EDUCATOR PACK

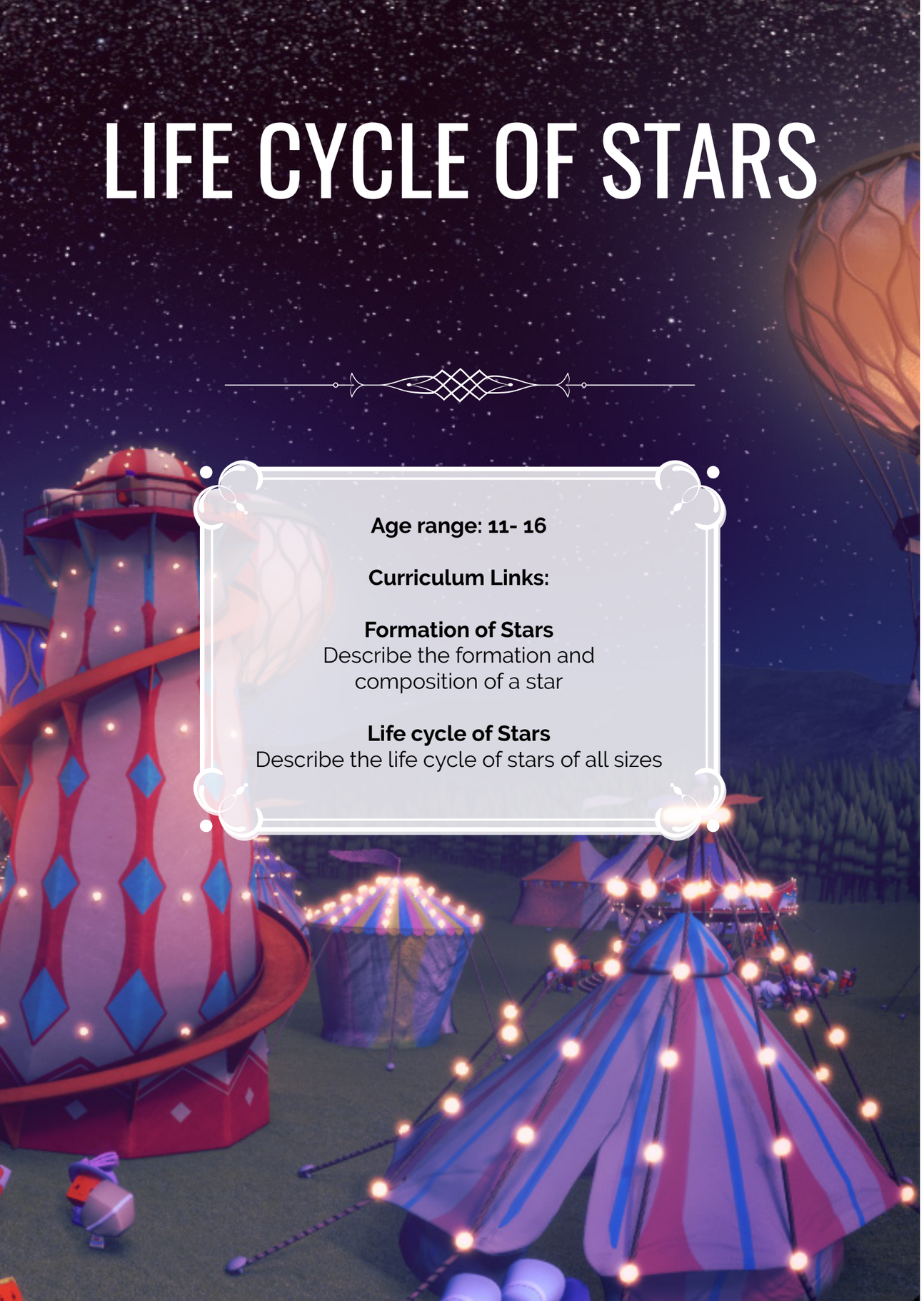
ROLL UP, ROLL UP...
COME INSIDE AND EXPERIENCE
THE UNIVERSE LIKE NEVER BEFORE...

NSC creative

NATIONAL SPACE ACADEMY

NATIONAL SPACE CENTRE

LIFE CYCLE OF STARS



Age range: 11- 16

Curriculum Links:

Formation of Stars
Describe the formation and composition of a star

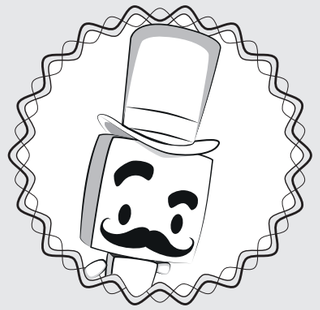
Life cycle of Stars
Describe the life cycle of stars of all sizes

LIFE CYCLE OF STARS LESSON OVERVIEW

This explores the various stages which a star goes through during its ‘lifetime’. While a star’s evolution takes place on a timescale of millions and billions of years, it undergoes dynamic changes as it ages. These changes can be influenced by many factors, the most important of which is the star’s size.

The focus of this resource is to explore and demonstrate the changes that stars of varying sizes go through. We will see the different stages in a star’s evolution and some of the cosmological phenomena that can be caused by the demise of these stars. The end stages of these stars can range from slowing cooling and fading, to some of the largest explosions in the Universe. Students will see how star size affects these final stages and will learn how this goes on to influence the rest of the Universe.

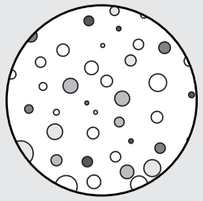
Alongside investigating stellar lifetimes, students will investigate the composition of stars and the universe to see how this is related. This can be used to show how first-generation stars went on to seeding current star forming regions with materials other than hydrogen and helium. These heavier elements were produced within stars before being expelled as they reach their dramatic end. This material would then go on make up other objects, like planets, and even us.



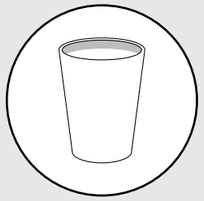
Please make sure all worksheets are printed on single sided sheets as they may need to be displayed separately or cut up for the activities.

THE LIFE CYCLE OF STARS

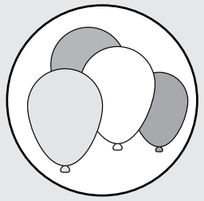
YOU WILL NEED:



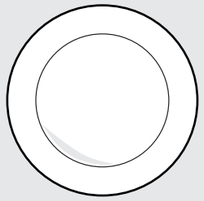
Coloured beads or pom-poms



Containers



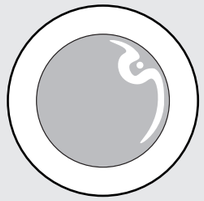
Balloons (1 x red, yellow, white and blue)



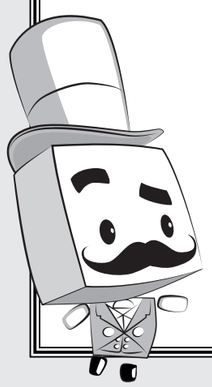
1 x ping pong ball

1 x balloon pump

1 x marble



1 x ball bearing



LEARNING OUTCOMES:

1. Understand how stars form
2. Understand the composition of a star
3 . Understand the lifecycle of stars of varying sizes. Investigate what happens to stars as they age

CONTENTS

STARTER ACTIVITY

Students work together in small groups to build a representation of the composition of a star.

Time: 0 – 15 mins

MAIN ACTIVITY

Students will investigate the lifecycle of stars. They will explore how this path changes depending on the size of the star. The mass of a star has a big effect on its physical characteristics and lifespan.

Time: 15 – 45 minutes

PLENARY

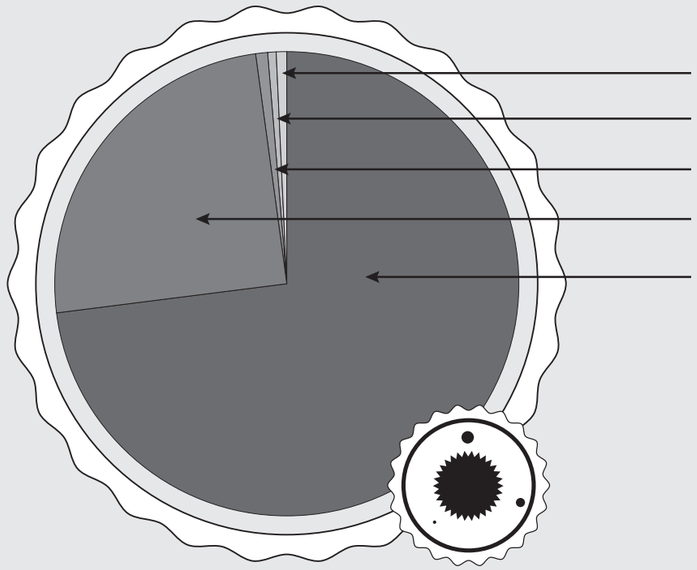
Using the composition models of stars created at the start of the lesson we can compare the composition of stars to the composition of planets and life.

Time: 45 – 60 minutes

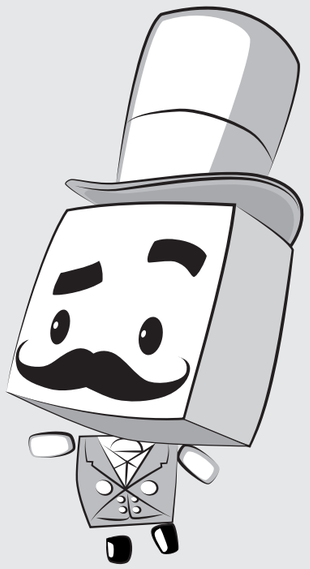
STARTER ACTIVITY

Students work together in small groups to build a representation of the composition of a star. Using coloured beads to represent each element, combine the beads in the appropriate ratio in a clear container (tall, thin ones work best). The number of beads can either be pre-calculated and given to the students, or they can calculate it themselves.

Composition:



Others:	0.8%
Carbon:	0.4
Oxygen:	0.8%
Helium:	25%
Hydrogen:	73%



Time: 0 – 15 mins

MAIN ACTIVITY

Students will investigate the lifecycle of stars. They will explore how this path changes depending on the size of the star. The mass of a star has a big effect on its physical characteristics and lifespan.

All stars begin the same way; as a large cloud of gas and dust called a nebular or molecular cloud. Over the course of a few million years, gravity causes these clouds to collapse into clumps. As this happens the core of the clumps gets hotter until the temperature is high enough to begin the process of fusion. Fusion is a process that sees atomic nuclei forced together to form new elements. This process releases a huge amount of energy, causing the star to shine.

As the stars fuse the hydrogen into helium they gradually expand. Eventually they start to fuse the helium creating heavier elements. The more massive the star, the heavier elements it can produce. Eventually the star runs out of fuel and either begins to fade or collapses violently.

First the students should separate into small groups. This activity can either be run as one group per star type, or each group can have their own set of stars.

Group 1	represents a Red star and they will need the red balloon.
Group 2	represents a Yellow star and they will need a yellow balloon with the 1" ping pong ball placed inside it.
Group 3	represents a White star and they will need a white balloon and a marble placed inside it.
Group 4	represents a Blue star and they will need a blue balloon with the confetti and small ball bearing inside.

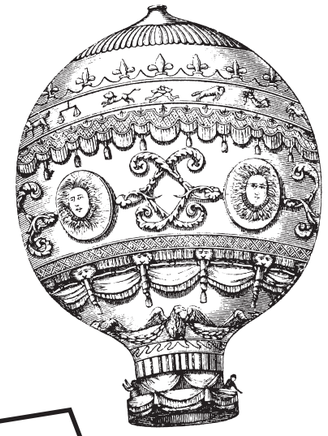
Each group will show the lifecycle of the stars via an interactive time line. This can be done as a Powerpoint or each group could be given cards with the details on and guided through it. The timeline can be found on Worksheet 1.

Time: 15 – 45 minutes

EVENT 1
0 YEARS

"Gravity pulls on the gas and dust inside huge clouds we call nebulae. The material is pulled into clumps of varying density. As density increases, so does pressure and temperature within the centre of the clump. Once hot enough the fusion reaction begins. The particles of hydrogen are forced together to form helium via the proton-proton cycle. This releases energy in the form of light and heat. The star begins to glow. This is the beginning of the Main Sequence."

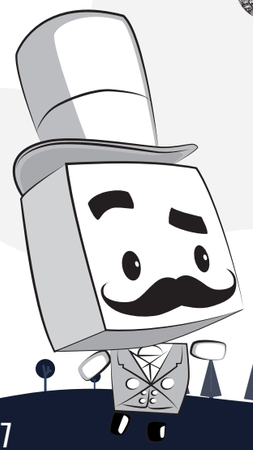
All groups use the baloon pump to inflate all the balloons to around 3" diameter.



EVENT 2
10 MILLION YEARS

"Blue stars are often the largest Main Sequence stars, as a result they burn hot and bright but use up their hydrogen reserves quickly. After around 10 million years they begin to run out of hydrogen. As the do they begin to fuse other materials. Helium to Beryllium, Beryllium to Carbon and so on. These reactions increase the pressure inside the star causing it to expand. As the star expands it begins to cool, its colour changing from blue. These stars are called red supergiants."

Inflate the blue balloon to around 6" diameter.



EVENT 3
11 MILLION YEARS

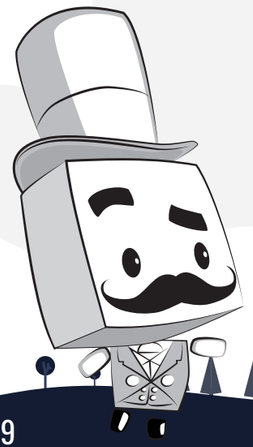
"After 11 million years, blue stars have used the lighter elements and begin to produce iron in the core. Fusion producing iron takes more energy than it creates. This results in a drop in pressure in the core. Gravity starts to dominate, causing the star to collapse. As this happens, the core is crushed causing a flurry of reactions to produce heavier elements. The shockwave from the collapse tears the star apart in a huge explosion called a supernova, scattering heavier elements across space. Meanwhile the huge mass crushes the core into a black hole"

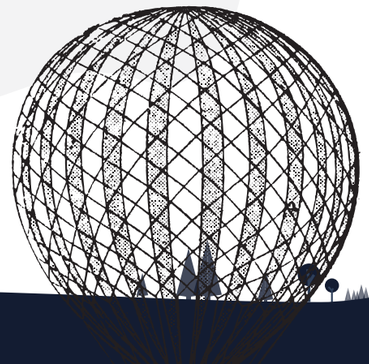
Inflate the blue balloon to its maximum and pop it. Let the ball drop into a tray below. The confetti is the star's material that is scattered into space.

EVENT 4
50 MILLION YEARS

"The white stars, like the blue stars, react quickly and are therefore very hot. After 50 million years it begins to run out of hydrogen. As it fuses elements other than hydrogen the pressure increases causing an expansion. Just like the blue stars, white stars also become red giants. "

Inflate the white balloon to around 6" diameter.

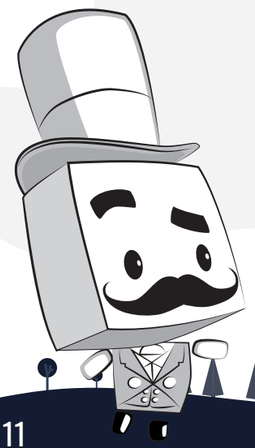


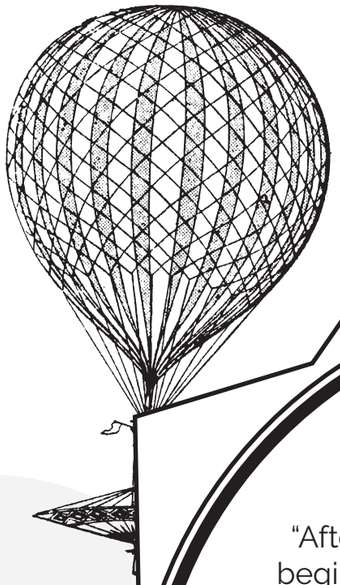


EVENT 5
55 MILLION YEARS

"At this point white stars begin to produce iron. This causes a drop in pressure and allows collapse due to gravity. The collapse causes a flurry of fusion reactions and the shockwave of energy released causes the star to explode in a supernova. As the white star is a little less massive compared to a blue star, the core isn't crushed as much. Rather than forming a black hole the core is crushed to form a neutron star. These are tiny, very dense stars, They are of similar mass to our Sun, but are only a few kilometres across."

Quickly inflate the white balloon to its maximum and pop it. Let the marble drop into a tray below.





