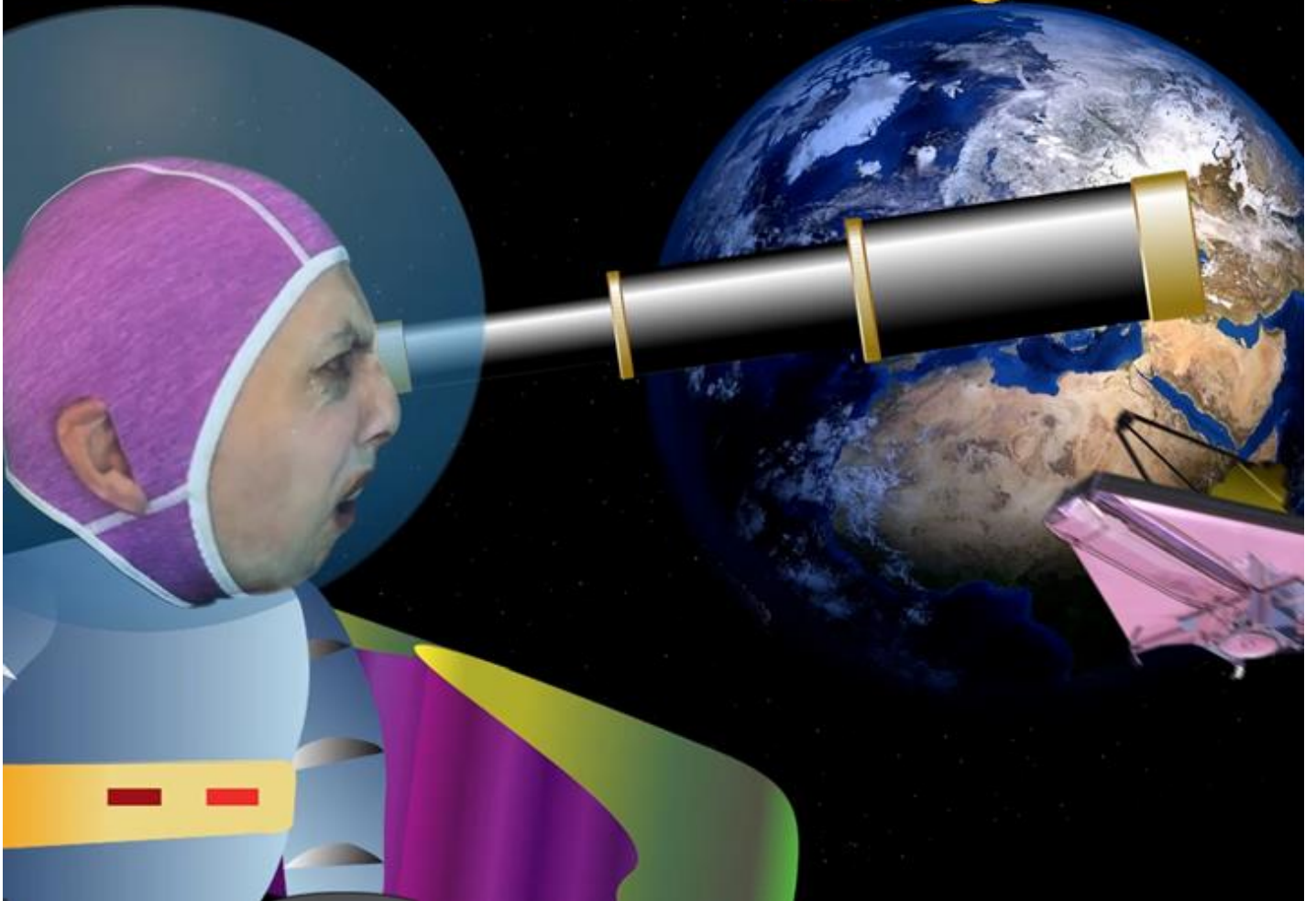


EN Song LOPEdia



# Notes on Space

A musical enrichment activity for Key Stage 3  
science

## Contents

Notes for the teacher.....	2
Suggested Lesson plan.....	3
Pre-evaluation.....	4
Us & the Universe.....	5
Lyrics and questions.....	5
Us & The Universe Questions - to be answered while you listen to the song.....	6
The Universe.....	7
Astronomical objects.....	7
Astronomical objects – Matching activity.....	8
Tools & Technology.....	9
Lyrics and questions.....	9
Tools & Technology Questions - to be answered while you listen to the song.....	10
Background for teacher.....	11
Telescope Activities.....	11
Discussion.....	11
How big is a telescope’s eye?.....	12
Homework Task – Write your own song!.....	13
Post Evaluation.....	16
Appendix – STFC infographics for JWST and ELT.....	17

## Notes for the teacher

This teachers' pack is intended as a science enrichment activity for students in years 7 or 8. It should be achievable within one 45-minute session, with some optional exercises if more time is available, and a homework task around the theme of science songwriting.

The pack is based around two songs and music videos from an educational music theatre show called *Ensonglopedia of the Human*. The full show consists of twenty-six songs, one for each letter of the alphabet, all providing different answers to the question "What does it mean to be human?" Answer "T" is that we are a tool-making species, and answer "U" is that we are a species who asks questions about its place in the Universe as a whole. The activities in this pack ask that the students watch the two music videos, answering some questions while listening, and then completing an additional exercise after each video.

The pack is designed to address the following bullet points on the Key Stage 3 National Curriculum in science:

### ***Working Scientifically***

- Describe science as iterative, building on previous work.

### ***Space Physics***

- Our Sun as a star, other stars in our galaxy, other galaxies.
- The light year as a unit of astronomical distance.

### ***Waves***

- Light waves travelling through a vacuum.
- The different frequencies of light.

