

DID YOU KNOW?

The idea of a Sun-centred solar system was proposed as early as about 200 B.C. by Aristarchus of Samos (Samos is an island off the coast of Turkey). However, the idea did not survive long because the famous Greek Aristotle did not believe in a Sun-centred solar system.



The Earth moves faster than Mars in its orbit and catches up with Mars at point (b) before overtaking Mars at point (d). As the Earth overtakes Mars, Mars appears to travel backwards on the sky, even though Mars is not really changing direction in space.

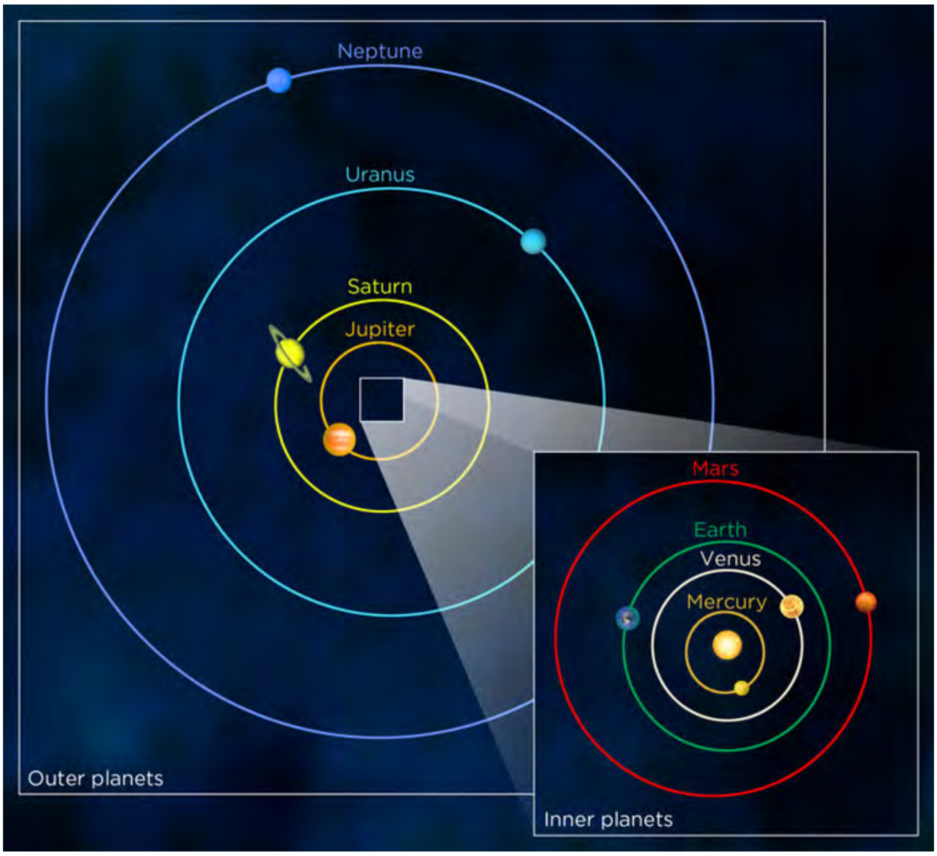
How can objects appear to move backwards when they are not really moving backwards? Let's do a test right now. Hold your arm outstretched in front of you and hold up your first finger. Cover or close your left eye and note where your finger appears against the background. Now cover or close your right eye instead. What do you notice about the position of where your finger appears? It moved to the right didn't it? But did you really move your finger? No, it just appeared to move because of your change in perspective.

The discovery that the planets' orbits are elliptical

Johannes Kepler.

Johannes Kepler was a German astronomer and mathematician. He spent ten years trying to explain the motion of Mars across the sky in detail. He could only get his model of the solar system to fit the observations of the planets' motions if he assumed that rather than moving in a circle around the Sun, the planets all orbited in ellipses (ovals). He discovered that the true shape of the planets' orbits is elliptical.

The Earth travels faster in its elliptical orbit when it is closer to the Sun than when it is farther away. This is because the gravitational force of attraction between the Earth and Sun is stronger when the Earth is closer to the Sun. This is true of the orbits of all planets around the Sun.