EVENT 6
10 BILLION YEARS

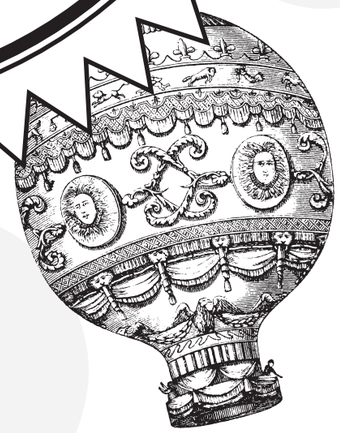
"After 10 billion years, the yellow star is now beginning to run out of hydrogen. As the total mass of the star is lower, less pressure is needed to overcome gravity. As the helium begins to fuse, the star begins to expand becoming a red giant."

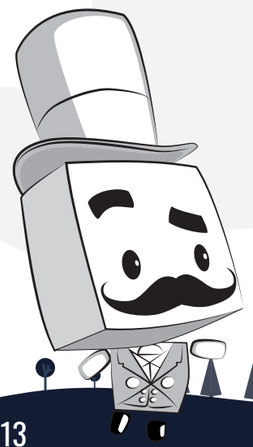
Inflate the yellow balloon to around 6".

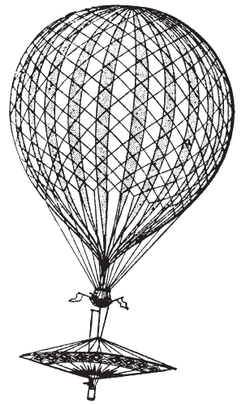
EVENT 7
12 BILLION YEARS

"The yellow star continues to grow. As this happens to our own Sun we are unsure of the fate of the Earth. Some people think the planet will be engulfed and incinerated in the Sun's interior. Other ideas suggest the Sun's gravity may lose grasp of the Earth causing us to drift away from the Sun and possibly out of the Solar system."

Continue to inflate the balloon.







EVENT 8
12.5 BILLION YEARS

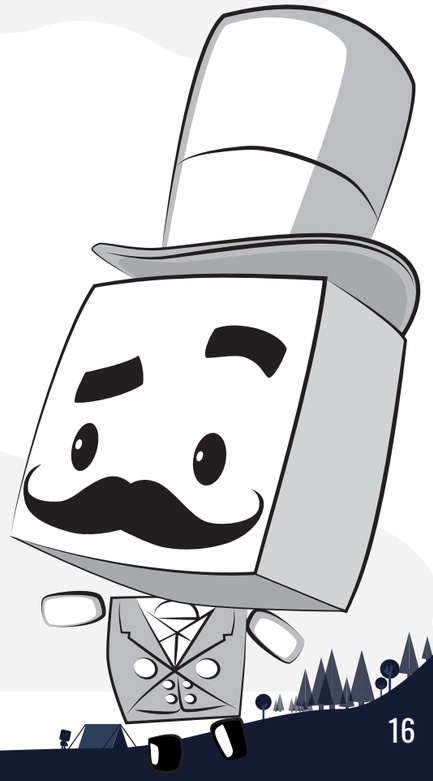
"The yellow star expands so much that its gravity begins to lose grip on the outer layers of the star. This material can then stream off into Space. This forms what we call a planetary nebula. Once this material has drifted off we are left with a white core, known as a white dwarf."

Deflate the yellow balloon and cut into pieces, scatter these pieces around you, creating a planetary nebula. Let the ball drop into a tray below.

EVENT 9
100 BILLION YEARS

"The red star begins to run out of hydrogen. The mass of red stars is so low that while the helium is pulled to the centre of the star the pressure isn't great enough to cause it to fuse. This means as the hydrogen runs out, the energy output of the star gets lower. The star begins to cool and shrink, gradually getting dimmer until it becomes a brown dwarf."

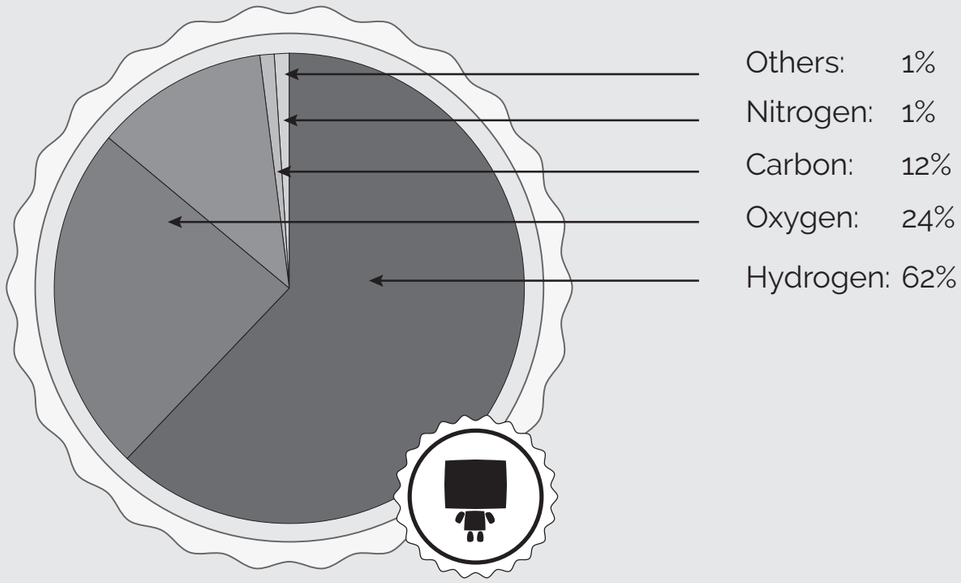
Slowly deflate the red balloon



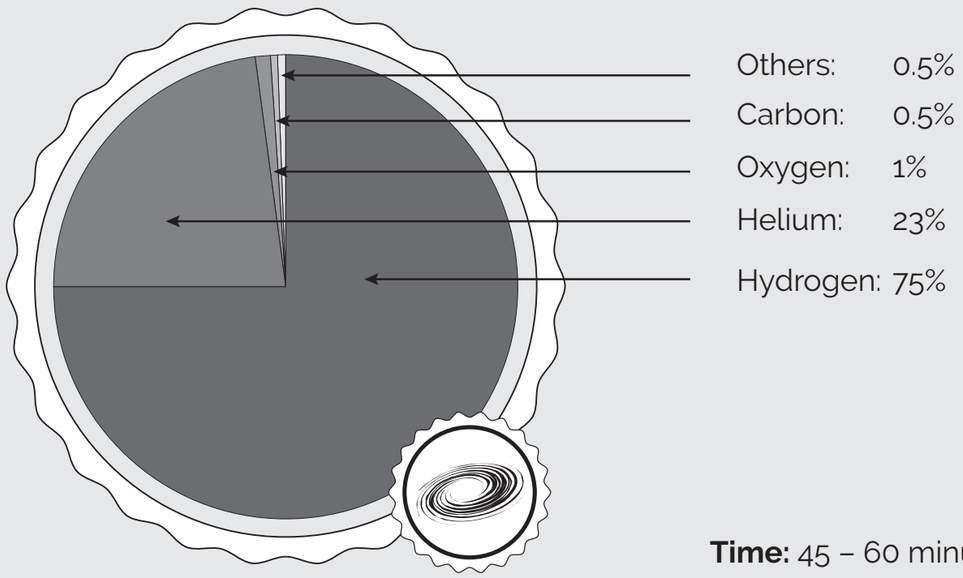
PLENARY

During supernovae and the formation of planetary nebulae, stars create the materials that go on to form the planets and ultimately us. Using the composition models of stars created at the start of the lesson we can compare this to the composition of planets and life.

Composition of a human, by number of atoms:



Composition of the universe, by number of atoms:



Time: 45 – 60 minutes

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PLANETS AND THE SOLAR SYSTEM

Age range: 7- 11

Curriculum Links: Earth and Space

Describe the movement of the Earth and other planets relative to the Sun in the solar system

Describe the Sun, Earth and Moon as approximately spherical bodies

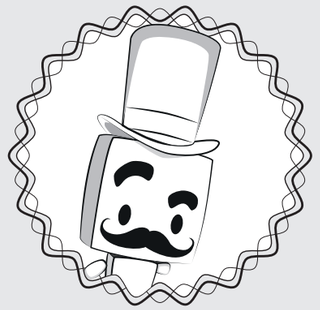
PLANETS AND THE SOLAR SYSTEM LESSON OVERVIEW

This lesson can be used to set the scene at the start of the topics relating to planets and the Solar System.

Students will begin to learn new facts about the 8 planets and other objects that make up the Solar System.

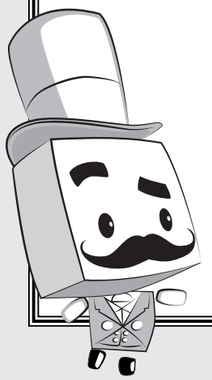
Students will learn what comets and asteroids are made of, and where they can be found in the Solar System, as well as understanding the order and relative places of both the planets and these other celestial objects.

This will be achieved by making simple models that can be made in any classroom. All the materials needed for this are listed in the "**what you need**" section of the lesson plan.



Please make sure all worksheets are printed on single sided sheets as they may need to be displayed separately or cut up for the activities.

PLANETS AND THE SOLAR SYSTEM



LEARNING OUTCOMES:

1. Understand the order of the planets in our solar system and their movement relative to the Sun.
2. Understand there are different objects in our solar system and name some of them

STARTER ACTIVITY

Using **Worksheet 1** students work in small groups to organise pictures of the Sun and planets into their relative order.

Time: 0 -10 minutes

MAIN ACTIVITY

Relative distances between planets in our Solar System, Make a Comet and Meteorite Activity.

PLENARY

Solar System bingo!

Students should cross off the correct answer and call out line or full house.

Time: 50 – 60 minutes

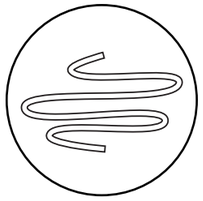
HOMEWORK

Ask children to find out and bring in interesting facts about either a planet or one of the other celestial objects in our solar system.

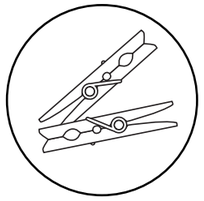
Time: 10 - 50 minutes

STARTER ACTIVITY

YOU WILL NEED



2 metres of string



Pegs

Worksheets

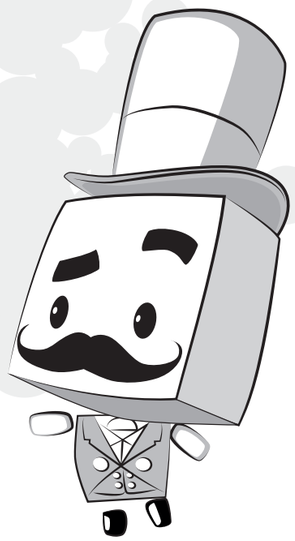
Using **Worksheet 1** students work in small groups to organise pictures of the Sun and planets into their relative order.

Discuss, as a class, what is the correct order. Work together to make a class washing line across the room with the Sun and the planets attached by pegs. At this point don't discuss the distance between the planets or what else may be in the Solar System (this is covered in the main activity), but you can add interesting facts about each planet.

Time: 0 - 10 minutes

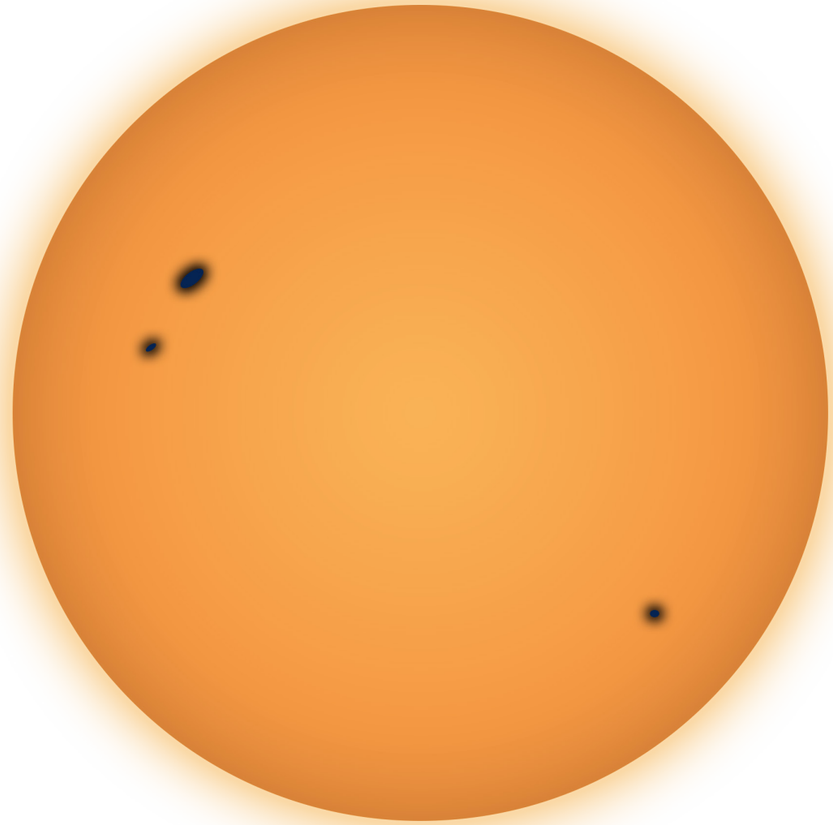
Planets and Sun not to scale!

Jupiter is so big, all the other planets in the Solar System could fit inside!



WORKSHEET 1: THE PLANETS IN ORDER

THE SUN



FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

MERCURY

FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

VENUS

FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

EARTH

FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

MARS

FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

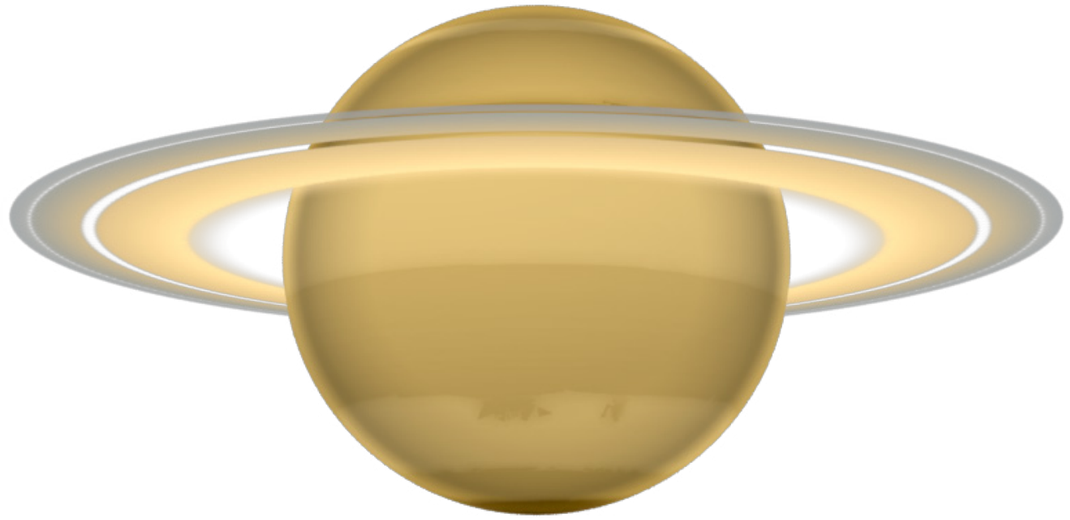
JUPITER

FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

SATURN

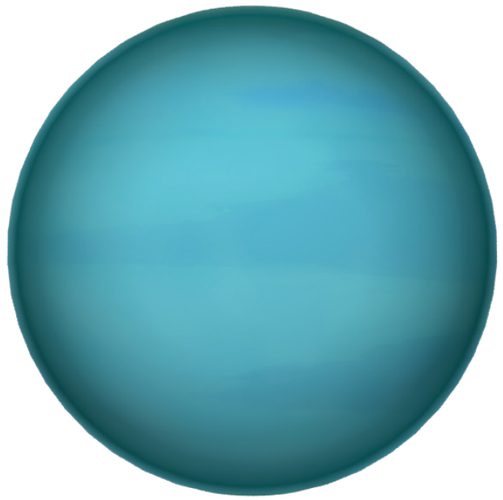


FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

URANUS

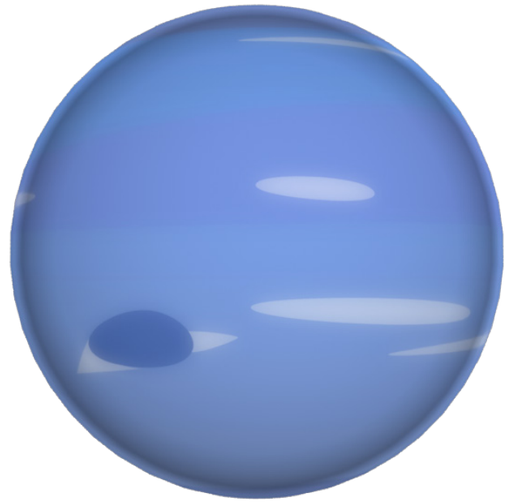


FACT SHEET:

1. _____
2. _____
3. _____

WORKSHEET 1: THE PLANETS IN ORDER

NEPTUNE



FACT SHEET:

1. _____
2. _____
3. _____

MAIN ACTIVITY

Start by checking children's understanding of what a planet and a star are and the differences between them.

