S4's Summer Show 2020

A GUIDED TOUR OF OUR UNIVERSE!!!

With Astronomer Mark Thompson

BONUS MATERIAL

Watch the show here:
youtu.be/-cA-UHKViRk

S4's Summer Showcase 2020 is all about space! Mark Thompson is an astronomer who studies distant objects in space. In our 2020 Summer Science Show, Mark takes us on a virtual, guided tour of the universe.

How do we study distant objects in space?

Telescopes use the radiation that distant objects in space emit (give off) to study those objects.

There are lots of different types of radiation.

Visible light, the light we can see with our eyes, is one type of radiation that telescopes can detect and measure. The ***Electromagnetic Spectrum*** is made of seven types of ***Electromagnetic Radiation.***

The Electromagnetic Spectrum

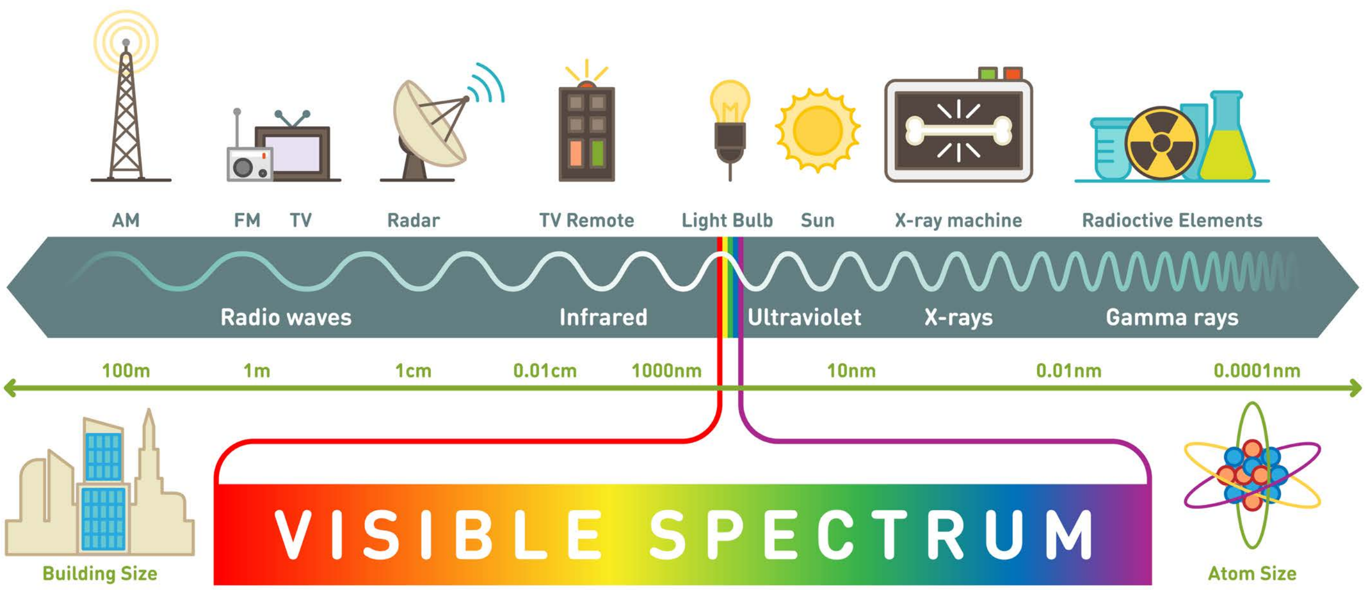
The electromagnetic spectrum is a group of seven types of radiation, including radio waves, visible light, and x-rays. These can travel as waves, even in space.

The seven types of radiation in the electromagnetic spectrum are grouped by the lengths of their waves (called their wavelength), which give them different properties, or behaviours.

To study the universe, we use telescopes that can detect all the different types of radiation within the electromagnetic spectrum.

This helps us to understand and study distant objects in more detail than if we just look at the visible light they emit (give off).

Astronomers and space scientists use observations of the radiation space objects emit to learn about stars and other objects in space, including what materials they are made from.



Try this at home!

MAKE A VISIBLE LIGHT SPECTRUM

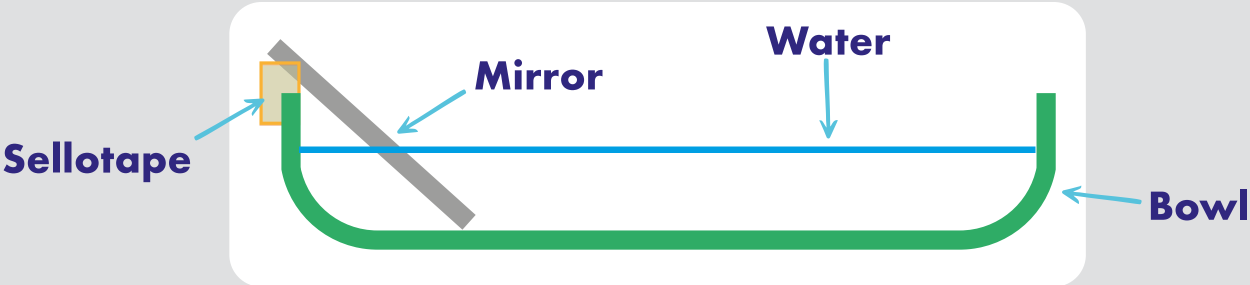
– ALSO KNOWN AS A RAINBOW!

