James Webb Space Telescope
DEEP SPACE DIARY

ACTIVITY 2.1
LIGHTS, MIRROR, ACTION

From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/lights-mirror-action/

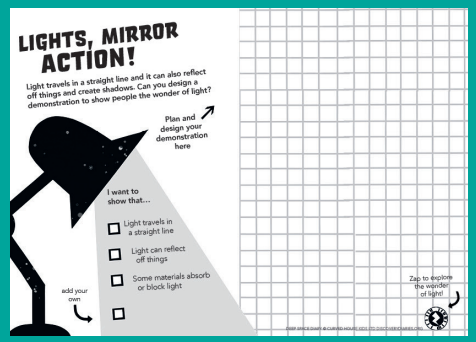
LEARNING LEVEL

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 understand how light moves.

Resources Required

- Smartphone/device or computer to access Zap code (optional)
- Drawing materials
- Torch (optional)

Risk Assessment

Ask students to consider the dangers of looking directly at light-sources (mainly the Sun) and how they can protect their eyes.

Background to this Activity

One of Webb's main goals is to observe galaxies that are billions of light years away, so that we can study how galaxies are formed. It does this by collecting light that's emitted from the stars in those galaxies. Because the light from these distant galaxies is very faint, Webb needs to collect as much as possible – the more light it collects, the more we can see. That's why its primary mirror is the largest ever to be sent to space – spanning 6.5 meters in diameter – more than double Hubble's primary mirror.

Webb's primary mirror is concave. When the light from space objects hits the primary mirror, the light is reflected from the mirror's golden surface into a more concentrated beam. This beam then hits the smaller convex secondary mirror, which reflects the light into the Webb's four special instruments. These instruments take pictures and also spread the light out into spectra. The information from the instruments is then digitised and sent back to Earth by radio link, so that scientists can study the observations.

Running the Activity

This activity asks students to plan, design and report on a demonstration which shows how light behaves.

Divide the class into small mixed ability groups. Provide each group with a selection of different items e.g. clear rulers/books/material/card etc, and a torch. Allow time for groups to discuss how they can use these resources to plan a demonstration of how light can reflect off things/absorb or block light/travel in straight lines.

Each group then feeds back their ideas to the class. This will provide all students with the opportunity to change or improve their demonstration.

Ensure that students understand the entire purpose of the task. At this point, you might want to provide students with additional information regarding examples of ways to carry out the task. Students should make notes on the worksheet about how they will achieve their task.

Provide some examples if students are struggling to come up with ways to investigate e.g. arrange three pieces of card with holes punched in them in the same place, in an uneven line. Shine the torch at the cards; the light will stop and cannot travel through all three cards if they aren't in a straight line. Then arrange the cards in a straight line; the light can travel through.

Considering the range of items students have, ask students to rate the items on how well they allow light to pass through them/absorb or block light.

Students can use clean foil to see what happens when a torch is shined on it. Crumple up the foil; shine the torch on it. What happens now?

Allow students to experiment with mirrors. What happens if you put a mirror in front of another mirror? Ask students to write a word on a piece of paper and hold it in front of the mirror? What happens?

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From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/lights-mirror-action/

LEARNING LEVEL

KS2, P5-7, Y4-6

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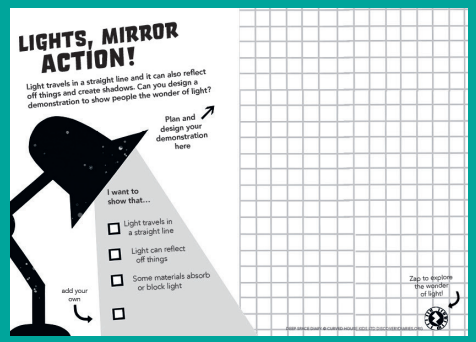

Questions for the Class

- What is light?
- Where does light come from?
- What is reflection?
- How are shadows created?

Additional Challenges / Extension Activities

Students could record and discuss their demonstration on an iPad/device.

