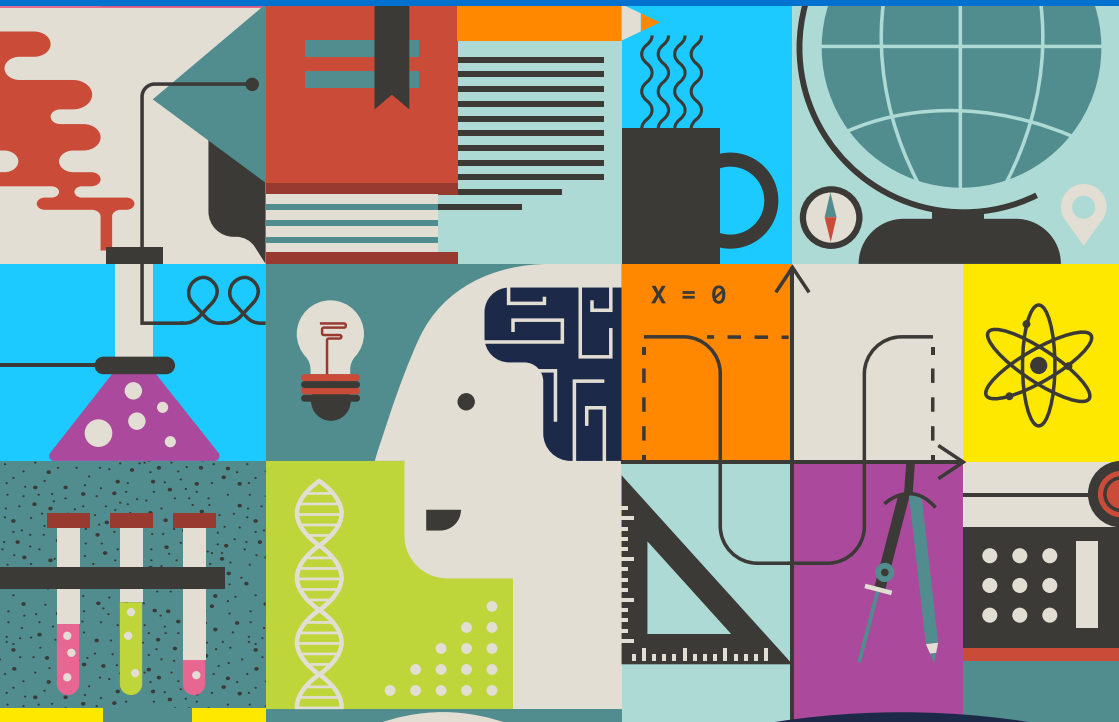
Big Book of Experiments

and bright ideas



Armagh Observatory & Planetarium

Exploring the Cosmos since 1790

INTRODUCTION

At the Armagh Observatory and Planetarium (AOP) our mission is to carry out front-line astronomy research and to make science accessible and easy to understand for everyone through education. The covid pandemic did not stop us from achieving this as our education team adapted and developed a new inspiring Science@Home programme. Starting out with a few experimental videos, the series grew in popularity throughout the lockdowns. This included online events such as interviews with our research staff and other famous astronomers, virtual star-gazing sessions and, last but not least, science experiment videos showing how to get involved and inspired from home. All of our activities can be viewed on our YouTube channel.

This book brings you our best Science@Home experiments with easy instructions, walkthrough videos and additional **"Did you know"** facts that will bring out the scientist in you from the comfort of your classroom. We hope you enjoy these experiments and share your own videos and photos with us on our social media channels @armaghplanet. Who knows, you might even be inspired to seek work experience or even embark in a research or outreach project at the Armagh Observatory & Planetarium in the near future!

For more information on AOP visit www.armagh.space

Thank you and enjoy the book!

The Science@Home AOP team

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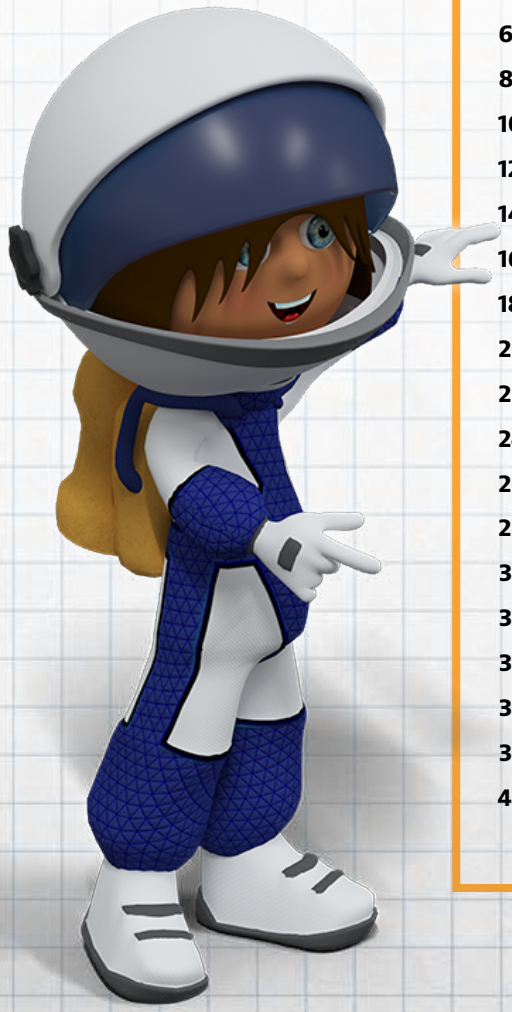

EASY:

MEDIUM:

DIFFICULT:

Moon Sand

You will need:

- Flour
- Baby Oil
- Mixing Bowl
- Spoon

Steps:

1. Add 4 cups of flour to a mixing bowl.
2. Pour in half a cup of baby oil and mix.
3. For more fun and best results mix with your hands!
4. Now you have mouldable Moon sand! What shapes can you make?

When you are finished playing, store in an airtight container until you are ready to play again.

DID YOU KNOW?

The surface of the Moon is covered in fine grey dust, some of which stuck to Apollo astronauts' spacesuits even as they returned to their Lunar Modules. Apparently, it smelled like gunpowder, although Buzz Aldrin, the second man on the Moon, said: 'It was like burnt charcoal, or like the ashes that are in a fireplace, especially if you sprinkle a little water on them.' Interestingly, the samples of lunar rock and dust that they returned to Earth now do not have any smell at all.

Tornado in a Jar

DID YOU KNOW?

The countries with most tornados per unit area in the world are not the USA and Canada – as you might think, because they are the most famous for them – but in fact the Netherlands and the UK! The UK sees about 30-50 tornados per year, but they are almost always small and do not cause damage. The UK is also home to one of the largest whirlpools in the world: the Gulf of Corryvreckan off the north coast of Jura in Scotland sees very strong tidal currents which, together with local geography, create a strong whirlpool, the sound of which can be heard ten miles away!

You will need:

- Water
- Washing Up Liquid
- Vinegar
- Glitter
- Jar
- Teaspoon

Steps:

1. Fill a jar with water not quite to the top. Add a teaspoon of washing up liquid, this creates some suds to see the tornado. Pour in a teaspoon of vinegar, this helps reduce too many suds forming.
2. Add glitter, this will act as debris in the tornado. Place the lid on the jar ensuring it is tightly closed.
3. Next, simply hold the jar carefully by the lid and rotate in a circular motion and watch as a tornado vortex forms!

The Science Behind

When you spin the water rather than air, you make a whirlpool rather than a tornado. The process behind both is quite similar. The 'tornado' in the jar appeared because of the combination of water's inertia (reluctance to move) and you forcing it to swirl around. The water is pushed to the sides of the jar, while the air and the soap suds are pushed to the middle because they are less dense than water. This creates the funnel shape, made even more visible by the soap suds.

Make your own Volcano

You will need:

- Baking soda
- Vinegar
- Red food colouring
- Small plastic bottle, beaker or glass
  (a small opening works best!)
- Tray
- Jug

Steps:

1. Place a bottle on a tray as things can get messy!
2. Add 3-4 tablespoons of baking soda to the bottle. You might need to use a funnel.
3. Pour 300ml of vinegar into a jug and add a few drops of red food colouring.
4. Pour the vinegar into the bottle and watch the volcano erupt!

DID YOU KNOW?

The largest volcano in our Solar System is Olympus Mons on Mars. It's over 21,000 metres tall which is almost two and a half Mount Everests on top of one another. Olympus Mons is so large for many reasons, the main one being that Mars is smaller than the Earth, which means its gravity is weaker, so mountains can rise taller. There is also less erosion than on Earth.

The Science Behind

Baking soda and vinegar combine with one another in a chemical reaction! Baking soda is a base and vinegar is an acid. Together they produce sodium acetate (we call that a salt, but it's not the same as table salt!), water, and carbon dioxide. Carbon dioxide (CO_2) is what makes the mixture bubble and foam, just like it does in fizzy drinks. CO_2 is also what is captured by the balloon in 'try this'. Unlike lava in a volcano, the mixture will be cool, not hot.

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Try this!

Pour vinegar into an empty bottle and add a few tablespoons of baking soda into a balloon. Place the balloon over the bottle neck and the baking soda will fall in.

What happens to the balloon?

Balloon Universe

The Science Behind

As the balloon inflates, its rubber membrane expands and has larger surface area. The dots or stars do not grow larger with it, so the distances between them grow. The same principle governs the expansion of the Universe: Galaxies hold to size and shape because of gravity, but as the Universe grows they move far away from each other.

You will need:

- Balloon
- Stick-on dots or stars

Steps:

1. Blow up a balloon until it is about the size of an orange. Hold the end so that air doesn't escape.
2. Stick on 6 to 12 dots or stars at random. Each one represents a cluster of galaxies, a hundred million light years across.
3. Blow up the balloon. **What happens to the dots or stars?**

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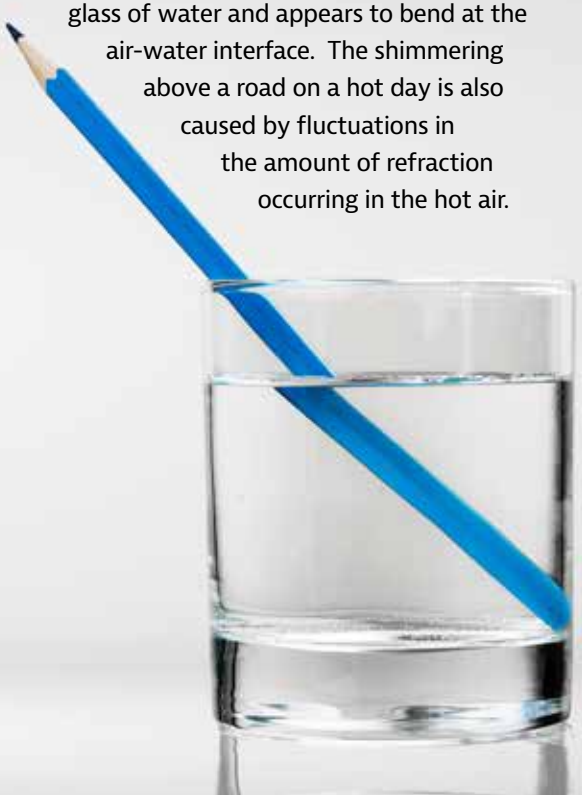
DID YOU KNOW?