You will need:

- A shallow bowl
- A small mirror (a compact or hand mirror will work well – we used a mirror from an old make-up palette)
- Sellotape/plasticine/blu-tack
- Water
- Bright sunlight or the torch on a smartphone
- A piece of white paper

Method:

1. Pour some water into your bowl, so it is about 3 quarters full.
2. Put your mirror into the bowl. You should lean it against the side of the bowl so it is at a 45° angle (diagonal). Part of the mirror should be underwater. Use the Sellotape, plasticine or blu-tack to hold it in place.



3. Shine the torch into the part of the mirror that is underwater or put the bowl in a sunny spot, so the sunlight can shine on the mirror underwater.
4. Hold the white paper above the mirror. Adjust the angle of the paper and move it around until you see the rainbow appear on it!
5. If you are doing this experiment inside with a torch, turn off the lights to make the room as dark as possible and try to spot the rainbow on your ceiling or walls.

What is happening?

The white light from the Sun (or from the torch) is actually all the visible colours (wavelengths) of light – from red to violet – at once.

When all the wavelengths of light are together, we see 'white light' rather than the individual colours of the rainbow.

Each colour of light has a different wavelength and they appear in a rainbow in the order of their wavelengths. Red light has the longest waves and is on the outside of the rainbow and violet light has the shortest waves and is on the inside of the rainbow (have a look for some upside-down rainbows next time you're out, or online!)

Some materials and objects can split white light into all its different colours by bending it. When we shine the white light into the water, it bends. Each colour of light bends by a slightly different angle because different colours of light move at different speeds in water.

When we reflect the light back out of the water using the mirror, we are reflecting the white light which has been split apart into all of the different colours of light, so a rainbow appears! **The water has split the white light into its different wavelengths.**

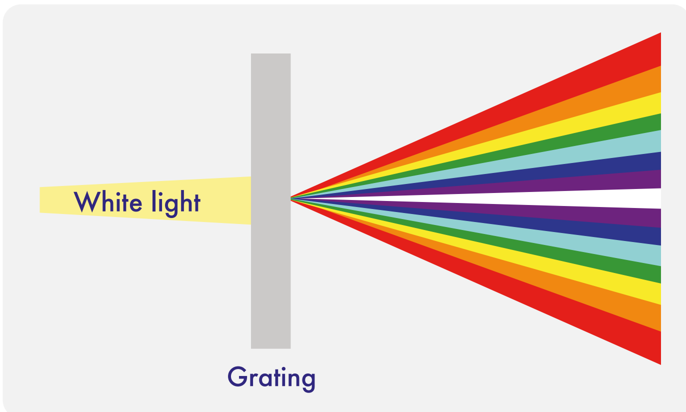
Why is this important?

Our eyes can only see visible light and not the rest of the ***Electromagnetic Spectrum***, but telescopes can be used to detect all types of radiation in the spectrum. Some telescopes use a tool called a ***diffraction grating*** to split radiation from stars into its different wavelengths.

Different materials emit different wavelengths of radiation.

Astronomers can use telescopes with diffraction gratings to measure all the different wavelengths of radiation emitted by a distant object, which will tell them what materials it is made from.

Diffraction Grating



Why do we study distant objects in space?

> "We revolve around the Sun like any other planet."
> – *Nicolaus Copernicus (1543)*

A long time ago, humans thought that the Earth was the centre of the universe and everything we could see in the sky orbited around us. This was called the Geocentric model of the universe (Geo means 'Earth' and centric means 'at the centre').

Astronomers studied the motions of the Sun, stars and other planets and discovered that the Earth and all the other planets in our Solar System actually orbited around the Sun. The Geocentric model of the universe was wrong, and they developed the heliocentric model of the universe instead (Helios means 'Sun' and centric means 'at the centre').

Galileo and Jupiter...

Not all scientists believed Copernicus. Many thought that Earth was the most important thing in space and so everything should orbit around Earth.

How did scientists find out that the planets orbit the Sun?

Galileo used a telescope to look at Jupiter in 1610 and he saw, for the first time in human history, that there were moons orbiting Jupiter. If all things in space orbited the Earth, then how could this be? Galileo then observed that, just like the moon, Venus went through phases of being partially visible, then fully. This could only happen if it was going around the Sun, not the Earth. Galileo's proof, that the planets orbit the Sun, caused so much trouble that he was tried for heresy (believing something that was against religion) by the Roman Inquisition and placed under house arrest for the rest of his life.

RESEARCH BOX

Get online and do some personal research about galileo and the heliocentric model.

What did you find out? You can share your findings with **@swansci4** using the #s4summershow

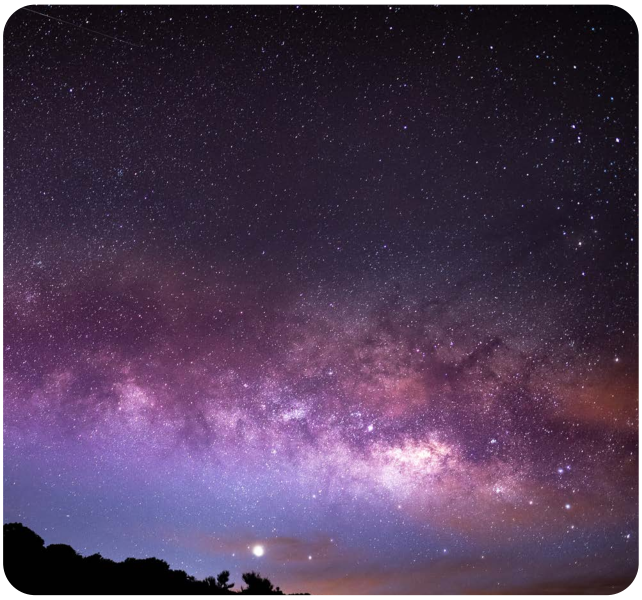
Our star

As astronomers studied the skies more and more, it became clear that the Sun itself isn't particularly special. It is a star, and a pretty average star at that!

