James Webb Space Telescope
DEEP SPACE DIARY

ACTIVITY 3.4
PACK YOUR PAYLOAD

From Chapter Three of the Deep Space Diary discoverydiaries.org/activities/pack-your-payload/

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.

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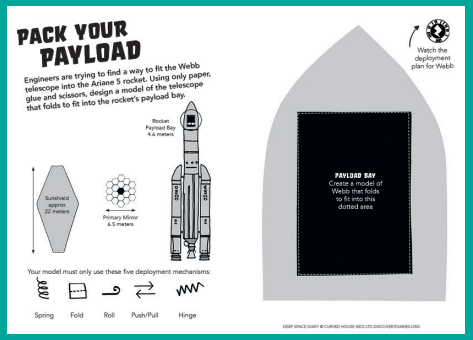

Learning Objective

To design a paper model using the provided techniques.

Resources Required

- Smartphone/device or computer to access Zap code (optional)
- Craft paper and other D&T materials
- Glue
- Scissors

Background to this Activity

The James Webb Space Telescope is the most ambitious space telescope humans have built to date. Its primary mirror measures 6.5 meters in diameter and its kite-shaped sunshield is approximately 22 metres by 10 metres when deployed (similar to the size of a tennis court). If we tried to send a telescope this large into space without folding it up to make it smaller, we would need a rocket far bigger than any we have currently built.

To fit Webb into the Ariane 5 rocket – Webb's vehicle into space – engineers designed it to carefully fold up. But fitting Webb into the rocket wasn't their only challenge. Engineers had to ensure that the telescope could unfold (or deploy) properly in space.

For reference images of how Webb was designed to fit in the 'payload bay' of the Ariane 5 rocket (i.e. the part of a rocket which contains the payload – the item/s being sent to space), see:

https://jwst.nasa.gov/images/ariane3.jpg

https://jwst.nasa.gov/images/ariane4.jpg

https://jwst.nasa.gov/images/ariane2.jpg

https://jwst.nasa.gov/images/ariane1.jpg

Most notably, you'll see that Webb's primary mirror is designed so that the rows of hexagonal mirrors on either side fold back at 90-degree angles, so that the mirror fits in the rocket. The sunshield membrane rolls up and its frame folds up on either side of the primary mirror for launch. The secondary mirror is held in place by a support structure made of three 'arms', one of which hinges over the primary mirror when Webb is inside the rocket. Webb's solar arrays hinged out during the early stages of deployment, to provide the telescope with power.

An excellent clip containing an overview the key components of Webb, along with how they folded up for launch, is available at: https://youtu.be/qysBZZjqTJM This clip also shows the telescope being built, giving a sense of its scale. NOTE: This clip shows an incorrect launch date of 2018.

Running the Activity

Show students this clip: https://youtu.be/qysBZZjqTJM. Ask them if they notice something about the date in the clip. Have the students seen this launch on the news? (Go onto explain that the date has been pushed back.) Ask students the questions below in relation to the clip. This will help to encourage an understanding of the telescope and its mechanisms.

Explain to the students that this activity asks them to plan (through discussion and experimentation) and design a model of the telescope that will fold away and fit into the payload bay. The number of components students need to include can be adjusted, according to ability. As a minimum though, models should include:

- Solar panels
- Sunshield
- Primary mirror

More capable students can be encouraged to include:

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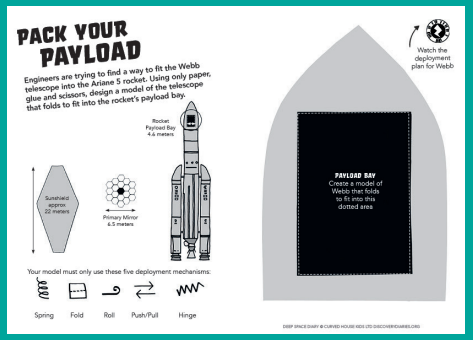

- the antenna (referred to in the clip as the communication dishes)
- Secondary mirror

Explain to students that they will need to use the different methods listed on the worksheet to make the model so that it will deploy. Allow students time to experiment with these different methods, so they have an understanding of how folding, rolling and manipulating paper in different ways will help them create a model that can 'deploy'. Use pop-up picture books to demonstrate applications of these methods that students might already be familiar with.

