

# Teaching STEM through Big Telescopes

This document introduces the “Big Telescope collection”, a set of teaching resources held on the National STEM-library that use these giant instruments as an inspirational context for STEM learning.

A global family of giant telescopes, on the ground and in space – present and future – is designed to gather light from across the Cosmos. The telescopes are huge international endeavours, carefully planned to operate at complementary wavelengths and with different fields of view. These telescopes include:

- The Very Large Telescope, on a mountaintop in Chile, is the largest optical facility in the world.
- The European Extremely Large Telescope will when constructed, also in Chile, be bigger than all the optical research telescopes combined.
- The Gaia Spacecraft is creating a detailed 3D census of the Milky Way.
- The James Webb Space Telescope will be the largest telescope in space – the “new Hubble”.

For an overview of the UK involvement in the biggest and best telescopes

[www.stfc.ac.uk/bigtelescopes](http://www.stfc.ac.uk/bigtelescopes)

## Big Telescopes and STEM learning

Using telescopes as a context for STEM teaching might spark some immediate questions:

- Just how far can telescopes see?
- So what is the biggest telescope in the world?
- Why do we have some telescopes on the ground and others in space?
- What is a “radio telescope”?

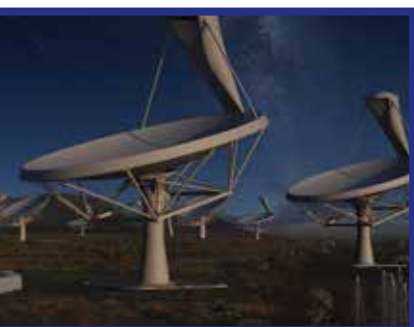
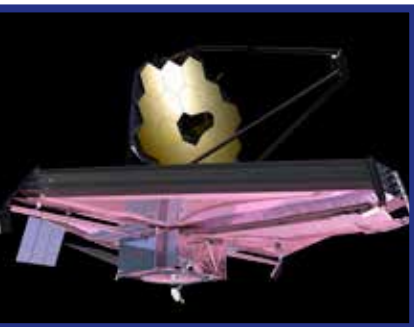
Astronomy can be thought of as a marriage of science and technology that begins with simple naked eye observing and progresses, through bigger and more sophisticated technologies, involving physics, chemistry and biology – all underpinned by computing. So telescopes offer inspirational contexts for a wide range of STEM learning, for learners from 9-18. Here are some ways that telescopes provide these contexts:

## Understanding the night sky

If you want to look at the night sky with your naked eyes you face the same essential challenges as those faced by astronomers using big telescopes:

- **A changing sky.** Just as we learn that the night sky changes over the course of a night, ground-based telescopes must be programmed to track astronomical objects for hours of observations.
- **Dark skies.** Big telescopes – just like naked-eye stargazers – need to be away from light pollution, including the natural “light pollution” caused by the Moon (and the Sun!). So astronomers choose their telescope locations and observing timetables carefully.
- **Clear skies.** Our atmosphere is turbulent and causes the stars to twinkle. Whilst this looks very pretty to the naked eye, it is a problem which engineers have to tackle, building systems to counteract this ‘blurring’.





## Physics

- The majority of the big telescope facilities use mirrors to reflect the light they are collecting, whether long radio waves or shorter infrared light. Many of the larger telescopes have mirrors which consist of smaller segments, requiring precise engineering to position them to nanometre accuracy. The optics of telescopes provides the opportunity for studying light in terms of reflection and refraction.
- The family of big telescopes working across different wavelengths provide an excellent context for teaching the electromagnetic spectrum. The radiation left over from the Big Bang, known as the Cosmic Microwave Background, is detected by radio telescopes. We know black holes exist because x-ray telescopes see the material around the edges of them.
- When considering the challenges of launching space telescopes forces such as gravity and friction can be investigated. Many of the large ground-based telescopes are in locations which are susceptible to earthquakes, and so have to be built to withstand the forces associated with these natural phenomena.

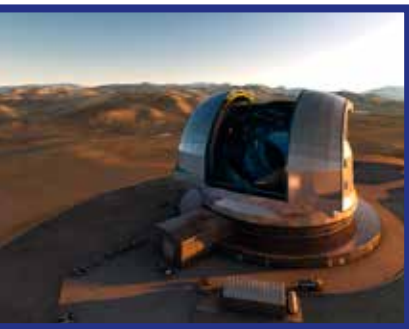
## Chemistry and biology

- The study of planets in our own solar system and the discovery and study of exoplanets – those planets orbiting stars other than our Sun – allow the chemical composition of the atmospheres of planets to be investigated.
- Telescopes like the James Webb Space Telescope will study the atmospheres of exoplanets, hoping to detect signals of life. The possibility of life on other planets opens up discussion for what life needs to survive on our planet and how different life forms adapt to their environment.
- Engineers designing telescopes, in particular space telescopes, and their instruments, have to investigate the properties of different materials and how they change under extreme conditions.
- Spectroscopy is used to analyse the chemical composition of the stars and planets.

## Computing

- Software engineers are involved at every stage of telescope development. They design programmes which allow the operation of these large telescopes and their instruments. In the case of telescope arrays like ALMA, this involves programming large numbers of telescope dishes to move in unison.
- These large telescope facilities produce vast amounts of data. Supercomputers are required to gather this data. Software engineers are responsible for archiving the information and making it available to the wider astronomy community, often just minutes after the observation has been performed. Astronomers create algorithms to analyse their data.





## The Big Telescope Collection

This collection of teaching resources is held on the national STEM e-library. They have been recommended by ESERO UK Space Ambassadors.