You can pick one of the dots to be our galaxy. If you look at how the other dots move relative to it, you might think that everything is moving away from it and that we are therefore at the centre of the expanding Universe. You can, however, pick any other dot as your starting point, and that will also appear to be the centre of expansion on the balloon sheet! Similarly, we see all distant galaxies in the sky rushing away from us, but if we were looking at the sky from one of those galaxies, everything would still appear to rush away from that galaxy too.

Light Refraction

DID YOU KNOW?

The speed of light is determined by the medium (e.g. air, water or glass) through which the light is travelling. Light travels faster in a vacuum than it does in any other medium. The speed of light changes as it passes from one medium to another, such as from air to water. This is called refraction. This causes the light to bend. We see this when a pencil is placed in a glass of water and appears to bend at the air-water interface. The shimmering above a road on a hot day is also caused by fluctuations in the amount of refraction occurring in the hot air.



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You will need:

- Water
- Glass
- Paper
- Marker pens

3

Steps:

1. On the piece of paper draw two arrows pointing in the same direction. One arrow near the top of the page and the other near the bottom.
2. Place the paper behind the glass making sure the bottom arrow is positioned behind the glass and the top arrow is not.
3. Fill the glass with water and watch what happens to the arrow!

Are the arrows still pointing in the same direction?

Try this!

This time draw two objects of your choosing, maybe a rocket or a shooting star?

Does the experiment still work?

The Science Behind

Because water is denser than air, light will travel through it a little slower, so light rays will be bent first when entering the glass and again when leaving it. This is called the refraction of light, and it does not only happen in water. In certain weather conditions, air can have layers of different densities which make light bend through them in strange ways, creating mirages.

Stars in a Jar

You will need:

- Glass jar
- Tin foil
- Pin
- LED tealight
- Scissors

Steps:

1. With your scissors cut a strip of tin foil ensuring that it will fit neatly in and around the sides of the jar.
2. Carefully use a pin to pierce holes in the tin foil. For best results completely cover the tin foil in holes and make them small.
3. Wrap the tin foil up and place inside the jar.

   Turn on the LED tealight and place it inside the jar, then close the lid.

   Go into a dark room or wait until night-time and watch your stars in a jar!

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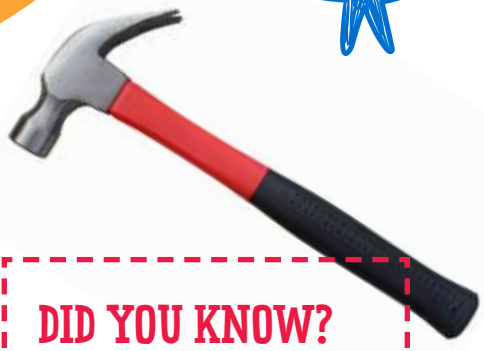
Try this!

Among the many tiny holes that you will be piercing, you can make some of them a little larger and arrange them into constellations. You can even connect the stars in the constellations with a marker so the jar will be interesting to look at even when the room is bright.

The Science Behind

A lot of LED tealights flicker to look more like the ordinary tealights; this will make the little pinpricks of light look even more like twinkling stars. Tin foil is a very thin sheet of aluminium metal. It is only about one or two hundredths of a millimetre thick, but still no light passes through it. This makes it a good candidate for making your little patch of night sky, where the only light we want to see comes from the pinpricked stars.

Gravity Investigation



The Science Behind

You might think that a heavier object would fall faster than a lighter one. There is, however, more to the problem than first appears! Gravity is the force that pulls together any two objects with mass. How much this force is able to move either objects depends then on their mass (according to Newton's second law), with smaller objects being pulled more easily than bigger ones. Thus, in principle, gravity would pull up the whole Earth towards the sheet of paper and the magazine just as it pulls these down to the ground. In practice, however, both objects are so much smaller than the Earth that not only are they the only ones to move but also they are pulled toward the ground in the same way. The sheet and the magazine should therefore hit the ground at the same time. That they don't is a result of air resistance, which slows down things that move through it depending on their shape and size.

DID YOU KNOW?

During the Apollo 15 Moon walk, Commander David Scott performed a live demonstration of a similar experiment for the television cameras. He dropped a hammer and a feather from the same height, and they fell to the (lunar!) ground at the same time, just as expected by the theory of gravity when there is no air resistance to complicate matters!

You will need:

- A4 magazine
- A4 sheet of paper

Steps:

1. Hold a magazine flat on one palm and a sheet of paper in the other. Hold them out in front of you at the same distance from the floor.
2. Drop them! Which one reaches the floor first? Record your results.
3. Crumple up the piece of paper.
4. Repeat the drop experiment with the crumpled piece of paper.
5. Which one hit the floor first this time?

Record your results.

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What if you hold the magazine and a (fresh) sheet of paper vertically – between your fingers and your thumb – and drop them?

Try this!

Make Moon Craters

The Science Behind

The craters on the Moon were made by asteroids and meteoroids hitting its surface at high speeds, creating craters, and spreading the lunar material around. With cocoa powder acting as the thin surface layer, you can see very similar effects from the comfort of your home or indeed classroom! Higher speeds and heavier objects will create deeper craters and throw more material around. Newer craters might overlap or partly destroy older craters. All these things can be seen on the Moon as well.

DID YOU KNOW?

One of the most prominent craters on the Moon is Tycho Crater in the southern hemisphere (the part with fewer dark areas). It is named after **Tycho Brahe**, a 16th century Danish astronomer who made measurements of the positions of stars, planets, comets, and other celestial objects.

You will need:

- Flour
- Cocoa powder
- Container or tray
- Spherical objects (Ping-pong ball, Maltesers, marbles, pebbles)

Steps:

1. Fill a tray 2cms deep with flour and spread it about, this will act as the Moon surface.
2. Sprinkle cocoa powder over the flour. Drop spherical objects of different sizes and mass.
3. Watch as impact craters form.

Do you notice a difference in the craters depending on the weight of the object?

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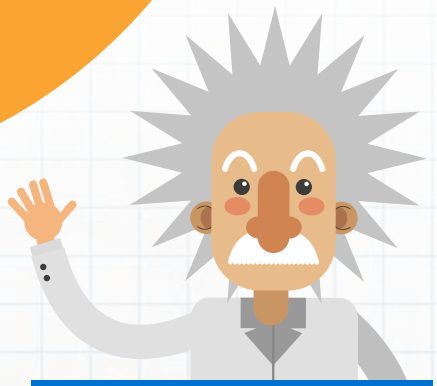
Try this!

Why not try dropping objects from different heights?

What about throwing them from the side?

Was there a difference?

Egg Drop



The Science Behind

This experiment tests Newton's First Law of Motion! It says that an object will stay at rest (or, if moving, remain moving in a straight line at a steady speed) unless there is a force acting on it. In our experiment, the force of your palm acted on the paper plate, and the plate acted on the tube a little, but the egg stayed at rest. When the plate and the card disappeared, the only force acting on the egg was gravity, so it fell. In the 'try this' part, the plate acts on the egg, so it does not stay at rest.

DID YOU KNOW?

Newton's Laws of Motion are very important for physics and astronomy. Together with his law of gravity, they explain the orbits of planets around the Sun, the Moon around the Earth, and even the Sun around the Milky Way. For cases where gravity is particularly strong, Einstein's Theory of General Relativity must be used instead of Newton's laws.

You will need:

- Egg
- Card toilet roll tube
- Paper plate
- Water
- Glass

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Steps:

1. Fill a large glass with water.

   Place a paper plate on top of the glass right side up.

   Place a card tube on top of the paper plate vertically in the centre.

   On top of the card tube position an egg on its side (it can be hard-boiled to avoid a mess).

2. Once everything is balanced, with one quick swipe hit the side of the paper plate with your palm. This needs to be forceful enough to push the plate off the glass (make sure not to push the glass!).

   Watch as the egg falls into the glass unbroken.

Try this!

Remove the card tube, does the experiment still work?

What happens?

Solar System Sun Catchers

The Science Behind

The colours we recommended for the planets are the colours we have seen them to be when spacecraft flew past and photographed them. The first four planets are small, rocky, and close to the Sun, and the other four are large, made of gas and ice, and far from the Sun. Jupiter – the largest of the gas giants – is about 11 times larger than Earth – the largest of the rocky planets – in diameter.

DID YOU KNOW?

All planets except for Mercury and Venus have moons. Our Moon is among the largest, but Ganymede and Titan are even larger than Mercury, the smallest planet! Titan is the largest moon of Saturn and Ganymede is the largest moon of Jupiter. It is one of the four 'Galilean moons', all four visible even with a good pair of binoculars or a small telescope, and all four similar or larger in actual size than our Moon.

You will need:

- Coffee filter paper
- Marker pens
- Spray bottle of water
- Tray
- Kitchen roll
- Tape

Steps:

1. Cut the coffee filter paper into circles to represent the 8 planets in the Solar System.

   In the middle of the card tube use a pencil to carefully pierce a hole on each side, making sure each hole is directly across from each other.

   Next, colour in the planets with marker pens - see reference below.

2. Place on a tray and spray water over the planets until completely saturated. You should see the colours starting to mix.

   Remove the planets from the tray to dry. You could hang them on the washing line or place them on a piece of kitchen roll. They should not take long to dry.

3. Once dried use a small piece of tape and stick to the window.

   Admire your Solar System sun catcher.