Explain that you are now going to look at the relative distances between the planets in our Solar System.

Ask students to work in pairs.

Give each pair a length of string approximately 2m in length and 11 white labels.

As a class, go through each of the measures and where to place the sticky labels for each of the planets. These can be found on **Worksheet 2**.

Once the model is complete, discuss as a class if any of the distances are surprising. Did they expect the planets to be closer together or further apart?

Explain now that the class is going to learn about other objects found in the Solar System. Ask if anyone can name any other objects they know in the Solar System.

Examples include:

1. Dwarf planet
2. Asteroid
3. Comet
4. Meteoroid

Definitions of these can be found in the glossary.

Split the class into 2 groups to work on the following activiities:

ACTIVITY 1: MAKING A COMET

For this you will need **Worksheet 3**. In this activity children will learn what a comet is made of, the main parts and little about its orbit.

ACTIVITY 2: METEORITE ACTIVITY

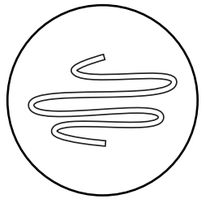
For this you will need **Worksheet 4**. In this activity children will find out what meteorites are made of. If this is made carefully students can take these home to eat!

As a class go through the activities with the students to see what they found out about comets and meteorites.

WORKSHEET 2: RELATIVE DISTANCES

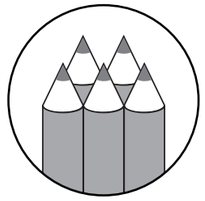
Today we are going to find out the distances between the 8 different planets in the solar system.

YOU WILL NEED

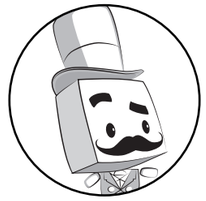


2m string

Sticky labels



Coloured pens or pencils



A friend to help

FOLLOW THESE INSTRUCTIONS TO MAKE YOUR SOLAR SYSTEM MODEL

1. In pairs take a length of string

2. On each of the sticky labels write one of the following:
- a. Sun
- b. Mercury
- c. Venus
- d. Earth
- e. Mars
- f. Jupiter
- g. Saturn
- h. Uranus
- i. Neptune

3. At one end of the string add the sticky label Sun. On the other end of the string add the label Neptune

4. Half way between Sun and Neptune add Uranus

5. Half way between the Sun and Uranus add Saturn

6. Half way between Sun and Saturn add Jupiter

7. Half way between Sun and Jupiter add Mars

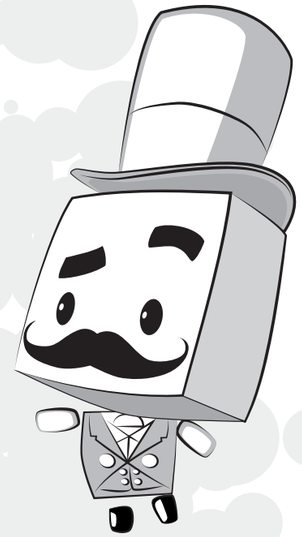
8. Half way between Sun and Mars add the Earth

9. Halfway between Sun and Earth add Venus

10. Halfway between Sun and Venus add Mercury

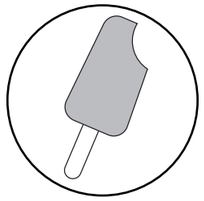
"Are the planets where you expected them to be?

Are they closer together or farther apart? "

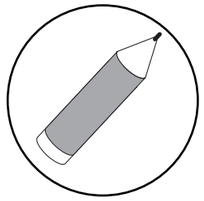


WORKSHEET 3: BUILD YOUR OWN COMET

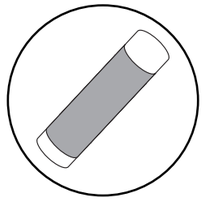
WHAT YOU NEED:



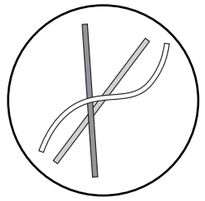
1 x lollipop stick



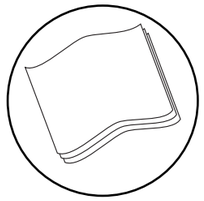
1 x felt tip pen



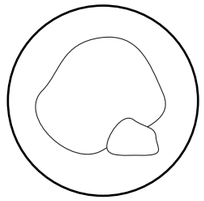
1 x glue stick



1/2 x pipe cleaner



Strands of tissue paper



Modelair or Plasticine

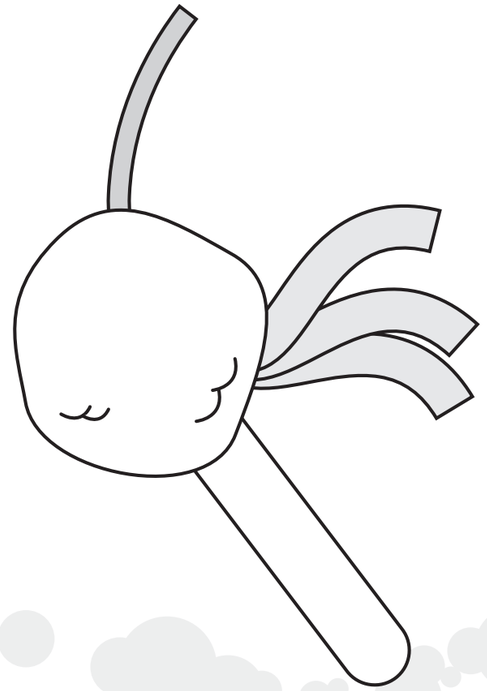
HOW TO PUT YOUR COMET TOGETHER:

1. **Draw a small dot on your lollipop - this is the nucleus of your comet.**
   Although this looks very small on our model, we sometimes call this part a giant dirty snowball because it is very large and made up of lots of frozen gases and water.

2. **Mould the Modelair or Plasticine around the lollipop stick – this is the coma around your comet.**
   A comet's coma can be as large as the diameter of Jupiter?

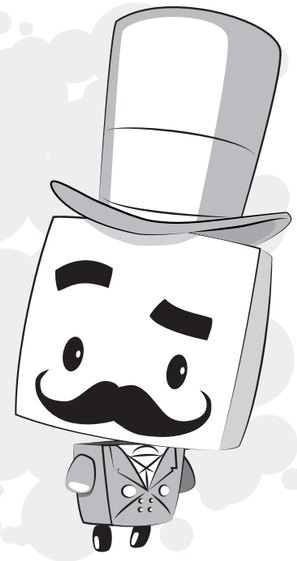
3. **Push the pipe cleaner into the Modelair or Plasticine – this is the gas tail of your comet.**
   The gas tail is formed by the solar wind (the same thing that causes the northern and southern lights). This means the gas tail is ALWAYS facing away from the Sun.

4. **Stick the ends of the strips of tissue paper to the modelair – this is the dust tail of the comet.**
   It also faces away from the Sun, but can be a little behind the gas tail. The tail can be up to around 150 million km or 1 astronomical unit.



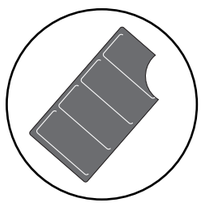
"You now have a completed comet!

If you blow on the tissue paper you can see the effect of the solar wind."

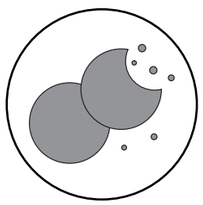


WORKSHEET 4: CHOCOLATE METEORITES

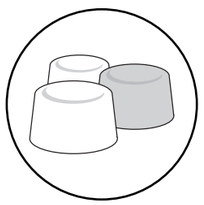
YOU WILL NEED:



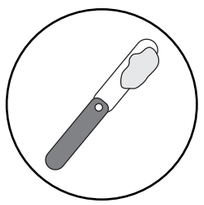
100g Chocolate bar and another 50g for dipping



50g Biscuits – plain digestives are best!



30g Mini Marshmallows



50g Butter

A meteorite is a rock from space that is found on the Earth. Before it lands and it is travelling through the atmosphere it is called a meteor and whilst in space it is called a meteoroid. They are significantly smaller than asteroids.

There are 3 main types of meteorite: Irony, Stony and Stony-Iron. These are mainly made of what their name suggests.

YOU ARE GOING TO MAKE A STONY IRON METEORITE

The rarest of the different types of meteorites is a stony iron meteorite but these also tell us a lot about our solar system. They have roughly equal parts silicates (rock forming minerals) and meteoric iron (a mix of iron and nickel). They are thought to have been formed between the core and mantle of an asteroid.

The biscuits represent the silicates found inside meteorites. The marshmallows represent the chondrules which are circular shaped molten or partly molten droplets from space. These are some of the oldest building blocks of the solar system and can tell us a lot about the history of its formation.

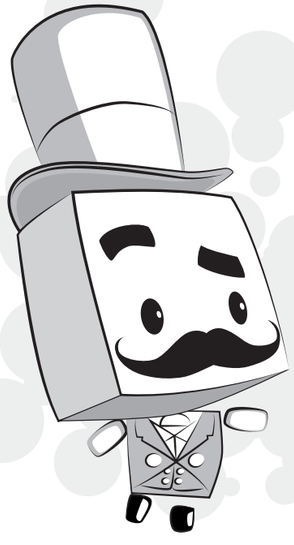
If you sliced open a meteorite and saw circular bubbly shapes this is what you would be looking at. The butter and chocolate form the rest of the stony mix and hold together your meteorite.

The outer layer of the meteorite is covered in another layer of melted chocolate which represents the dark fusion crust that is formed when a meteor travels through the atmosphere and the outer crust becomes burnt.

RECIPE

1. In a plastic bag break up the biscuits into approximately 1cm pieces
2. In a plastic bowl, melt chocolate and butter (make sure you have the help of an adult for this). The chocolate is the stony part of the meteorite
3. Mix together the marshmallows, biscuits and chocolate
4. Place in a plastic box lined, with greaseproof paper
5. Leave in the fridge to cool and set
6. Break into pieces
7. Dip in another layer of melted chocolate to create the fusion crust

Once you have made your meteorite cut into slices and see if you can spot the round chondrules and the angular shaped silicates inside.



“Did you know scientists can find out about how planets formed and developed by looking at what makes up the chondrules in meteorites.”

Look at a slice of the chocolate meteorite and draw a picture of it below.

Can you label:

- **The fusion crust** - this is the outer layer that is heated up on entry through the Earth's atmosphere
- **The chondrules** these are round droplets within the meteorite
- **The nickel-iron** inside the meteorite

PLENARY: PLANET BINGO

Hand out the bingo cards to small groups of students

Read aloud any of the following questions at random- the answers are written in the answer column

Students should cross off the answer to the question on their bingo cards

The winner is the first group to shout out "Planets" once all words on their card have been crossed off.

No.	Question	Answer
1	I give off light and heat	Sun
2	I orbit around a star	Planet
3	I orbit around a planet	Moon
4	I am made of a frozen gases and dust	Comet
5	I am made of left over rock from the beginnings of the solar system	Asteroid
6	I am a small rock coming through the Earth's atmosphere	Meteor
7	I am the furthest planet from the Sun	Neptune
8	I am a dwarf planet	Pluto
9	I am the closest planet to the Sun	Mercury
10	I am the hottest planet in the solar system	Venus
11	I am the biggest planet in the solar system	Jupiter
12	I am known as the red planet	Mars
13	The Sun is a	Star
14	I am a type of meteorite	Irony
15	I am known as the ringed planet	Saturn
16	The planet we live on	Earth
17	This planet rolls like a barrel through space	Uranus

WORKSHEET 5: PLANET BINGO

PLANET	SUN	MOON
COMET	ASTEROID	METEOR
VENUS	MERCURY	PLUTO

MARS	IRONY	MOON
COMET	JUPITER	METEOR
VENUS	MERCURY	PLUTO

PLANET	METEORITE	MOON
COMET	ASTEROID	METEOR
STAR	MERCURY	PLUTO

PLANET	SUN	JUPITER
STAR	ASTEROID	METEOR
VENUS	MERCURY	MARS

PLANET	NEPTUNE	IRONY
COMET	ASTEROID	METEOR
VENUS	STAR	PLUTO

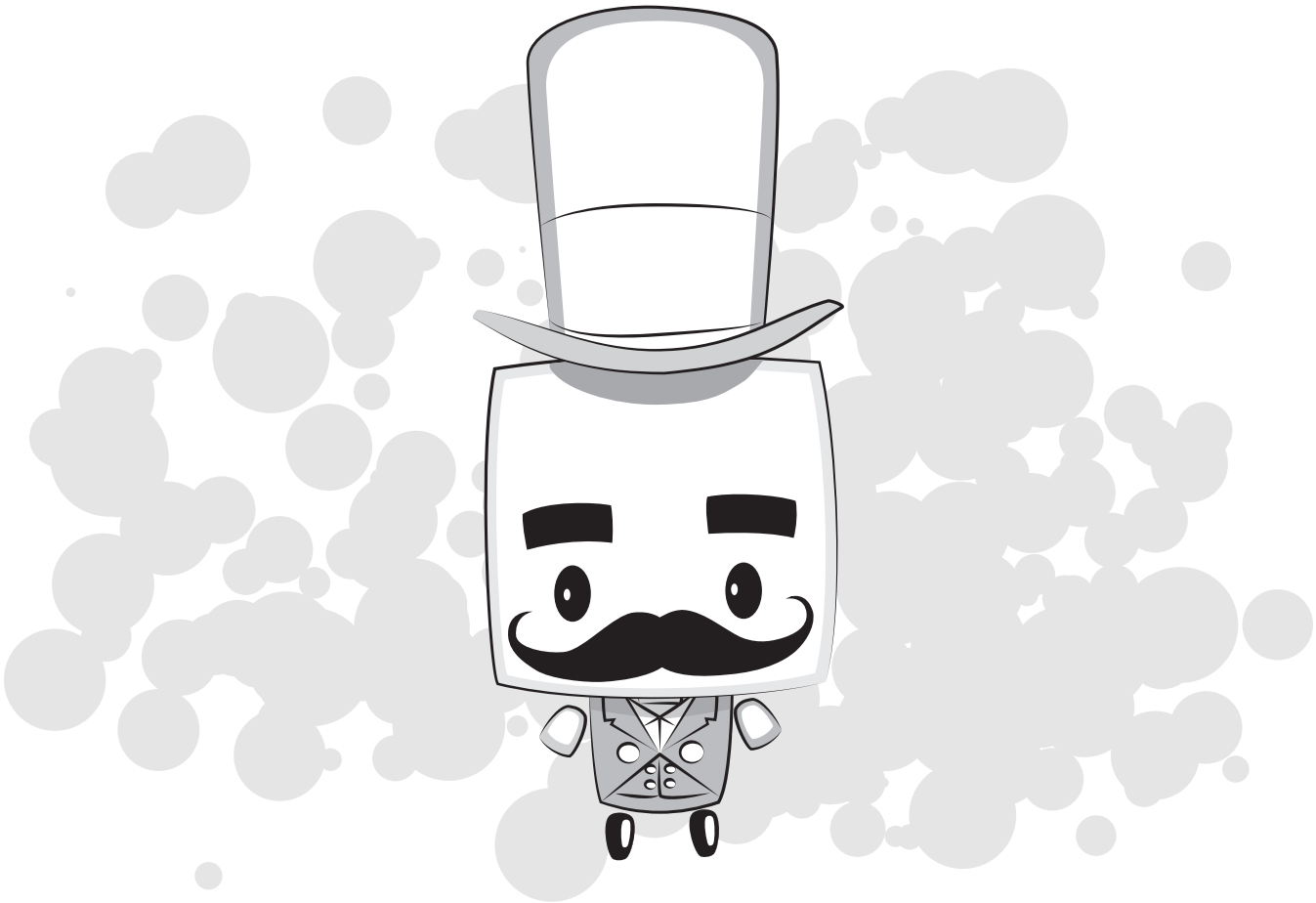
SATURN	SUN	MARS
COMET	STAR	METEOR
VENUS	MERCURY	PLUTO

PLANET	SUN	MOON
EARTH	SATURN	IRONY
VENUS	MERCURY	STAR

NEPTUNE	URANUS	MOON
COMET	MARS	STAR
VENUS	MERCURY	PLUTO

SATURN	STAR	MOON
EARTH	ASTEROID	NEPTUNE
VENUS	MERCURY	PLUTO

PLANET	EARTH	STAR
COMET	ASTEROID	METEOR
JUPITER	MERCURY	PLUTO



EDUCATOR PACK

ROLL UP, ROLL UP...
COME INSIDE AND EXPERIENCE
THE UNIVERSE LIKE NEVER BEFORE...