The Sun is one of billions of stars in our galaxy, which is called the Milky Way. There are more than 100 billion galaxies in our universe.

That's a lot of stars! In fact, if you could count every single grain of sand on Earth, this number would be smaller than the number of stars in our universe.

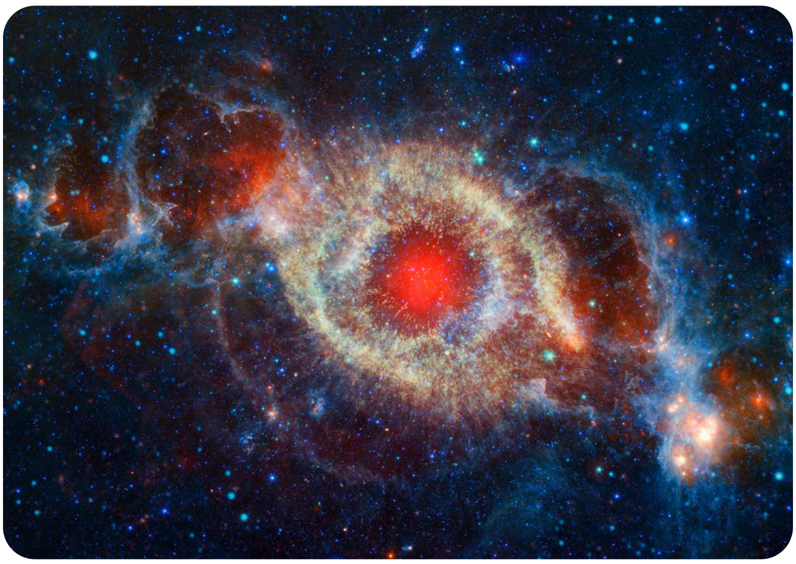
By studying these stars, we have learned a lot about our place in the universe, our past and our eventual fate.



Milky Way Galaxy

Our past – how did we get here?

All the stars we can see in the sky were formed inside nebulae.



Nebulae (plural of nebula)

A nebula is a giant cloud of gas and dust in space. Nebulae are mostly made from hydrogen and helium gas, with small amounts of some other materials, like oxygen, carbon and dust.

Try this activity

Nebulae are some of the most beautiful and colourful objects in space. Some nebulae are given names after things they resemble (look like). Can you match each of these names to the picture of its nebula?

Ring Nebula, Pillars of Creation (in the Eagle Nebula), Butterfly Nebula, Cat's Eye Nebula, Crab Nebula, Horsehead Nebula

Image Credit: NASA/ESA/Hubble

Choose a nebula

Select

Image Credit: NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA)

Choose a nebula

Select

Choose a nebula

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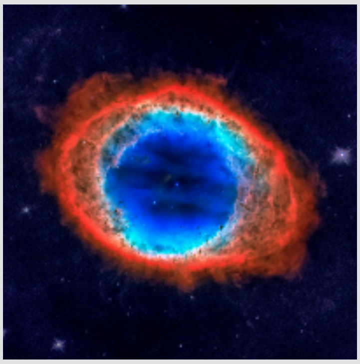

Choose a nebula

Select

Image Credit: NASA/ESA/Hubble Heritage Team

Choose a nebula

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Choose a nebula

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Some nebulae are called Stellar Nurseries, because they are where new stars form. Our Sun and everything in our solar system, including Earth, formed inside a Stellar Nursery.

Inside Stellar Nurseries, the gases contract (squish together) in different regions (areas) to produce stars.

The dust and gases in nebulae are very diffuse (spread apart) but some small, charged particles are pulled together by ***electrostatic forces,*** which is the force that causes static electricity. Eventually, the particles start to form larger lumps and the larger lumps form bigger lumps until eventually, a star is born.

All because of static electricity!

Try this at home!

1. THE CLASSIC

Static electricity tricks

You will need:

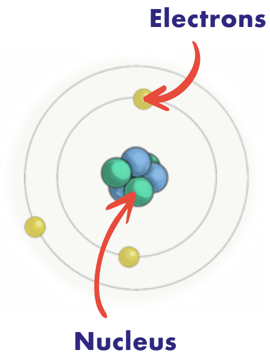
- A balloon
- Someone with hair
- A mirror

Method:

1. Blow up a balloon.
2. Rub the balloon over your hair (or somebody else's – with their permission).
3. Pull the balloon slowly away from you. You should notice your hair is attracted (moves towards) the balloon.
4. Take balloon completely away from your hair and look in the mirror. Some of your hair should be standing on end as the individual hairs repel (move away from) each other.

What is happening?

Everything is made of atoms. Each atom has a nucleus (made of protons and neutrons) at its centre, which has a positive charge. Small particles called electrons orbit the nucleus. These particles are called electrons.



The positive charge of the nucleus is balanced by the negative charge of the electrons, so the atom has an overall charge of zero (it is neutral).

When you rub the balloon against your hair, some electrons move from the atoms in your hair to the surface of the balloon. The balloon becomes negatively charged and your hair becomes positively charged.

The rules with charges:

- Opposite charges attract (move towards each other) – positive charges are attracted to negative charges.
- Same charges repel (move away from each other) – positive charges repel positive charges and negative charges repel negative charges.