It may be necessary to print out pages 5-6 and 8-10 (and 13-15 if you're setting the homework task) for your students to reference and fill in. The information for your students to reference for the songwriting task can be found in the appendix in this pack and the attached PowerPoint.

If you have any feedback on this pack (or indeed just to tell us that you've put it to use!), please email [everything@ensonglopedia.com](mailto:everything@ensonglopedia.com).

This pack, and the two music videos it's based on, were made possible thanks to a grant from the Science & Technology Facilities Council. Additionally, the *Ensonglopedia of the Human* project as a whole was supported by an Arts Council England Project Grant.

We hope you and your students find the contents useful and entertaining.

## Suggested Lesson plan

Below is a suggested plan for a 45 minute lesson. Please feel free to amend as needed. We have also included suggested lesson objectives.

- **Describe** – science and technology as a progressive process, building upon past findings.
- **Compare** – James Webb Space Telescope (JWST) to other ways of observing space.
- **Compose** – your own song (or poem) about science.

Time	Activity	Description
0	Starter	Students write down how they think scientists research space. The pre-evaluation could be used here.
5	Universe song	Play <i>Us &amp; The Universe</i> . While students listen to the song they can highlight and collate any words they are unfamiliar with. We have given some questions for them to answer about the song.
10	Activity 1 - Celestial Objects	Activity where students get a grasp on difference between different bodies in the Universe. Print out and distribute p.8 for your students to fill in.
15	Tools song	Play <i>Tools &amp; Technology</i> . While students listen to the song they can highlight and collate any words they are unfamiliar with. We have given some questions for them to answer about the song.
20	Discussion - Telescopes	Why do astronomers use telescopes? Where are these telescopes? What are some benefits and drawbacks of launching telescopes to space? Introduce the James Webb Space Telescope (JWST) and Extremely Large Telescope (ELT) along with the maths task.
30	Activity 2	Give your students the infographics on JWST and ELT. They are then led through a songwriting task to write a song about one of these telescopes.
40	Plenary	Wrap up & evaluation
45	Lesson end.	

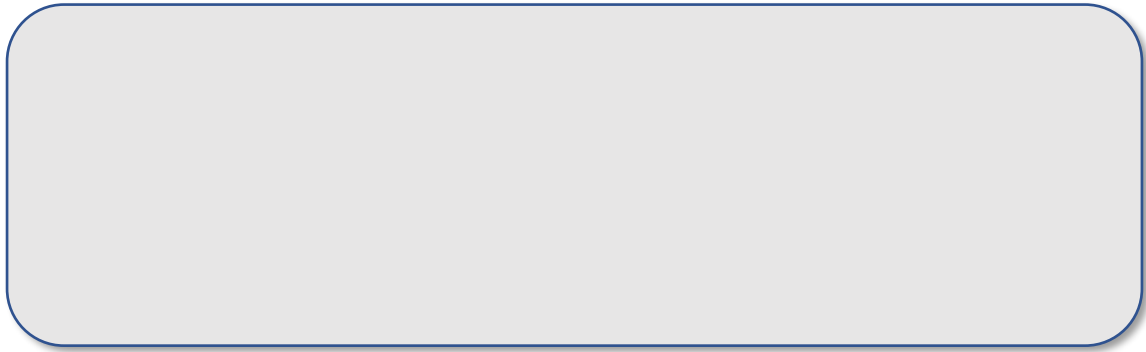
## Pre-evaluation

**Name:** \_\_\_\_\_

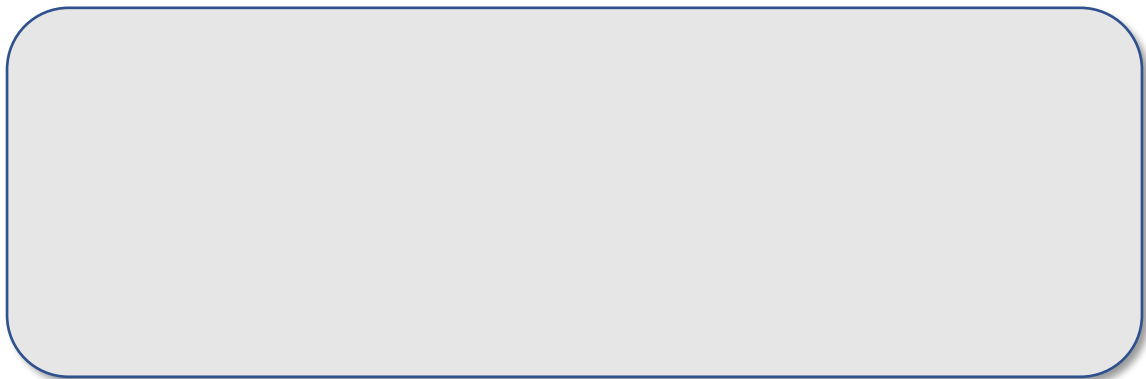
**Class:** \_\_\_\_\_

---

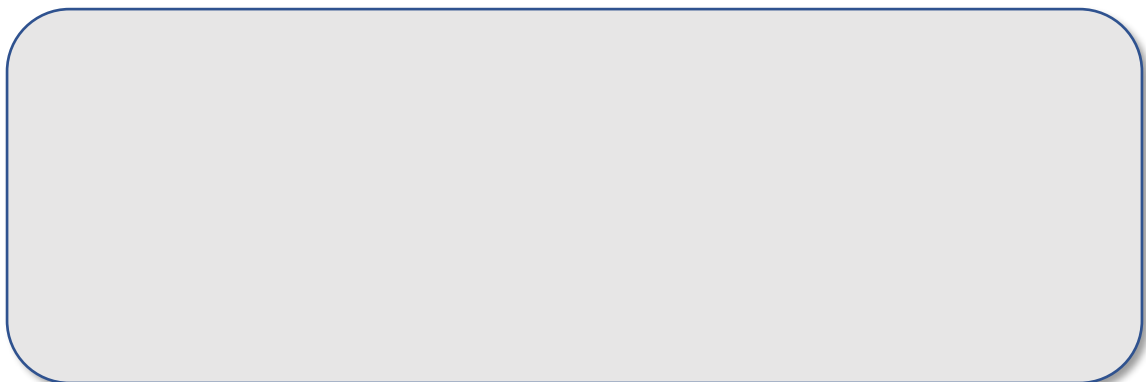
How many different astronomical objects can you name?