NSC creative

NATIONAL SPACE ACADEMY

NATIONAL SPACE CENTRE

MOLECULES

Age range: 14-18

Curriculum Links:

Types of Bonding
Describe the different types of chemical bonding and the properties in each

Molecule Structure
Investigate how molecules bind together.

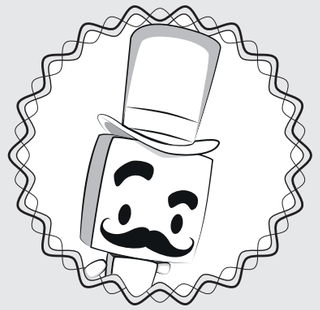
MOLECULES LESSON OVERVIEW

Molecules play a huge role in the Universe. As atoms bond together, the resulting molecules form the building blocks of life as we know it. In the “We are Stars” planetarium show we hear the story of the first molecules and how they came together eventually to form the Universe we see around us.

This resource provides a way to investigate this story further to see how these atoms are held together, and how we can build some of the organic compounds we find. In this lesson, students will familiarise themselves with the different types of bonding that hold molecules together. These bonds and the properties associated with them can then be investigated further. Once an understanding of molecular bonding has been achieved, students look at how atoms are joined together to create molecules vital for life as we know it.

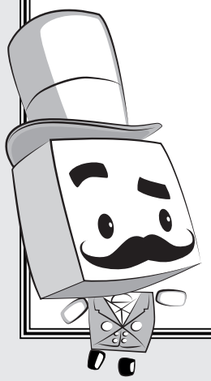
This resource looks to support pupils who have access to molecule building kits already, as well as providing an alternative resource that aids in exploring the structure of molecules.

This resource also assists students with understanding the construction of molecules and the bonds that join them. It can also be used as an aid to assist with chemical nomenclature and can be extended well beyond the scope of the examples specified here.



Please make sure all worksheets are printed on single sided sheets as they may need to be displayed separately or cut up for the activities.

MOLECULES



LEARNING OUTCOMES

1. Understand the different types of chemical bonds that form and the properties associated with them.

2. Understand how atoms join to form different molecules

3. Understand how complex molecules can be formed through a combination of simple atoms.

STARTER ACTIVITY - BOND QUIZ

Students are given a list of compounds and need to sort them based on the type of molecular bonding present (**Worksheet 1**). Revision cards are available to provide assistance if required (**Worksheet 2**).

MAIN ACTIVITY

Students will investigate how molecules bind together. Using the molecule cards (**Worksheet 3**), or molymod sets if available, students will replicate various molecules important to life from their chemical formula.

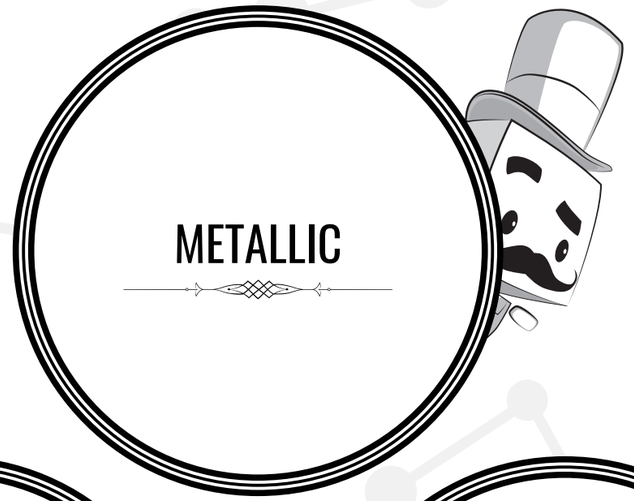
PLENARY

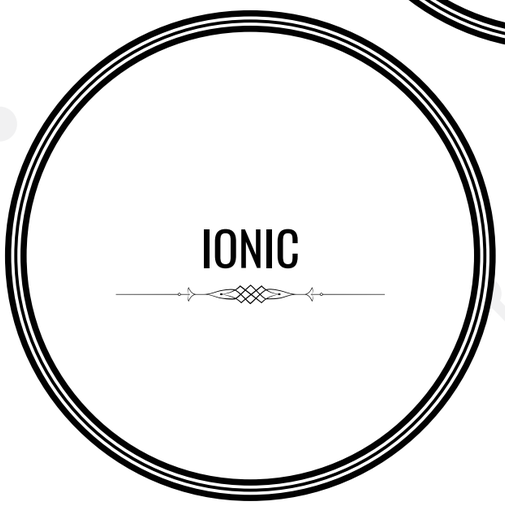
Using the molecule cards, we can investigate many natural reactions to see how molecules can change from one molecule to another.

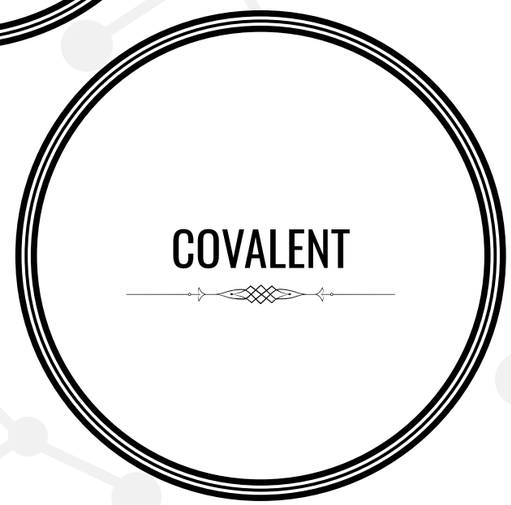
MOLECULES WORKSHEET 1 - BOND QUIZ

WRITE THE CHEMICAL FORMULAE IN THE CIRCLE THAT MATCHES THE BOND TYPE.

- Ozone – O_3
- Lithium Flouride - LiF
- Methane – CH_4
- Copper - Cu
- Carbon Dioxide – CO_2
- Calcium Sulphate – $CaSO_4$
- Platinum - Pt
- Hydrogen Chloride – HCL
- Potassium Bromide – KBr
- Sodium Sulfide – Na_2S
- Ethanol – CH_3CH_2OH
- Gold – Au



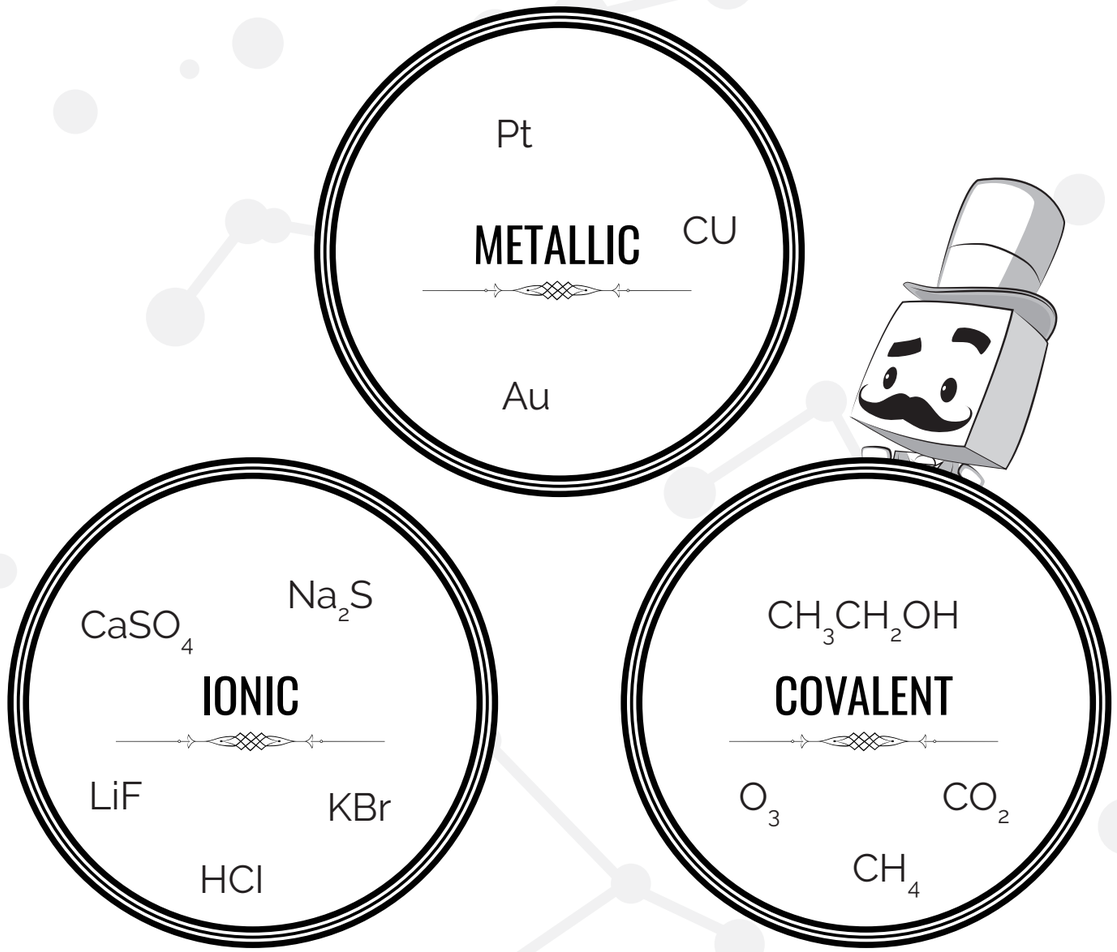




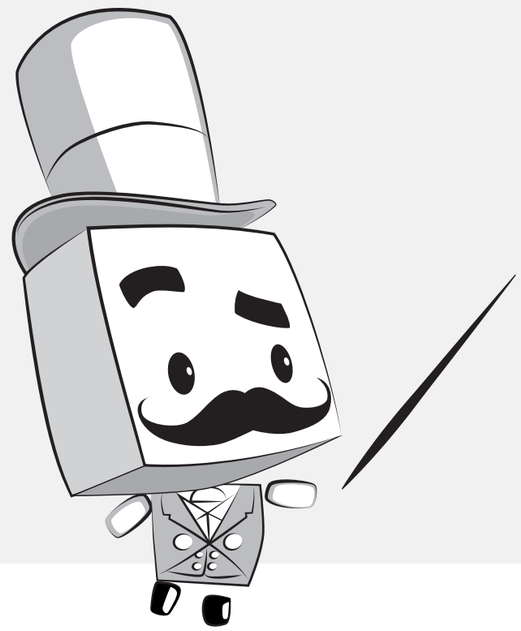
MOLECULES WORKSHEET 1 - BOND QUIZ - ANSWERS

WRITE THE CHEMICAL FORMULAE IN THE CIRCLE THAT MATCHES THE BOND TYPE.

- Ozone – O_3
- Lithium Flouride - LiF
- Methane – CH_4
- Copper - Cu
- Carbon Dioxide – CO_2
- Calcium Sulphate – $CaSO_4$
- Platinum - Pt
- Hydrogen Chloride – HCL
- Potassium Bromide – KBr
- Sodium Sulfide – Na_2S
- Ethanol – CH_3CH_2OH
- Gold – Au



REVISION CARDS



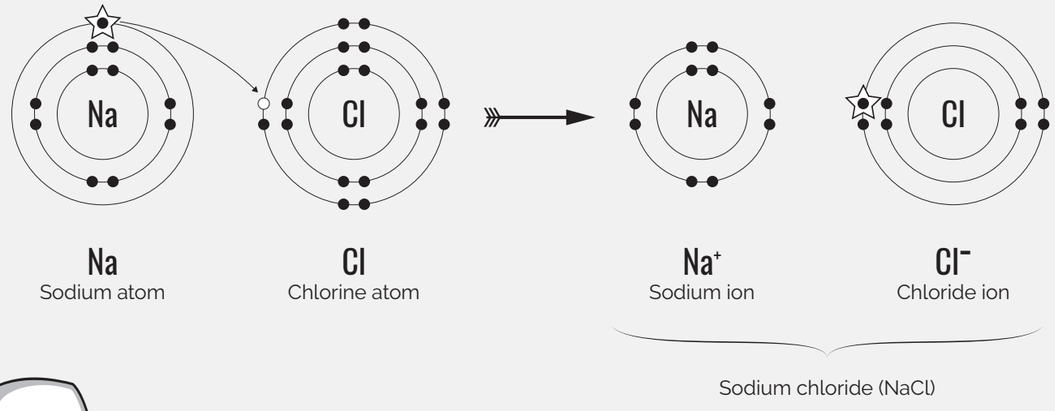
IONIC BONDING REVISION CARD

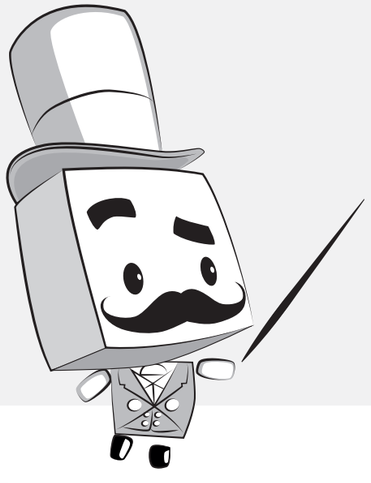
This type of bonding occurs between metallic and non-metallic atoms, for example, sodium chloride (NaCl).

In this type of bonding electrons are transferred between atoms

Compounds joined by Ionic bonding have high melting points because of the strong electrostatic forces between the ions.

Ionic compounds form fixed lattice structures when solid. This means they can only conduct electricity when molten or in solution.





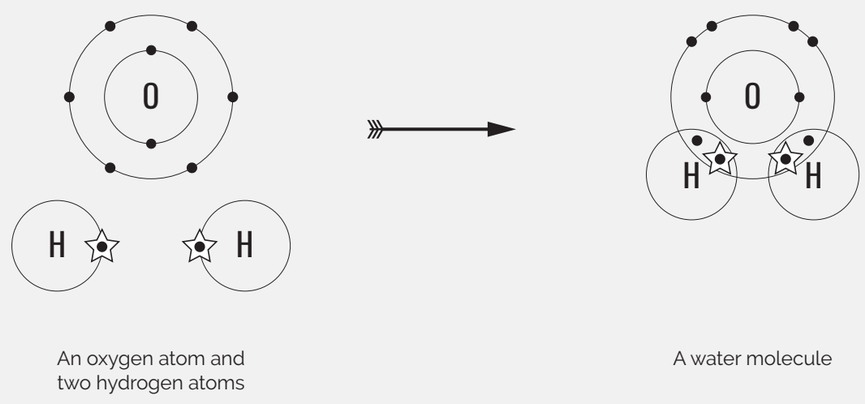
COVALENT BONDING REVISION CARD

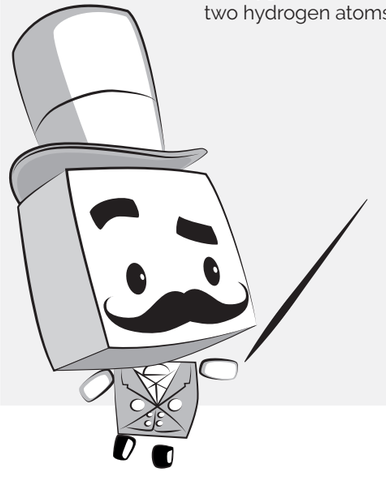
Covalent bonding occurs between two-metallic atoms, for example, water (H_2O)

In this type of bonding electrons are shared between atoms

Covalent molecules have weak intermolecular forces, so they have low melting points.

Covalent compounds have no free electrons or ions, so they cannot conduct electricity.





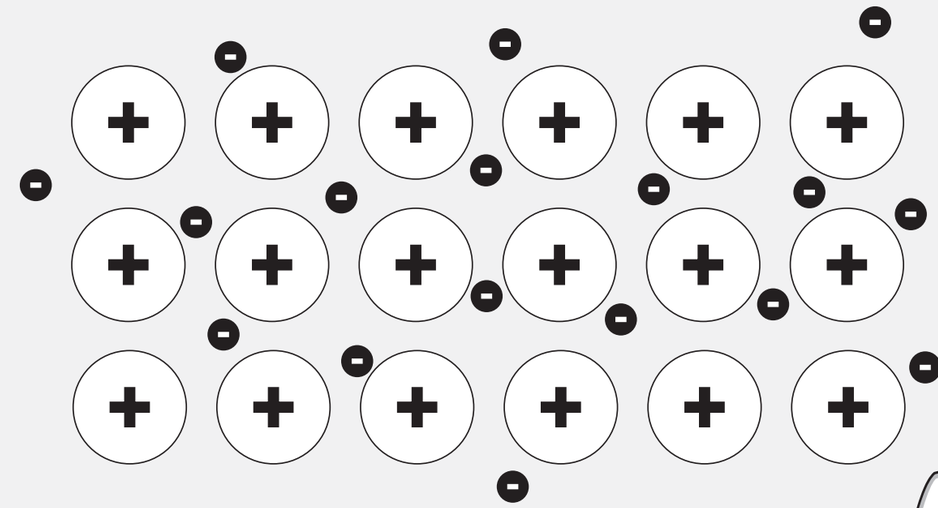
METALLIC BONDING REVISION CARDS

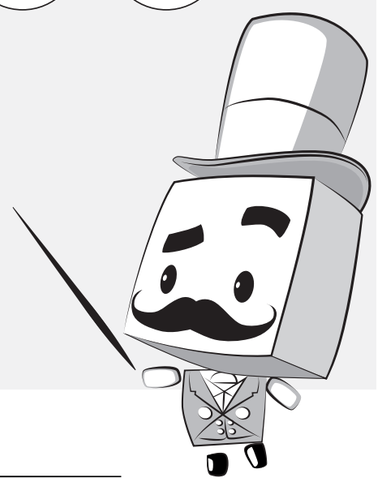
When metals bond, the electrons become a sea/cloud of delocalised electrons around a lattice of positive metal ions.