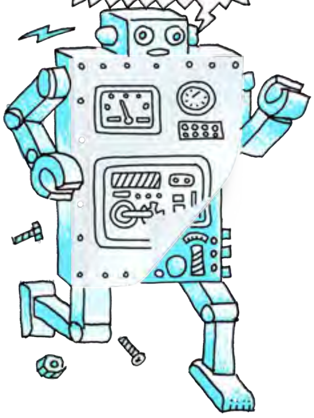
The Earth and the other planets in our solar system orbit around the Sun in an ellipse.

Galileo's discoveries using his telescope

Galileo Galilei was an Italian physicist, mathematician and astronomer. He built his first telescope in 1609 and was the first astronomer to use a telescope. In 1610 he published a book called the *Sidereal Messenger,* listing the discoveries he had made using his telescope.

TAKE NOTE

Although Galileo wasn't appreciated during his lifetime, his experimental and mathematical approach to physics was revolutionary and way ahead of his time.



Galileo displaying his telescope.

Galileo discovered the four largest moons of Jupiter (which are now called the Galilean moons). Over several nights he watched them move and realised that they were actually orbiting around Jupiter.

The four largest moons of Jupiter, left to right in increasing distance from Jupiter: Io, Europa, Ganymede and Callisto.

TAKE NOTE

Heresy is having a belief or opinion that is against the official teachings of the church at the time.

He also found that Venus has phases just like the Moon (and just like all planets). He discovered that the Moon has craters and that the Sun has dark spots which are called sunspots. These imperfections on the Moon and Sun discredited the belief held by the Catholic Church at the time that the heavens were perfect and unchanging.

The Catholic Church allowed Galileo to conduct his research, as long as he did not openly publicise his findings. In 1632 Galileo angered the head of the Catholic Church (the Pope) when he published a book in which he stated that the Earth was moving around the Sun. He was put on trial and found guilty of heresy. He was first imprisoned and later placed under house arrest.

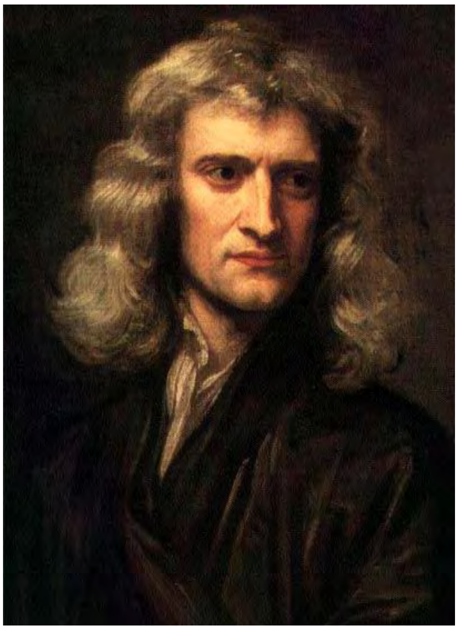
VISIT

Learn more about gravity and general relativity (video)

bit.ly/1fpDg6L

Newton discovers gravity

Isaac Newton was an English physicist and mathematician and is considered one of the greatest scientists of all time. He derived mathematical laws to describe the motions of objects but his greatest discovery was that of the force of gravity. In 1687 he published a book called *Philosophae Naturalis Principia Mathematica*, or in English: *Mathematical Principles of Natural Philosophy,* in which he explained his ideas about the motions of objects and gravity.



Sir Isaac Newton aged 46.

There is a famous story which says that Newton was sitting under an apple tree when an apple fell on his head and he began to think about gravity and falling objects. The apple didn't really land on his head but he did watch an apple fall and began to wonder why apples always fall down. He suggested that it was the force of gravity that caused apples to fall.

Amazingly, he made the mental leap from Earth to space and realised that it was the force of gravity that was holding the Moon in its orbit around the Earth. According to Newton, gravity is the reason that objects fall to the ground when dropped and why planets orbit the Sun and why moons orbit planets. Up until Newton no one had been able to explain what held the Moon and the planets up in their orbits.

DID YOU KNOW?

Quotes from Sir Isaac Newton: "I can calculate the motions of the heavenly bodies, but not the madness of people."

ACTIVITY: Interview with a revolutionary

MATERIALS:

- reference materials about famous historical astronomers.

INSTRUCTIONS:

1. Work in pairs in this activity. One of you will play the role of an early famous astronomer and the other will play the role of a journalist.
2. Astronomer: Pick which famous astronomer you are going to be and answer the questions your partner asks you.
3. Journalist: Ask the "astronomer" what they have discovered and why their discoveries are important.