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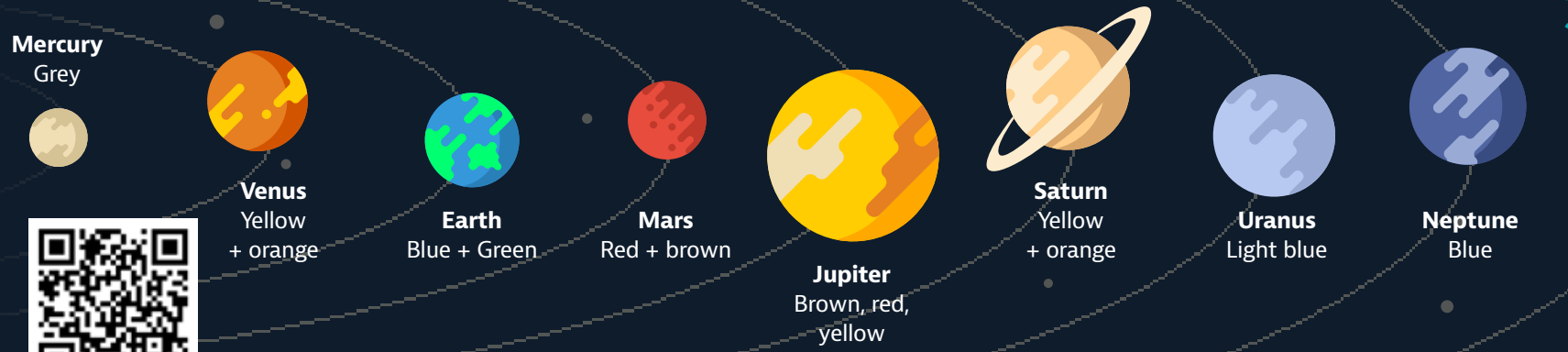


EASY

Make your own Satellite

The Science Behind

Satellites are shaped so that they can fit inside the rockets that take them to space, which means they cannot be very large or very heavy. Their solar panels are folded up and only deploy fully when the satellite is in orbit. Solar panels are useful because they help the satellite charge its batteries. Without them, someone would have to go on a rocket to reach the satellite and change the batteries every time they were low – very inconvenient and very, very expensive!!

You will need:

- Cardboard tube
- Card
- Lollipop stick
- Tin foil
- Scissors
- Glue
- Pencil

Steps:

1. Wrap tin foil around a card tube and fold the ends inside the tube.

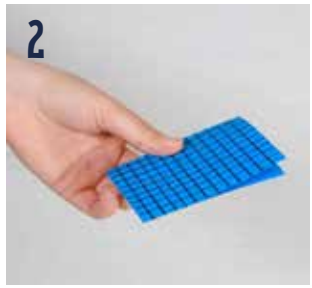
   In the middle of the card tube use a pencil to carefully pierce a hole on each side, making sure each hole is directly across from each other.

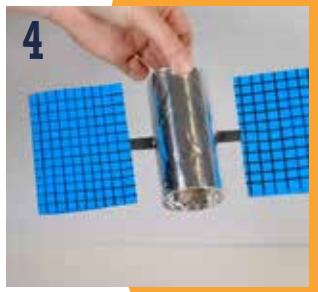
   Place a lollipop stick through the holes.

2. Cut the card into two rectangles, these will be the solar panels of your satellite. We cut rectangles 14cm x 6cm.

3. Fold and glue along the 6cm edge of the card and place the lollipop stick between the card. Repeat on the opposite side and let glue dry.

4. **Finally, decorate and name your satellite!**





When you look at the night sky, you can sometimes see the ISS passing across, as a bright dot moving from west to east.

DID YOU KNOW?

The International Space Station (ISS) is also a satellite, just much larger, and capable of having astronauts on board! It was built in parts over several years, with each part launched into space separately and then joined together with the rest.

Cloud in a Jar

The Science Behind

Shaving foam floats on water just as the clouds float in the air because they are both light enough to not sink. You may wonder how water can be lighter than air, if it can also fall as rain and even make up rivers, lakes, and oceans. The key here is that clouds are made of tiny water droplets, which are too small to rain down. This is because at such small sizes air resistance makes them fall down so slowly that in practice, they get constantly pushed back up by air currents in the clouds. To understand this better, think of the tiny dust particles that, when viewed against a shaft of sunlight, appear to float in the air.

You will need:

- Jar
- Water
- Shaving foam
- Food colouring

Steps:

1. Fill a jar with water, this will represent the air in our atmosphere.
2. Place shaving foam on top of the water to create a cloud.
3. Drip food colouring onto the top of your 'cloud'.

Watch as the food colouring passes through the 'cloud' and into the water creating a rain like effect.

DID YOU KNOW?

Armagh Observatory and Planetarium has been measuring rainfall since 1836. The wettest day we've recorded was 15th August 1970, when 78.3mm of rain fell in a single day.

This is about the same amount of rainfall as we usually see fall in the entire month of August!

Dancing Raisins

DID YOU KNOW?

Ships are made from steel or similar materials, and steel doesn't float on water on its own. Ships still float, and this is because the shape of a ship puts a lot of air under the surface of the water. And as long as the average density of the whole volume of the ship is less than that of water, it will float.

You will need:

- Sparkling water
- Raisins
- Small funnel
- Tray or basin (optional)

Steps:

1. Open the bottle of sparkling water and place inside a basin to catch any water that might spill.

   Place a funnel in the bottle of sparkling water.

2. Pour in the raisins. **Watch as the raisins float up and down as if they are dancing.**

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The Science Behind

When the raisins are added to the sparkling water, they sink because they are denser than water. Sparkling water has a lot of carbon dioxide dissolved in it at a pressure higher than air pressure, and that starts appearing as bubbles and escaping when the bottle is opened. The bubbles rise and stick to the raisins. When enough bubbles attach, the raisin floats up. This is because buoyancy – the property of floating things – is related to the average density of the whole object, and now the 'object' includes both the raisin and the CO_2 bubbles. When that density is lower than density of water things float up. When it is higher, they sink. Upon reaching the water surface, the bubbles that touch the air will burst and the raisins sink. The dance with the bubbles will repeat over and over again.

Fizzy Rocket

DID YOU KNOW?

Rockets that go to space need something more powerful than a fizzy tablet to get them there, but they are also launched by some material reacting and being pushed out at the bottom. If you have seen a video of a rocket launch, you will know the engines at the bottom produce a lot of fire and smoke, but fire is just another kind of a chemical reaction!

You will need:

- Plastic tube
- Effervescent tablet (such as vitamin tablet)
- Water
- Adult supervision

Steps:

1. Fill the plastic tube one quarter the way up with water.
2. Add a fizzy tablet and secure the cap as fast as you can.
3. Place the tube on the ground, lid facing downwards and stand back.

Watch as the fizzy rocket takes off!

The Science Behind

This is a chemical reaction that creates carbon dioxide. Like any gas, carbon dioxide will want to expand into the available space as much as it can, raising the pressure inside the tube. At some point the pressure will be too much, and the gas will escape the easiest possible way – from the bottom of the tube – taking the liquid with it. Since according to Newton's third law every action has an equal and opposite reaction, while the tube ejects the liquid, the liquid pushes the tube upward, making it a rocket.

Try this experiment with different quantities of water inside the tube.

Is the height the tube rocket reaches affected?

Try this!

Create Jupiter's Great Red Spot

The Science Behind

The Great Red Spot is the largest storm in our Solar System, and one of the most persistent! It is so large it could swallow the Earth whole and has been raging for at least 300 years. The interesting red colour is caused by the gases Jupiter has in its own atmosphere, although most of its surroundings are brown and beige rather than red, making it stand out even more. Water can behave in a similar way, but on a much smaller scale. Therefore you are able – with some help from food colouring and cornflour to see things better – to see a similar effect in your own bowl!

DID YOU KNOW?

The Great Red Spot is the most famous storm in the Solar System, but it does not have the strongest winds. That distinction goes to the planet Neptune: the blue ice giant has an atmosphere that is both extremely cold and extremely windy. The winds there have been measured at 2,100 km/h or 1,300 mph. Meanwhile the Great Red Spot has winds of up to 430 km/h or 270 mph. This is slow in comparison, but similar to the fastest tornadoes on Earth.

You will need:

- Cornflour
- Water
- Red food colouring
- Mixing bowl
- Teaspoon

Steps:

1. Pour 400ml of water into a mixing bowl.
2. Add in a heaped teaspoon of cornflour and stir well.
3. Next pour in a few drops of red food colouring and mix.
4. Leave the mixture to settle for a few minutes.
5. Once it settles, run your teaspoon across the surface of the mixture and watch as eddies appear just like on the surface of Jupiter. (An eddy is the swirling of a fluid).
6. **Can you see the similarity to the Great Red Spot?**

Comet on a Stick

The Science Behind

Much like the wind you make by moving your tin foil comet makes the ribbons stream behind it, the solar wind pushes the dust and gas from comets, making the comet tails. Space is mostly empty, though, so solar wind is not the same as that on Earth: it is made up of tiny electrically charged particles which speed away from the Sun and into space. There are not very many of them, so the space is still close to a vacuum, but they are really fast, so they can nudge the gases and dust from the comet and make them into tails. The gas tail points straight away from the Sun, while the dust tail follows the path of the comet while being slowly pushed away from the Sun.

You will need:

- Tin foil
- Skewer stick
- Ribbon, thread or wool

Steps:

1. Tape a skewer stick to a sheet of tin foil.
2. Cut strips of ribbon, thread and wool of different lengths and tape them to the top of the skewer stick where it lays on top of the tin foil. These strips will act as the comet's tails of dust and gas.
3. Next, roll the tin foil up into a ball making sure the ribbon, thread and wool sticks out from the tin foil.
4. Now it is time to fly your comet! Hold it by the skewer stick and move it side to side. Watch as the tails follow behind.

DID YOU KNOW?

AOP researchers and PhD students have recently studied the first interstellar comet ever found, called 2I/Borisov. This is a comet that originally belonged to another solar system around a distant unknown star, but that somehow managed to escape it travelling into space until it finally whirled around our own Sun. Using powerful telescopes in Chile, AOP astronomers concluded that our Solar System was most likely the first ever visited by such an interstellar traveller.

Newton's Magic Beads

The Science Behind

It is easy enough to explain why the beads keep falling: most of the beads in the cup are sitting still. Some are rising up and over the edge, while others are falling down. The side that is falling down is longer and therefore heavier than the side that is rising up, so it will always win the 'tug of war' of gravity pulling on both ends, and the beads will keep falling. But why do they rise? The simple explanation is that as they move, the beads have inertia and resist the change in movement – Newton's First Law – from going up on one side to going down on the other. This resistance means the beads need a while to change direction once they start going, so a rising arch will form.