What do astronomers use to study space?



Can you name any telescopes?



## Us & the Universe

### Lyrics and questions

*It's extraordinary to think that the nursery rhyme Twinkle Twinkle Little Star was only written two hundred years ago. "How I wonder what you are" – just two hundred years ago, we had no idea what stars actually were. But we did have theories. Likewise, there were theories about everything else we see in the night sky. Now that we've worked a lot of it out, it's time the nursery rhyme got a little update.*

Of all of the creatures who've lived on this Earth  
The ones we call humans seem to be the first  
To ponder their place in the Universe.

Twinkle twinkle, little star,  
How we used to wonder what you are.  
Were you fixed to a heavenly plane?  
Could you help us predict the rain?  
Did you chart our past and future?  
Could you help us find our suitor?  
Twinkle twinkle little star,  
Now we know much better what you are.

Twinkle twinkle little planet,  
Oh how we endeavoured to understand it.  
Was your shine divine and godly?  
Were you a star that twinkled oddly?  
Why did Mars sometimes reverse its direction?  
What happened to celestial perfection?

Twinkle twinkle big round Sun,  
How a total solar eclipse would stun.  
What did this baffling occurrence portend?  
Was the world soon about to end?  
Was the Sun being eaten by a beast?  
Did it represent a warning, at least?

We now know stars  
Are all suns much like ours,  
And a planet is a sphere  
Like this Earth we've got here,  
And total eclipses  
Happen when ellipses  
Lunar and solar  
Fleetingly cross over.

As for the strange path of Mars, it's explained by the fact that the Earth's not the centre of our Solar System. Those old superstitions have been superseded as peer reviewed science has lately replaced received wisdom. But so many questions remain. There is still so much left to explain.

The idea that the stars were literally fixed to the inside of a vast 'celestial sphere' or 'firmament' was very common since ancient times, and was first challenged by Giordano Bruno in 1584.

Of course, some people still believe that the position of the stars can predict future events here on Earth. But they can't.

The link between the planets and the gods lives on in their names: all the planets except Earth are named after Greek or Roman gods or goddesses.

Mythological beasts who ate the Sun during a solar eclipse include a Vietnamese giant frog, Norse wolves, a Chinese dragon, a Native American bear, and the decapitated head of the Hindi god Rahu.

As the Earth passes Mars on its orbit round the Sun, Mars will briefly appear to travel in the opposite direction across the sky. This is called 'apparent retrograde motion'.

Twinkle twinkle distant sun,  
By alien lifeforms are you overrun?  
Why is space missing so much of its matter, and  
What explains the mountain chains  
On the moons of Saturn?  
At the end, will it just disappear?  
Why is the Universe here?  
Twinkle twinkle distant glow  
The simple fact is that we do not know.

There's something extremely puzzling about the amount of matter in the Universe. There doesn't seem to be nearly enough stuff out there to explain the way galaxies behave. The missing stuff (which should account for 85% of all matter) is termed 'dark matter'. And then there's also the mystery of 'dark energy', but don't get me started.

Collect the words you are unfamiliar with here.

### Us & The Universe Questions

- to be answered while you listen to the song

1. What weird thing does Mars sometimes do?

2. What is the difference between The Sun and other stars?


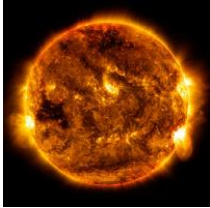


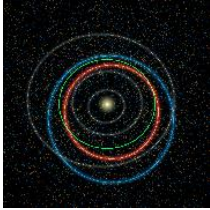
3. How does the song explain eclipses? (Either in your own words or using the song's words)

## The Universe

The Universe contains many different celestial objects. In the following activity your students will be introduced to five major objects astronomers observe.

### Astronomical objects

Below are the answers to the following matching activity.

<b>Planet</b>		<b>Jupiter</b>	A body that is large enough to be spherical due to its gravity, but not large enough for nuclear fusion to happen. They usually orbit a star.
<b>Star</b>		<b>The Sun</b>	Ball of gas that is so massive that gravity forces nuclear fusion to happen. They often come in pairs.
<b>Galaxy</b>		<b>Milky Way</b>	Groups of millions, to 100s of billions of stars, with a supermassive black-hole at the centre.
<b>Nebula</b>		<b>The Pillars of Creation</b>	Huge clouds of gas, many light years wide. These are the birthplace and graveyards of stars.
<b>Planetary System</b>		<b>The Solar System</b>	The collection of planets, asteroids and other satellites gravitationally bound to a star or star system.



## Astronomical objects – Matching activity

Connect the matching name, picture, example, and explanation of these different astronomical objects. You can use different coloured pencils to help tell the lines apart!

<b>Galaxy</b>		<b>The Sun</b>	Huge clouds of gas, many light years wide. These are the birthplace and graves of stars.
<b>Nebula</b>		<b>Milky Way</b>	Ball of gas that is so massive that gravity forces nuclear fusion to happen. Often come in pairs.
<b>Planet</b>		<b>Jupiter</b>	Groups of millions, to 100s of billions of stars, with a supermassive black hole at their centres.
<b>Planetary System</b>		<b>The Solar System</b>	Collection of planets, asteroids and other satellites gravitationally bound to a star or star system.
<b>Star</b>		<b>The Pillars of Creation</b>	A body that is large enough to be spherical due to its gravity, but not large enough for nuclear fusion to happen, and usually orbits a star.