The strength of a metal depends on this bonding. It is controlled by the charge on the metal ion and the size of the metal ion.

The positive metal ions have a strong attraction to the delocalised cloud of electrons, this gives metals a high melting point.

Metals can conduct electricity as the delocalised electrons are free to carry charge through the structure of the metal.





MAIN ACTIVITY

Students will investigate how molecules bind together. Using the molecule cards (**worksheet 3**), or molymod sets if available, students will replicate various molecules important to life from their chemical formula.

A good start to this activity involves getting the students to replicate some common hydrocarbon structures such as **methane**, **ethane** etc. This can be achieved in varying ways, depending on the knowledge level of students. They could just be given the names of the molecules or the chemical formula. To make it simpler the structural formula could be given as well. Alternatively, they could build molecules and then attempt to name them as nomenclature practice.

Following on from a simple introduction, these chemical cards can be used to build on and extend students' understanding of molecular structure. A few examples of chemicals students may have come across is included below. These can be easily built by the cards included in this pack. It is also possible to use these cards to show the reactions between different molecules. This can be seen in a little more detail in the Plenary section of this lesson.

Example chemicals to build:

- Methane - CH_4
- Ammonia - NH_3
- Ethane - C_2H_6
- Ethanol - C_2H_6O
- Glycine - $C_2H_5NO_2$
- But-2-ene - C_4H_8
- Acetic Acid (Vinegar) - CH_3COOH
- Methylamine - CH_3NH_2
- Glycerol - $C_3H_8O_3$
- Butyric Acid - $C_4H_8O_2$

Time: 15 – 35 minutes

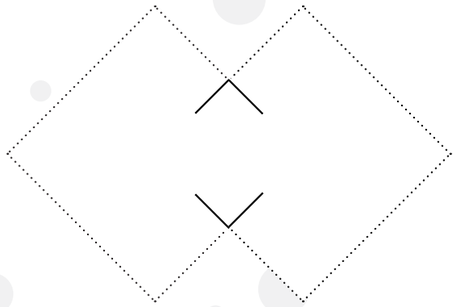
MOLECULES WORKSHEET 3

Print and cut these molecule cards out so that students can assemble molecules, for double bonds overlap on corners.

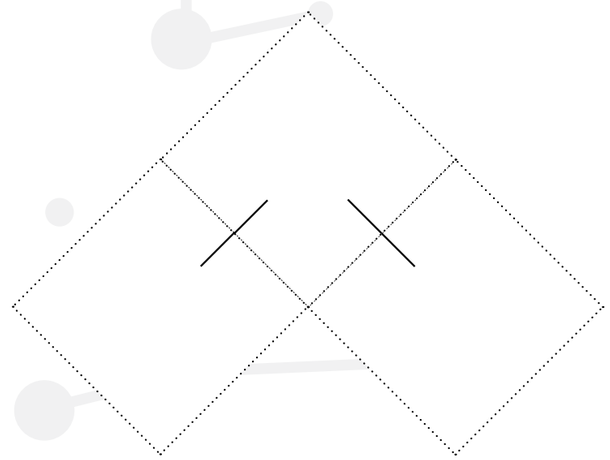
C	H	H	O
C	H	H	O
C	H	H	O
n	n	n	n

MOLECULES WORKSHEET 3A

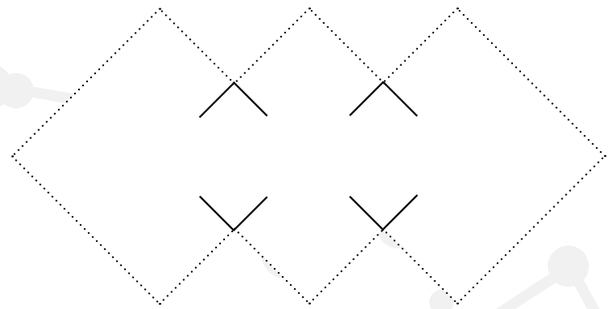
LAYOUT GUIDE: SIMPLE MOLECULES



O_2 - Oxygen



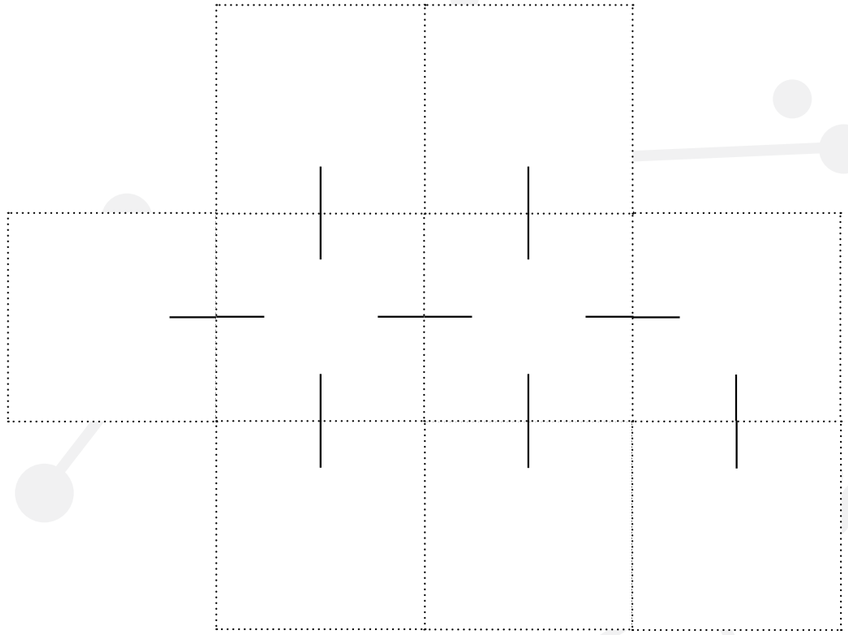
H_2O - Water



CO_2 - Carbon Dioxide

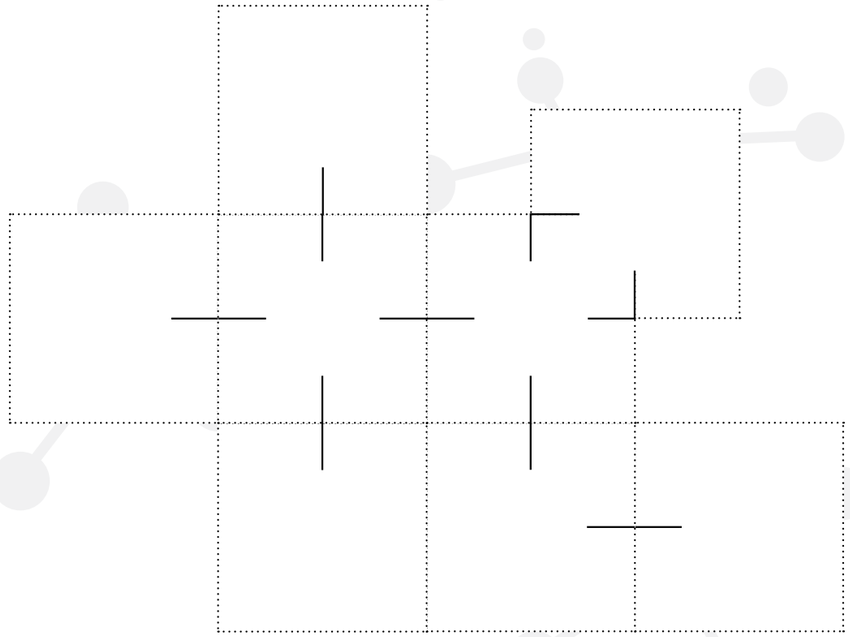
MOLECULES WORKSHEET 3B

LAYOUT GUIDE: ETHANOL - C_2H_5OH



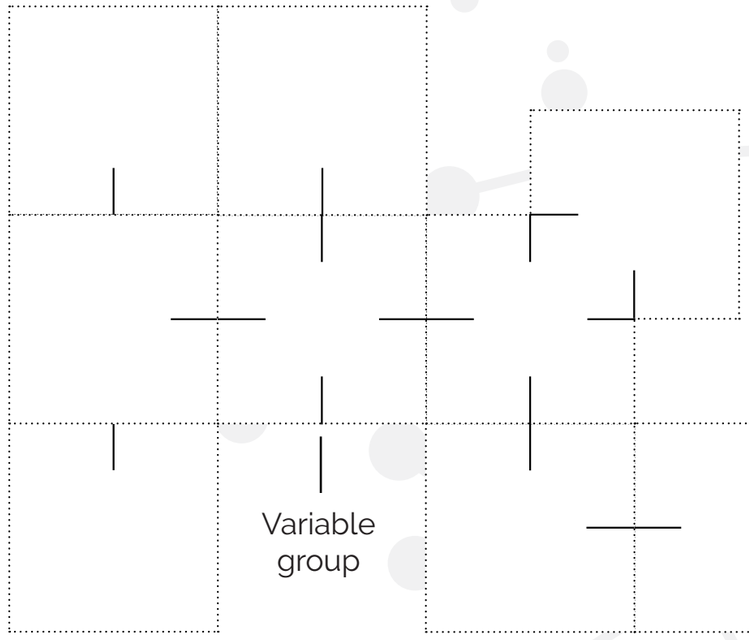
MOLECULES WORKSHEET 3C

LAYOUT GUIDE: ETHANOIC ACID (VINEGAR) - CH_3COOH



MOLECULES WORKSHEET 3D

LAYOUT GUIDE: AMINO ACID/PROTEIN



MOLECULES PLENARY

Using the molecule cards, we can investigate many natural reactions to see how molecules are changed from one molecule to another. Using the cards students can demonstrate the following reactions:

- Combustion of **alkanes**
- Fermentation of **glucose**
- **Ethene** and **steam** to produce **ethanol**
- Production of **esters** via **ethanol** and **ethanoic acid**

For each reaction the students will need to alter a chemical or add additional elements. Below are a couple of hints that can be useful in guiding the students towards the correct answer.

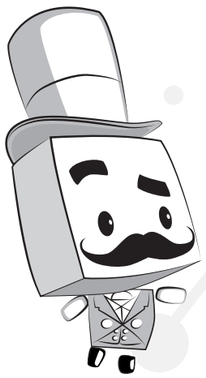
Combustion – Combustion is the reaction of a chemical with oxygen. Oxygen must be added to the system as part of the reaction. Combustion reactions are either complete or incomplete. In a complete reaction the entirety of the fuel (the **alkane** in this example) is converted **carbon dioxide** and water. Incomplete combustion yields **water** and **carbon monoxide**.

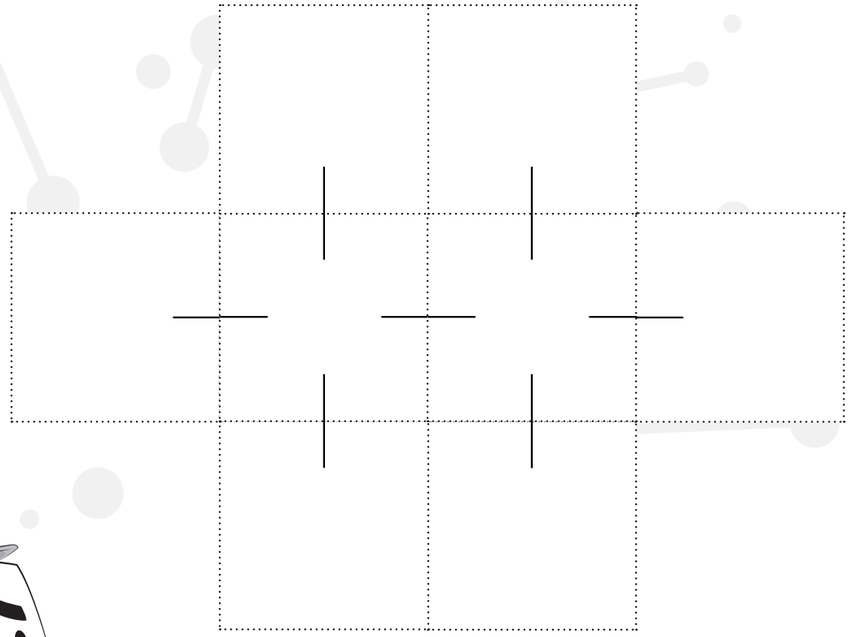
Fermentation of glucose – During the fermentation process **glucose** is converted to **ethanol** and **carbon dioxide**. With this information it should be simple for students to rearrange to see how the starting product is reduced to the two end products. Using the cards provided it is also possible as an extension to show the intermediary stages of **glycolysis** or even other variants of this reaction such as **lactic acid** fermentation.

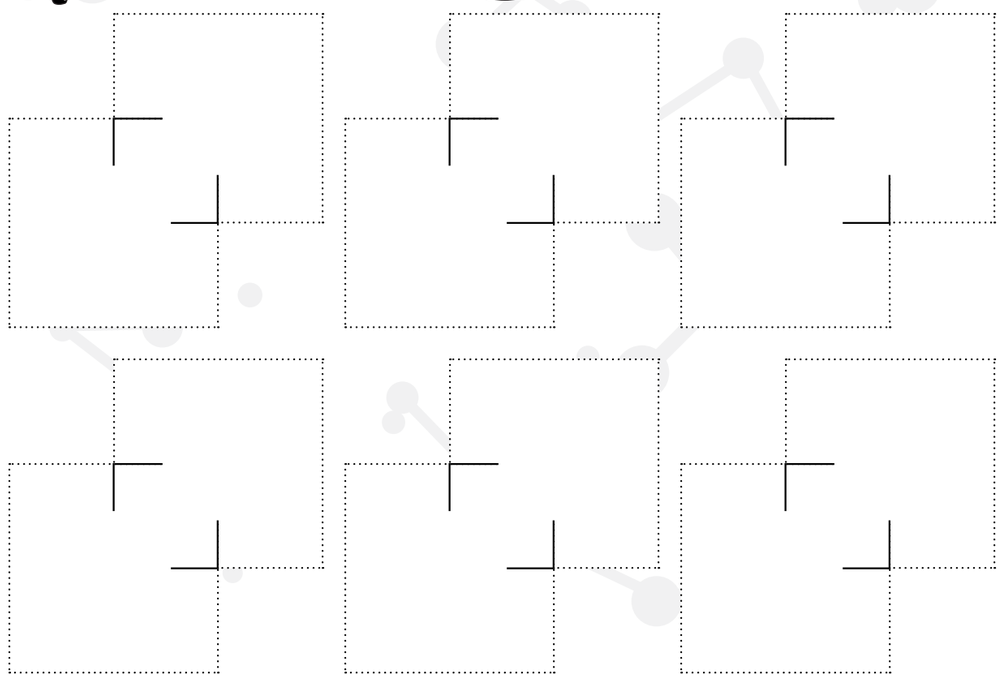
Ethene and steam -> ethanol – Fermentation provides one method to produce **ethanol**, another is to take **ethene** produced during crude oil cracking and react it together with **steam**.

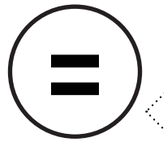
Production of esters – **Esters** are fragrant organic molecules. They are produced when alcohols and carboxylic acids are reacted together A simple example of this is the combination of **ethanol** and **acetic acid**. When these two molecules react together water is produced. This can be a useful clue to guide students towards showing this reaction in action.