**Big Telescopes.** This is an A5 brochure, also available as an A1 wall poster, which includes an infographic showing how the global family of big telescopes is designed to operate across the electromagnetic spectrum. They can be printed from the webpage or ordered online from the Science and Technologies Facilities Council.

[www.stfc.ac.uk/1889.aspx](http://www.stfc.ac.uk/1889.aspx)

**All about telescopes.** Produced by ESERO-UK, these short video clips look at a range of different telescopes and give advice and guidance on choosing a telescope for your school.

[www.nationalstemcentre.org.uk/elibrary/resource/829/all-about-telescopes](http://www.nationalstemcentre.org.uk/elibrary/resource/829/all-about-telescopes)

**The Space-based Astronomy Educator Guide.** These resources from NASA look at why telescopes are put into space. Students build simple spectroscopes and telescopes to learn the answer to this question.

[www.nationalstemcentre.org.uk/elibrary/resource/1134/space-based-astronomy-educator-guide](http://www.nationalstemcentre.org.uk/elibrary/resource/1134/space-based-astronomy-educator-guide)



**The ESA/ESO Astronomy Exercise Series.** The object of this resource, produced by ESA and ESO, is to present various small projects that will pass on some of the excitement and satisfaction in scientific discovery, to students. Using elementary geometrical and physical considerations, students will be able to derive answers that are comparable with the results of much more sophisticated analyses described in scientific literature. The exercises are suitable for higher ability 14-16 year olds or post-16 groups.

[www.nationalstemcentre.org.uk/elibrary/resource/6114/the-esa-eso-astronomy-exercise-series](http://www.nationalstemcentre.org.uk/elibrary/resource/6114/the-esa-eso-astronomy-exercise-series)



**Galaxies.** This resource has been devised by The Royal Observatory Edinburgh with the Institute of Physics Scotland, to inspire secondary science classes. They are mainly used by students aged 11-14 years but can be used from upper primary to upper secondary. Students investigate galaxies. They use data from real research in group work and model-making.

[www.nationalstemcentre.org.uk/elibrary/resource/6605/galaxies](http://www.nationalstemcentre.org.uk/elibrary/resource/6605/galaxies)

**Exoplanets.** This resource has been devised by The Royal Observatory Edinburgh with the Institute of Physics Scotland, to inspire secondary science classes. They are mainly used by students aged 11-14 years but can be used from upper primary to upper secondary. Students investigate exoplanets. They use data from real research in group work and model-making.

[www.nationalstemcentre.org.uk/elibrary/resource/6604/exoplanets](http://www.nationalstemcentre.org.uk/elibrary/resource/6604/exoplanets)

**ALMA.** From the European Southern Observatory, this video describes ALMA, the largest astronomical project currently being built. ALMA is a state-of-the-art telescope to study light with wavelengths of about one millimetre, shining from some of the coldest objects in the Universe..

[www.nationalstemcentre.org.uk/elibrary/resource/3540/atacama-large-millimetre-submillimetre-array-alma](http://www.nationalstemcentre.org.uk/elibrary/resource/3540/atacama-large-millimetre-submillimetre-array-alma)

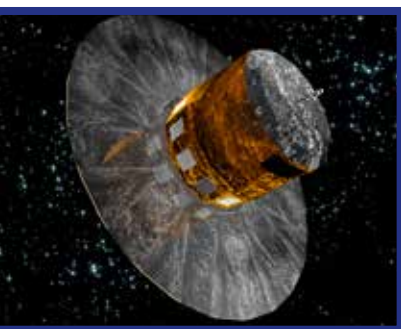




**The Very Large Telescope.** From the European Southern Observatory (ESO), this video describes the construction and work of the Very Large Telescope. (VLT) [www.nationalstemcentre.org.uk/elibrary/resource/3677/very-large-telescope](http://www.nationalstemcentre.org.uk/elibrary/resource/3677/very-large-telescope)

**The James Webb Space Telescope: Inspiration and Context for Physics and Chemistry Teaching.** This article from School Science Review, describes the design, delivery, evaluation and impact of a CPD course for physics and chemistry teachers. A key aim of the course was to use the context of the James Webb Space Telescope project to inspire teachers and lead to enriched teaching of STEM subjects.

[www.nationalstemcentre.org.uk/elibrary/resource/7236/the-james-webb-space-telescope-inspiration-and-context-for-physics-and-chemistry-teaching](http://www.nationalstemcentre.org.uk/elibrary/resource/7236/the-james-webb-space-telescope-inspiration-and-context-for-physics-and-chemistry-teaching)



## Other websites

[www.stfc.ac.uk/bigtelescopes](http://www.stfc.ac.uk/bigtelescopes)

Make this your first stop for an overview of UK involvement in big telescopes. The page has links to the Big Telescope Collection and to the other site about telescopes including:

[www.eso.org](http://www.eso.org)

The UK is a member of the European Southern Observatory which operates a suite of mountaintop telescopes in Chile, providing access to the skies of the southern hemisphere.

[www.esa.int](http://www.esa.int)

The UK is a member of the European Space Agency whose missions include space telescopes and observatories.

[www.skatelescope.org](http://www.skatelescope.org)

The UK is a member of the Square Kilometre Array organisation which is leading the development of the world's largest radio telescope.

There are a number of mountaintop robotic telescopes for students to use from classroom.

For an overview of these telescopes see [www.darkskydiscovery.org.uk/training\\_resources.html](http://www.darkskydiscovery.org.uk/training_resources.html)

The National STEM Centre also hosts a wide variety of teaching and learning resources on telescopes at: <http://stem.org.uk/cx3wb>