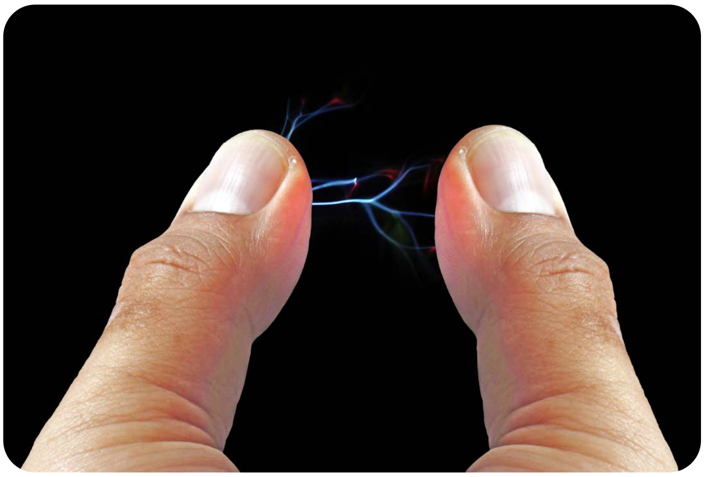
Your positively charged hair is attracted to the negatively charged balloon. When you take the balloon away, your hair stands on end. This is because each hair has a positive charge, so each hair is trying to move away from all the other hairs (because same charges repel each other).

Try this at home!

2. THE PRANKSTER

You will need:

- A carpet
- A pair of socks
- A metal doorknob, or someone willing to be shocked (very mildly!)



Method:

1. Put on the socks.
2. Move along the carpet, shuffling your feet as you go, so that your socks rub against the carpet.
3. Touch a metal doorknob or a person (with their permission) with one finger. Electricity should move between you and the doorknob or other person, which you will feel as a small electric shock.
4. If you try this in the dark, you might be able to see a spark of electricity – just remember to be careful and remove anything you might trip over before you switch off the lights.

What is happening?

When you rub your socks against the carpet, electrons move from the ground to your body, so you become negatively charged.

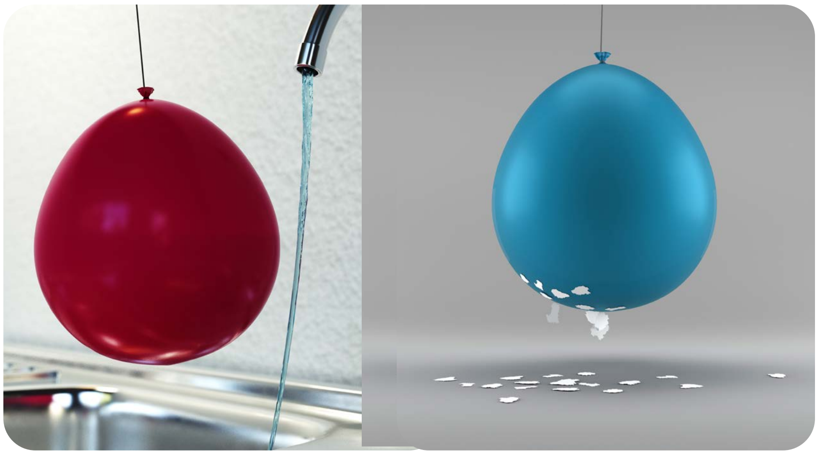
When you touch a metal doorknob or another person, the extra electrons jump through the air to reach them. This fast movement of electrons causes the electric shock that you feel.

Try this at home!

3. THE MAGICIAN

You will need:

- A balloon or a plastic comb
- A tap
- Small bits of paper or aluminium foil



Method:

1. Blow up the balloon.
2. Rub the balloon against your hair, or a jumper, to build up a charge on the surface of the balloon.
3. If you are using a plastic comb, comb your hair a few times.
4. Turn a tap on, then slowly turn down the water until you have a very thin stream of water flowing.
5. Move the balloon or comb slowly towards the water. The stream of water should bend as the water is attracted towards the balloon or comb.
6. Make sure the balloon is dry, then rub it against your hair or jumper to recharge the surface.
7. Put the small bits of paper or foil on a flat surface.
8. Hold the balloon above the paper/foil and slowly lower it. The paper/foil bits should 'jump' up and stick to the balloon.

What is happening?

When you rub the balloon against your hair or a jumper, the surface of the balloon becomes negatively charged. Positive charges in the water, paper and foil are attracted to the negatively charged balloon, so they are pulled towards it.

Why is it important?

The charged particles in a nebula will be attracted to each other and collect together to create small clumps. Gravity then pulls these clumps together.

The clumps will continue to grow, so their gravitational force will get stronger and stronger, pulling in more and more material from the nebula.

As they get larger, the pressures and temperatures inside the large clumps rises. When the temperature and pressure at the centre of a clump becomes high enough, hydrogen atoms will crash together and fuse (join) to make helium atoms. Heat and light energy are released in this process.

This is the birth of a star!

Further into space, further back in time

Light and time.

This ability to look back in time by looking a long way in space is based on the fact that light has a speed limit.

The speed of light is 186,000 miles per second.