You will need:

- Plastic cup
- String beads (the longer the better)

Steps:

1. Find the end of the beads and feed them into a plastic cup trying to lay them down in layers. Be careful and try not to tangle the beads.
2. Next, hold the cup high with one hand and with the other hold the top end of the beads over the edge of the cup and drop.
3. Watch as the beads flow from the cup to the floor and as the speed picks up the string of beads will rise over the rim of the plastic cup.

DID YOU KNOW?

Newton's Beads were brought to public attention by a viral video in 2013. This sparked scientific discussion and a number of publications on the matter. The new understanding of this curious effect may have consequences in areas as varied as textiles on the one hand and space engineering on the other! This goes to show that even in a matter as apparently simple as string beads, there may still be mysteries to unravel.

Northern Lights Chalk Rubbing

You will need:

- Chalk
- Paper
- Black paper or card
- White paint
- Paintbrush

Steps:

1. Roughly tear a sheet of paper to create a mountain landscape.

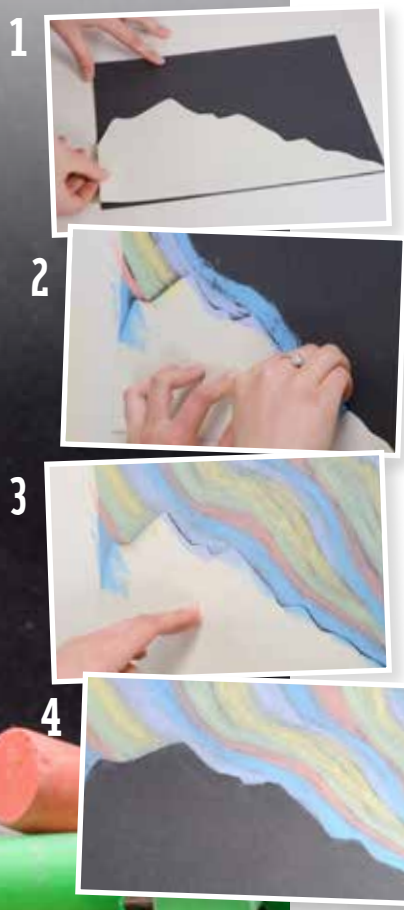
   Place the paper on top of the black card lining up the bottom corners.

2. Use the side of the chalk to draw approximately 2cm diagonal lines across the black card, alternating between colours. Rub the chalk in with your fingers.

3. With a paint brush flick white paint onto the chalk to make a starry effect.

4. Remove the sheet of paper to reveal the mountain landscape and the Northern Lights artwork.

You can also experiment with different colours and patterns! See if you can find some pictures of northern lights and get inspired by them.



The Science Behind

Northern lights – also known more generally as 'the aurora' – happens because the Sun is not only shining light on us, but also sending lots of tiny, charged particles through the Solar System. The Earth acts like a giant bar magnet with poles close to the North and South poles of rotation. Close to those poles, the charged particles from the Sun can reach the atmosphere most easily and when they do that, they connect with the atmosphere. When that happens, light is made, and it can be green, orange, red, blue, and even purple!

DID YOU KNOW?

A really large amount of those tiny, charged particles from the Sun hit the Earth in 1859 in what is known as the Carrington Event, named after one of the people who described it. Such large numbers of particles pushed the aurora further south, and it was visible almost from the equator! In the weather records of Armagh Observatory, a 'bright aurora' was recorded in the sky for several nights at that time.

Moon Rock

The Science Behind

Like the surface of the Moon, most Moon rocks that Apollo astronauts returned to earth were grey. Lava from volcanoes on Earth turns into a grey or brown rock we call basalt, and the Moon rocks are mostly basalt as well. This means there used to be volcanoes oozing lava on the Moon, too, just not necessarily the cone-shaped ones we know and love!

DID YOU KNOW?

When you look at the Moon, the lighter parts are older, more rugged, and at greater height than the darker parts. Those dark parts are called 'maria', which is Latin for 'seas', because early astronomers thought they might be actual seas of water. They are, in fact, huge areas which were once covered by lava flows and then cooled down to make basalt.

You will need:

- 200g of baking soda
- 30ml of water
- Glitter (lots!!)
- Black paint
- Mixing bowl
- Spoon

Steps:

1. Add baking soda into a mixing bowl.

   Add in glitter; gold and silver work well.

2. Pour in water and mix.

   Add a small amount of black paint to turn the mixture grey like the Moon.

3. Once all the ingredients are combined mould the mixture into Moon rocks!

4. Leave to dry overnight.

Try this!

Once the Moon rock has dried the following day, pour vinegar over them.

What happens?

Density Tower

DID YOU KNOW?

Saturn is less dense than water, so if there was a body of water large enough to hold Saturn, it would float! Saturn's density is so low because it is made up of gases and not solid like Earth.

You will need:

- Honey
- Washing up liquid
- Dyed water
- Cooking oil
- Baby oil

Steps:

1. Start by pouring honey into a glass, this will be the first layer of the density tower.
2. Next, pour in washing up liquid, followed by dyed water, cooking oil and baby oil. You will see how each liquid sits on top of the other. This is because each liquid that is added is less dense than the next.

Why not try dropping in objects of different density and see what happens. For example, a coin, a small piece of fruit and a bottle cap.

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The Science Behind

The density of a liquid is determined by its mass or by how closely the molecules of the liquid are packed together. The honey has the highest density, so it sits at the bottom of the glass, whereas the baby oil has the lowest density so stacks at the top.

MEDIUM

DIY Craft Telescope

DID YOU KNOW?

Telescopes were first invented in the early 17th century by placing lenses in a tube at different distances. They were small and many had less magnification than a large pair of binoculars today. Modern telescopes often use mirrors instead, because they can be made larger than lenses, and sometimes even several mirrors are used instead of one large one.

You will need:

- Card kitchen roll tube
- Scissors
- Glue stick
- Marker pens
- Tin foil
- Elastic bands
- Coloured paper

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Steps:

1. Wrap tin foil around a card tube and fold the ends inside the tube.

   Decorate the coloured paper. The brighter the better!

2. Wrap the coloured paper around the card tube and place 3 elastic bands over the top, placing them at the top, middle, and bottom of the card tube. This secures the paper as well as allowing movement up and down the card tube.

   Hide the elastic bands by gluing tin foil over them.

3. Now it's time to take the telescope outside and go exploring!

   REMEMBER NEVER LOOK DIRECTLY AT THE SUN!

The Science Behind

This is not in fact a proper telescope, because it will not magnify the picture. It will, like a telescope, help you to focus on a small area of your surroundings at any one time. Telescopes and binoculars use lenses or mirrors to magnify and focus the image.

Constellation Projector

Orion

You will need:

- Tin foil
- Pencil
- Pin
- Scissors
- Tracing paper
- Cardboard tube

DID YOU KNOW?

Different cultures around the world have found different patterns in the sky and made constellations out of them. The constellations we are most familiar with today mostly come from the mythological traditions of Ancient Greeks and Romans in the northern hemisphere, and from European explorers and navigators of 14th-16th centuries in the southern hemisphere.

Steps:

1. Carefully cut off the bottom of the tube. You might need to ask an adult for help!
2. Use the end of the tube to trace circles on the tracing paper and draw on your favourite constellations. Some of our favourites are Leo the Lion, Orion the Hunter, Canis Major (the Great Dog) and the Plough (which is part of the constellation of Ursa Major the Great Bear).
3. Put tin foil over one end of the tube and place the tracing paper on top of the tin foil, making sure to flip the image so it looks back to front.

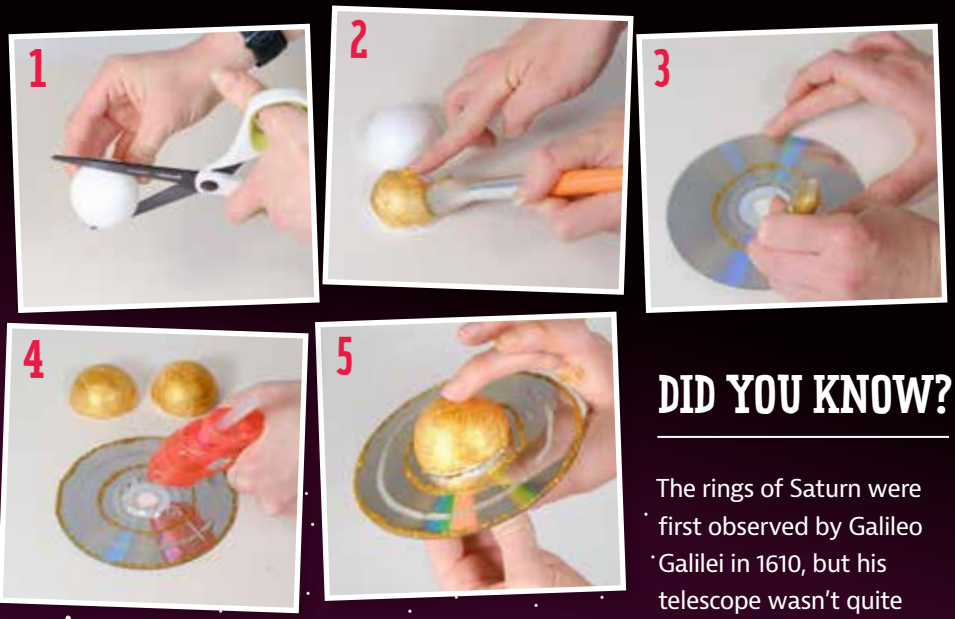
   Poke holes with a pin where the stars are positioned.
4. Look through the other end of the tube and see the constellation!

   Swap around the tin foil to see other constellations.

The Science Behind

Because our Galaxy is so big, stars that appear close to each other on the sky in a constellation are not actually close together in space! In the Plough, for example, the closest of the seven main stars is 78 light years away while the farthest is 124 light years away.

CD Saturn



DID YOU KNOW?

The rings of Saturn were first observed by Galileo Galilei in 1610, but his telescope wasn't quite good enough to see them for what they are: he thought they looked a little like 'ears' of Saturn, or perhaps two smaller planets on either side of Saturn, and was very confused by them.

You will need:

- Old CD
- Scissors
- Polystyrene ball
- Glue gun
- Gold or yellow paint & paintbrush
- Glitter glue
- String

The Science Behind

Saturn is famous for its rings, which are extremely thin and made of small particles or blocks at most a few metres across and that are made almost entirely of water ice. These icy particles and blocks move together around Saturn while all lying on the same plane. They form several rings rather than a single solid disk, thus looking more like the glitter circles on your CD, not like the CD disk in itself. While Saturn itself is about 120,000 km across, the rings you can see with a telescope are almost twice as wide again but never more than 1 km thick. This is over 2,000 times thinner than your CD!

