Learning Objective
To recognise similarities and differences in images.

Resources Required
• Smartphone/device or computer to access Zap code (optional)
• Tracing paper (optional)
• Paints and art supplied (optional)

Background to this Activity
The James Webb Space Telescope uses infrared technology to observe space. This means it can see through the space dust that has previously obscured our view and prevented us from learning more about how stars are formed inside dark dust clouds. Its huge primary mirror also means it can collect light from galaxies that formed about 400 million years after the Big Bang. Because they’re so far away, light waves from these galaxies have been stretched to longer, infrared wavelengths as they cross our expanding Universe. No other space telescope has been sensitive enough to detect these very faint galaxies in the infrared light needed to see them. Using Webb, we can see further and in greater detail than ever before.

Running the Activity
Consider enlarging the worksheet onto A3 paper for class discussion of this activity.

Talk about how the two images are similar/different and discuss reasons for this. Relate this to prior learning about optical photographs versus infrared images (see Activity 2.4: Infrared Selfie: discoverydiaries.org/activities/infrared-selfie/) and the evolution of telescope technology (see Activity 1.4: The Starry Messengers: discoverydiaries.org/activities/the-starry-messengers/).

Students should use two pieces of tracing paper to mark out visible features, first from the optical image and then, with the other piece of tracing paper, from the infrared image. By overlaying the two, they will be able to make comparisons more easily. They can also use different colours to highlight differences between the two images.

Students can use the Zap code to access information about the different celestial features, or they can refer to the PowerPoint presentation accompanying this activity.

In tracing the visible features, students will have created their own ‘distant galaxy’ pictures based on the images provided. This lesson leads naturally on to further discussion about artistic representations of galaxies. In 1850, astronomer Lord Rosse depicted for the first time what a distant galaxy might look like, in a drawing called ‘Whirlpool Galaxy’. You can view his drawing here: https://bit.ly/2Htyg5P

Many of us will be familiar with Vincent van Gogh’s ‘Starry Night’ painting (1889), which is commonly thought to depict the night sky. In 2015, US artist and photographer Michael Benson suggested in his book Cosmographics (Abrams, 2014) that the painting actually depicts galaxies in the universe, and was likely inspired by drawings of the cosmos at the time. There is further information on this theory on the following webpage: https://www.pri.org/stories/2015-01-29/was-van-goghs-starry-night-inspired-scientific-drawing

Encourage students to discuss how van Gogh’s painting ‘Starry Night’ may have been influenced by the artistic representation of the Whirlpool Galaxy. Discuss the use of texture, movement, swirls and patterns as well as colour to add depth and tone. Take a look at this video https://www.youtube.com/watch?v=Bm9YvhBUmc4 (an animation of the painting which enhances the movement within the paint strokes).

Using a selection of oil paints, students could experiment with a range of techniques to create their own artistic interpretations of the distant galaxies and other celestial features.
features captured by Webb. Students could create their own comparisons of the night sky as viewed with an optical telescope or an infrared telescope like Webb.

A class display could show students' work beside the telescope images.

Solutions to the Activity

M81: Messier 81 is an example of a spiral galaxy. When viewed in infrared, we can see star-forming regions. We can also see the spiral arm structure more clearly, revealing areas of dust and gas that are ready to become new stars. https://webbtelescope.org/contents/media/videos/2018/08/1083-Video

The Sombrero Galaxy: This galaxy has a distinct ring of dust that circles a bulge of stars. When viewed in infrared, we can clearly see its dust and inner flat disk. Because we view this galaxy from its side, it appears very flat. Our Milky Way would look like this if it was view from the side too. https://webbtelescope.org/contents/media/videos/2018/10/1085-Video

Maffei 2: This barred starburst galaxy is very difficult for us to see without infrared because thick clouds in our galaxy obscure it. With infrared we can see the shape of Maffei 2. https://webbtelescope.org/contents/media/videos/2018/05/1086-Video

L1014: This dark cloud hides a secret that we can only see in infrared: a protostar – or baby star! With infrared technology, we can see a disk of gas surrounding the protostar. This feeds it and provides material for building planets. http://www.spitzer.caltech.edu/uploaded_files_graphics/high_definition_graphics/0008/8368/ssc2004-20a2_Ti.jpg?1333387284

NGC 253: When we view this galaxy with just visible light, its shape is difficult to determine because of our viewing angle, its dark dust clouds and the light from its massive stars. Infrared reveals the long spiral arms and the central bar, showing that NGC 253 is a barred galaxy. https://webbtelescope.org/contents/media/videos/2018/08/1082-Video

Pillars of Creation: Part of a young cluster of stars in the Eagle Nebula, the Pillars of Creation are composed of gas and dust, which prevents us from discovering what's within them with visible light. With infrared light however, we're able to see a multitude of stars which are otherwise hidden. https://www.spacetelescope.org/images/heic1501c/

A ‘surprise’ distant galaxy: Because Webb’s mirror is so huge and its instruments detect infrared light, it can catch light from galaxies that are so distant, we otherwise wouldn’t know they’re there. What would you name a galaxy if you were to discover one?

Questions for the Class

• How are the two images similar?
• What differences can you see between the two images?
• Why is the optical image different to the infrared image?
• Do you think van Gogh’s painting was based on what we can see of our night sky or was he creating a painting based on a telescope image? Why/why not?