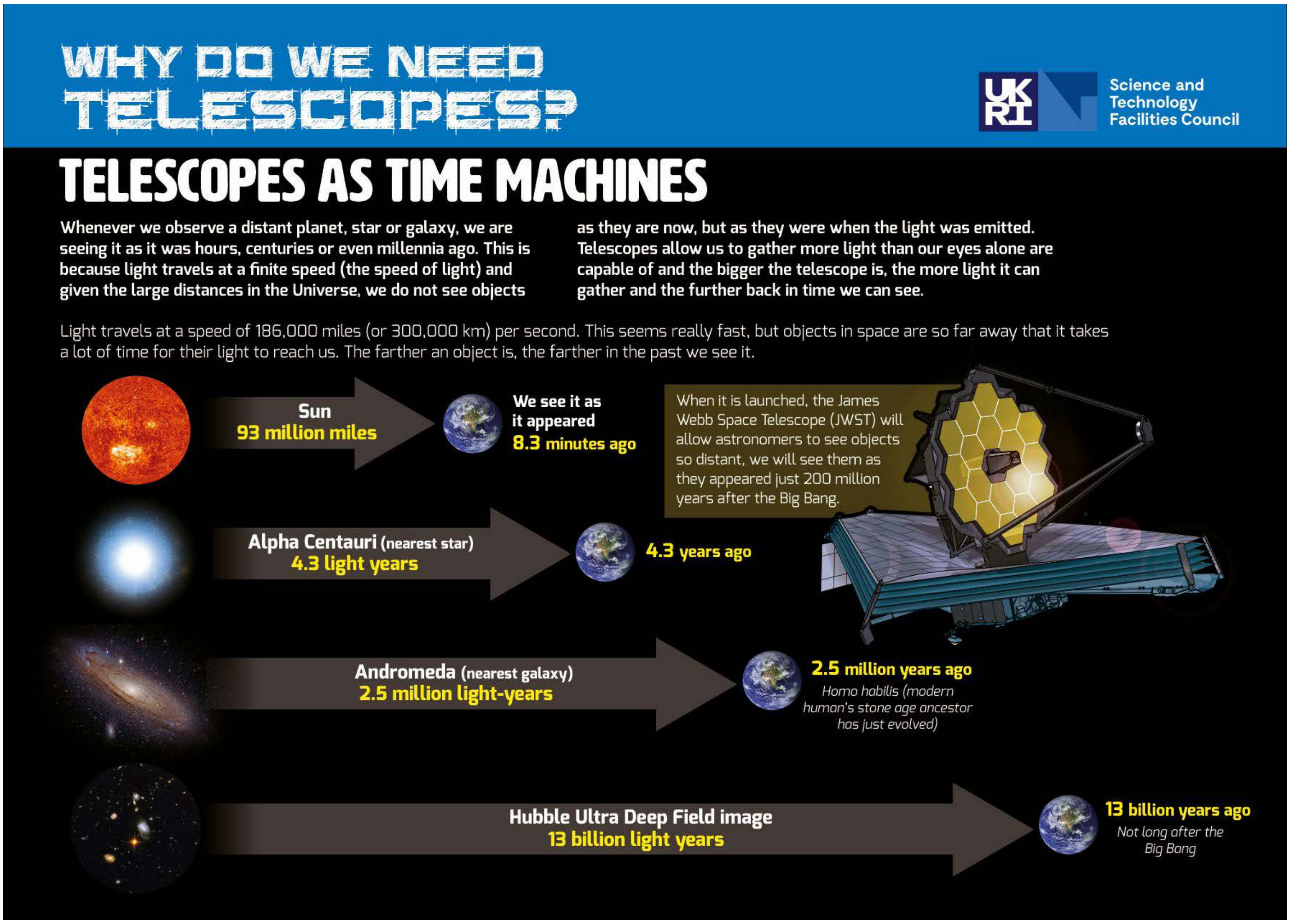
That means that sunlight (photons) reaching Earth now, left the sun just over eight minutes ago.

The further into space you look with a telescope, the more time has passed since the light you are observing set off on its journey towards your telescope.

If you look at a star that is 30 ‘light years’ away, you are seeing what that star looked like 30 years ago, because the light reaching your telescope from that star left the star 30 years ago.

The same applies to stars that are millions of light years away. The telescope is observing what that star looked like millions of years ago.

Telescopes



The closest known nebula to Earth is called the Helix Nebula. It is about 700 light-years away from Earth, which means it takes 700 years for the light from this nebula to reach us here on Earth.