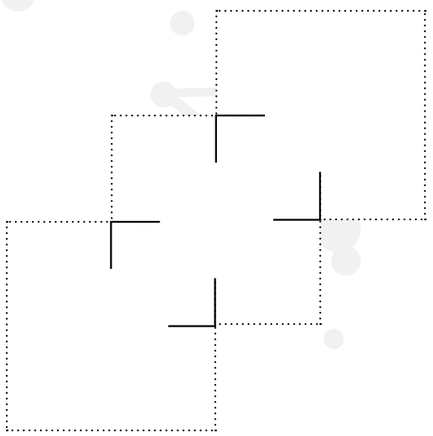
WORKSHEET 4A: LAYOUT GUIDE: COMBUSTION OF ALKANES

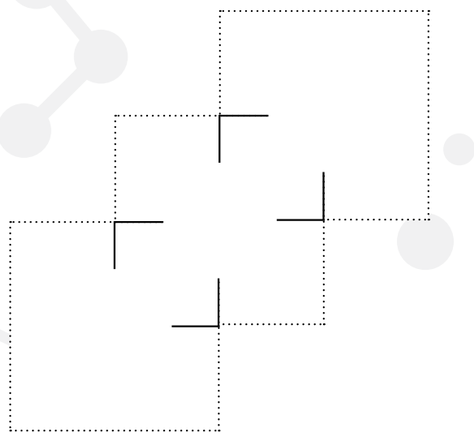




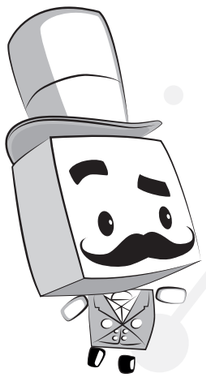


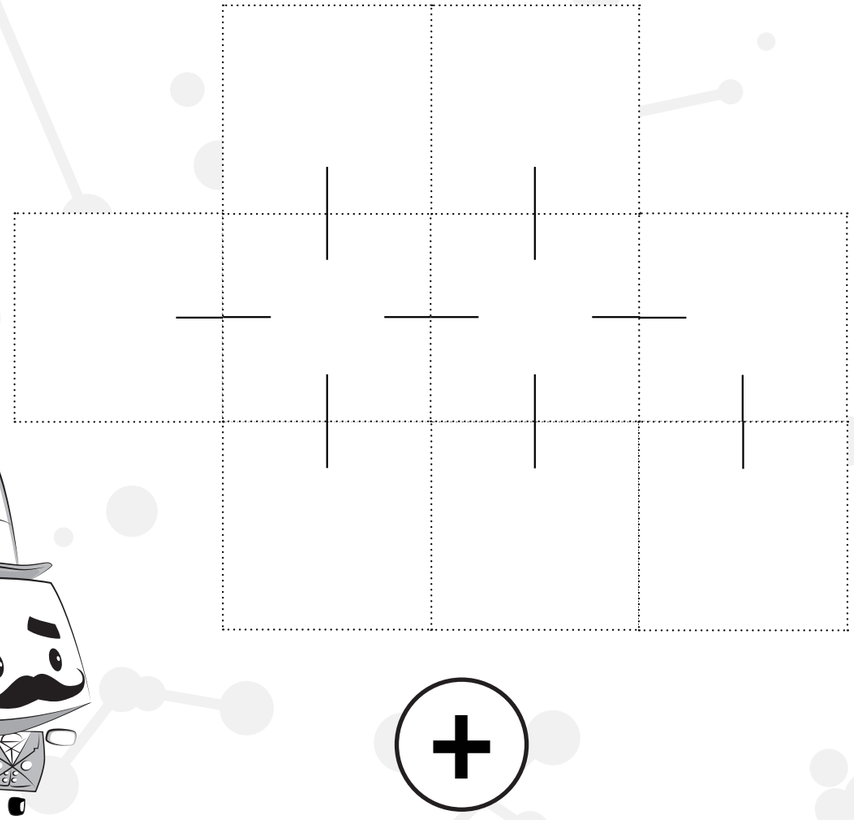


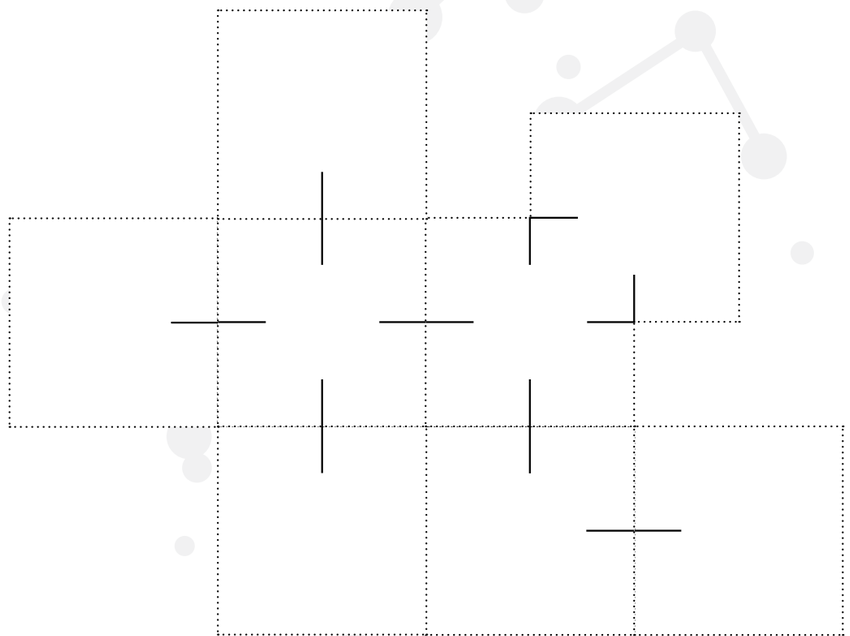


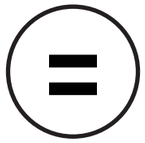


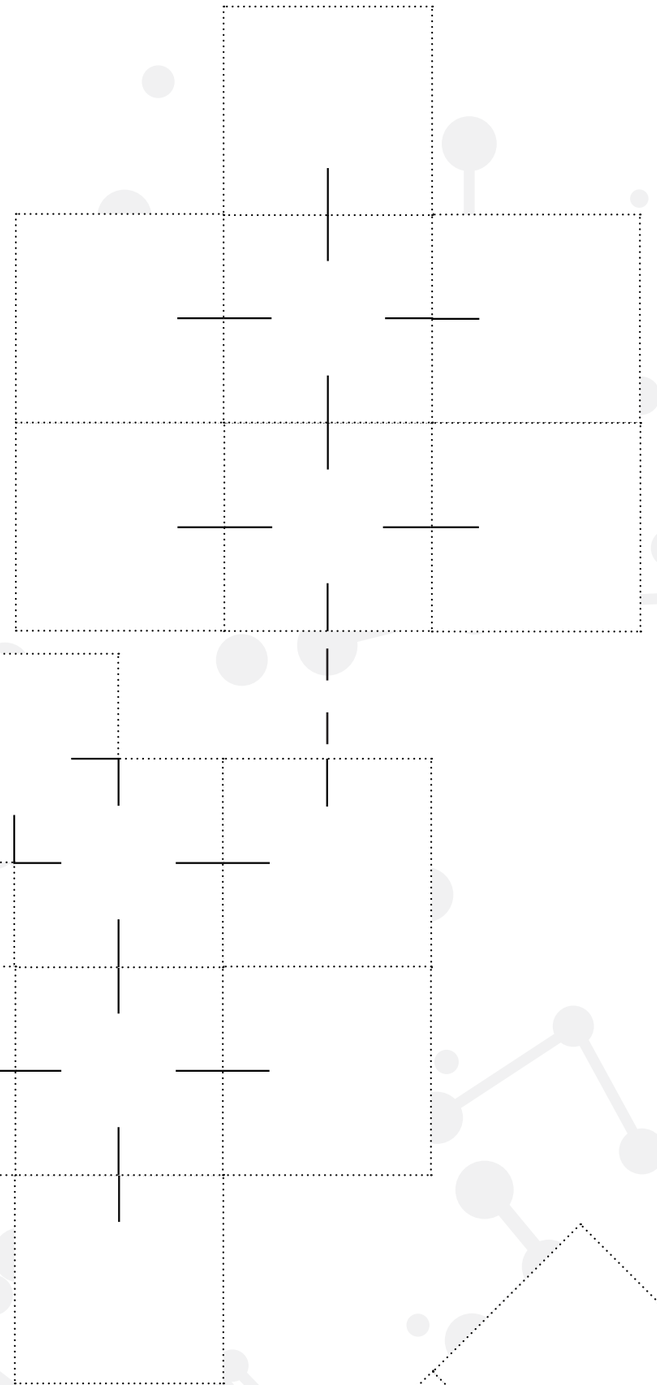
WORKSHEET 4B: LAYOUT GUIDE: PRODUCTION OF ESTERS

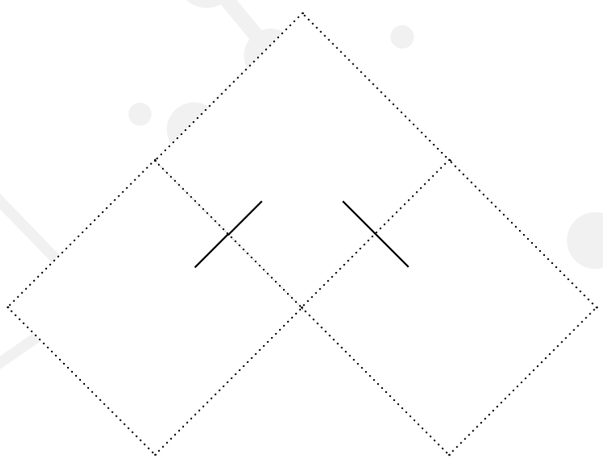












EDUCATOR PACK

ROLL UP, ROLL UP...
COME INSIDE AND EXPERIENCE
THE UNIVERSE LIKE NEVER BEFORE...

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EVOLUTION AND INHERITANCE

Age range: 9- 14
Curriculum Links:

Living things and their habitats
Give reasons for classifying plants and animals based on specific characteristics

Evolution and Inheritance
Identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution.

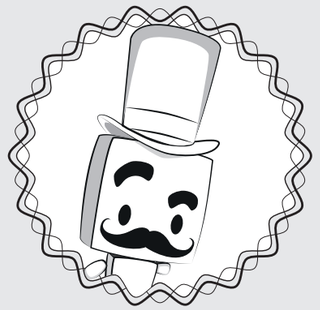
EVOLUTION AND INHERITANCE LESSON OVERVIEW

In this lesson students will learn about the evolution of animals and understand the difference between evolution, inheritance and mutation. They will look at habitats in which animals live and how some random mutations may be beneficial in some habitats and some mutations are not.

This is taught through a simple dice game that can be played in groups or individually.

Students will draw an animal, either real or fictional, then they will roll the die to find out what happens next. Each time a player rolls the die an event or mutation will take place. These are listed on **Worksheet 3**. The player will need to note down the outcome of each roll using **Worksheet 4**.

This will tell them how well the population of their animal fared. The game can be played for as many times as you like, but it is recommended each player rolls at least 6 times.

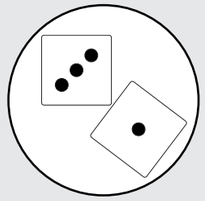


Please make sure all worksheets are printed on single sided sheets as they may need to be displayed separately or cut up for the activities.

EVOLUTION AND INHERITANCE

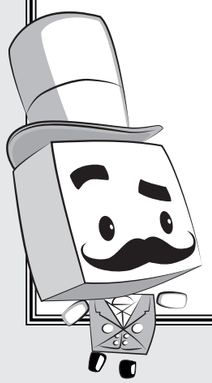
YOU WILL NEED

Worksheets



Dice

LEARNING OUTCOMES



1. Understand the classification of living things based on their habitat

2. Understand inheritance, evolution and mutation

3. Understand these changes can be good or bad

CONTENTS

STARTER ACTIVITY

Students to sort animal cards into different habitats and discuss what features help them to live in each area. Would they still survive in another habitat and why?

Time: 0 – 15 mins

MAIN ACTIVITY

The Evolution Game! Students will design an animal and follow its evolution through a series of changes to its environment. Will they survive, thrive and evolve to adapt as their habitat changes?

Time: 15 – 45 minutes

PLENARY

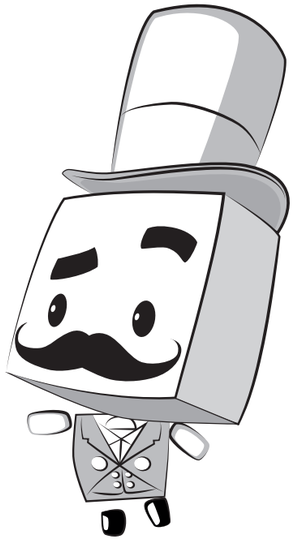
Discuss which animals lasted the longest or survived the best. Why was this. Would they have survived in the other environments or were they particularly suited to their environment?

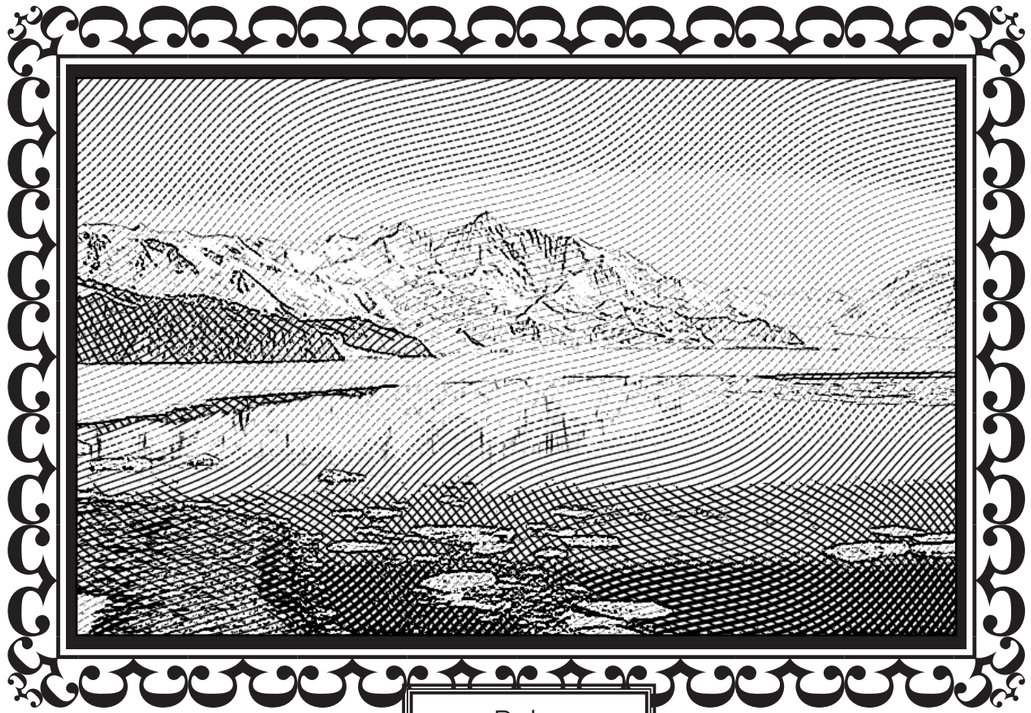
Time: 45 – 60 minutes

STARTER ACTIVITY

“Sort the animal cards into different habitats and discuss what features help them to live in each area.

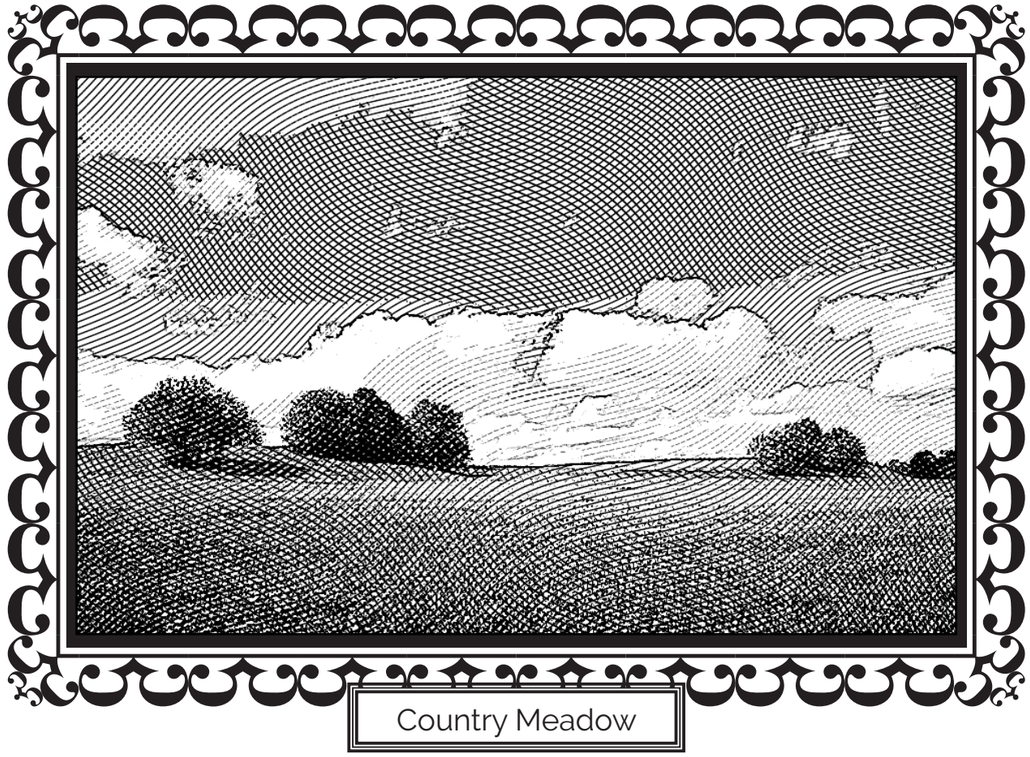
Do you think they would be able to survive in another habitat?”