VISIT

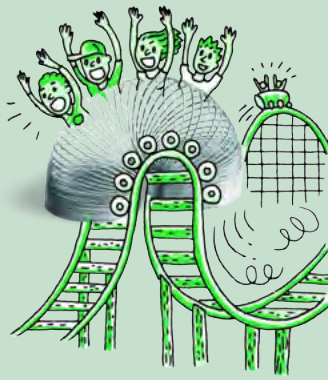
A short documentary about the search for habitable planets.

bit.ly/1fpDqei

Modern day discoveries

Scientists are continually making new discoveries, and with every new discovery comes a new question.

ACTIVITY: Research a new discovery, invention or scientist



INSTRUCTIONS:

1. Research either a recent discovery made in astronomy, or an invention used in astronomy or about a famous astronomer.
2. You can choose to write about one of the examples provided in the text below, or you can choose your own example.
3. Your teacher will inform you how you must present your work.

Some example discoveries:

Exoplanets - An exoplanet is a planet orbiting around a star other than our own Sun. The first exoplanet was discovered in 1992 when several planets were found orbiting around a small, rapidly spinning star. As of June 2013, 890 exoplanets have been discovered and more and more are being found all the time.

VISIT

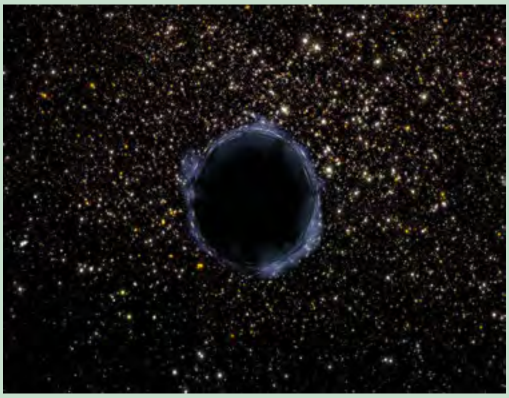
Planet Quest - the search for another Earth.
bit.ly/1beOoDn
Citizen science - help look for other planets.
bit.ly/1dL91Tt

This image compares the smallest known exoplanets orbiting outside the solar system, to our own planets Mars and Earth.

Black holes-Black holes are super-dense regions in space which have very strong gravity, so strong that not even light can escape from them. Although you cannot see a black hole directly astronomers know they exist because of their pull on objects close to them. If you were to fall into a black hole feet first, you would be pulled apart like a piece of spaghetti.

VISIT

Black holes are super-dense regions in space which have very strong gravity, so strong that not even light can escape from them. Read more about black holes.
bit.ly/15vM5HU



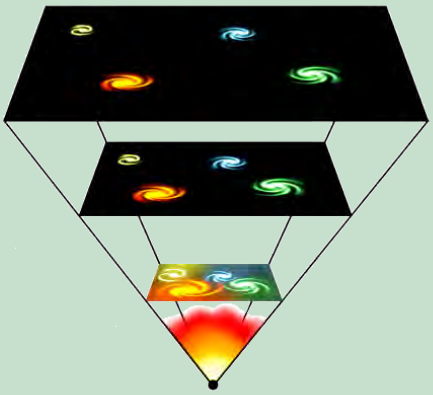
A black hole in the universe.

An artist's drawing concept. On the left, the yellow, sun-like star comes too close to the black hole, and is stretched (middle yellow blob), until it is ripped apart. Some these remains of the star swirl into the black hole (blue-white cloudy ring on the right).

VISIT

Watch a black hole swallow a star.
bit.ly/1aqMrOa

The Expansion of the Universe-In 1929, astronomer Edwin Hubble made the astonishing discovery that our universe is expanding. Looking at galaxies outside our Milky Way galaxy, he found that all the galaxies he looked at were moving away from the Earth, and that the most distant ones were moving away fastest. This implies that every galaxy is moving away from every other galaxy. In fact the space between galaxies is itself expanding.



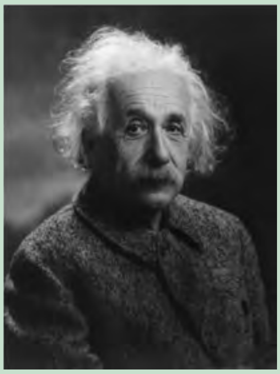
As the Universe expands, galaxies move further and further apart.

ACTIVITY: Modern day astronomers and physicists

INSTRUCTIONS:

Look at the photographs below and match the face to the description of the person.