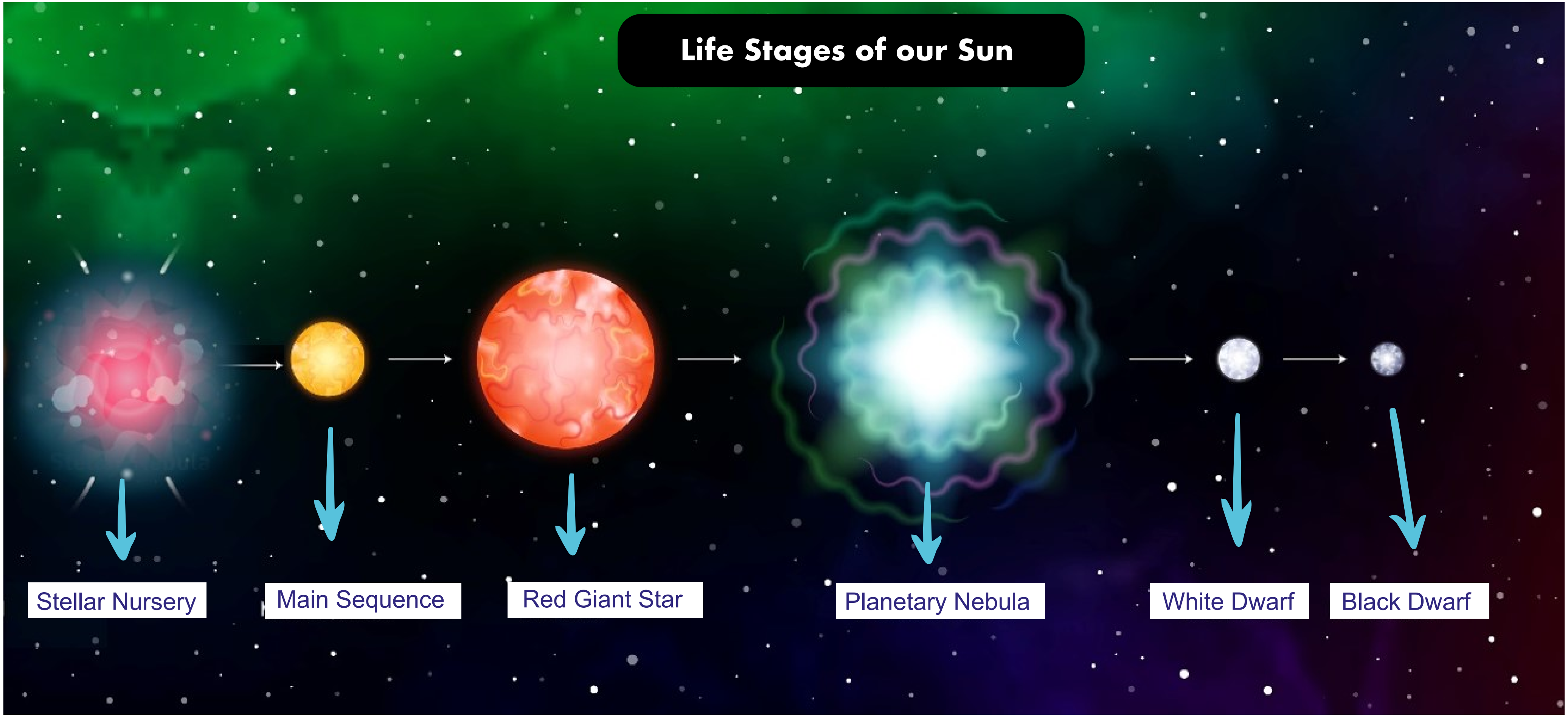
When we look at the Helix nebula with a telescope, we are seeing what it looked like 700 years ago.

When we look at the Helix nebula, we are looking back in time.

We can see objects much further away than this. The further they are from Earth, the longer it takes for the light from these objects to reach us, so the further we are looking back in time. This means we can use objects that are a very long way away in space, to study the history of our universe.

Our present – where are we now?

Our Sun is now in the main sequence stage of its life cycle.



During the main sequence, stars will fuse hydrogen in their core (centre) to form helium and release energy. This is called nuclear fusion.

The colour and temperature of a main sequence star depend on its size. Small stars are red and orange in colour and cooler than large stars, which are blue and white in colour. **Our Sun is a yellow, average-sized star.**

Try this at home!

THE COLOUR OF STARS

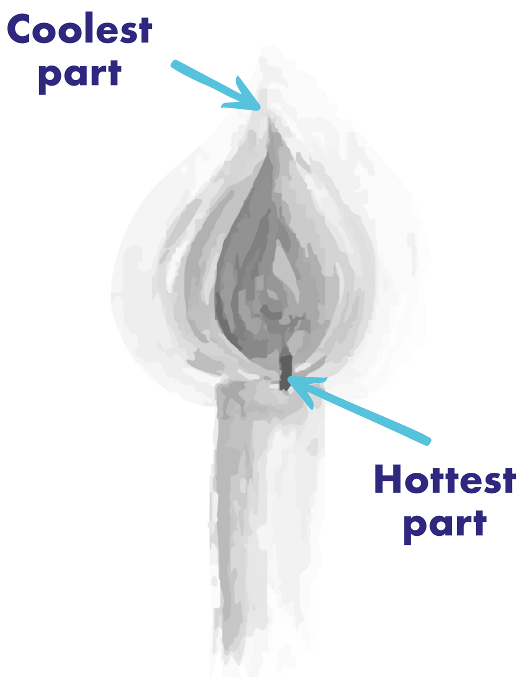
You will need:

- A candle
- A candle holder
- Matches
- Colouring pencils

Get permission from an adult before doing this activity and get help using matches. Take care around flames and any hot materials. Do not touch the flame.

Method:

1. Put the candle securely in the holder.
2. Light the candle.
3. Study the colours you can see in the candle flame and add these colours to the candle drawing on the right.
4. The hottest part of the flame is at the wick (string) and the flame gets cooler as you move away from the wick.



What is happening?