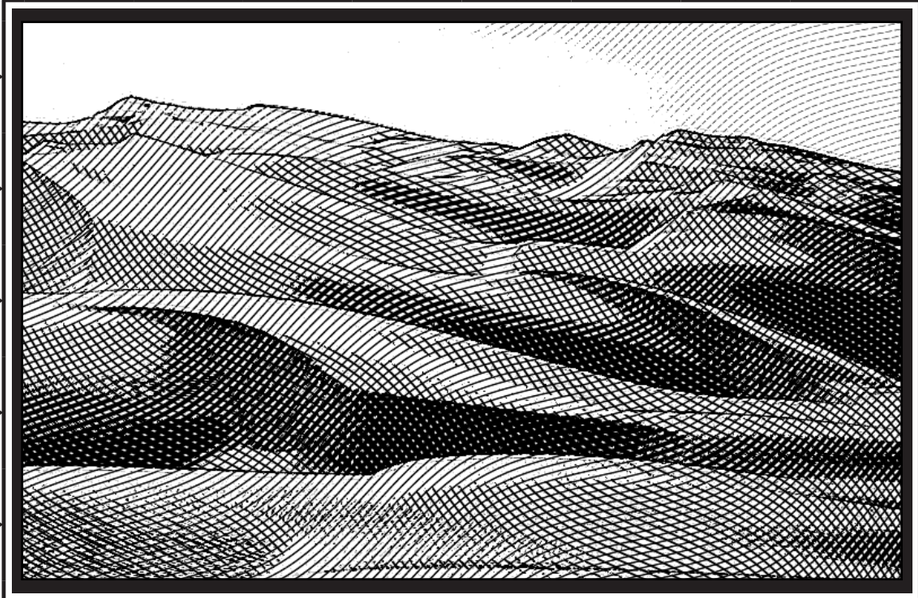


Polar

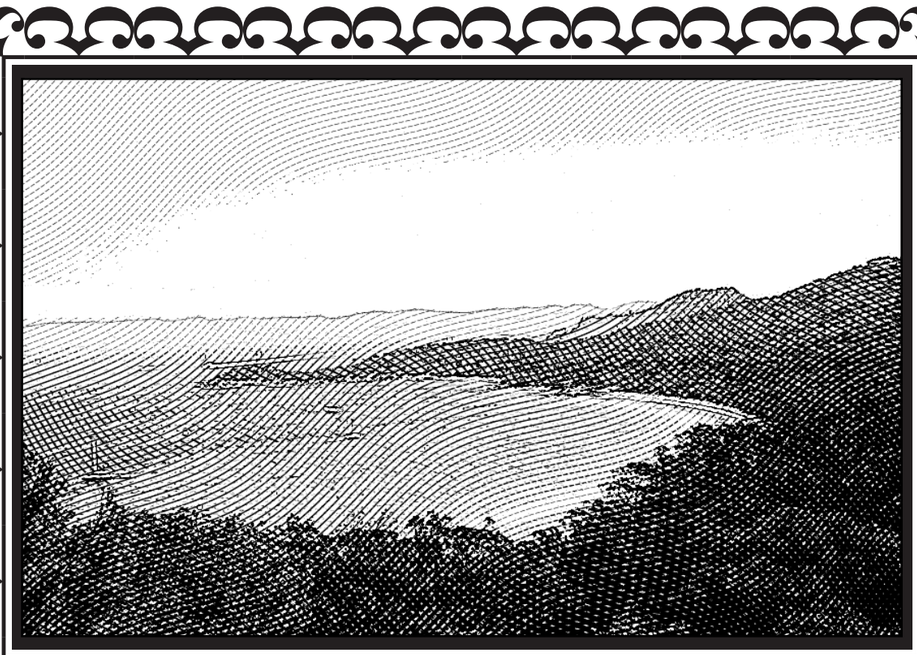
Rainforest



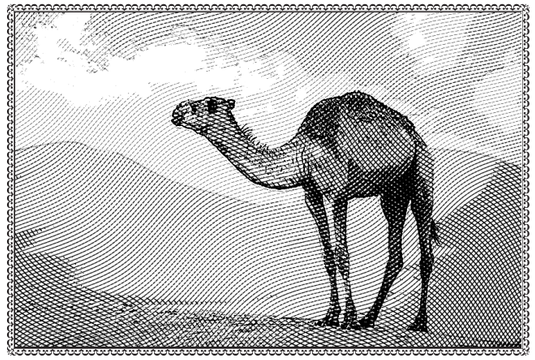
Country Meadow



Desert



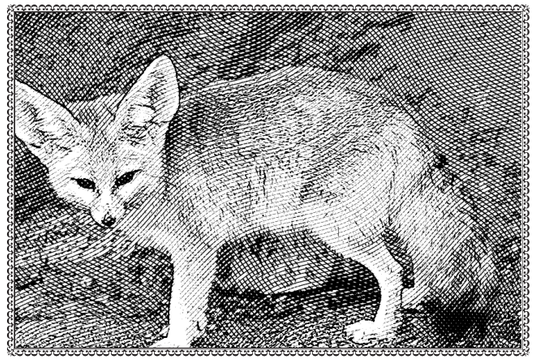
By the sea



Camel

Features:

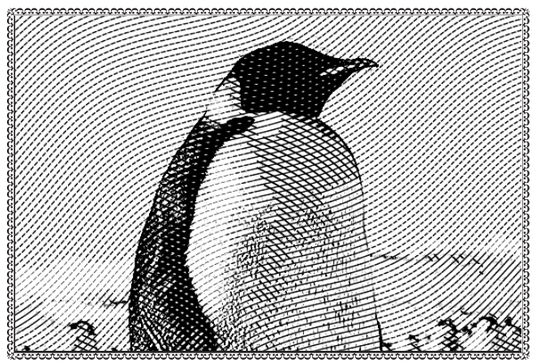
- Long eyelashes for dealing with sandy conditions.
- Camels store fat in their hump to use for energy.
- Thick lips to help eat prickly plants.
- Blend with their environment due to their sandy colouring.



Fennec Fox

Features:

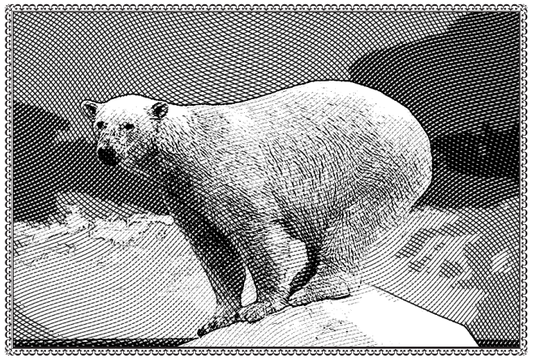
- Large ears dissipate excess body heat on hot days.
- Nocturnal animals come out at night when it is cooler.
- Thick fur on the soles of their feet help to insulate their bodies.



Penguin

Features:

- Webbed feet for swimming at speeds up to 15mph.
- Thick skin and blubber help them to keep warm in cold weather.
- Dark coloured feathers help to absorb heat.



Polar Bear

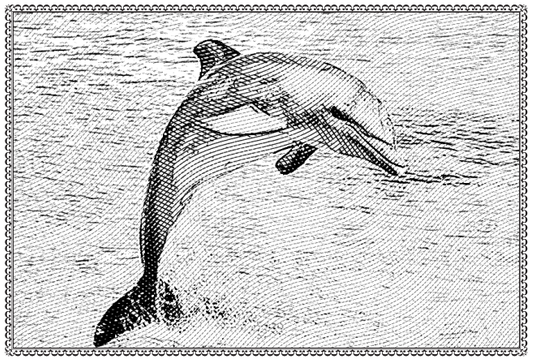
Features:

- White fur helps them to blend with their surroundings.
- A layer of fat under the skin helps to keep the polar bear warm in cold conditions.
- Large wide paws help the polar bear to swim.

Mouse

Features:

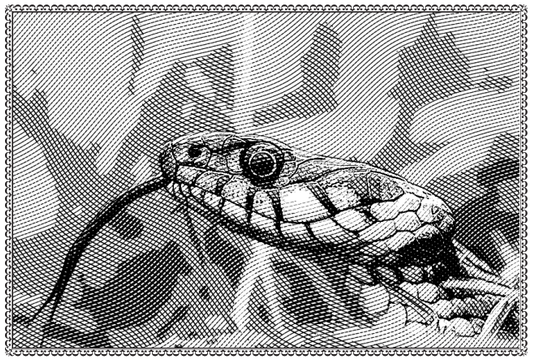
- Omnivores can eat almost anything to survive.
- They can burrow underground to protect themselves from predators.
- Mice are good jumpers and can jump up to 18 inches.



Dolphin

Features:

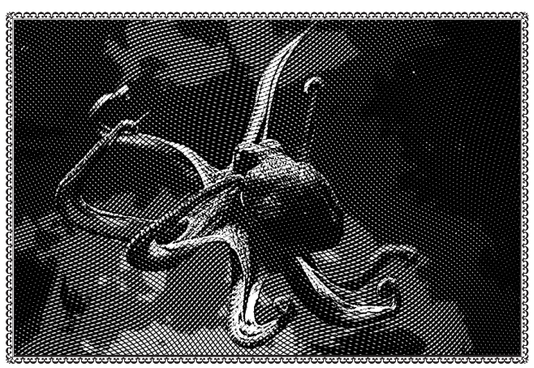
- Mammals.
- Flippers to help them move through water.
- They have a layer of blubber under the skin to insulate and keep the dolphin warm.
- Breathes air so needs to come to the surface regularly.



Grass Snake

Features:

- They have no legs or arms.
- They can slither through grass.
- They can smell with their tongue to find their prey.
- Jaws are adapted to open as wide as possible to help eat large sized prey.



Octopus

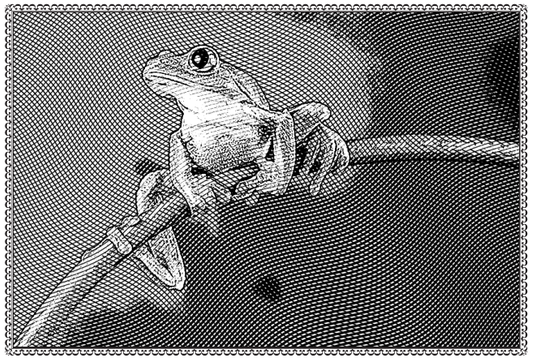
Features:

- 2 rear arms operate like legs to push off hard floors.
- Can change colour to adapt to their environment.
- Can squeeze through small spaces to avoid predators and find prey.

Spider Monkey

Features:

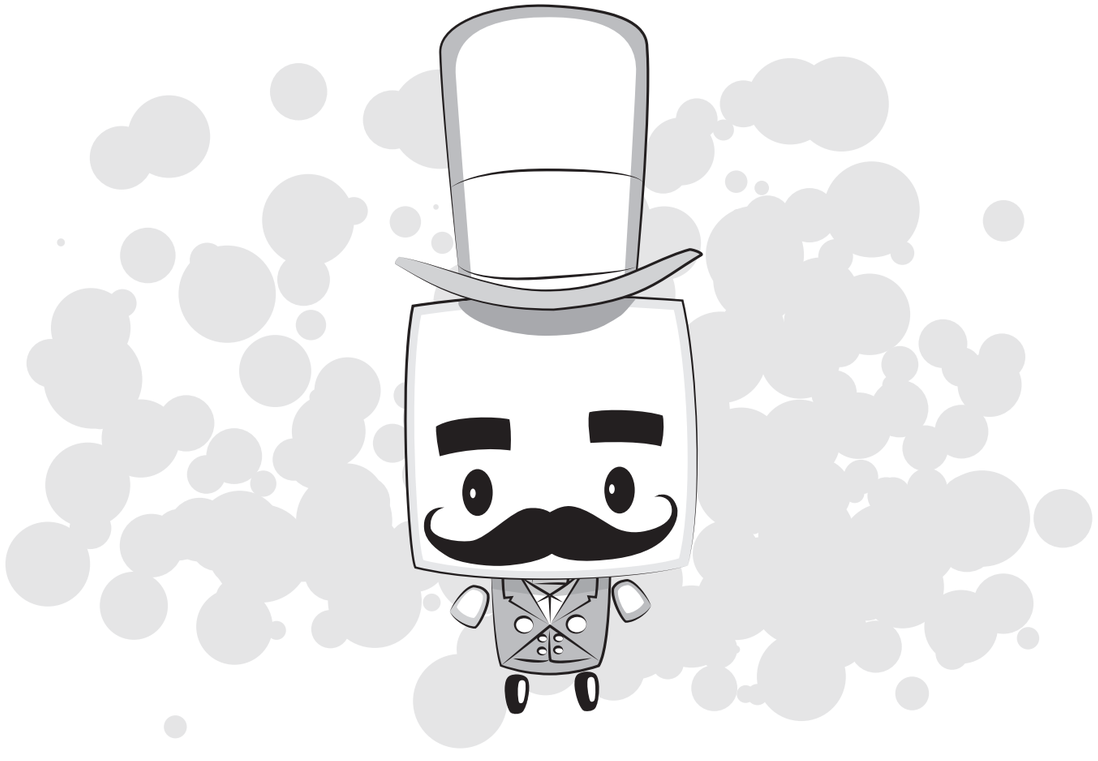
- Long limbs to help swing from trees.
- They spend all their time in the trees which conserves energy and helps them find food.
- They don't have an opposable thumb as this is not helpful for moving through trees.



Tree Frog

Features:

- Bright red eyes stun their predators and give them chance to escape.
- It also helps them to see at night.
- They have sticky discs on their feet to help them climb trees.

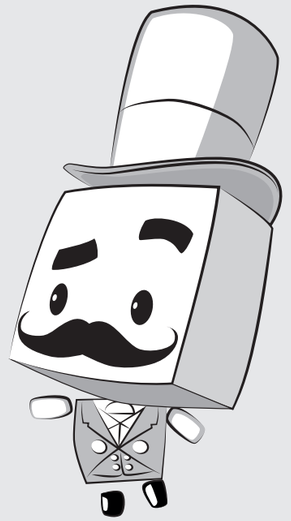


MAIN ACTIVITY: THE EVOLUTION GAME!

Make sure students understand that we inherit certain characteristics from our parents but some things change due to random mutations.

Evolution is the change in hereditable characteristics over a few generations.

Charles Darwin put forward the theory of natural selection. This is the process in which the best adapted parents will have more children and thus spread these characteristics.



Now students will experiment with random mutation and characteristics with the evolution game.

First, each student should design an animal that would thrive in this environment (refer back to mutation, inheritance and natural selection and make sure children understand characteristics change over generations due to evolution and natural selection).

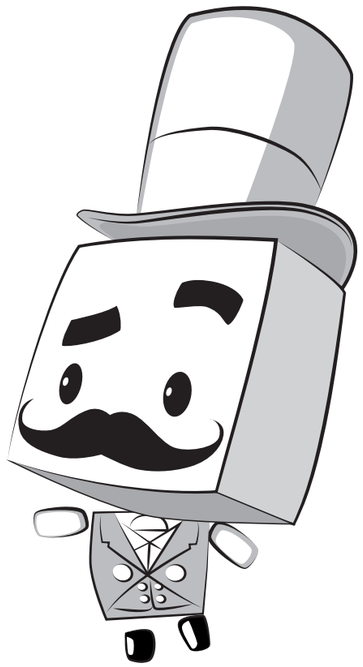
Next, each student should roll the dice to decide which environment it lives in.

Next, students must play the game. Each student must roll the dice at least 3 times and up to 6 depending on the time you have. Each roll of the die is a generation of their animal.

After each roll students must write down how well that generation would have fared in their chosen environment

Time: 15 – 45 minutes

THE EVOLUTION GAME!



Evolution is the process of change to life over time and generations. Mutations are the changes to genes that are not inherited from parents, and are random changes. Sometimes these mutations can be beneficial to the animal and sometimes not. If beneficial, these mutations may, over generations, become the adaptations that help life to evolve to live in certain environments.

In the following game you will roll the dice to see what changes happen to your animal's population. These changes can be to your animal's characteristics (random mutations) or to the environment in which it lives.