Steps:

1. Carefully cut the polystyrene ball in half with scissors. You might need an adult to help.
2. Paint the two halves of the polystyrene ball and leave to dry.
3. While the polystyrene ball is drying take the CD and draw circles the whole way around it with the glitter glue. Leave to dry. Alternatively draw circles with PVA glue and sprinkle on glitter.
4. Use the glue gun to glue the polystyrene ball to the centre of the CD, each half on its own side.
5. Place a pin in the top of the polystyrene ball and wrap a piece of string around it, so you can hang up your very own Saturn with rings!

You can make the rings shiny from both sides by using two CDs and gluing their top (printed) sides together. See if you can match the glitter circles on both sides!

Try this!

DIY Compass

The Science Behind

When you rub the magnet against the needle it magnetises, meaning it becomes a weak and temporary magnet. The magnetised needle can then interact with Earth's magnetic field and by floating the needle on paper in the water it allows the needle to do so freely. Once the needle has stopped moving it has aligned itself along magnetic axis.

DID YOU KNOW?

Magnets, just like the Earth as a whole, create an invisible magnetic field around them, which acts on other magnets and many metals, too. This is why, when close to magnets, metals that are not magnetic to start with can start being magnetic: their internal structure is changed by magnets a little until they, too, start creating the magnetic field. It is usually weaker and more temporary, depending on the metal, but still good enough for a DIY compass!

You will need:

- Magnet
- Needle
- Paper
- Scissors
- Plate or bowl
- Marker pen
- Water
- Adult supervision

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Steps:

1. Trace a circle on a piece of paper 2cm across and cut out. Draw 'N' for north at the top and 'S' for south at the bottom.

   Pour water onto a plate.

2. Now it's time to magnetise the needle. Take one end of the needle and rub it against the magnet at least 30 times. Make sure to rub in the same direction.

3. Carefully thread the needle through the centre of the paper. Face the needle point that was rubbed by the magnet towards the labelled 'N'.

   Place the paper and needle onto the plate of water and watch as your homemade compass points towards north!

Check your results against a real compass or a compass App on a phone.

Straw Rocket

You will need:

- Straw
- Pencil
- Paper
- Tape
- Scissors
- Marker pens

Steps:

1. Cut a piece of paper 4cm by 30cm and decorate.

   Wrap the strip of paper diagonally along the length of the pencil to form a paper tube to make the body of your paper rocket.

   Next, place tape on the paper tube at the top, bottom and middle to secure and remove the pencil.

2. Cut the ends of the paper tube with scissors to make them straight, then fold over one end and tape it shut.

3. Cut and colour some triangle fins and attach them to the bottom of the paper rocket with tape.

4. Insert a straw into the paper rocket. To make your straw rocket blast off, simply blow into the straw. **How far does your rocket go?**

DID YOU KNOW?

Many birds – and glider pilots – will search for 'thermals' to help them rise up without any work on their part. Thermals appear when the ground heats up the air above it more than usual. The hot air expands, becomes lighter, and rises up. You did work similar to a thermal, because you helped the rocket fly without it needing to do any work. This is also similar to the way wind can blow into an umbrella and turn it inside out, except in this case we let the 'umbrella' - the paper rocket – get blown away.

The Science Behind

Most large rockets work by throwing away material quickly from the bottom. This one does not! Instead, you blast it off by blowing into the straw, so the air pushes against the inside of the rocket. Because you taped the top shut, the air has no way of escaping. Instead, it pushes the rocket away.

Try this!

Change some parts of the design, like how many fins you attach, the thickness of paper and so on to see if this changes how your rocket flies!

Sun, Earth, Moon model

DID YOU KNOW?

The fact that the Moon always shows the same face to us is not entirely obvious from just considering the orbits. This happens because the Moon goes around the Earth in about the same time it takes to spin around its own axis, in a bit more than 27 days. This has to do with tides. On Earth they are, as you probably know, caused by the pull of the Moon and the Sun on the Earth, which gives us high tides and low tides. While the Moon pulls on the Earth, the Earth also pulls on the Moon, making it spin slower and slower over millions of years, until the orbit and the spin matched up precisely.

The Science Behind

This simple model of the Sun-Earth-Moon system shows the relationships between the three. The Sun is the largest, the Earth smaller, and the Moon the smallest. The Earth orbits around the Sun in an anticlockwise direction, when seen from above the North Pole and the Moon orbits around the Earth, also anticlockwise.

Try this!

Try to turn the Moon around the Earth at the same time as you turn the Earth around the Sun.

You will notice that the path of the Moon around the Sun looks quite strange!

You will need:

- Card
- Marker pens
- 3 paper fasteners
- Scissors
- Pencil

Steps:

1. Cut out a circle the size of a small plate, this will represent the Sun.

   Next, cut out two smaller circles: one the size of an apple and the other the size of a satsuma. They will represent the Earth and the Moon.

   Also cut out two strips of card at 20cm and 10cm in length, and each 2cm in width.

2. Colour in the Sun, Earth and Moon.

3. Carefully pierce a paper fastener through the centre of the Sun and at the end of the long card strip. You could try placing the strip and the circle on a ball of putty or something similar, push the pin through, and then carefully remove the putty. Open the paper fastener to secure in place.

4. This time pierce a paper fastener through the Earth, the opposite end of the card strip attached to the Sun and one end of the remaining strip. Again, open the paper fastener at the back to secure.

   Lastly, attach the Moon to the end of the last strip with a paper fastener.

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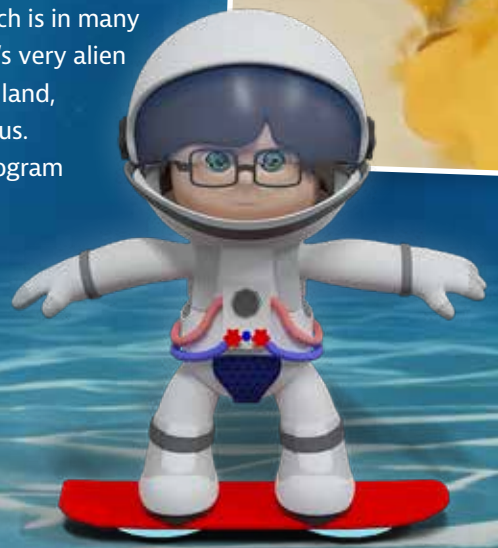
Neutral Buoyancy Laboratory

DID YOU KNOW?

To prepare them for future space missions, NASA and ESA send most astronauts to the NEEMO (short for 'NASA Extreme Environment Mission Operations') Program. This is the world's only fully underwater research station and future astronauts stay and train in it for up to three weeks at a time. This helps them learn how to live in confined spaces with a small crew, how to do difficult tasks in spacesuits, and how to survive in the hostile environment like the bottom of the sea, which is in many ways like that of space – it's very alien for us used to living on dry land, and it is also quite dangerous. The crew of the NEEMO Program are called 'aquanauts'.



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You will need:

- Basin or sink of water
- Rubber gloves
- Nut and a bolt
- Stopwatch
- Paper
- Pencil

Steps:

1. Time yourself screwing a nut onto a bolt. Record how long this takes.

   Fill a basin or sink with water.

2. Put your rubber gloves on, this will give you an idea what it is like to work while wearing a spacesuit.

3. Now time yourself screwing the nut onto the bolt underneath the water. How long did it take you this time?

Did you find it easier or more difficult using the gloves under the water?

The Science Behind

Because water is a lot denser than air, the feeling of moving through it is very different than moving through air. On the plus side, its higher density means that you might have a chance to catch the nut or the bolt if it slips from your hands before it falls too far, which you couldn't do in the air. Gloves also make it harder for you to have a good feel for small movements like the action of screwing a bolt. Gloves on spacesuits are a lot thicker than your kitchen or garden gloves! These things get easier with practice, which is why astronauts practice a lot on Earth before they fly to space.

Jumping Pepper

The Science Behind

You created static electricity by rubbing the balloon on your hair. The rubber in the balloon is a material that likes to collect extra electrons – these are tiny negatively charged particles – and it is quite easy to get them from hair. In the end, the balloon has a lot of extra electrons, so it is negatively charged. Pepper and salt are both without any charge. Pepper flies up to the balloon while the salt stays still, mainly because ground pepper is a lot lighter than ground salt, so it is much easier to lift. Secondly, the fact that like charges repel holds on tiny level as well, so the electrons run away from the parts of the pepper closer to the balloon and stay in the parts further from it. This is harder in salt because of its microscopic properties. The newly positive part of pepper then gets attracted by the balloon and flies up.

You will need:

- Balloon
- Salt
- Pepper
- Plate

Steps:

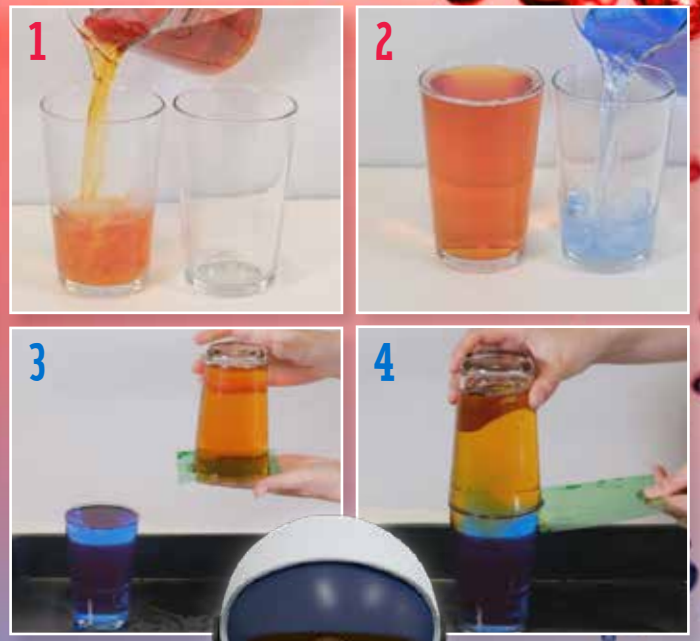
1. Pour ground salt and ground pepper onto a plate and mix them together.
2. Blow up a balloon and rub it on your hair or a friend's hair for 30 seconds. This creates static electricity.
3. Next, hold the balloon over the salt and pepper and watch what happens!

   The pepper should separate from the salt and attach to the balloon.

DID YOU KNOW?

