James Webb Space Telescope
DEEP SPACE DIARY

ACTIVITY 3.1
BLUEPRINT FOR SPACE

From Chapter Three of the Deep Space Diary discoverydiaries.org/activities/blueprint-for-space/

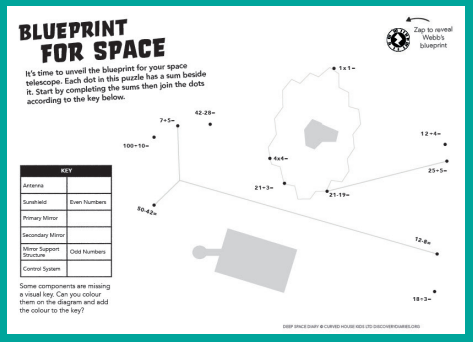
LEARNING LEVEL

KS2, P5-7, Y4-6

CURRICULUM LINKS & DIFFERENTIATION IDEAS

View detailed curriculum links for England, Scotland, Northern Ireland and Wales in the Teacher Toolkit, plus differentiation ideas for your region and year level.

discoverydiaries.org/resources/teacher-toolkit/



Learning Objective

To show an understanding of using a key.

Resources Required

- Smartphone/device or computer to access Zap code (optional)
- Rulers

Background to this Activity

This activity helps students understand the James Webb Space Telescope's structure while explaining its 'hot and cold' sides.

Webb has a unique structure, especially when compared with other space telescopes which are often cylindrical with long solar panels. Webb's gold-coated hexagonal primary mirror, mounted in the centre of its silver-coloured sunshield, gives it a striking appearance.

The main features of the Webb are:

Primary mirror: the distinctive gold mirror, made of 18 hexagonal segments. The primary mirror collects infrared light from objects in space.

Secondary mirror: this smaller mirror is positioned to face the primary mirror, reflecting collected light into Webb's scientific instruments.

Scientific instruments (not shown on worksheet): Webb's four instruments – which include cameras and spectrographs – are housed in the Science Instrument Module, which sits behind the primary mirror.

Sunshield: the kite-shaped sunshield is roughly the size of a tennis court and it plays a crucial role for Webb. It shields Webb's mirrors and science instruments from the heat and light of the Sun, Earth and Moon, keeping the telescope very cold. In order to detect the faint infrared light emitted by distant space objects, Webb's optics and instruments must be protected from any other sources of heat – including the telescope itself. The sunshield is made of five layers of shiny, silver material with gaps in-between them, to reflect and disperse heat. Through passive cooling, the sunshield keeps Webb's cool side at a temperature of lower than –200 degrees Celsius.

Solar panels (not shown on worksheet): Webb's solar panels provide the telescope with power by converting sunlight into electricity. They are positioned to always face the Sun.

Spacecraft control system: this component houses Webb's steering and control machinery, including its computer.

Antenna: the Earth-pointing antenna is Webb's link to Earth. It sends scientific data to Earth and receives commands from Mission Control.

Webb has a 'hot side' and a 'cold side'. Its sunshield can be likened to a beach umbrella or parasol, separating the two sides. Webb's hot side faces the Sun and includes everything that is in front of the sunshield: the solar panels, the control system and the antenna. Everything behind the sunshield forms the cold side: the primary and secondary mirrors, and the Science Instrument Module.

In order to observe space, Webb's specialist instruments must be kept at a very cold temperature. The sunshield keeps the cold side of Webb at a temperature of –234 degrees Celsius – cold enough to ensure that it won't emit infrared light. Three of Webb's four instruments can detect light from space objects at this temperature. The fourth instrument – the Mid-Infrared Instrument (MIRI) – must be kept at an even colder temperature to function properly. To achieve this, engineers have created a special cryocooler – essentially a space refrigerator! – for MIRI, which keeps it at -266 degrees Celsius. MIRI is attached to the Science Instrument Module with special insulating carbon struts designed to avoid heat transfer.

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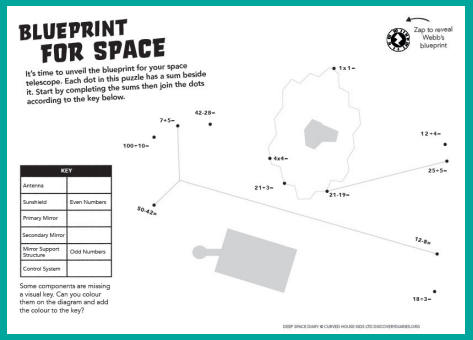

Activity 3.3: Space Lab (discoverydiaries.org/activities/space-lab-2/) explores cooling and insulation further.

Useful Links below includes diagrams showing Webb's hot and cold sides.

Running the Activity

Start by asking the class for examples we protect ourselves from the Sun (e.g. sunscreen, sunglasses, hats, UV protection clothing, seeking shade or staying indoors during the hottest parts of the day, using umbrellas at the beach). Explain to students that this activity is about the structure of Webb, and how its design protects it from the Sun.