Students can make their own periscope: https://www.stem.org.uk/elibrary/resource/31673

Make shadow puppets and ask the students to experiment with how to make the shadows bigger and smaller. Record results in a table.

What is the best distance for a large, clear shadow?

Ask students to make observations when using concave or convex reflective surfaces, like those on a spoon. What happens to a reflection when a mirror isn't flat?

Ideas for Differentiation

Support:

- For support, students could work in a guided group and be given suggested activities to use for their demonstration. They could then work independently to create and write up their plan and carry out their demonstration. For a greater challenge, students could include additional information on their plan and use scientific vocabulary.

Challenge:

- Students to be in mixed ability groupings.
- Students to be given ideas prompt cards to help scaffold their learning if needed.
- Students to include a detailed plan using scientific vocabulary.

Useful Links

Animation of how light travels through Webb: https://youtu.be/y9Z2GbFJWmo

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DEEP SPACE DIARY

ACTIVITY 2.2 MAKE-YOUR-OWN COLOUR WHEEL

From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/make-your-own-colour-wheel/

LEARNING LEVEL

KS2, P5-7, Y4-6

CURRICULUM LINKS & DIFFERENTIATION IDEAS

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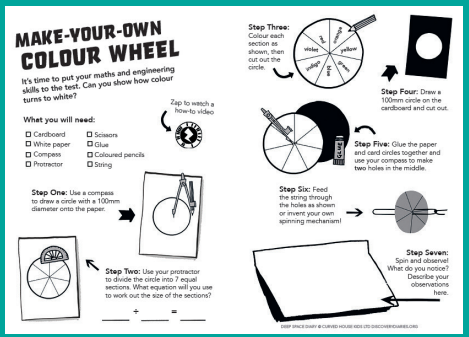

Learning Objective

To create a colour wheel to recognise that light contains a spectrum of colours.

Resources Required

- Smartphone/device or computer to access Zap code (optional)
- Cardboard
- White paper
- Compass and protractor
- Scissors
- Glue
- Coloured pencils or paint
- String

Background to this Activity

This activity allows students to explore how white light is made up of colours, and therefore how it can be split into the spectrum. It will prepare students for the activities in Chapter 5, which introduces the concept of spectroscopy and how this science can be used to help us learn about the Universe, with the help of telescopes like Webb.

Running the Activity

Begin by reviewing what students know about the light spectrum. Ask students questions about colour: what different colours are there? Can you combine colours and what happens if you do combine them? If available, use filters to demonstrate how combining different colours can have different results.

Next, ask students: what colour is light? Discuss – this could be made more interactive by having pieces of paper around the room (the seven colours of the rainbow and white) and asking students to move to the space near the colour they think is light.

You don't need to tell students the answer at this stage but can tell them you will return to this question at the end of the lesson.

Ask students: how many colours are in a rainbow? Make links to rainbows and ask for suggestions about how the colours of the spectrum can be remembered e.g. a mnemonic like Richard Of York Gave Battle In Vain.

Explain that the task of the lesson is to make a colour wheel to explore what happens when the colours in the spectrum are mixed.

Gather resources and follow the instructions on the worksheet.

At the end of the session, ask the question: What colours make white light? Through discussion, guide students to the conclusion that white light is made up of the colours of the spectrum.

Solution to this Activity

The equation to be used in Step Two is:

360 ÷ 7 = 51 (rounded to the nearest whole number)

Questions for the Class

- What are the colours in the spectrum?
- How can we remember these?
- What colours make up white light?
- When do we see the different colours of light in nature?
- CHALLENGE: Are these the only colours in the spectrum? Why do you think this?
- CHALLENGE: Why do we see the colours of the spectrum in a rainbow?