The first known experiments with static electricity were done by Thales of Miletus around 600 BC. He discovered that he could pick up leaves and dust with a piece of amber after he rubbed it, just like you rubbed the balloon. In fact, the Ancient Greek word for amber is 'electron', which is where words like 'electricity' and the name 'electron' for the negatively charged particle came from!

Hot vs Cold Water Flip



You will need:

- Two glasses
- Food colouring
- Water
- Piece of card

Steps:

1. Fill one glass with cold water and a few drops of food colouring. Fill the other glass with hot water and a few drops of food colouring of a different colour. Do not use boiling water and we recommend using one dark colour and one light colour. This is best done somewhere where water spillage is not a problem, like a sink.
2. Place the card on top of the hot water and very carefully flip the glass. The card should stick to the rim of the glass due to atmospheric pressure.
3. Place the flipped hot water glass on top of the cold water glass and carefully remove the card.
4. **Watch what happens to the water! Does the water mix? How can you tell?**

The Science Behind

Hot water is less dense than cold water and will rise above it. In this experiment the hot water is already above, so it will mix very little with the cold water. When you flip the glasses around, the cold water ends up on top and the hot water on the bottom. Because of different densities, they will move in the opposite direction and mix, which can be seen in the mixing of colours.

Try this!

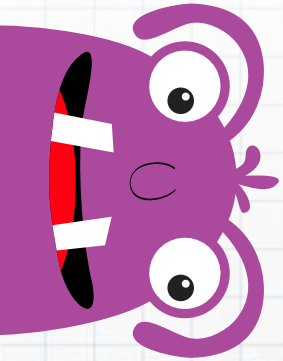
Try flipping the two glasses around.

What happens to the water now?

DID YOU KNOW?

This layering of densities happens all the time on Earth as well: warm ocean currents flow on top, while cold ocean currents stay at the bottom unless they hit obstacles like the continents. Warm and cold air also do not mix easily, which is why weather forecasters talk about cold fronts and warm fronts passing over us.

Alien Slime



The Science Behind

The alien slime is a non-Newtonian fluid. For physicists, the word 'fluid' means all gases and liquids which can flow in some way, as opposed to solids which cannot. A non-Newtonian fluid does not always behave the way we might expect a normal fluid like air or water to behave. When pushed hard, the alien slime will act almost like a solid, but when handled gently, it will be more like a liquid.

Try this!

Can you try and squeeze the Alien Slime into a ball? You will have to be quick!

You will need:

- 200ml water
- 250g of cornflour
- Mixing bowl
- Food colouring

Steps:

1. Add cornflour to a mixing bowl.

   Next, add water to the mixing bowl.

2. Add a few drops of food colouring to the mixture.

3. Mix it up with your hands.
   This can get messy!

4. With your fingers or fist put pressure on the mixture? What happens?

   This time gently place your fingers into the mixture. What is the difference this time?

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DID YOU KNOW?

Some everyday materials are non-Newtonian, but they do not all act the same as our mixture of water and cornflour. They include yoghurt, whipped cream, some types of jelly, many paints, nail varnish, ketchup, molasses, and custard.

Atmospheric Pressure

DID YOU KNOW?

Atmospheric pressure changes all the time. The average pressure at sea level is 1013 millibars, but it drops with height and changes with weather, dropping when the weather is bad and increasing when it's nice and sunny. Air in regions of high pressure gets pushed toward areas of low pressure, and this is is what causes winds. This is also happening on other planets, but their conditions can be very different. On Venus the pressure at ground level is 90 times the one on Earth, whereas on Mars it is 100 times smaller!

You will need:

- Water
- Glass
- Piece of cardboard

Steps:

1. Fill a glass with water up to the rim.

   Place a piece of card over the top of the glass.

2. Hold the card in position and quickly turn the glass, then slowly let go of the card. (This experiment is best attempted over the sink or basin in case things go wrong!)

The Science Behind

Two effects are at play here: atmospheric pressure and surface tension. Water stays in the glass (if things went well!) because the atmosphere is pushing at it from below, helped by water's innate ability to cling to things: surface tension. This last part is why the 'try this' experiment fails to contain the water: soap's job is to stop things clinging to anything, be it your hands or water itself.

Try putting soap around the rim of the glass and repeating this experiment. What happens this time? Be sure to do this over a sink!

Try this!

Simple Sun Dial

DID YOU KNOW?

Astronomers call the time 'local noon' when the Sun is highest in the sky, and so halfway between sunrise and sunset. Ideally, this 'local noon' would line up with our clocks, but then every town would measure slightly different time when you moved east or west, which could get very confusing. This is why time zones were invented and standardised. The whole GMT or Greenwich Mean Time zone, for example, reads noon when it is noon in Greenwich, London. When summer time is used, the sundial will not match with the clocks any more, but will be an hour away instead.

The Science Behind

Sundials are some of the oldest devices for measuring time – the oldest known one is in Egypt and dates to 1500 BC. They are even the reason the 'clockwise' direction is the way it is; see how the hours on your sundial are arranged: if you are in the northern hemisphere, they will be increasing in the clockwise direction. In the southern hemisphere the shadow of the pencil will be moving anticlockwise. Since the first mechanical clocks were made in the northern hemisphere, they took inspiration from their predecessor, the sundial.

You will need:

- Paper plate
- Marker pens
- Sharp pencil
- Plasticine/ Play-Doh
- The Sun

Steps:

For best results, this activity should be completed on a sunny day before 12 noon.

1. On the back of a paper plate write down the number 12 where you would find it on a clock.

   With a sharp pencil carefully poke a hole in the centre of the paper plate.

2. Push the pencil through the hole and secure it in place with plasticine underneath. The plate should be upside down.

3. At 12 noon, take the plate and pencil to a sunny location with clear views to the south. Turn the plate so the shadow of the pencil falls in line with the number 12.

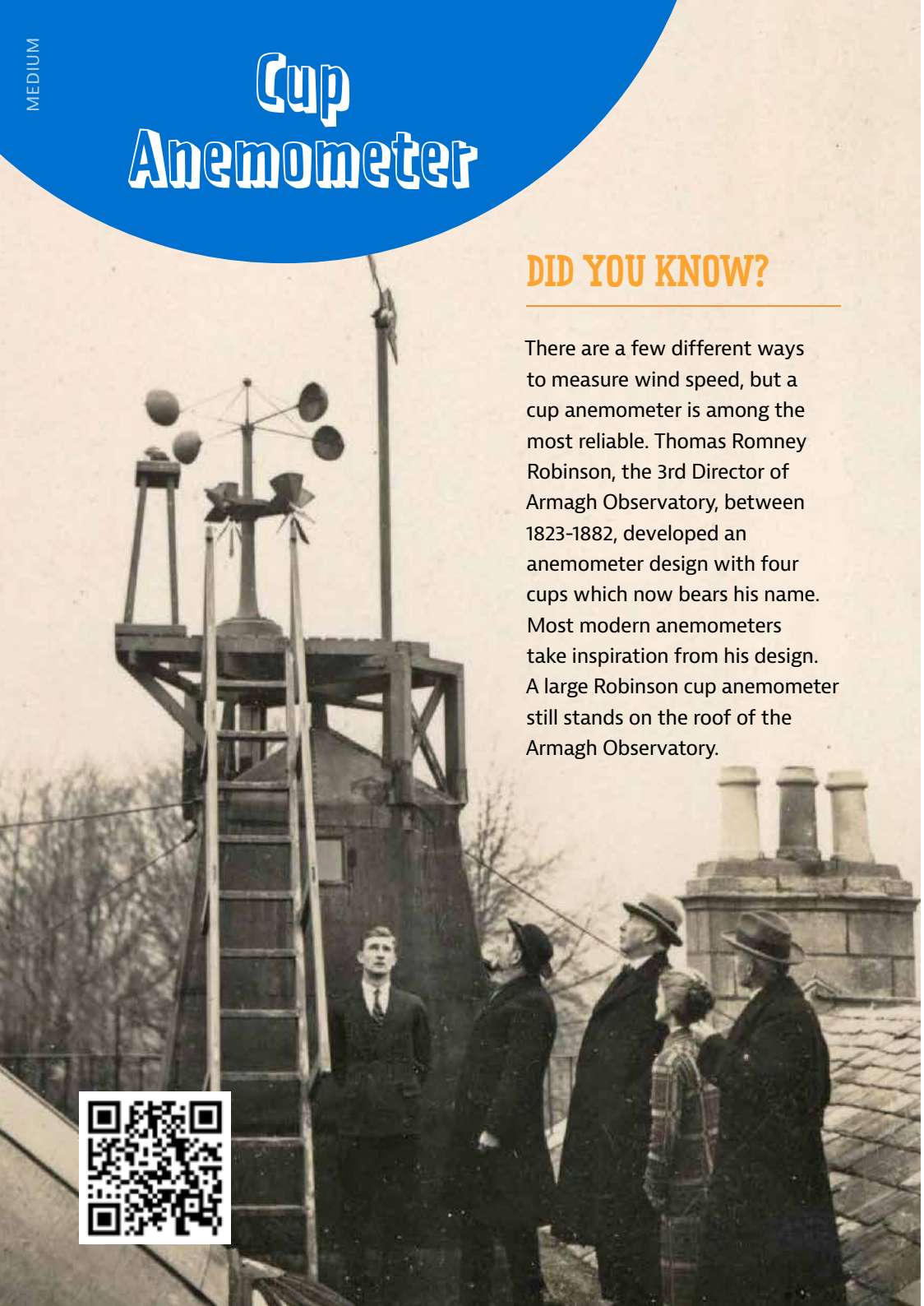
   You might also need to add a weight on top to prevent the sundial from moving or the wind catching it.

   One hour later, at one o'clock, check the position of the shadow. Write down the time where the shadow falls and repeat this every full hour until dark.

   The next morning you can add the full hours before noon, too.

   You now have a working sundial!

Cup Anemometer



DID YOU KNOW?

There are a few different ways to measure wind speed, but a cup anemometer is among the most reliable. Thomas Romney Robinson, the 3rd Director of Armagh Observatory, between 1823-1882, developed an anemometer design with four cups which now bears his name. Most modern anemometers take inspiration from his design. A large Robinson cup anemometer still stands on the roof of the Armagh Observatory.

You will need:

- Cardboard
- 4 plastic or paper cups
- Scissors
- Straw
- Skewer stick
- Stapler
- Plasticine

Steps:

1. Cut out 2 cardboard strips 30cm in length and 3cm wide.

   Make a cross with the cardboard stripes and staple together at the centre.

2. Carefully pierce a hole in the centre with a pencil.

   Staple or use a hot glue gun to attach each cup below the ends of the cardboard arms.