Using the background information above, discuss Webb's structure with students. Read as a class (or pick individuals to read) information about the main features of Webb and ask students if they can identity the different components. Use the image 'Basic Structure 1' as a prompt: discoverydiaries.org/wp-content/uploads/2019/05/Deep-Space-Diary-1.2-Blueprint-For-Space-Basic-Structure-1.jpg

Once students have guessed which component is which, they can check their responses against the image 'Basic Structure 2': discoverydiaries.org/wp-content/uploads/2019/05/Deep-Space-Diary-1.2-Blueprint-For-Space-Basic-Structure-2.jpg.

NB: Both these images can be found under Other Helpful Stuff for the Activity on the activity webpage.

Explain to students that Webb has hot and cold sides on either side of its sunshield, just as a beach umbrella does. Show the class a picture of a tennis court to explain that this is the size of the sunshield: https://jwst.nasa.gov/images4/jwsttennis.jpg

Ask students to study the telescope and discuss with a partner (or as a class) what they notice. For each of Webb's components, can they guess whether that component sits on the hot or cold side?

Ask the questions below. Students to discuss with a partner and feedback to the class.

Explain to students that they are going to unveil the blueprint for the telescope.

Discuss the term 'key' and allow students to explore the different components of Webb listed on the key, matching it to the blueprint. To check that students understanding of the key, ask them to find and trace their finger over the control system, antenna and the primary mirror. Once they have familiarised themselves with the components, they can create their key.

Explain that they will be working out two sets of numbers – odd and even – recap what the difference is and what types of numbers they will be looking for. Ensure that students understand that the purpose of the task is to work out the sums, record the answers and then join up the dots according to the key (odds and evens).

See Useful Links below for images of Webb showing its hot and cold sides.

Solutions to the Activity

Sums for the sunshield/even numbers equal: 2, 4, 6, 8, 10, 12, 14 and 16

Sums for the secondary mirror and support structure equal: 1, 3, 5 and 7

Questions for the Class

- What stands out for you about the telescope?
- Why do you think the hot side of the telescope has been named this?
- What do you notice about the mirrors positioning on the telescope? (Try to draw out from the children the sunshield helps to stop the heat from the Sun.)
- Where are the solar panels? What do solar panels

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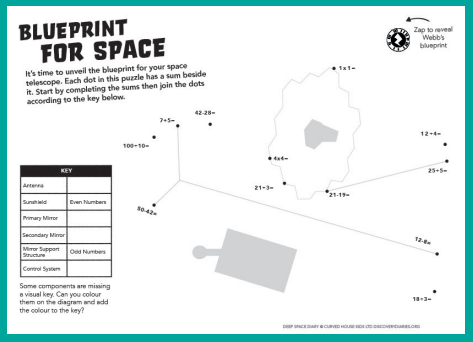

do? Do you think the solar panels or on the hot side or the cold side of Webb? Why?

Additional Challenges / Extension Activities

Investigate which sides of Webb are hot and cold, and find out the temperature ranges they can withstand.

Design Webb on the computer and label it.

Film a one-minute news report discussing Webb and answering questions about it.

Create a fact file about any interesting facts about Webb.

Ideas for Differentiation

Support:

- Students to work with a partner or in small groups to answer the mathematical questions
- Students to record each number on the line
- Differentiate by providing solutions; students to join up the dots (odds or evens) from the smallest to largest

Challenge:

- Students to work independently/with a partner to answer the mathematical questions
- Can students add any other details to the blueprint?
  - — Label the hot side and cold side of Webb
  - — Label the temperature range of each side
  - — Using arrows, show the direction light of the Sun
- Can students come up with their own sums for the dot-to-dot solutions?

Useful Links

Basic Structure 1: This line drawing shows a cross section of the structure of Webb without revealing the hot and cold sides or the shape of the primary mirror: discoverydiaries.org/wp-content/uploads/2019/05/Deep-Space-Diary-1.2-Blueprint-For-Space-Basic-Structure-1.jpg. Use it as a prompt for students to identify Webb's components.

This version of the same line drawing identifies the features of Webb's structure listed in Background information: discoverydiaries.org/wp-content/uploads/2019/05/Deep-Space-Diary-1.2-Blueprint-For-Space-Basic-Structure-2.jpg.

This image shows the key features of Webb with hot and cold sides noted: https://jwst.nasa.gov/images2/sunshieldhotcold.jpg

While this image includes some complex information about Webb's range of viewing, it demonstrates how Webb is positioned in space, in relation to the sun, with hot and cold sides noted: https://bit.ly/2SiMiMB

ZAP! Students can independently access multimedia resources using the Zappar mobile/tablet app. See Zappar instructions at the link below and note that the mobile/tablet will need to be on a WIFI connection: marsdiary.org/resources/#teacher-toolkit

If you don't have access to the internet in the classroom, all Zap code content is available to download on the activity's web page (see link to the left) as a PowerPoint presentation or as bundles of images.

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Find more great space-themed STEM resources at https://www.stem.org.uk/esero