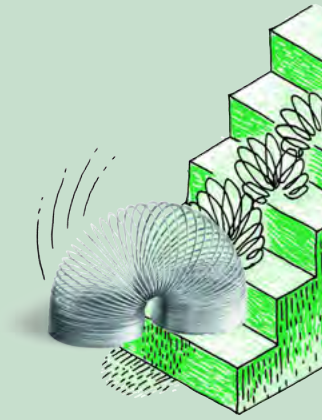


Descriptions:

Stephen Hawking, a famous British physicist diagnosed with ALS, a form of Motor Neuron Disease, shortly after his 21st birthday. He is famous for his work on black holes.

Cecilia Payne-Gaposchkin, the astronomer responsible for discovering that stars are made up mostly of hydrogen and helium.

Albert Einstein, a German physicist famous for his work on gravity and the nature of space and time.



VISIT

Universe awareness.

bit.ly/16Bs24C

VISIT

The concept maps in your workbooks were created using an open source programme. You can download it from this link if you want to use it to create your own concept maps for your other subjects.

bit.ly/16spQTO

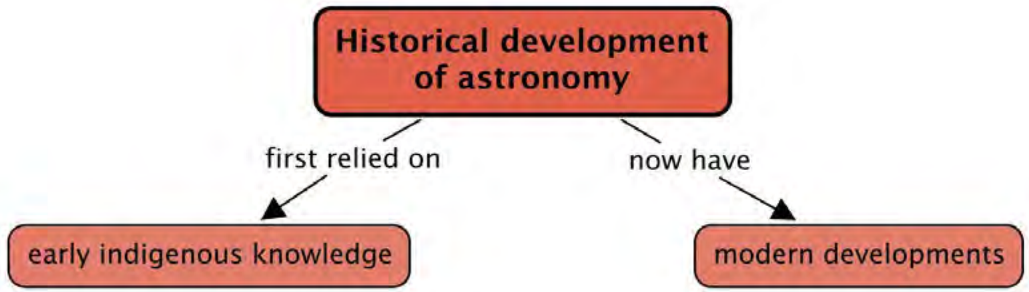
SUMMARY:

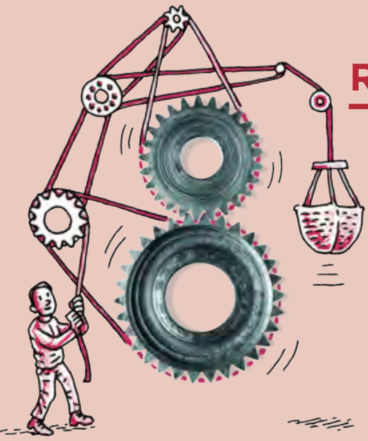
Key Concepts

- People have watched the stars for thousands of years. They have created stories about the stars and constellations which have been passed on from generation to generation.
- Early scientists believed that the Earth was at the centre of the solar system.
- Copernicus found that the observations of planetary motion could be more easily explained if the Sun were at the centre of the solar system.
- Galileo was the first astronomer to use a telescope and found that Jupiter had moons orbiting around it.
- Newton discovered gravity and explained that planets and moons are held in orbit by the force of gravity.
- New discoveries are continuously made using modern telescopes.

Concept Map

Throughout this year we have been looking at how to produce concept maps after each chapter. This is now your chance to make your own concept map. The concepts in this chapter about the development of astronomy can easily be divided into two main themes. Firstly, about "early indigenous knowledge" and then about the "modern developments" that people have made and are still making. The concept map has been started for you. Copy this into your notebook to first practice drawing your concept map. Once you have your final version, with the help of your teacher, draw it into the space below to act as the summary for this chapter.


Historical development of astronomy
first relied on
now have
early indigenous knowledge
modern developments



REVISION:

1. What motions could the ancient Greek model of the solar system not explain? [2 marks]

2. How did Copernicus's model of the solar system differ from the ancient Greek model of the solar system and how was it similar? [2 marks]

3. Explain in your own words why Mars sometimes appear to move backwards relative to the motion of the background stars? [3 marks]

4. List two different discoveries that Galileo made using his telescope. [2 marks]

5. Do planets travel around the Sun in circles or ellipses? [1 mark]

6. How does the speed of a planet vary as it travels around the Sun? [2 marks]

7. What practical uses for the stars were used by early cultures? [2 marks]

8. How did early San people explain the Milky Way? [2 marks]

9. Does the phases of the Moon have an effect on human behaviour? [1 mark]

Total [17 marks]