3. At the centre push a skewer about 1cm through the hole and cover it with plasticine to secure it in place.

   Place the skewer into the straw, this will allow it to move independently.

   Go outside and hold up the cup anemometer by the straw and watch as it catches the wind!

The Science Behind

The cups make for good wind-catchers, and it does not matter which way the wind is coming from. This is unlike a windmill, which will turn best if the wind comes in from the right direction. Scientific anemometers do their best to avoid as much friction between the fixed base and the spinning cups, so they can measure wind speed more accurately.

3D Planets

The Science Behind

The planets and the Sun look like perfect spheres, but they are not in fact quite perfect. If you stood on the poles of the Earth, you would spin around once per day but not really move much. If you stood on the equator, however, you would travel the distance of the entire circumference of the Earth – 40,000 km or about 25,000 miles – in a day. That is really fast, so the Earth is pushed out ever so slightly at the equator in response, and other planets and the Sun behave the same way. This turns them into spheres which have been slightly squashed at the poles.

DID YOU KNOW?

There are eight planets in our Solar System, but other stars have their own planets too! We call them 'exoplanets', to make it clear they are not in our Solar System. We have now found over 4,000 such planets and counting! Astronomers have many ways to find exoplanets, including looking for tiny drops in the brightness of stars as their planets pass in front of them. But some stars change brightness in their own way. At AOP we are experts in such "variable stars" and our work is key to tell real from fake exoplanet discoveries.

You will need:

- Coloured card
- Scissors
- Pencils
- Large circle stencil (10cm diameter)
- Small circle stencil (5cm diameter)

Steps:

1. Trace 9 circles 10cm in diameter onto coloured card and cut out. Remove one large circle and save for later.

   Trace 8 smaller circles at 5cm in diameter and cut out.

2. Fold the circles in half.
3. Cut a slit down the centre of the larger circles starting at the fold and stopping short of the edge.

   Repeat with the smaller circles.

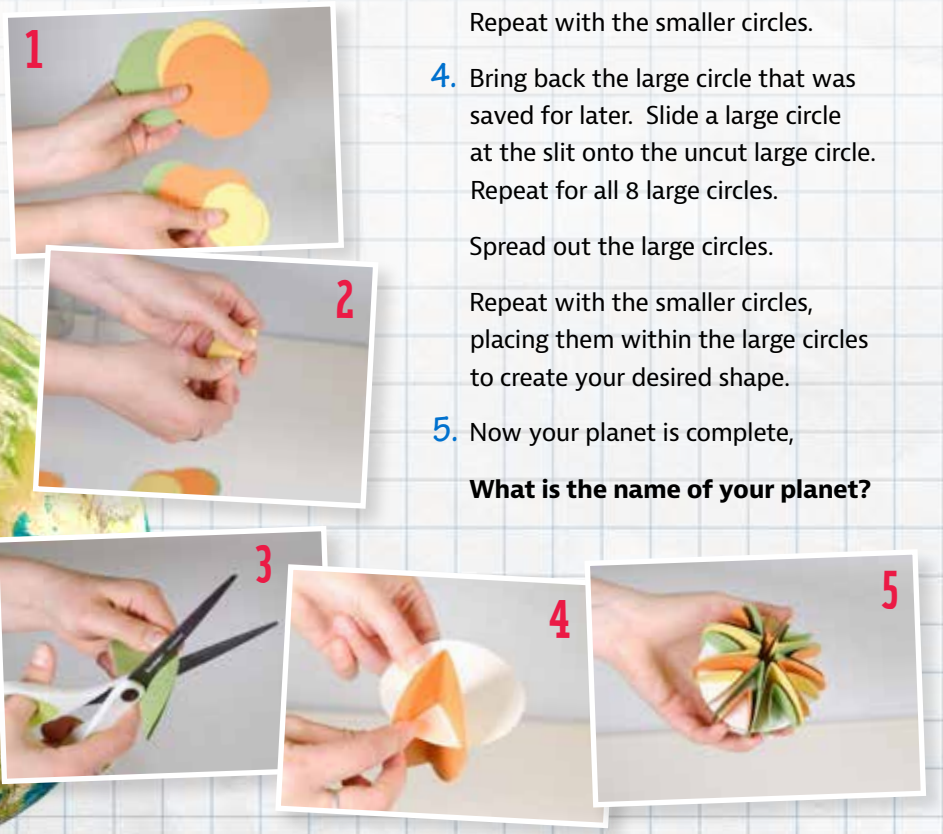
4. Bring back the large circle that was saved for later. Slide a large circle at the slit onto the uncut large circle. Repeat for all 8 large circles.

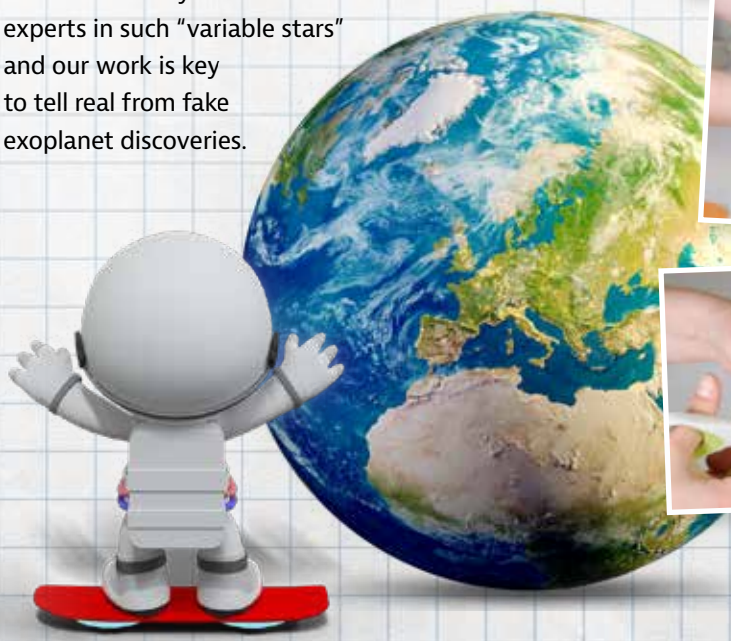
   Spread out the large circles.

   Repeat with the smaller circles, placing them within the large circles to create your desired shape.

5. Now your planet is complete,

   What is the name of your planet?





Try this!

Add a piece of string or thread to the uncut large circle to hang your planet.

DIFFICULT

Asteroid Launcher

DID YOU KNOW?

In his novel "From the Earth to the Moon", writer Jules Verne uses a gigantic 'space cannon' with which three people are launched to the Moon in a capsule. In reality, this method of sending people to space is not practical, not only because the cannon would have to be huge but also as the capsule would have to be shot at such an initial speed that it would cause to break apart due to drag in the air. The benefit of a multistage rocket is that they would lift off more gently, with some of that speeding up being done while already high up.

Try this!

Draw a scoreboard on a large sheet of paper or cardboard, place it on the ground and stand back, then launch your asteroids at the scoreboard to win points.

You will need:

- Tin foil
- 2 x Card toilet roll tubes
- Pencil
- Scissors
- Tape
- Elastic bands

The Science Behind

What you have created is a version of a small catapult or slingshot. Unlike the traditional one, however, this one can keep the tin foil 'asteroids' at the top of the tube until you wish to launch it. You can also mark the folded tube with lines along its length and then, for example, always pull it out to the same line before launching. This can make your launches a lot more consistent.

Steps:

1. Decorate one of the card tubes with paint or marker pens.

   Next flatten the other card tube and fold in half lengthways.

2. Carefully, pierce the pencil through the flattened tube towards one of the ends. Leave the pencil in the middle.

3. On the first tube cut two flaps directly across from each other at the bottom of the tube. Each flap should be about 2cm long and wide.

4. Put an elastic band around each flap and then tape the flap above it to the rest of the rim to secure in place. The elastic bands should be long enough to stretch the whole length of the tube without breaking.

5. Place the end of the decorated card tube that does not have the flaps over the flattened tube.

   Pull the elastic bands and place around the pencil.

   Roll up tin foil in balls to make 'asteroids'.

   Place an asteroid inside the top of the launcher, which is the opposite side of the pencil. Pull back the pencil and release!

Watch as the asteroid launches across the room!

Milk to Plastic

The Science Behind

We call 'plastic' many different materials that can be moulded into shapes for further use. The important thing that makes plastic sturdy are long polymer chains which keep the whole material together. Polymer chains are simply very, very, very long molecules made up of identical smaller molecules which have been stuck together in a line with some chemical reaction. Sometimes plastics are hard and brittle, sometimes soft and stretchy, but they all have them. Most plastics are made from crude oil, but the chemical reaction between milk and vinegar makes polymer chains, too! We do not use plastics made out of milk as much because they do not last as long.

DID YOU KNOW?

One of the first widely used plastics was celluloid, made out of cellulose - a common fibre present in all plants. It was used for billiard balls, jewellery, instruments, photography and film, and even for children's toys. It is used only rarely today, because it catches fire easily and could sometimes even explode!

You will need:

- Warm milk
- Food colouring
- Vinegar
- Mesh strainer
- Kitchen roll
- Shaper cutters

Steps:

1. Heat 1 cup of milk in the microwave until it is warm.

   Add 4 tablespoons of vinegar and stir. You will start to see the milk clump.

2. Pour the milk through the strainer, leaving behind the clumps.

   Press on the clumps in the strainer with a spoon to remove the remaining liquid.

   Transfer the contents of the strainer on kitchen roll. With another piece of kitchen roll press on top to remove more liquid.

   Add a few drops of food colouring and mix it up. Tip: use gloves to avoid food colouring staining your fingers.

3. Transfer the contents into a mould with kitchen roll or a plate underneath and pat down.

4. Leave aside for 2 days to dry.

1


2


3


4


Light Box Experiment

You will need:

- Large box
- 3 plastic bottles
- Water
- Food colouring
- Scissors

Steps:

1. On the top of a cardboard box, draw around the bottom of 3 bottles and carefully cut out the shapes. You might need some adult help with the cutting.
2. Next, cut out a rectangular viewing hole on the side of the box large enough for you to see into. You could also decorate your box with paint or marker pens.
3. Fill each of the bottles with water and add separate food colouring into each bottle. We recommend blue, red, and green.
4. Then, place the bottles in the cut-out holes about halfway in. The holes should be tight enough so that the bottles do not fall through.
5. Next, place the box in a sunny area and look through the viewing hole. **What can you see?**

DID YOU KNOW?