Write down the objects in ascending size order (starting with the smallest).

## Tools & Technology

### Lyrics and questions

*It is often very difficult to know exactly when certain types of tool were invented, especially a long time ago. There is also lots of debate about how to define certain eras in tool-making history. However, by and large, all the inventions mentioned in this song are listed in the order that we think they first appeared.*

As far as toolkits go, there is no older one  
Than the stone age toolkit called the Oldowan.

The Oldowan Toolkit was widespread between 2.6 and 1.7 million years ago, and consisted of simple stone tools made by chipping off flakes with another stone

The Stone Age is split into the Paleolithic,  
The Mesolithic and the Neolithic,  
And the stuff that they came up with was utterly terrific.  
Knock knock knock with a fist-sized rock.  
Scrape scrape scrape with a sharp flint flake.  
Whack whack whack with a rough hand axe  
Boom boom boom, it's the world's first spoon.

'Paleo-' means ancient, 'Meso-' means middle, and 'Neo-' means new. The exact dates of these eras were different in different places.

*Tool, tool, tool me up.  
I'm fashioning a tool and I just can't stop.  
From the first sharpened stick to the conquest of space  
Tools are a trait of the human race.*

Then came the time when we started to engage  
With the smelting of metal alloys. It was all the rage.  
First came the Bronze Age and then the Iron Age.  
Oh how exciting! It's the first recorded writing!  
I just can't cope! We've now got soap!  
Woah man, for real! It's the first spoked wheel!  
It's harder to harm a soldier in armour!

Most useful metals can't be found in the ground in pure form (gold is an exception), and therefore need to be smelted. This process was invented over 8000 years ago.

Then, with our own age getting nearer and nearer,  
Comes the start of the historical era  
When the dating of inventions is a lot lot clearer,  
Wow, that's ace!  
It's the spiral staircase!  
Wow, that's brill!  
It's the first windmill!  
Yes yes yes!  
It's the printing press!  
There's still hope!  
It's the telescope!  
This must be a dream!  
Things are running off steam!

The 'historical era' is defined as the period about which we have a reliable written record. The inventions listed here span the period 480BCE - 1710CE.

*Tool, tool, tool me up.  
I'm fashioning a tool and I just can't stop.  
From the first sharpened stick to the conquest of space  
Tools are a trait of the human race.*

The invention of electricity was a magical  
Turning-point in making the world more practical.  
This is the era electromechanical.  
Night time's solved! It's the first light bulb!  
This is fantastic! We're making stuff with plastic!  
Woah, what a trip! It's the world's first zip!  
This is blowing my brain! It's the first aeroplane!

Now mankind is really on a roll  
And the speed of progress is taken to a whole  
New level. Things are spiralling out of control!

Personal computers! Chemotherapy for tumours!  
Manned space flight! The LED light!  
Infrared lasers! Rechargeable razors!  
Mp3s! DVDs!  
The International Space Station!  
CRISPR Cas-9 gene manipulation!  
A vaccine against COVID-19!  
What are the next  
Technological steps?  
A telescope that sees even further galaxies?  
Will we integrate technology into our biology?  
Will we live in space?  
Have the power to erase  
Humanity at the press of a key?  
What new toolkits do we want to see?

*Tool, tool, tool me up.  
I'm fashioning a tool and I just can't stop.  
Without apology, I think technology is ace,  
For I am a member of the human race.*

Collect the words you  
are unfamiliar with here.

People have known about the  
existence of natural forms of  
electricity for thousands of years -  
such as electric eels, lightning and  
the related phenomenon of  
magnetism. However, it wasn't until  
the late 1700s that electricity was  
well-enough understood for its  
power to be harnessed.

The rate of technological growth  
really has been speeding up over  
the past decades and centuries.  
One reason for this is that new  
inventions are not only based on  
older inventions but are actually  
designed *using* those inventions.  
For example, there's no way we'd  
have found a COVID-19 vaccine so  
quickly without computers.

### Tools & Technology Questions - to be answered while you listen to the song

1. Circle which invention in each of  
these pairs came first, according to  
the song.
  - a. Wheel or soap?
  - b. Telescopes or printing  
press?
  - c. Aeroplanes or zips
  - d. Mp3s or the International  
Space Station?
2. What invention mentioned in the  
song is used to look at galaxies?

## Background for teacher

The tools that this pack focus on are telescopes. In this section, your students will get to learn about the James Webb Space Telescope (JWST) and the Extremely Large Telescope (ELT).

One important consideration of where to place your telescope is what sort of EM radiation you wish to capture. For example, if you want to capture visible light, then ground based observations are just fine, as the atmosphere lets the vast majority through. However, while near-infrared light (infrared light that is near to visible light) can pass through the atmosphere, mid or far-infrared light (infrared light that is far from visible light) cannot, and so you need to send your telescope in to space to capture this form of light.

A downside of space based telescopes is that you have to send them to space. This means that they cannot be as large as ground based telescopes as they have to fit in a rocket. The JWST employed very intricate origami to fold it into the small space available in the rocket, with its mirror opening out to a diameter of 6.5m after launch. Compared to that, the next generation ground based telescope ELT will have a diameter of 39.3m (that's almost the length of 4 buses!).

