

Keeping Things Cold



James Webb Space Telescope's sunshield

Overview

In this activity children learn about how the James Webb Space Telescope is designed to keep itself cold. They find out about the sunshield and how it works then explore how they can keep cold things cold, when they are exposed to heat. Investigating the best material and number of layers for doing this most effectively.

Background

One of the challenges involved in the design of the JWST was to keep the mirror extremely cold (a cryogenic temperature of -220°C). This is because the mirror will be looking into deep space, which is extremely cold. It is designed to gather the infrared light given off by distant stars and galaxies in the early Universe. Because warm objects give off infrared light, or heat, if Webb's mirror was the same temperature as the Hubble Space Telescope's, the infrared light from distant galaxies would be lost in the infrared glow of the mirror.

The solar panels are facing the sun, which provides power to the telescope. As heat travels from hot to cold the problem that the design team needed to solve was how to keep the cold side cold. They solved this in two ways:

- sending it into deep space, (100million miles away from earth)
- developing a large sunshield that will shade the mirrors and instruments from the Sun's heat, keeping them separated from the warm spacecraft

The sunshield effectively isolates the two sides of the telescope, so heat is prevented from travelling to the cold side of the telescope, so it will keep its extremely cold temperature. The 5-layer tennis court sized sunshield is made out of a special material called Kapton and thin metallic layers. The metal reflects the light and the Kapton provides insulation. Heat is lost to space at each layer, so it gets progressively colder with very little heat from the sun making it to the cold side.

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This short video provides a useful overview of the temperature in space:

<https://www.youtube.com/watch?v=QC2tdZEHczk&list=PLcy1hEnsejK22GOXkFNRGzjEUwYRDuVpj&index=11>

Curriculum areas

- > Materials and their properties
- > Thermal insulators
- > Working scientifically

Learning objectives

To explore thermal insulators

To understand how the James Webb Space Telescope has been designed to stay cold. **Big questions**

What is it like in space?

How do we explore space?

What do space engineers and scientists do?

Vocabulary

Cryogenic, Kapton, Thermal insulator, Reflect, Sun energy, Heat pump, Infra-red light, Visible light.

Resources



Ice cubes



Scales (balance)



Beakers



Measuring cylinders



Stopwatches, timers



Warm water



Cold water



Thermometers



A range of materials including: Bubble wrap, Newspaper, Corrugated card, Plastic, Cling film, Aluminium foil, Fabric, Coloured foil.

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Advance preparation

Freeze ice cubes for the groups to use. As small ice cubes will melt quickly you may wish to freeze a cup full of ice or use an ice pop. Freeze enough so each group can have a few each, so they can change their investigation and start again if needed. The ice should be taken out of the freezer as late as possible. Children should ask for it when they are ready to investigate.

Safety

Make sure children have dry hands before touching the ice, as it could stick to wet hands. Make sure that warm water is hand hot and not hot enough to cause burning.

Introduction

Look at the image of the James Webb Space Telescope on the presentation.

Ask children if they know what this is? Explain that it is a new telescope that will take pictures of heat coming from distant objects such as stars and planets.

Ask children to find some of the main parts of the telescope. What do they think they are? Explain that there are two mirrors, (a large one and a smaller one) and a sunshield. Ask them questions to get them thinking about the telescope. Which way does the mirror face? To space or towards our sun? The telescope will be powered by the sun using special solar panels. Which way do the solar panels face? Why is this? Which side will be hotter, the side facing the sun or away from it?

Explain that the mirror is collecting heat that is given off from stars and planets very far away. It can create pictures of these distant objects using the heat that comes from them. Say that it is important the mirror and instruments are kept cold, so they can detect heat coming from very distant stars and planets.

Children could feel their forehead with their hands and say if they can feel the heat from their own body. They could try this when they have very cold hands and when they have very warm hands. When can they feel the warmth from their foreheads best, when their hands are warm or cold?

Ask them to think about how designers of James Webb found a way of keeping the side facing deep space cold. Draw their attention to the sunshield, ask how big they think it is.

Watch this short video to 2:04 mins and ask them to tell you 2 things that they have learnt about the sunshield. Answers may include: it is made of Kapton, it has 5 layers, It is reflective, keeps sun energy getting to the telescope, keeps out visible light. Kapton is a plastic film material, thermal insulator, each layer rejects the heat from the sun and the spacecraft

Ask children why the people working on the sunshield are wearing and why? They are working in a 'clean room' where everything is kept as clean as it can be. They don't want anything like skin cells, hairs, microbes or dirt falling onto any of the equipment or machine that they are using. Surgeons and nurses wear similar outfits when working in operating theatres.

Activity - Investigating materials that are thermal insulators

Tell the children that when the designers of the telescope were faced with the challenge of how to keep the cold side cold. They began looking for a material that would be an effective insulator, stopping heat travelling to the cold side.

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They also looked at how many layers of this material would work the best at doing this job. Tell them that they are going to plan and carry out an investigation to see who can come up with the most effective insulator.

They will be using an ice cube to represent the cold side of the JWST and warm water to represent the heat from the sun.

Their challenge is to find the best material for stopping heat from warming up the ice cube.

They need to consider:

- the material used
- and how many layers of material are most effective
- how they will test this
- what they will measure

Show them the possible thing that they can use to carry out this investigation and say they must plan their test, carry it out and report their finding to the class. Explain that there may be different ways of doing this, but they must agree as a group. They may also try out one way to find that it doesn't work, they need to then come up with another way. Emphasise that they are working like the design team, trying out possible ideas to come up with the best solution.

A planning template is provided, though some children may wish to come up with their own.

Here are some suggestions for what they could do:

One idea is to have several beakers or cups of water per group, so they can test different materials at once. Each cup should have the same volume of water and the investigation start at the same temperature. You will also need the sample of ice to be the same size.

1. Wrap 1 layer of each material around the ice samples.
2. Put the wrapped samples into a cup of warm water at the same time.
3. Observe which melts first, this will be the worst insulating material.
4. Now carry out the test again, but with a different number of layers of the same insulating material wrapped around the ice sample.

Children should be encouraged to think about what they need to keep the same and what they change in each test. Possible things to change are:

- size ice cube/sample
- water temperature at the start
- time when they are placed in the water
- the material they are testing
- number of layers of material

If the samples float on the surface of the water- ask children if we need to ensure they are pushed down and how we might do this.

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An idea for running this is to use aluminium foil cases as boats for the ice cubes to float in. This would ensure that the insulating material is kept water tight. They could leave them for a set time then compare how much of the ice cubes have melted. They could also weigh the ice cubes or collect the water and measure it to see how much has melted.

Plenary

Children feedback on their testing, explaining what they did. Explain which material and how many layers they found to be the best at keeping the ice cold.

Encourage them to explain about any changes they made to their test.

Further links

James Webb Space Telescope, NASA:

<https://jwst.nasa.gov/index.html>

James Webb Space Telescope, ESA:

<http://sci.esa.int/jwst/>