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ACTIVITY 2.2 MAKE-YOUR-OWN COLOUR WHEEL

From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/make-your-own-colour-wheel/

LEARNING LEVEL

KS2, P5-7, Y4-6

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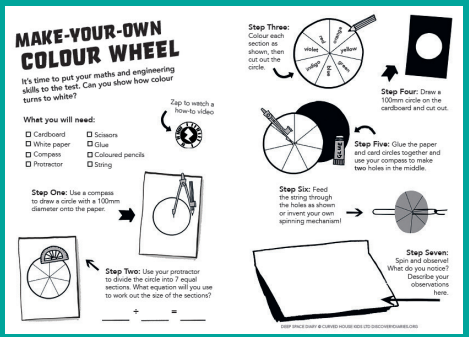

Additional Challenges / Extension Activities

Make your own spectrometer: https://www.stem.org.uk/resources/elibrary/resource/28165/make-your-own-spectrometer

Explore why the sky is blue. Follow the instructions and demonstration here: https://www.stem.org.uk/elibrary/resource/29943

Ideas for Differentiation

Support:

- Circles could be provided rather than require students to draw and cut out their own circles.
- Lines could be pre-marked on the circles if students do not have experience in using a protractor (angle measurer).

Challenge:

- Students could be given a template to draw around to create a circle instead of using a pair of compasses.
- Students could be given the angle they need to draw if they struggle to use a protractor accurately.

Useful Links

How to make a colour wheel: https://www.youtube.com/watch?v=7iV1m4j2wJQ

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James Webb Space Telescope
DEEP SPACE DIARY

ACTIVITY 2.3
RECIPE FOR A RAINBOW

From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/recipe-for-a-rainbow/

LEARNING LEVEL

KS2, P5-7, Y4-6

CURRICULUM LINKS & DIFFERENTIATION IDEAS

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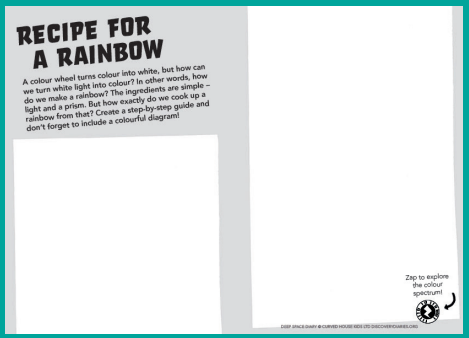
RECIPE FOR A RAINBOW

A colour wheel turns colour into white, but how can we turn white light into colour? In other words, how do we make a rainbow? The ingredients are simple – light and a prism. But how exactly do we cook up a rainbow from that? Create a step-by-step guide and don't forget to include a colourful diagram!

Zap to explore the colour spectrum!

Learning Objective

To understand that white light can be split into a spectrum (Lower).

To recognise that light appears to travel in straight lines (Upper).

Resources Required

- Smartphone/device or computer to access Zap code (optional)
- White paper or surfaces
- Torches and other light sources
- A range of prisms

Background to this Activity

The James Webb Space Telescope uses the light collected by its huge primary mirror to help us learn about distant stars. Some of its specialist instruments split the light into spectra, which astronomers use to discover more about objects in space, such as what they are made of. Specifically, Webb sees light in the infrared region of the spectrum. The human eye cannot detect these wavelengths (for example, we cannot see light emitted from a remote control we use to change the channel on a TV), so we need specialist instruments like those on Webb to detect and study what would otherwise be invisible.

Infrared was first discovered by Frederick William Herschel in 1738, when he split light through a prism to form a spectrum and then measured the temperature of each colour. He then measured the temperature next to the red light – where there appeared to be no colour – and found it was even hotter than any colours in the spectrum. Following this discovery, Herschel went on to prove that this invisible light – which came to be known as infrared – refracted and reflected the same way that sunlight did. Infrared light is explored in Activity 2.4: Infrared Selfie. The scientific technique of splitting light into the spectrum is called spectroscopy. Astronomers use spectroscopy to learn about the properties of stars.