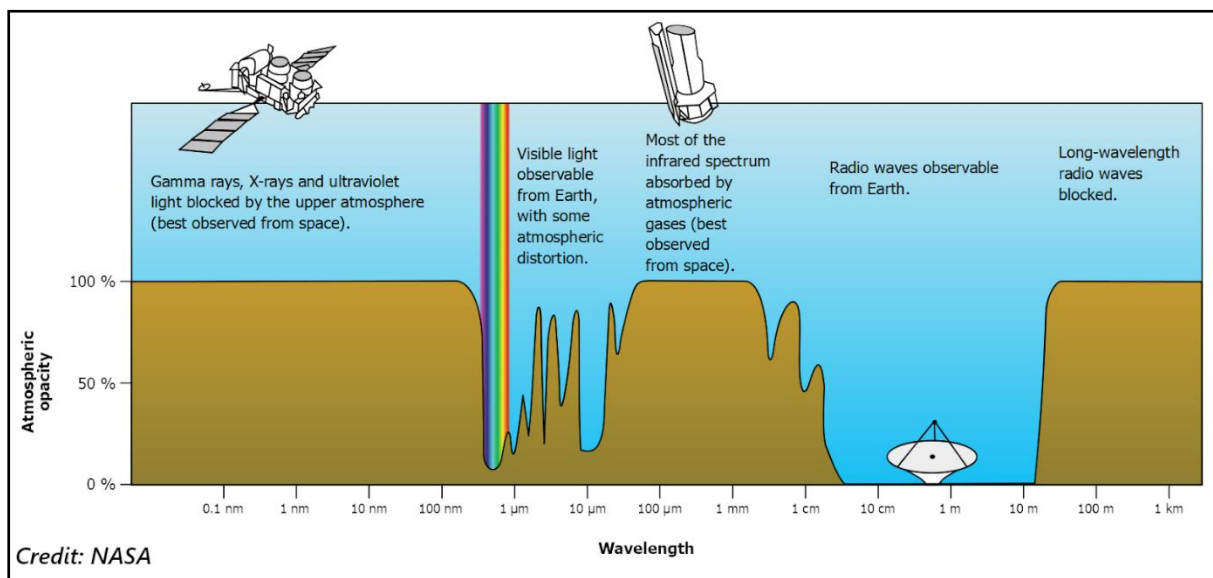


Figure 1 Representation of what types of electromagnetic radiation are absorbed by our atmosphere.

## Telescope Activities

### Discussion

1. Give your students about 30 seconds to come up with reasons why telescopes might be better than the naked eye at studying space. (e.g. collect more light, can resolve more, can take pictures etc.)
2. Some telescopes are on the ground, some in space. In groups, give your students about 30 seconds to think of some benefits and drawbacks of each position.

### How big is a telescope's eye?

We have included a maths activity. This is to calculate aperture area from the telescopes' main mirror's radius, including opportunities for them to practice rearranging equations.

Two examples of next generation telescopes that the UK is involved in are the James Webb Space Telescope (JWST) and the Extremely Large Telescope (ELT). To focus the light they receive these telescopes use huge mirrors.

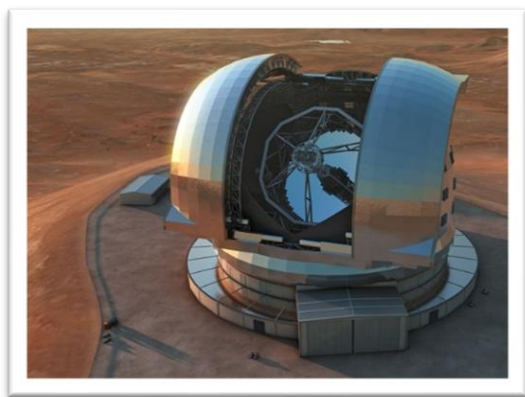


Figure 2: The ELT is currently being built. Note the cars in the foreground - this telescope will be extremely large! Credit: ESO/L. Calçada

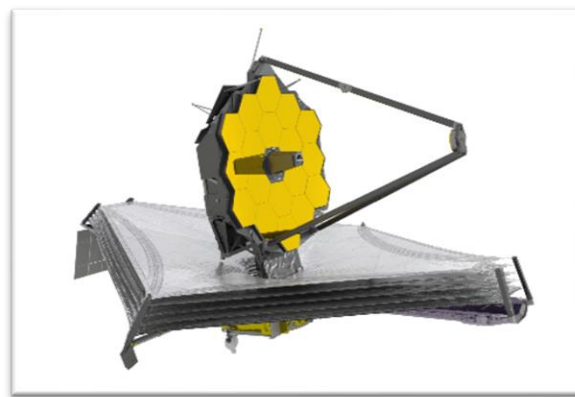


Figure 3: The JWST's sunshield is as big as a tennis court. Credit: European Space Agency/ATG medialab

Using the equation for area of a circle:  $A = \pi r^2$

Object	Diameter (m)	Radius (m)	Total area ( m <sup>2</sup> )
Pupil of human eye (think about how many you have)	0.0050	0.0025	0.00016 As people usually have 2 eyes.
James Webb Space Telescope	6.50	3.25	33.2
Extremely Large Telescope	39.3	19.65	1213

Students can discuss which would be able to collect the most light and why this is important.

## Homework Task – Write your own song!

Now that you've had a listen to two of my songs about science, it's time for you to write your own. Here are the steps I go through when I'm settling down to write a science song, and I'd like you to follow them.

### 1. What is your song about?

The list of possibilities is almost endless, so I'll make it a bit easier for you. Your song is going to be about a telescope. Specifically, it'll be about either the James Webb Space Telescope (JWST) or the Extremely Large Telescope (ELT). What? You don't know anything about them? Don't worry! We have infographics!

#### a) Split into groups

While I generally write my lyrics alone, it can help to write them in pairs, especially when time is limited. Threes can work too. But I wouldn't really recommend many more than that.

#### b) Each group gets one infographic

These infographics were made by the Science & Technology Facilities Council, who part-funded the JWST, and also part-funded the activity pack you're currently reading (thanks for the money!).

Each group (of 1 to 3 people) gets one sheet, which is about one aspect of one of the Telescopes. Read it. Read it again, and if you don't understand anything, ask or look it up.