GLOSSARY

acceleration due to gravity:	the acceleration given to an object by the attractive gravitational force of the Earth or other celestial body
axis:	a real or imaginary straight line about which something turns; the imaginary axis of the Earth passes through the North and South Pole
cellulose:	a carbohydrate which plants use to form leaves and stems
coal:	brown or black rock that can be ignited and burned, and which consists of carbonised plant matter
constellation:	a group of stars that when viewed from Earth form a pattern in the sky
crude oil:	a dark oil found in rock formations deep underground, used as fuel
day:	the length of time it takes for a planet to spin once on its axis
decompose:	to break down or decay
direct:	the shortest way
eclipse:	the blocking of light coming from a celestial object, for example, a solar eclipse or a lunar eclipse
ecosystem:	a community of living organisms and their interaction with the environment
equator:	an imaginary horizontal line around the middle of the Earth, at an equal distance from the North Pole and the South Pole
equinox:	occurs twice a year (around 20 March and 22 September) when the Sun's rays fall directly on the Earth's equator
fossil fuels:	a natural fuel such as coal, oil or natural gas, formed in the geological past from the remains of living organisms
glucose:	a carbohydrate produce by most plants, which is energy rich
gravitational force:	the force that attracts an object with mass towards another object with mass
gravity:	the force that attracts a body towards the centre of the Earth or towards any other celestial body having mass
hemisphere:	one half of a sphere or globe; the Earth is divided at the equator into the Northern and Southern hemispheres
indirect:	not direct, by a longer way
intensity:	the concentration or amount of something
intertidal zone:	an area that is above water at low tide and under water at high tide (i.e. lies between low and high tide levels)

lunar calendar:	a calendar based on lunar cycles (phases of the Moon)
lunar:	related to the Moon, e.g. lunar surface (Moon's surface), lunar day (the Moon's day)
mass:	the quantity of matter an object contains
moon:	a body that orbits around a planet or small body such as an asteroid (not a star)
natural gas:	a flammable gas, consisting largely of methane, occurring naturally underground and used as fuel
neap tides:	tides with the minimum difference between low and high tides which occur when the Moon and Sun are at right angles to each other
non-renewable:	something of which there is a limited supply, or which can only be used once
oblique:	at an angle other than 90 degrees, slanting inward
observatory:	a room or building housing a telescope or other scientific equipment for observations and research, especially of objects in space.
orbit:	the path followed by a planet , moon, or other object in space as it travels around another object; the path of the Earth around the Sun is an orbit
photosynthesis:	the process whereby green plants use sunlight (energy), water and carbon dioxide to produce glucose, which is food for the plant; oxygen is released during this process
prograde:	direct or forward motion (proceeding from west to east across the sky)
renewable:	something of which there is an unlimited supply found in nature, or which can be reused
retrograde:	reversed motion (proceeding from east to west across the sky)
revolution:	the orbit of Earth (or other object or planet) around the Sun
rotation:	the spinning of the Earth (or other object or planet) on its axis
season:	each of the four divisions of the year (spring, summer, autumn, winter) which have different weather patterns and daylight hours
solar calendar:	a calendar whose dates indicate the position of the Earth in its orbit around the Sun
solar energy:	energy from the Sun's light and heat
solstice:	occurs twice in a year (around 21 June and 21 December), when the Sun's rays strike the Tropic of Capricorn (southern summer solstice) or the Tropic of Cancer (northern summer solstice) directly
sphere:	any round object that has a surface that is the same distance from its centre at all points, for example, a ball or globe
spring tides:	extreme tides with the maximum difference between low and high tides which occur when the Earth, Moon and Sun are in alignment

star lore:	mythical stories about the stars, planets and constellations
starch:	a carbohydrate consisting of a large number of glucose units
telescope:	an instrument designed to make distant objects appear nearer and magnified
tidal bulge:	a swell in the sea level in line with the Moon on either side of the Earth (along the Earth-Moon line)
tides:	the regular rise and fall of the oceans (and some rivers and lakes) twice per day caused by the gravitational attraction of the Moon and to a lesser extent the Sun
tilt:	to slant or tip
vegetation:	the general word used for plant growing in an area or region
weight:	the force exerted on a mass due to gravity

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