Following on from Activity 2.1: Lights, Mirror, Action and Activity 2.2: Make-Your-Own Colour Wheel this activity provides students with the opportunity to learn – or revisit – how prisms and other objects can be used to split white light into those colours. It has been designed to be as open as possible, so educators can adapt it to their available resources and their students' existing knowledge.

Running the Activity

Gauge the level of understanding within the class. Students should know that light travels in straight lines and, having explored colour wheels, should have an idea that white light is made up of a spectrum of colours.

Provide students with a variety of resources and allow time for them to discuss (in pairs and small groups prior to whole class discussion) how they might explore the idea of showing the colours in the light spectrum.

Resources should, ideally, include:

- white paper or surfaces
- torches and other light sources
- a range of prisms.

If you do not have access to prisms, the experiment can be carried out using crystals and bright sunlight, which will show the colours on a pale surface. You could also have images of rainbows, oil spills on wet roads and bubbles showing the colours of the spectrum.

Students should be encouraged to consider for themselves how they might go about splitting white light from a torch (or other light sources).

Students can record in different ways what they plan

James Webb Space Telescope
DEEP SPACE DIARY

ACTIVITY 2.3
RECIPE FOR A RAINBOW

From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/recipe-for-a-rainbow/

LEARNING LEVEL

KS2, P5-7, Y4-6

CURRICULUM LINKS & DIFFERENTIATION IDEAS

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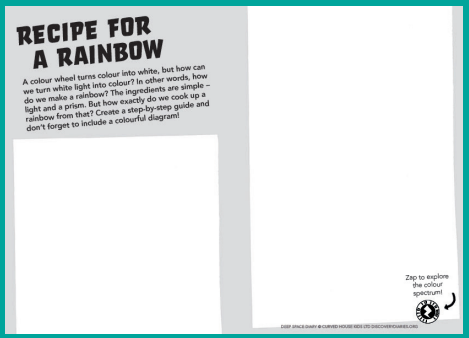
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Zap to explore the colour spectrum!

to do and what they predict is going to happen. They should be encouraged to work scientifically, selecting the equipment and recording the process using diagrams and labels, as well as numbered and/or bullet pointed lists.

Solution to this Activity

This very short clip explains how the prism causes the light to be refracted (rather than reflected): https://www.youtube.com/watch?v=hLFcf58qD4w

It also includes a simple demonstration of how students could set up their own experiment to split white light into a spectrum to show the colours of the rainbow.

Questions for the Class

- How have you shown the different colours contained in white light?
- How many colours have you managed to split white light into?
- Can you describe what has happened to the light as it has travelled through the prism?
- Where do we see these colours together in the natural world?

Additional Challenges / Extension Activities

Explore the idea of refraction.

Investigate the wavelength bands of the spectrum and represent them on a graph or visually.

Explore invisible light by investigating UV. Conduct an experiment with UV beads, such as this one: https://buggyandbuddy.com/sun-shelter/ or contact your local STEM ambassador for more ideas: https://www.stem.org.uk/stem-ambassadors/local-stem-ambassador-hubs

Ideas for Differentiation

Support:

- Provide only one type of light source and one type of prism to guide students when creating their own experiments.

Challenge:

- Provide a range of resources, some of which are not particularly relevant, to enable students to develop the skills to identify what is useful and what is not.
- Ask students to explore the idea that there could be more than seven colours in the light spectrum.

Useful Links

Refraction of Light – this clip includes an example of using a prism to split white light, as well as useful information for teachers: https://www.youtube.com/watch?v=KgqV975EtA0

NASA clip about the discovery of infrared and how it can by used by scientists: https://youtu.be/i8caGm9Fmh0

Why are soap bubbles so colourful - https://www.youtube.com/watch?v=1cNoTy6USdA

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James Webb Space Telescope
DEEP SPACE DIARY

ACTIVITY 2.4
INFRARED SELFIE!