### 2. Mindmap the topic

Write down the main theme of your infographic in the middle of a bit of paper. It is up to you if you want to have one bit of paper for the group and designate a scribe, or have one each.

Spread out over the rest of the bit of paper, write down words that are related to the topic you wrote in the middle, and draw a line from the middle to those words. For example, if the topic was "Mars", subtopics might include geology, atmosphere, orbit, human colonisation, the Roman God of War, why it's red...

Some of the related words may have related words of their own (for example, human colonisation might be further split into SpaceX, NASA, space food...).

You can use the words that appear on your infographic, but it might be nice if you find words of your own to describe what you've found out.

### 3. Rhyme!

Ideally in a different colour, write down words that rhyme with the words on the page in front of you. The most useful rhymes are ones that are also in some way related to the topic (for example, if your topic was “Horses”, and your related word was “Ride”, then an excellent rhyming word would be “astride”, since that is a word you also use in relation to horses). Write as many possibly-useful rhyming words for each word that you can think of.

**A note on true rhymes and half rhymes:** “Ride” and “astride” are known as true (or perfect) rhymes, because both the vowel (the “i”) and the final consonant (“d”) sound the same when you say them. “True” and “crew” are also true rhymes, even though the ending is spelt differently, because in songs it’s the sound that’s important. There is also something called a half-rhyme, which is where either the vowel or the consonant don’t sound exactly the same. An example is “ride” and “wild”. Or “horse” and “house”. The important thing is that **half rhymes are absolutely fine!** When you listen to a song, you hardly notice when a rhyme is not perfect. So, for this exercise, do use half-rhymes and don’t let anybody tell you off for it!

Remember to find a rhyme or two for the topic that’s written in the centre of your bit of paper too.

### 4. Expand the rhymes in to couplets

The next step is to try to communicate the information that’s on your infographic to everyone else but using rhyme rather than just telling them the information.

So, try to flesh out the rhyming pairs you’ve already found into full lines that convey the information as accurately as possible. You are allowed a bit of poetic license, such as adding your own opinion, or introducing metaphors or wordplay. But what you’re not allowed to do is get any of the science wrong!

Ideally, the lines should have the same rhythmic meter (the same number of stressed beats per line), but don’t worry too much about this. Here are two examples, with the stressed beats underlined, and both of which add a personal opinion to the information:

I like to sit astride  
My horse and have a ride.

Mars missions have been planned by SpaceX and NASA,  
But personally I put more trust in the latter.

(Notice the half-rhyme – “NASA” and “latter” almost rhyme but not quite, and **that’s fine.**)

If you’ve got time, write more couplets. Don’t worry if they seem bad to you at the moment – it’s best just to write them down, because once they’re down you may spot a way to improve them, or someone else might. Don’t censor yourself while you’re creating – write it all down.

## 5. Verses

There are lots of different parts to a song – there’s the intro, the outro, the middle-8, the bridge, the instrumental... but for the moment, let’s just concentrate on the chorus and the verses.

We’re going to say that what you’ve been writing so far are verses. Everyone whose infographics were about JWST were writing verses of one song, and everyone whose infographics were about ELT were writing verses of another song.

Share the verses – read them out to each other. Then do your best to put them in an order. It could be that two groups’ couplets might go together into the same verse, or it may be that they should go in different verses. There’s no right or wrong and it’s not like the ‘best’ verse should go first or last or somewhere in between, it’s just a question of what seems to make sense. If there’s a disagreement, teacher decides!

And now it’s time to write the chorus!

## 6. Chorus

This may be your homework task. Now that you know a fair bit about the particular telescope you’re writing about, write a catchy, rhyming chorus that can be repeated again and again between each verse, and that kind of sums up the essence of the telescope, or maybe addresses some other aspect of it that isn’t covered by any of the infographics. You may need to do some more research for this task.

## 7. What next?

Well, it’ll need a tune (unless it’s spoken word). Then you’ll need to pick up an instrument (or lay down some beats). Then form a band and I look forward to seeing you on tour ☺

If you fancy hearing some of the hundreds of other science songs I’ve written, search YouTube or Spotify for “Ensonglopedia”.



## Post Evaluation

Name: \_\_\_\_\_

Class: \_\_\_\_\_

What is the JWST?

Give one benefit and one drawback of having a telescope in the following locations