Game instructions:

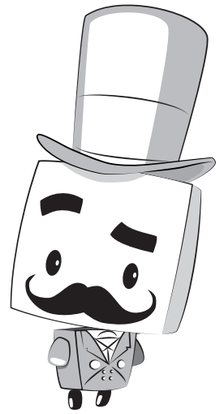
1. Draw your animal (either real or fictional) on **Worksheet 1**
2. Write down the important features of your animal including what it eats
3. Roll the die to find out which habitat your animal lives in – these are listed on **Worksheet 2**
4. Cut out the Chance Cards (from **Worksheet 3**) and have these facedown ready on the table

Each time you roll the dice, use **Worksheet 3** to find out what changes have happened to your animal. If you roll a 2, 3 or 4 you will need to roll again to find out the exact change that has taken place.

5. You then need to note down on **Worksheet 4**, how well your animal fares on each roll of the dice and how many of the population survive.

EVOLUTION AND INHERITANCE - WORKSHEET 1

"Roll the dice to find out which habitat your animal lives in. The number of the habitat is on the top of each of the habitat cards."



Habitat

What features help your animal to live here?

What does your animal eat?
Meat/ fish/ insects/ plants

What features could help your animal to eat this?

What is the name of your animal?

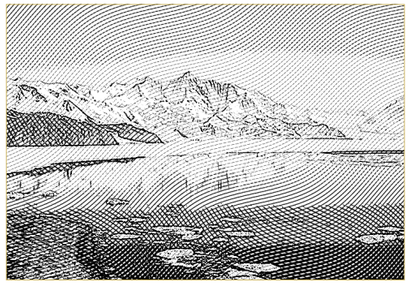
DRAW YOUR ANIMAL IN THE BOX

EVOLUTION AND INHERITANCE - WORKSHEET 2

1: DESERT

- Barren landscape which can be hostile for plant and animal life. There is a distinct lack of vegetation.
- There is little water in this area.
- Much of the land is covered in sand, which can become blown around by dust storms.
- Day time can be very hot and night time very cold average temp 34°c.
- There are beetles that live in this area.

2: POLAR REGION



- Receives the least amount of sunlight and are therefore the coldest of our habitats. Cold winds whip across the surface and cause blizzard conditions.
- During winter dark night can last for months and during the summer a day can last equally for months. Average temperature is -5°c.
- Dry environment due to lack of rain. Much of the water is frozen over in the winter months.
- During the summer months there are many types of fish and birds in this area.

EVOLUTION AND INHERITANCE - WORKSHEET 2

3: BY THE SEA

- Coastal habitat where water meets land this habitat has sandy beaches and warm environment.
- This area has much rain and sunshine.
- Occasional high winds and waves.
- Molluscs can be found clinging to the rocks and there is a huge variety of seaweed.
- Average temperature is 25°c.

4: COUNTRYSIDE: MEADOW

- This area is full of an abundance of vegetation and colour. There are small streams of fresh water.
- The temperature varies during the year but is generally warm 16°c average temp.
- There is a lot of rain in this area.
- There is a lot of long grass in this area and the ground is very flat but it can be easy for predators to spot small animals.

EVOLUTION AND INHERITANCE - WORKSHEET 2

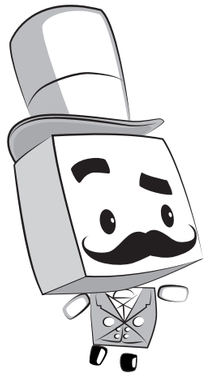
5: COUNTRYSIDE: WOODLAND

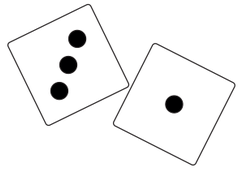
- This area is full of an abundance of vegetation and colour. There are small ponds of standing water.
- The temperature varies during the year but 10°c is the average temp at night the temperature drops and becomes rather cold. It can be very dark.
- There is a lot of rain in this area.
- There are many tall trees with green leaves and lots of flowering plants in this area there are many predators in this area that can fly.

6: RAINFOREST

- This area is full of an abundance of vegetation and colour. There are large lakes and waterfalls.
- The temperature is generally warm, 25°c on average.
- There is a huge amount of rain in this area.
- There are many tall trees with large green leaves.
- There are large carnivorous mammals in this area which are predators for smaller animals.

EVOLUTION AND INHERITANCE - WORKSHEET 3



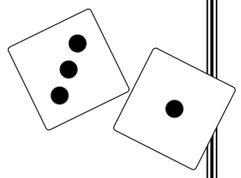


DICE ROLL

1. **No change**
2. **Colour change** – roll the dice again and find out which colour your animal changes to in the box below.
3. **Feature change** - Change 1 feature of your animal – roll the dice again to find out which in the box below. Roll a third time to find out if the feature gets bigger or smaller.
4. **Change the habitat of your animal** – roll the dice again to find out which from the numbered habitat cards (if you get the same habitat roll again)

5 or 6. Pick up a chance card

COLOUR:

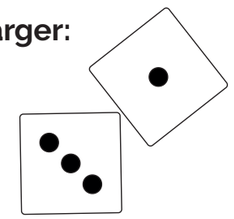


1. Red
2. Green
3. Brown
4. Yellow
5. Black
6. Pink

FEATURES:

1. Tail
2. Legs
3. Eyelashes
4. Neck
5. Eyes
6. Mouth or Beak

Roll to find out if your animal's features get smaller or larger:



Roll 1 – 3 for feature to get larger
Roll 4 – 6 for the feature to get smaller

EVOLUTION AND INHERITANCE - CHANCE CARDS

CHANCE

The temperature rises by 5°c in your environment. This lasts for 1 turn.

CHANCE

Predators pray on your animal and many of your species are wiped out this turn.

CHANCE

There is heavy rain for 1 turn.

CHANCE

A new predator arrives in your habitat you must be camouflaged to survive for the rest of your turns.

CHANCE

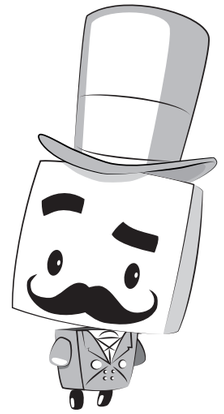
A new food source can be found in your habitat. Congratulations there is an abundance of food for your animal for the rest of your turns.

CHANCE

There is heavy snowfall and temperatures drop to -1°c for 1 turn.

CHANCE

There is drought in your habitat for 1 turn.



EVOLUTION AND INHERITANCE - WORKSHEET 4

After each roll of the dice decide how well your animal would have survived:

1. Is the temperature in this habitat suitable for your animal? YES/NO

2. Was there enough food for your animal? YES/NO

3. Is your animal safe from predators? YES/NO

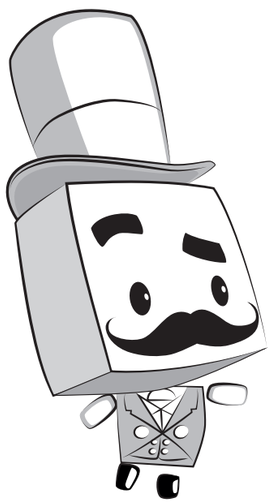
If you answered yes to all 3 questions well done 100% of the population survived *and* it doubled in size!

If you answered **no** to **1** question, **100 %** of the population survived.

If you answered **no** to **2** questions, only **50%** of the population survived

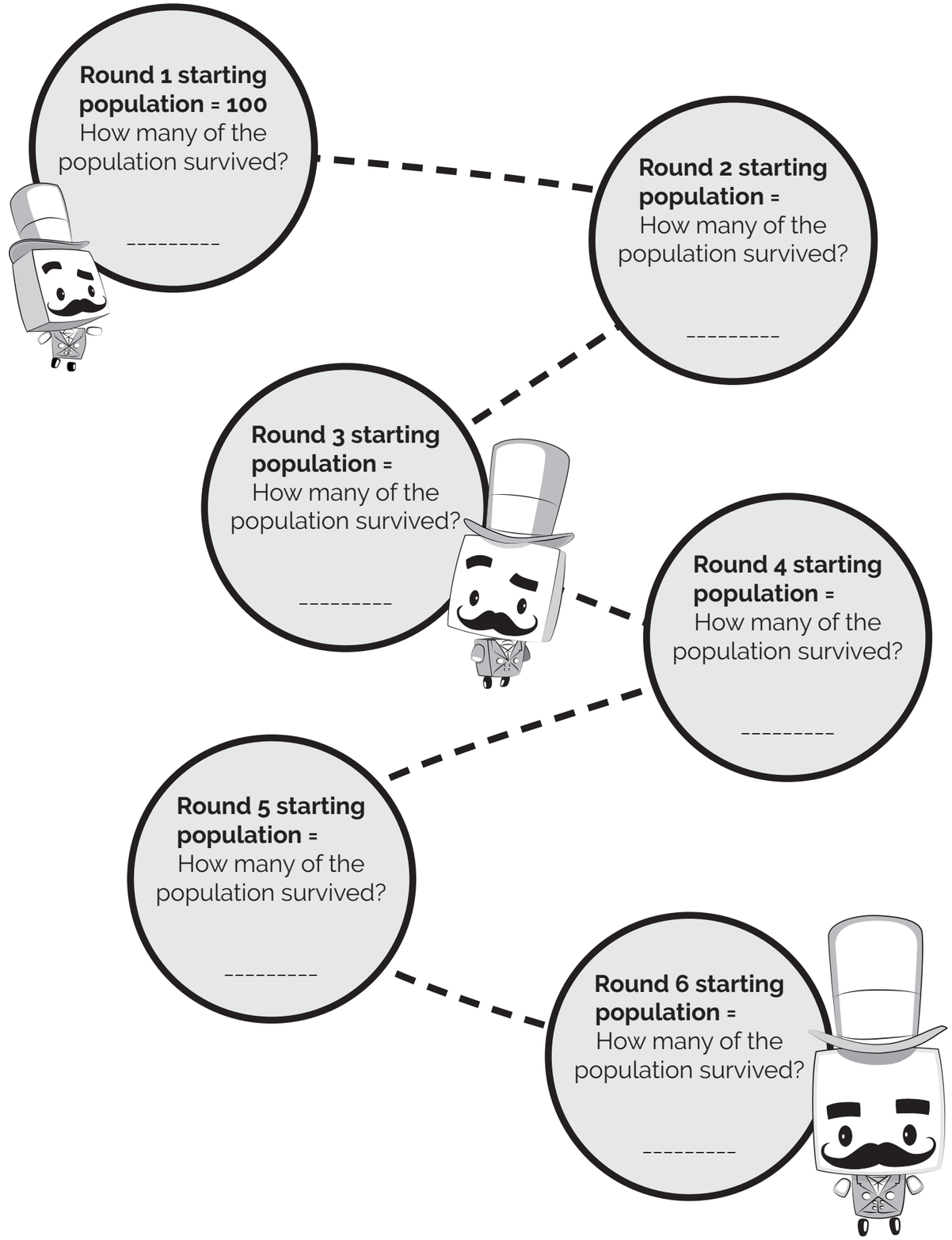
If you answered **no** to all **3** questions only **25%** of the population survived

Assuming you started with 100 as your original population what is your end result?



"At the end of the game, if less than ten of your population are still alive, they are now an endangered species.

If you have more than 200 your population is thriving! Well done!"



PLENARY

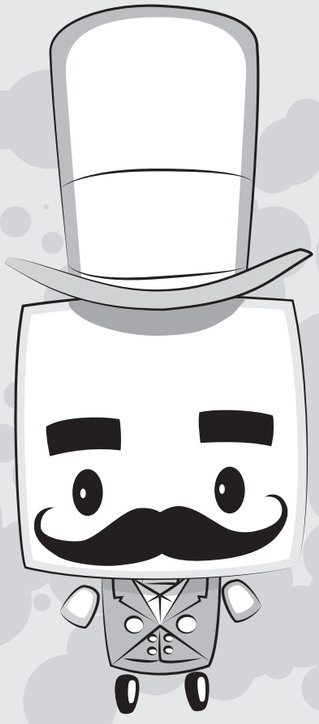
Discuss which animals lasted the longest or survived the best. Why was this? Would they have survived in the other environments or were they particularly suited to their environment?

Give students the following words and ask them to write questions for which that word would be the answer.

Mutation
Habitat
Adaptation
Evolution
Inheritance

Students can then share questions and make sure they are correct. This can be done in small groups as a peer assessment activity. This will check students' understanding and address any misconceptions.

Time: 45 – 60 minutes



EDUCATOR PACK

ROLL UP, ROLL UP...
COME INSIDE AND EXPERIENCE
THE UNIVERSE LIKE NEVER BEFORE...

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WE ARE STARS - GLOSSARY

A

Adaptation
Asteroid – A small rocky body orbiting the Sun
Atmosphere - The envelope of gases surrounding the Earth or another planet
Atom – The smallest particle of a chemical element that can exist

B

Big bang – The cataclysmic explosion thought to have started the universe
Black hole – A region of space with a gravitational field so intense that nothing can escape

C

Combustion – Rapid chemical combination of a substance with oxygen.
Comet – An icy body orbiting the Sun
Compound – Something made up of two or more elements
Covalent Bond – A molecular bond between atoms that involves the sharing of electrons
Craters – The bowl-shaped structure left in the ground after a meteorite impact

D

Dwarf planet – A small body similar to a planet that does not meet the planetary criteria

E

Electron – A negatively charged sub-atomic particle. They are found in all atoms
Element – The simplest substances available. They cannot be chemically broken down into anything simpler
Evolution – The gradual development of something
Extinction – The disappearance of a species from the Earth

F

Fermentation – Chemical breakdown of a substance by bacteria, yeast or other microorganisms
Fossil – Remains of a living thing, preserved by petrification
Fusion – A nuclear reaction where light (low atomic number) elements join together with other to form heavier (higher atomic number) elements
Fusion crust – A glassy coating formed on a meteorite when its surface cools after entering an atmosphere

G

Gravity – The force that attracts one object to another. The strength of the force is determined by the two objects mass

H

Habitat – The natural environment of an organism
Hydrocarbon – A compound made of hydrogen and carbon

I

Inheritance – A trait that is passed from a parent organism to a child as a result of genetics
Ion – An atom or molecule that has a net electric charge. This can be a result of gaining or losing one or more electrons
Ionic Bond – A molecular bond between ions with opposite electric charges

M

Main Sequence star – A star is in the Main sequence when it is fusing hydrogen and there is a balance between the inward force of gravity and the outward reaction pressure
Mantle – the region of a planetary body between its crust and its core.
Chondrules – A spherical mineral grain found in stony meteorites
Meteor – A piece of material falling from space interacting with an atmosphere (sometimes called a shooting star when seen on Earth)

Meteorites – A piece of material (usually rock or metal) that has fallen from space to the surface of the Earth (or other celestial object)
Meteoroid – A small piece of material found in space, often fragments of asteroids or comets
Minerals – A solid, naturally occurring inorganic material
Molecule – A group of atoms that are bonded together
The Moon – The natural satellite of the Earth
A moon – A natural satellite of any planet
Mutation – A separate distinct form created by a change in an organism's genetic makeup

N

Nebula – a cloud of gas and dust in outer space. Often visible in the night sky
Neutron – A subatomic particle that has the same mass as a proton, but instead has no electric charge
Neutron star – A very small and dense remnant formed after the collapse of a massive star. Mainly made of closely packed neutrons

P

Planet – A celestial body in orbit around the Sun. The International Astronomical Union set the following rules for officially being a planet.
A celestial body which:
1 – Is in orbit around the Sun
2 – Has sufficient mass to assumer hydrostatic equilibrium (a nearly round shape)
3 – Has 'cleared the neighbourhood' in its orbit
Planetary Nebula – A ring or spherical shaped nebula formed by a shell of material expanding around an ageing star.
Proto star – A collection of gas that is coming together in the early stages of star formation, before nuclear fusion has begun.
Proton – A subatomic particle that occurs in all atomic nuclei. This particle has a net positive charge

Q

Quark – A subatomic particle that has a fractional electric charge, these join together to form other subatomic particles, like protons and neutrons

R

Red dwarf – A small, cool star
Red Giant – A large, cool star

S

Satellite – an artificial body placed in orbit round the Earth or another planet to collect information
Silicates – a mineral that contains silica (silicon and oxygen)
Solar system - The system of Planets, moons and other celestial bodies that orbit the Sun.
Star – A object in space that emits energy generated by nuclear fusion. Usually consists of a self-gravitating ball of gas
Subatomic – something smaller than a single atom
Supernova – A star that undergoes a catastrophic explosion that ejects most of its mass

T

The great bombardment period – A period roughly 700 million years after the formation of the solar system, when the inner objects of the solar system were bombarded by many comets, asteroids and planetary fragments

U

Universe – all existing matter and space

W

White dwarf – A small, very dense star, roughly the size of a planet.