From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/infrared-selfie/

LEARNING LEVEL

KS2, P5-7, Y4-6

CURRICULUM LINKS & DIFFERENTIATION IDEAS

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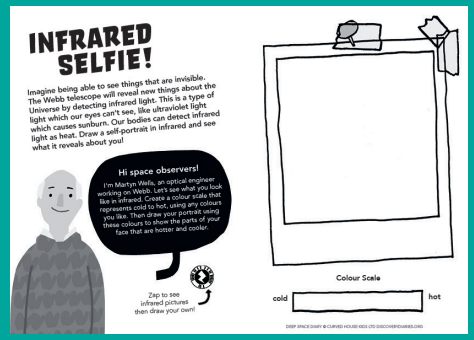

Learning Objective

To create a colour scale and use it to visually represent different temperatures.

Resources Required

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

Background to this Activity

The James Webb Space Telescope detects infrared light, which can penetrate thick clouds of space dust. This means that with Webb, we can see things that are otherwise hidden, like protostars (baby stars).

Infrared is a form of light that human eyes can't see but which we can feel as heat. Everything in the Universe that is warm – from stars and planets to animals, microbes and even non-living things like a lump of charcoal – emits thermal radiation/light. How much thermal radiation they emit depends on how hot they are. The majority of thermal radiation for things of 'normal' temperature are in the infrared spectrum, meaning they will be detected by infrared (IR) cameras, like those on Webb.

Infrared technology can also tell us about the temperature of the object. Generally, the settings on IR cameras will depict hot objects (or regions/areas/parts) as bright and cold objects (or regions/areas/parts) as dark. Thermal-imaging cameras, such as night-vision cameras, use infrared technology.

Before conducting the activity, ask your school administration if they have an IR camera for thermal testing. Alternatively, schools in Scotland can borrow a thermal camera from their local authorities, for in-class demonstrations. For more information about this scheme, contact SSERC (www.sserc.org.uk).

Running the Activity

Students should have prior knowledge of portraiture and be familiar with blending techniques using colouring pencils. Students will need a selection of colouring pencils for this task. Students can base their colour scale on a traditional cold to hot/blue to red scale, or they can invent their own scale.

Begin by asking students if any of them know what 'infrared light' is. Ask them if they know any other forms of light (visible light, ultraviolet (UV) light etc). Tell them that some animals can see different wavelengths of light that we can't see (bees can see UV light and snakes can see IR light). TV remotes use infrared light which we can't see but this can be picked up on some phone cameras. (If you point the remote at the camera and press a button, you may see the bright infrared beam through the phone screen but not with your own eyes.)

Look at the example provided by the iTunes link in Useful Links below and discuss how infrared has been used in space research. Pause the footage at 2min 45s to discuss the various features on the presenter's face. As a class, discuss the colour range within the infrared camera (from black through to bright white and moving through a spectrum of blue, purple, red, orange, yellow as temperature increases). Have students colour in the colour scale bar either to represent this, or ask them to create their own scale from cold to hot.

When everyone has created their scale, it will be time to introduce students to infrared images. Start by showing them some images of animals, taken with an infrared camera (see Useful Links). Note which animals have fur and which don't. How do these images compare? What differences do students notice when an animal is warm-blooded or cold-blooded? And what happens if a person is wearing glasses, which block infrared light?

Students can now begin drawing their selfies. Establish the relatively warm and cool parts of their face. Ask

James Webb Space Telescope
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ACTIVITY 2.4
INFRARED SELFIE!

From Chapter Two of the Deep Space Diary discoverydiaries.org/activities/infrared-selfie/

LEARNING LEVEL

KS2, P5-7, Y4-6

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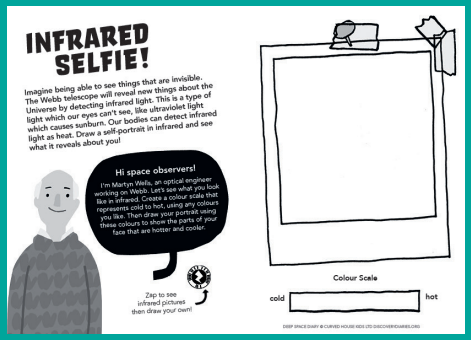

students to think about which parts of their faces are warmer than others. Typically, ears and noses will be cooler and eyelids, mouths and lips will be warmer. Using their fingertips, can students detect which areas of their faces are warmer and cooler? Once students have spent some time exploring, they can then use this information to sketch out their face and begin to shade it with their colouring pencils, carefully blending from cool to warm through the spectrum of colours in their scale. Students who wear glasses can choose how they represent themselves. Other students might like to draw themselves wearing sunglasses.