**On the ground**

Benefit

**In space**

Benefit

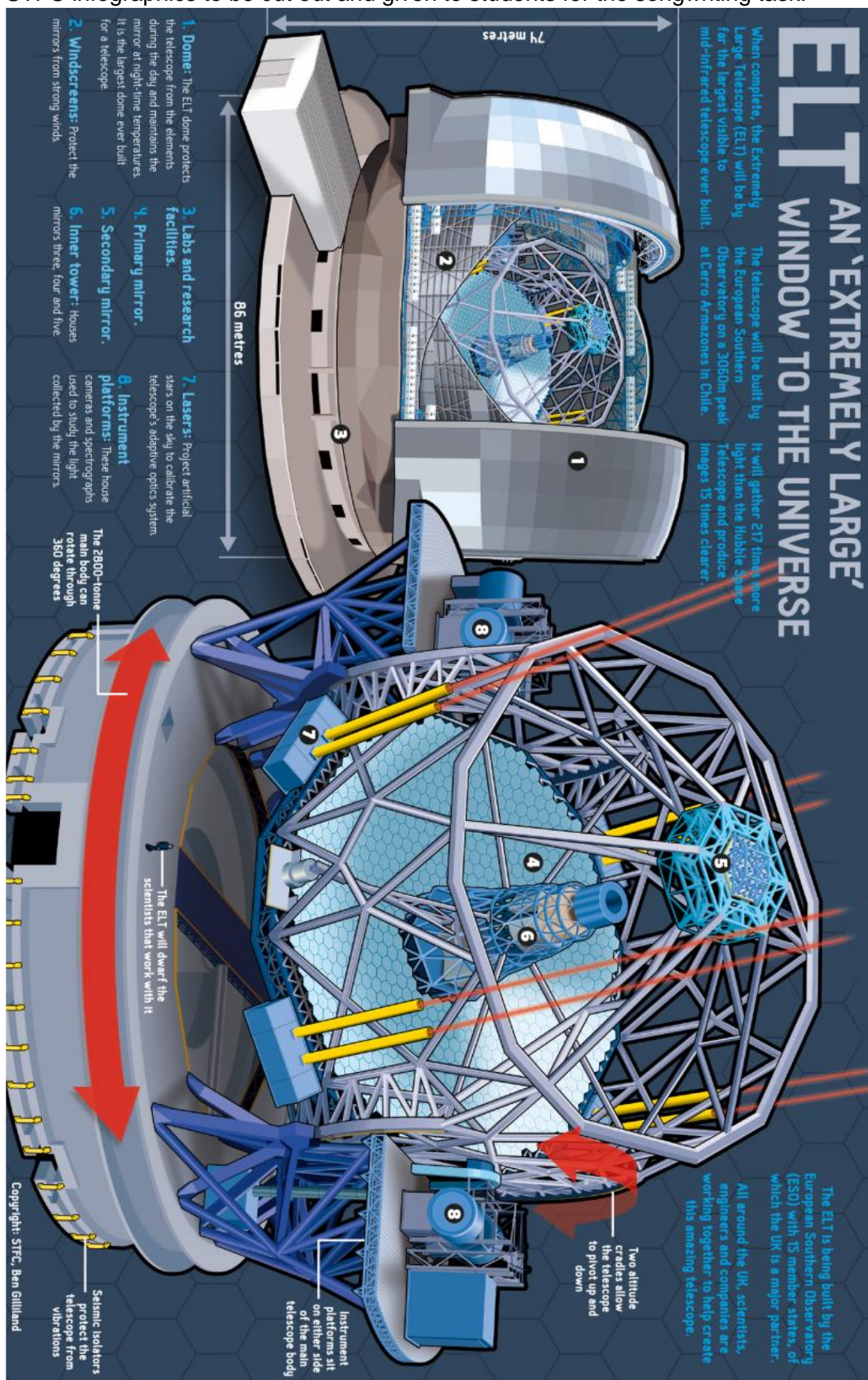
Drawback

Drawback

How many different astronomical objects can you think of?

## Appendix – STFC infographics for JWST and ELT.

STFC infographics to be cut out and given to students for the songwriting task.



# JWST information

Copyright: Ben Gilliland, STFC

**Looking back in time**  
Light travels very fast, but its speed is finite and can take a long time to reach us. As a result, the moon distant on object is, the further back in time we looking. Hubble can see back to the 'fodder' stage of the universe when it was barely 1 billion years old. Webb will be able to capture light from universe's 'baby' stage when the first stars were born after the Big Bang.

JWST will be able to reveal stars and galaxies that are too distant, dim or obscured for Hubble to see (as this Hubble image and a simulated Webb image show)

**Hubble JWST**

**1** Unlike Hubble, which orbits the Earth, Webb will sit at area in space called a Lagrange point. Webb will occupy Lagrange 2, which is a region about 1.5million km from Earth, where the Sun's gravity and Earth's gravity cancel each other out – allowing the craft to remain relatively stationary.

**2** JWST will not be exactly at the L2 point, but circle around it in a halo orbit.

**3** This means that Webb isn't subjected to the same extreme heating and cooling cycles as an Earth-orbiting craft.

Moon's orbit 384,400km  
Hubble orbit 570km  
JWST 1.5million km

To the Sun

Copyright: Ben Gilliland, STFC

**How the mirrors work**  
The ELT has a unique system of five mirrors and an advanced adaptive optics system.

**a. Mirror 1:** The 33.3-metre primary mirror collects light and reflects it to the secondary mirror.

**b. Mirror 2:** A 4.2-metre mirror that reflects light back down to the third mirror.

**c. Mirror 3:** This 3.6-metre relay light to the adaptive mirror located directly above.

**d. Mirror 4:** Mirror 4's adaptive optics system uses data derived from stars to compensate for atmospheric distortions.

**e. Mirror 5:** This 2.6x2.1-metre mirror is mounted on a fast-moving stage that allows it to tip and tilt to stabilise the image.

**f. Mirror 5** directs the light to instruments - cameras and spectrographs - on the stationary platforms.

More than 5000 actuators allow the mirror's surface to change shape thousands of times a second.

2.4 metres

39.3 metres

**The primary mirror**  
Spanning 39.3 metres across, the primary mirror of the ELT will be made up of 798 individual hexagonal mirror segments – each measuring 1.45 metres. Pistons allow each segment to tilt and tip.

Each mirror segment can move independently to compensate for changes in the shape caused by temperature fluctuations and gravity.

1.45 metres

Science Instruments

Copyright: STFC, Ben Gilliland

**ELT science**  
Copyright: STFC, Ben Gilliland

The ELT's huge light-collecting area will allow us to peer deeper into the Universe and see fainter objects. Its ability to correct for atmospheric distortion will provide images of unprecedented detail. This combination will allow the ELT to deliver ground-breaking science in many areas of astrophysics and observational cosmology.

The ELT will be the only telescope capable of directly imaging rocky planets beyond our Solar System that up to now have only been seen indirectly. We will measure the atmospheric composition and even search for possible biomarkers.

The ELT will be able to provide major insights into the nature of black holes and how galaxies form and evolve. It will be able to peer back to the earliest galaxies that formed after the Big Bang.

The ELT will also help us to understand the elusive dark matter that pervades the cosmos and even more mysterious dark energy that seems to be causing the Universe to expand at an ever-increasing rate.