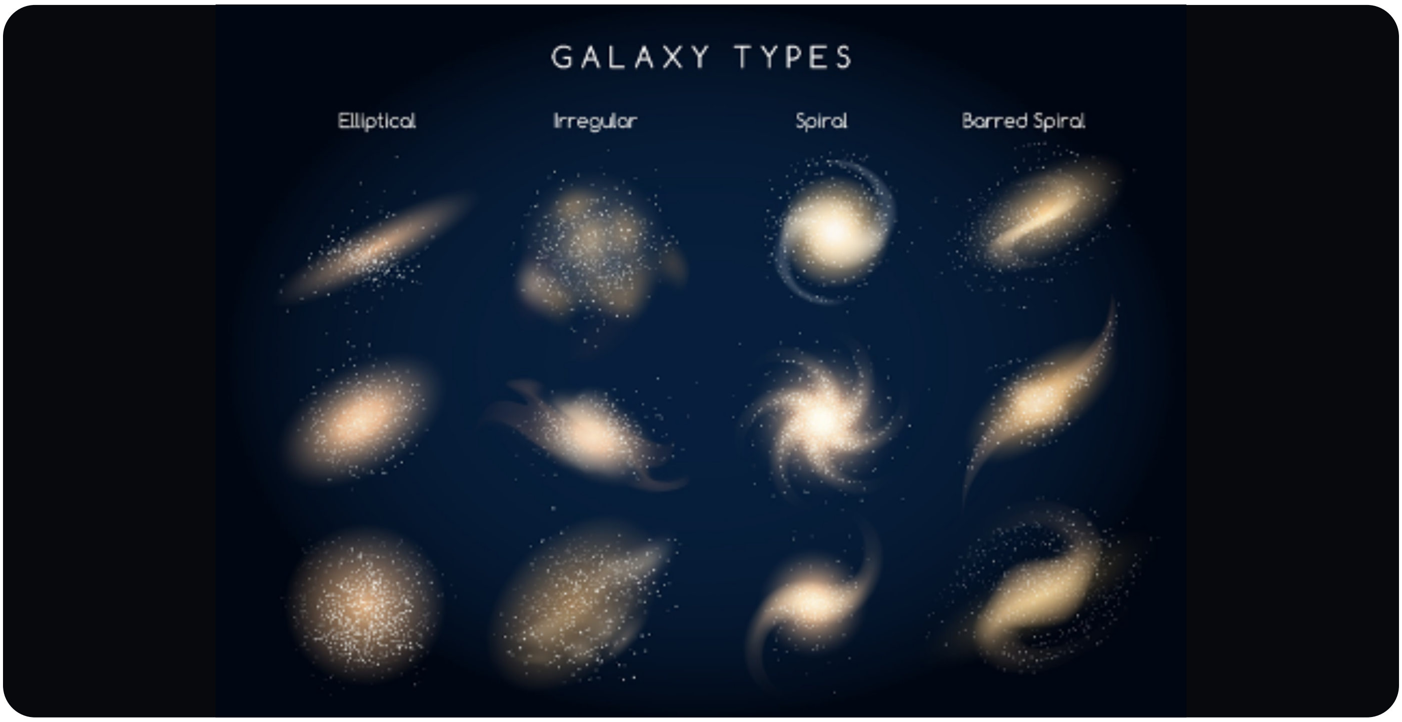
Stars are much hotter than the flame of a candle, but the relationship between temperature and colour is the same for stars as it is for the candle flame.

The blue part of the candle flame is hotter than the yellow and red parts. Blue stars are hotter than yellow and red stars.

Galaxies

Stars are found within galaxies.

A galaxy is a huge collection of dust, gas, billions of stars, and their solar systems (including planets). They can be a few different shapes, including round, oval, spiral and barred.



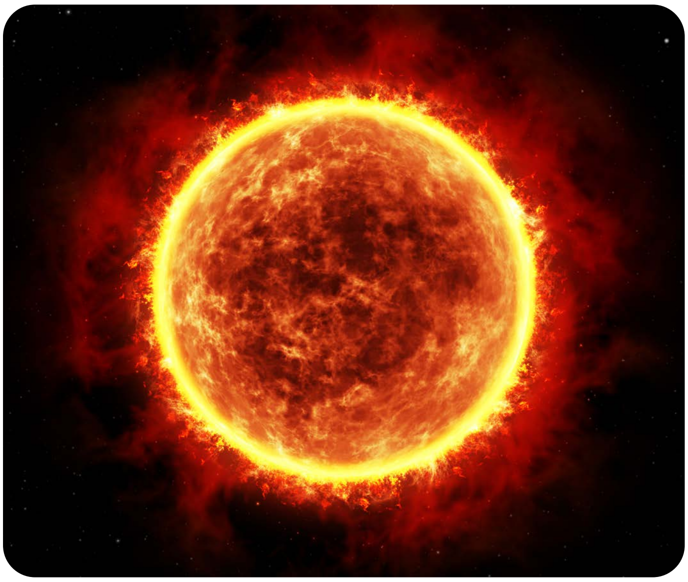
Milky Way

We live in a spiral galaxy called the Milky Way. We are probably about two thirds of the way out along one of the spiral arms.

We are here

Our future – what will happen to our Sun in the future?

When an average-sized star (like our Sun) uses up all its fuel, it expands (grows) and turns red as it cools down. When that happens, our sun will have become a ***Red Giant.***



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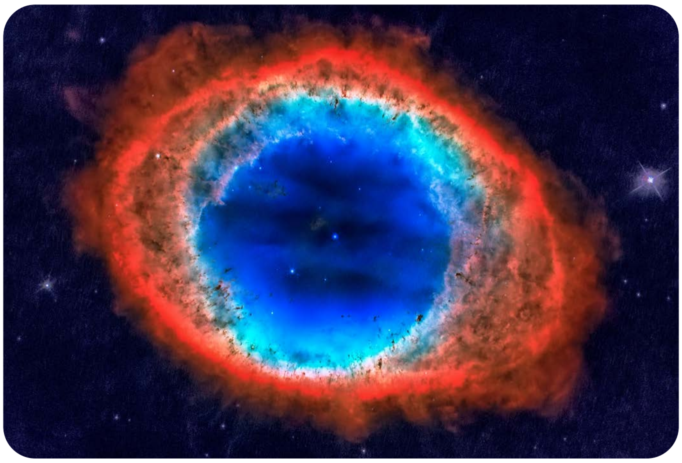


A small dense core, called a white dwarf is left behind. A ***white dwarf*** is so dense that a chunk of its surface, the size of a matchbox, would weigh the same as 15 elephants! The white dwarf will cool and dim to become a ***black dwarf.*** This is what will happen to our Sun in about 5 billion years.