At the end of the lesson, ask students what they have learnt about infrared light.

Questions for the Class

- What type of light can humans see?
- What other types of light are there?
- How can infrared light help us in the study of space?
- Based on the colour scale a student has chosen, what colour would something cool show up as on an infrared camera? What about something warm?

Additional Challenges / Extension Activities

Explore infrared light through this experiment: https://www.exploratorium.edu/snacks/infrared-remote

Ideas for Differentiation

Support:

- Create the colour scale together and model the task on the board.
- Demonstrate blending techniques and allow students to practise blending colours together before they start.

Challenge:

- Students create the colour spectrum more independently, with less teacher input.
- Students could use watercolour pencils.

Useful Links

How infrared works and is used by astronomers (please note this clip was made in 2007, before the referenced Spitzer telescope was launched): https://itunes.apple.com/de/podcast/infrared-more-than-your-eyes-can-see/id83226711?i=1000088349329&l=en&mt=2

This clip explains infrared and includes examples of how glasses block infrared light: https://www.youtube.com/watch?v=zmiU5tJRJd4

For images of animals in IR, visit this NASA site: http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/zoo.html

Clip about how Webb uses infrared (please note this clip was made before Webb was launched): https://youtu.be/C0unmfkTlG8

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DEEP SPACE DIARY

WORD SEARCHES

Found throughout the Deep Space Diary

Chapter Two: discoverydiaries.org/activities/chapter-two-word-search/
Chapter Three: discoverydiaries.org/activities/chapter-three-word-search/
Chapter Four: discoverydiaries.org/activities/chapter-four-word-search/
Chapter Five: discoverydiaries.org/activities/chapter-five-word-search/

LEARNING LEVEL

KS2, P5-7, Y4-6

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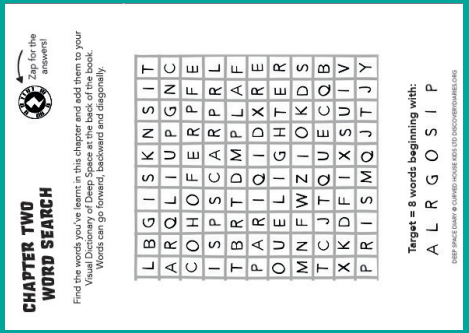

CHAPTER TWO WORD SEARCH

Zap for the answers!

Find the words you've learnt in this chapter and add them to your Visual Dictionary of Deep Space at the back of the book. Words can go forward, backward and diagonally.

L	B	G	I	S	K	N	S	I	T					
A	R	Q	L	I	U	P	G	N	C					
C	O	H	O	F	E	R	P	F	E					
I	S	P	S	C	A	R	P	R	L					
T	B	R	T	D	M	P	L	A	F					
P	A	R	I	Q	I	D	X	R	E					
O	U	E	L	I	G	H	T	E	R					
M	N	F	W	Z	I	O	K	D	S					
T	C	J	T	Q	U	E	C	Q	B					
X	K	D	F	I	X	S	U	I	V					
P	R	I	S	M	Q	J	T	J	Y					

Target = 8 words beginning with:
A L R G O S I P

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Learning Objective

To develop scientific vocabulary.