Q/A: Discuss in small groups/tables:

- What ways can we make paper move?
- How can we make paper bounce/spring up?
- How can you make the paper become smaller?

Discuss students' answers and share with the rest of the class. Make sure all five different mechanisms are recorded on the class whiteboard, so students can refer to these during their plan/making.

Divide the class into small mixed ability groups.

Provide each group with resources needed – paper, glue and scissors etc.

Explain to students they will have some thinking and talking time to discuss their ideas. Give students time for individuals to discuss their ideas with the person next to them. Students will need to think about how they are going to create the telescope and what mechanisms they will use where.

Allow time for students to share their ideas with their peers – this will help support and allow others to 'magpie ideas.' This will also allow students the opportunity to change or improve their ideas.

Ensure that all students understand the entire purpose of the task. At this point, you might want to provide them with additional information regarding examples of ways to carry out the task. Point out to students that they can use more than one of the deployment mechanisms to deploy each component of Webb (e.g. roll and hinge or fold for the sunshield).

Solutions to the Activity

In order for their telescope to deploy properly, students should create a model that unfolds in this order (suggested methods for each mechanism in brackets):

- Solar array (fold and hinge)
- Antenna (hinge)
- Sunshield (roll and hinge)
- Secondary mirror (hinge)
- Primary mirror (fold)

This means that they will have to fold it up in reverse order.

Questions for the Class

- Who built Webb?
- Why is it important that Webb folds away?
- How did they refer to the size of the heat insulation sunshield?
- How long will the journey take and how far will it travel?
- What did you notice about the way Webb unfolds?
- What mechanisms did you see in the clip?
- Why do the scientists have to wait for so long before they can use the telescope?

Additional Challenges / Extension Activities

Taking on the role of Telescope Engineer, students could

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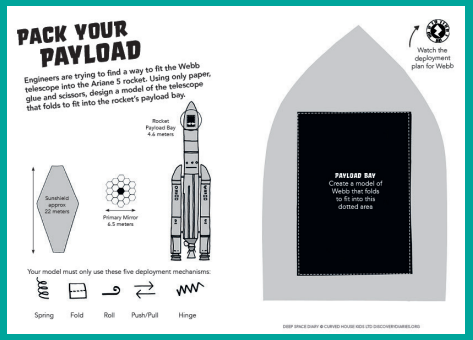

explain the different mechanisms they have used in their model, by demonstrating their design solution either in person or by recording a presentation.

Students could be encouraged to research other telescopes and create a model.

Students could write a diary entry in the perspective of a person working for NASA, covering the lead-up the launch/the actual building of the telescope.

Record an interview: a Q&A session with an employee of NASA and the news team.

Challenge students to think of other ways to make a self-deploying structure.

Ideas for Differentiation

Support:

- For support, students could work in a guided group/ with a partner.
- Students to be given ideas via prompt cards to help scaffold their learning if needed. These can include the different mechanisms.
- Students to create a planned drawing with mechanisms labelled on the plan. This will help to structure the learners and allow them to follow the plan.

Challenge:

- Students to be in mixed ability groupings.
- Students to work independent.
- Students to be given ideas prompt cards to help scaffold their learning if needed.
- Students can be given opportunity to draw a quick plan on a whiteboard to follow if needed.

Useful Links

Animation showing how Webb fits the Ariane 5 rocket (please note that sunshield retraction isn't included in the clip): https://www.youtube.com/watch?v=30Lv8JjCqhU

Time lapse footage of primary mirror being folded: https://www.youtube.com/watch?v=KGaagak_ACE

An animated clip of how Webb's launch sequence and deployment is available at: https://youtu.be/bTxLAGchWnA

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: discoverydiaries.org/toolkit/discovery-diaries-zappar-instructions/

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