Air in the atmosphere also varies in density and moves around, constantly bending the light from stars in slightly different directions in the process. This is what causes stars to twinkle! While twinkling stars makes for good rhymes, astronomers do not like this as it makes their images blurrier. Modern telescopes can now correct for this twinkling and obtain images as sharp as those obtained by the Hubble Space Telescope. AOP astronomers use this technique to find supermassive black holes at the centre of external galaxies, and it is what led German and American teams to study the supermassive black hole in the Milky Way and win a Nobel Prize in 2020.

Try this!

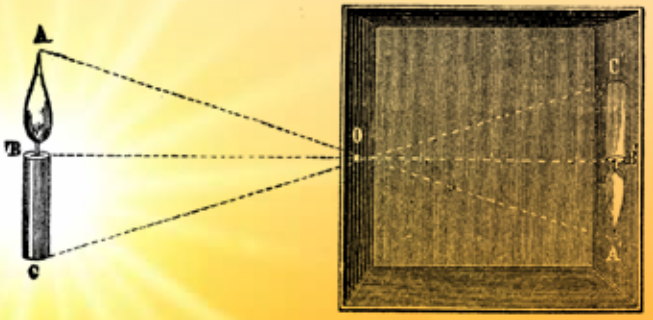
Gently move the box from side to side.

What happens?

The Science Behind

Water is denser than air. This means the light travels through it a little slower, so any light ray that does not hit perpendicularly to the surface of the water or the bottles, will be bent first when entering the bottles and again when leaving them. This effect is called the refraction of light.

Safe Sun Viewer



DID YOU KNOW?

Some early astronomers used a similar viewer to look at the Sun. To get the sharpest image, the pinhole should be at least 100 times smaller than the distance from it to the projection screen (so a 1 mm hole for 10 cm distance, for example); a larger hole will make a brighter but fuzzier image.

The Science Behind

You just made a simple pinhole projector also known as 'camera obscura' - that's Latin for 'dark chamber', because you need a dark room (or cardboard box!) to see the projection well. It works similarly to your eye, where the pupil is the 'pinhole' and the back of the eye is the 'projection screen'.

Try this!

Instead of a small circular hole, make a small triangular hole with the pin. Will the projected image of the Sun also become a triangle? What happens on the projection screen if you make more than one hole in the tin foil?

You will need:

- Cereal box
- Tin foil
- Scissors
- White card
- Pin
- Sellotape

Steps:

1. At the top of your cereal box, cut out two square windows, one 3cm squared and one 5cm squared.

   Cut a piece of white card the same size as the bottom of the box and insert it so that it sits at the bottom of the box. This will be your projection screen.

2. Cut a square of tin foil to cover the larger window (your projection window). Tape the tin foil over the projection window and seal up any extra holes in the box.

3. Take a pin and make a small hole in the foil. This is the pinhole for your projector.

   Decorate your sun-safe viewer. Go outside and stand with your back to the sun.

   REMEMBER NEVER LOOK DIRECTLY AT THE SUN!

4. Hold the box pointed at the ground so that the Sun's light can pass through the pinhole and into your projection screen. The Sun will have to be directly behind you to shine through the pinhole and onto your projection screen properly.

Moon Turn Toy Lunar Phases

DID YOU KNOW?

You can see the Moon during the day! You can often see it in the sky near sunrise or sunset, as well as at other times, depending on its phase. First Quarter Moon will rise around noon and set around midnight, for example, and the other way around for Last Quarter Moon.

The Science Behind

If you make the Sun, Earth, and Moon model as well, you will be able to see how the lunar phases come about. The Sun always shines on one half of the Moon, just like it always shines on one half of the Earth. The relative position of the Moon with respect to the Sun-Earth line, however, changes how much of the Moon we can see lit up in the sky, and what time of day we can see it. When the Moon is 'behind' the Earth, we see the entire lit hemisphere and it is Full. Half a month later, it is in between the Earth and the Sun, so we do not see the lit-up side at all, and it is a New Moon.

You will need:

- 2 Clear plastic cups
- Permanent marker
- Scissors
- Pen
- White, black & yellow paper
- Glue

Steps:

1. Cut out a small yellow circle and stick it to the outside of a cup, then place the cup inside the second cup.

   Trace the 8 phases of the Moon onto the outer cup with a permanent marker.

2. Shade in the New Moon, First Quarter, Last Quarter and trace Full Moon first – all evenly spaced – then fill in the remaining crescent and gibbous Moons between these to ensure they will fit. Make sure to colour in the dark parts – leaving behind the yellow circle in the shape of the right lunar phases – rather than the light parts!

   Write the names of the Moon phases on a piece of paper, cut to size and glue underneath.

   Place black paper inside the inner cup. This will act as the night sky background.

3. Lastly hold the top cup with one hand, the second cup with the other hand and twist!

   Watch as the phases of the Moon change.

Moon Phases

DIFFICULT

Galactic Gyroscope Toy

DID YOU KNOW?

If you look at your spinning toy from the top or from the bottom while the paper strips are twisted, it will look a lot like a spiral galaxy. Spiral galaxies, like our Milky Way, are made up of millions and billions of stars which aren't attached to one another like bits of a paper strip are attached to other bits of a paper strip. Gravity holds them together instead.

You will need:

- Paper
- Skewer stick
- Scissors
- Glue stick
- Glue gun
- Pencil or pin
- Adult supervision

The Science Behind

When you spin the toy, the bottom part lifts, and the paper strips twist around. The twisting happens because the tops of the strips start spinning first while the bottom is still, so they must pull the bottom along with them, which causes a bit of a delay and twist. The strips untwist when the whole thing is spinning together, but twist again when you change directions, and for the same reason: the bottom is lagging behind the top. The reason the bottom part lifts up is because spinning things which are not fully attached to the middle want to fly outwards because of forces that act upon them.

Steps:

1. Cut 8 paper strips the length of an A4 page and 2cm in width and cut 4 paper circles 5cm in diameter.

   Next, take one paper circle and the 8 strips. Glue one end of all 8 paper strips onto the circle, evenly spaced around.

   Cover the top with another circle by gluing it in place.

2. Next place the third circle on top of the second one, but do not glue it there. Instead, glue the other end of the strips to the third circle.

   Once attached, glue the last circle on top to secure in place.

3. With a pencil or a pin carefully pierce a hole through the centre of all circles.

   Place a wooden skewer through the holes, leaving the skewer poking out about 1cm at the top. One glued pair of circles (with ends of strips sandwiched in between them) should now be at the top, and one hanging below.

4. Hot-glue the skewer to the pair of circles at the top. Let the hot glue dry.

   Make sure that the hole in the bottom pair of circles is wide enough for their easy movement up and down.

5. Finally spin the skewer between your hands one way and the other and watch what happens to the paper strips!

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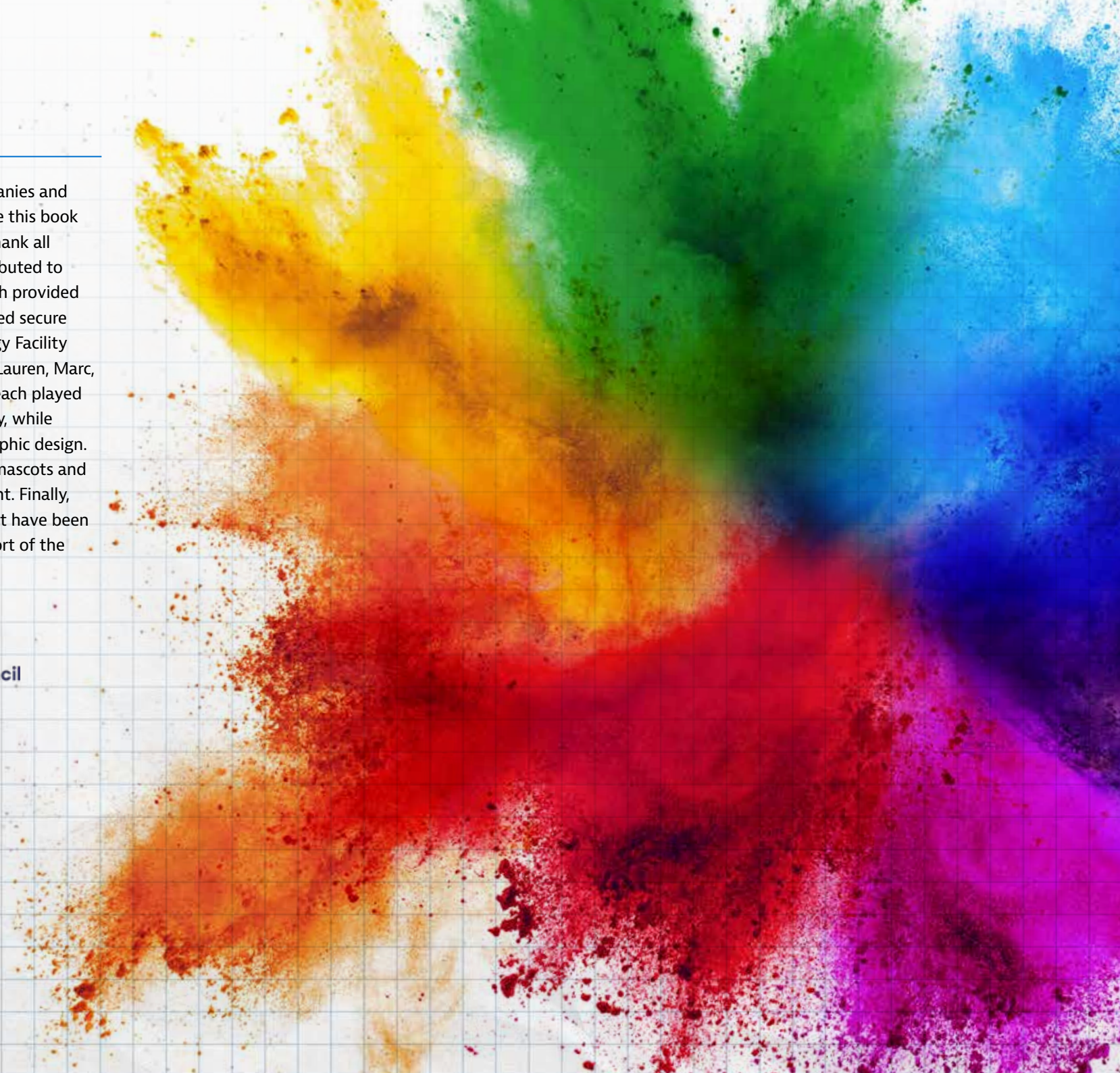

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