Resources Required

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

Background to this Activity

Word searches are a fun way to extends your students' vocabularies. Students can add the words they find to their Visual Dictionary of Deep Space: discoverydiaries.org/activities/visual-dictionary-of-deep-space/

Running the Activity

The word searches provide an opportunity to review and discuss what has been covered in each chapter. As students work through the chapters, remind them to write key words in their Visual Dictionary of Deep Space (see Activity 6.2: discoverydiaries.org/activities/visual-dictionary-of-deep-space/) to help create a word bank.

For each word search, look at the starting letters noted below the word search grid. As a class or in student pairs, discuss what some of the words might be. Ask students if they can identify any of those words.

Subsequent word searches can be tackled more independently once students understand the format.

Solutions to this Activity

Word Search Chapter 2: Light, Prism, Reflect, Spectrum, Infrared, Optical, Gradient, Absorb

Word Search Chapter 3: Discovery, Construct, Experiment, Structure, Mirror, Method, Engineer, Payload

Word Search Chapter 4: Program, Commands, Deploy, Encryption, Calibrate, Instrument, Decode, Sequence

Word Search Chapter 5: Astronomer, Spiral galaxy, Protostar, Data, Infographic, Celestial, Planet, Atmospheric

For definitions, see the Deep Space Glossary: discoverydiaries.org/toolkit/deep-space-glossary/

Additional Challenges / Extension Activities

Ask students to make their own deep space-themed word searches. Download and print our blank word search template to use with your class: discoverydiaries.org/toolkit/word-search-template/

Ideas for Differentiation

Support:

- Work as a class or in groups to find definitions, assigning words to students.
- Work as a class or in groups to create a song using vocabulary from the chapter.
- Provide hidden words to students.

Challenge:

- Once students have completed the word searches, ask them to develop their own using their dictionaries. They can then test a classmate with their word search. Differentiate by giving clues as the whole word, the first letter or a clue/definition of the word.

Useful Links

Deep Space Glossary: discoverydiaries.org/toolkit/word-search-template/

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/

James Webb Space Telescope

DEEP SPACE DIARY

WORD SEARCHES

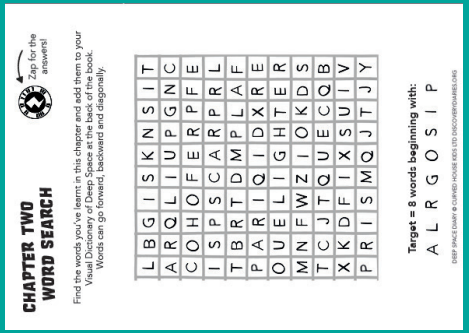
Found throughout the Deep Space Diary

Chapter Two: https://discoverydiaries.org/activities/deep-space-diary-word-search-2/
Chapter Three: https://discoverydiaries.org/activities/deep-space-diary-word-search-3/
Chapter Four: https://discoverydiaries.org/activities/deep-space-diary-word-search-4/
Chapter Five: https://discoverydiaries.org/activities/deep-space-diary-word-search-5/

LEARNING LEVEL

KS2, P5-7, Y4-6

discoverydiaries.org/resources/teacher-toolkit/



CHAPTER TWO WORD SEARCH

Zap for the answers!

Find the words you've learnt in this chapter and add them to your Visual Dictionary of Deep Space at the back of the book. Words can go forward, backward and diagonally.

L	B	G	I	S	K	N	S	I	T					
A	R	Q	L	I	U	P	G	N	C					
C	O	H	O	F	E	R	P	F	E					
I	S	P	S	C	A	R	P	R	L					
T	B	R	T	D	M	P	L	A	F					
P	A	R	I	Q	I	D	X	R	E					
O	U	E	L	I	G	H	T	E	R					
M	N	F	W	Z	I	O	K	D	S					
T	C	J	T	Q	U	E	C	Q	B					
X	K	D	F	I	X	S	U	I	V					
P	R	I	S	M	Q	J	T	J	Y					

Target = 8 words beginning with:
A L R G O S I P

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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.

GET ZAPPAR
ZAP THE CODE

Download on the App Store | GET IT ON Google play

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