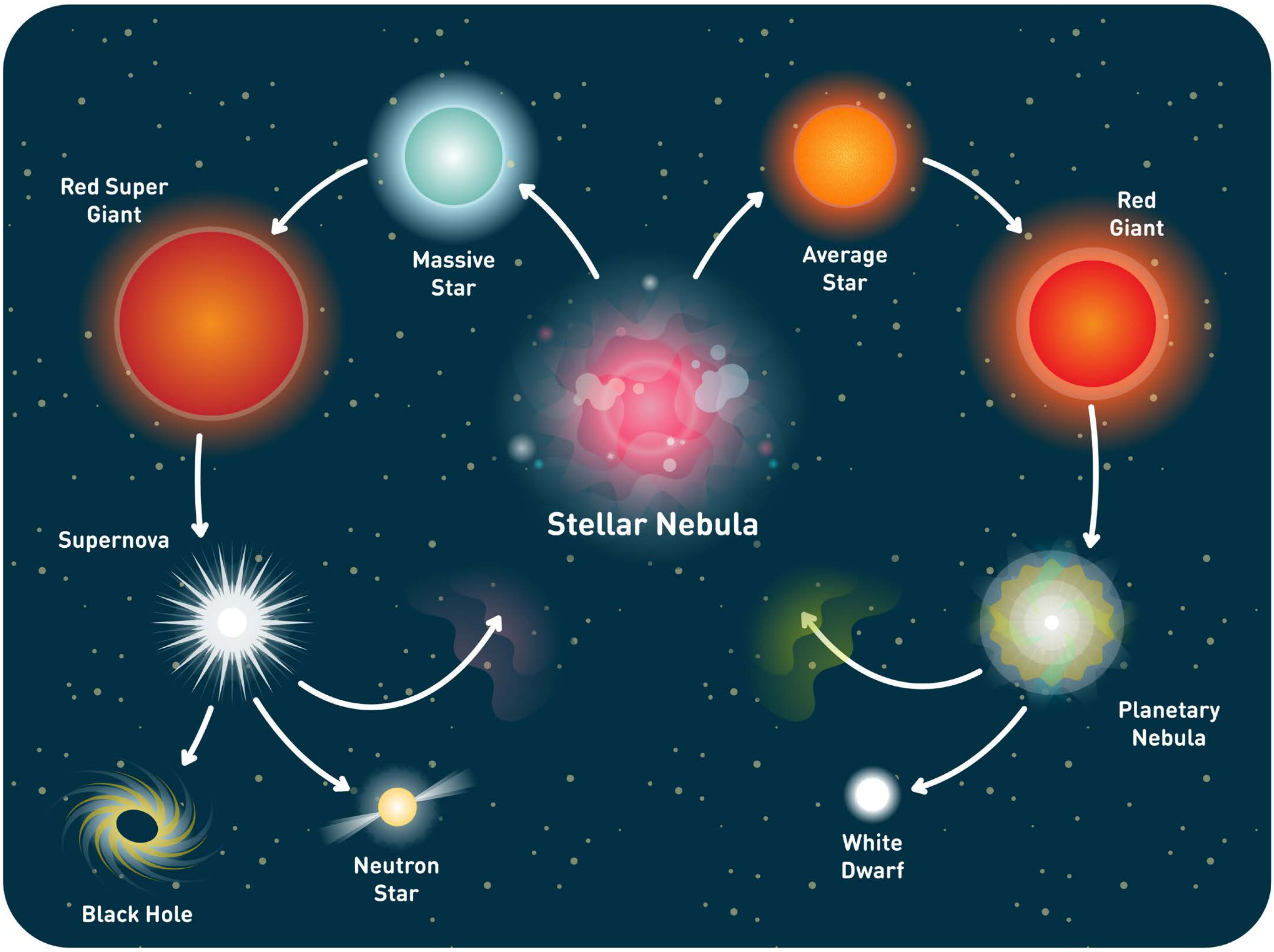
When a larger star (more than 7 times bigger than our Sun) comes to the end of its life, it will expand and cool to become a Red Supergiant.

The death of a Red Supergiant is much more spectacular. There will be a fiery explosion called a ***supernova,*** creating a type of nebula called a ***supernova remnant.*** This can shine as bright as an entire galaxy and can take a few days to fade completely.

The core of the star is left behind as a neutron star. These are even denser than white dwarfs and spin around really fast, sometimes several hundred times a second.

However, if the star was big enough (more than 20 times bigger than our Sun), it will become a black hole. Black holes have such strong gravity that nothing can escape them, not even light!

Star life cycle



Find out more

- Explore the night sky using this free **Stellarium software**.
- Get help identifying constellations and other night-sky objects with this free **Star Walk 2 Stargazing app**.
- Watch this **YouTube video by NASA** about how stars form.
- Watch S4's '**What's in the Night Sky? Science Club videos** to get astronomy tips and learn more about stars and deep-space objects.
- Learn this **BBC Bitesize** about the lifecycle of a star.

Swansea University Science for Schools Scheme

Swansea University Prifysgol Abertawe

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(S4) Funded by the European Social Fund and the Welsh Government.