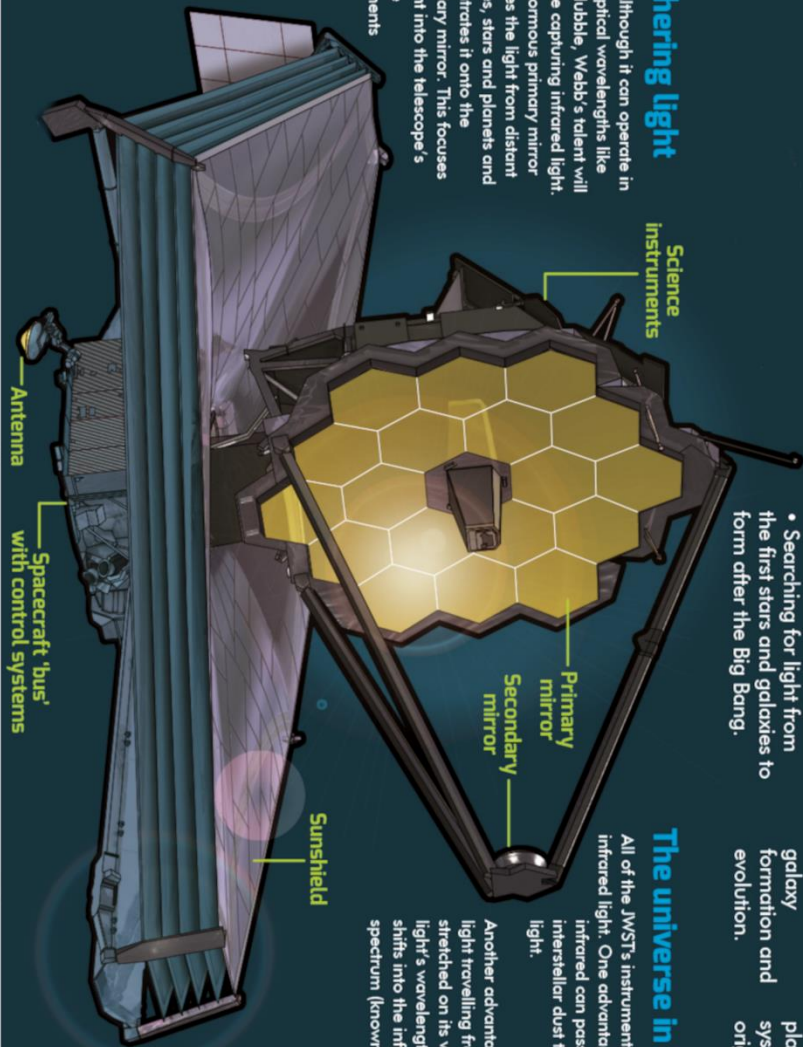
Of course, the most exciting discoveries will be those that we can't even predict yet!

Image: MPA

# ELT information

## Gathering light

1 Although it can operate in optical wavelengths like Hubble, Webb's talent will be capturing infrared light. The enormous primary mirror captures the light from distant galaxies, stars and planets and concentrates it onto the secondary mirror. This focuses the light into the telescope's science instruments.



**The JWST will be tasked with:**

- Searching for light from the first stars and galaxies to form after the Big Bang.

- Studying galaxy formation and evolution.
- Studying planetary systems and the origins of life.

## The universe in infrared

All of the JWST's instruments will observe infrared light. One advantage of that is that infrared can pass through the interstellar dust that blocks visible light.

Another advantage is that visible light travelling from a distant star is stretched on its way to us. The light's wavelength gets longer and shifts into the infrared part of the spectrum (known as redshift).

Three of the JWST's detectors are tuned to the near infrared. One of JWST's most important detectors, the Mid Infrared Instrument (MIRI), has been designed and built by a UK-led consortium including STFC.

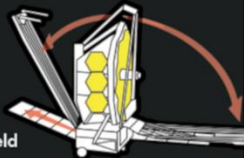
## Telescope origami

Webb is too big to be launched in its operational configuration, so it will unfold in space.

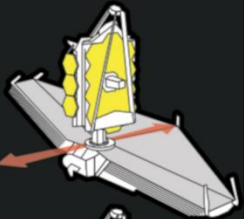


Launch configuration.

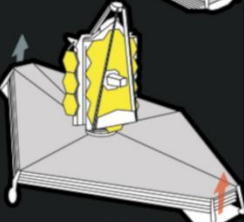
Solar array is deployed and sunshield unfolds.



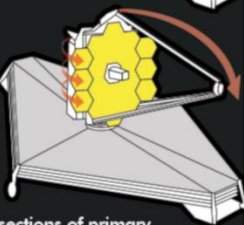
Sunshield extends.



Sunshield's layers are raised and separated.



Secondary mirror is deployed and folded sections of primary mirror move into position.



## The mirror

The mirror has about seven times the light-collecting area of Hubble and has a field of view more than 15 times larger.

### Hubble



2.4 metres



JWST

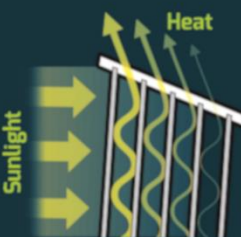
6.5 metres



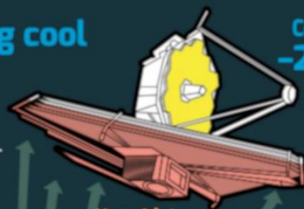
## Keeping everything cool

Webb is primarily an infrared telescope and, since infrared radiation is heat, it has to be shielded from the Sun's radiation.

The tennis court-size sunshield is made of five layers of metallised plastic about as thick as a human hair.



Each layer blocks and deflects some heat, which is then vented away from the telescope.



Cold side  
-233°C

Hot side  
85°C