Additional Challenges / Extension Activities

Students could look at other artists’ depictions of galaxies/nebulas etc. Check out Alexander Calder’s work or, for more contemporary examples, work by Katie Paterson.

Students could experiment with other media such as watercolour paints, to create additional paintings of the celestial features.

More able students could use ICT software such as drawing applications to create an image with labelled celestial features.
ACTIVITY 5.1
FIRST FINDINGS
From Chapter Five of the Deep Space Diary
discoverydiaries.org/activities/first-findings/

LEARNING LEVEL
KS2, P5-7, Y4-6

CURRICULUM LINKS & DIFFERENTIATION IDEAS
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discoverydiaries.org/resources/teacher-toolkit/

Ideas for Differentiation
Support:
• Students can work in pairs to compare and contrast the two images.
• Provide adult support with navigating the web resources, such as the PowerPoint presentation.

Challenge:
• Peer assessment of completed paintings.
• Students could be given responsibilities in creating the class display by creating labels, headings and short pieces of text to accompany the images.

Useful Links
This image of Saturn’s moon Titan shows the additional detail we can see using infrared. The left half of the picture saws Titan as seen with visible light, the right shows Titan using the infrared camera aboard the Cassini spacecraft: https://www.nasa.gov/image-feature/jpl/seeing-titan-with-infrared-eyes

More infrared images of Titan are available here: http://www.esa.int/spaceinimages/Images/2019/01/Seeing_Titan_with_infrared_eyes

Article about van Gogh’s Starry Night: https://www.pri.org/stories/2015-01-29/was-van-goghs-starry-night-inspired-scientific-drawing

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

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Find more great space-themed STEM resources at https://www.stem.org.uk/esero
Learning Objective
To interpret and analyse data.

Resources Required
- Smartphone/device or computer to access Zap code (optional)
- Science Encyclopedia, Science Dictionaries or access to internet – to support research into the four gases: water, carbon dioxide, carbon monoxide, methane.

Background to this Activity
The James Webb Space Telescope plays a key role in helping us learn about the atmospheres of planets – even those in other solar systems (known as exoplanets). By analysing data collected by Webb, scientists can discover which chemicals are present in a planet’s atmosphere. This means they can search for the building blocks of life – like water, carbon dioxide and methane – elsewhere in the Universe.

But how do scientists do this? One method involves studying a distant planet as it passes between us and its sun (a star). When a planet passes (or ‘transits’) in front of a star, a fraction of starlight is absorbed by the planet’s atmosphere. Using spectroscopy – measuring the intensity of light at different wavelengths – scientists can determine which wavelengths have been absorbed. Different chemical elements and compounds absorb light at specific wavelengths, forming ‘chemical fingerprints’ which can be used to work out which gases are in exoplanet atmospheres.

This complex concept is explained clearly and simply in this animation, and will help students understand the premise of this activity: https://youtu.be/W1bel0ODIDE

Teachers wishing to simplify the theory behind this activity can explain to students that Webb’s scientific instruments are used to identify the gases in an exoplanet’s atmosphere.

Running the Activity
Hook:
What are exoplanets? What is needed on a planet to support life, and what might be signs of life? Why might we want to know about other habitable planets? Have an open discussion and question time with the class about this, uncovering prior understanding before going into more detail about the activity. Relate discussion back to Webb and its role in learning about exoplanets.

Starter:
Read through the activity and questions with the class. Model Dataset 1, asking the class what we know about these gases, and what we can interpret from the symbols.

Some facts about each gas you might like to cover include:

Carbon dioxide:
- molecules are made of one carbon atom and two oxygen atoms
- is essential for animal and plant life on Earth. Green plants use carbon dioxide during photosynthesis, producing oxygen for humans and animals to breathe.
- humans exhale carbon dioxide, which green plants can then use
- the fizz in fizzy drinks comes from dissolved carbon dioxide.

Water:
- molecules are made of two hydrogen atoms and one oxygen atom
• is essential for life on Earth
• regulates human body temperature, carries nutrients and oxygen to cells, protects our organs and tissues and removes waste products
• 75% of the human brain and 50% of a living tree is water.

Carbon monoxide:
• molecules are made from one carbon and one oxygen atom
• is a colourless, odorless gas
• is toxic to humans and animals who breathe oxygen
• comes from car emissions.

Methane:
• molecules are made from one carbon atom and four hydrogen atoms
• is produced by living creatures, including cows and microbes
• is often used as fuel in the form of natural gas
• as a refined liquid, it can be used to fuel a rocket.

Classify each gas as one of the following:
• toxic to life
• useful for life
• required for life.

Students can create their own colour-coding system for these three options and colour in the circles on the worksheet accordingly.

Main Activity:
Using the information from Dataset 1, ask students to analyse each of the ten exoplanet ‘fingerprints’ in Dataset 2 and consider:
Which gases does it contain?
Does this planet contain anything toxic/useful/required?
For each data set, students need to discuss, reason and justify whether it is likely that life could exist on the planet, giving reasons for their answers. They can then colour-code that fingerprint accordingly.

Plenary:
Can students present back, communicating which exoplanet they think is most likely to support life and their reasons why?

Solutions to the Activity

Dataset 1:
Carbon dioxide (one carbon + two oxygen) – released by animals and humans when they exhale; used by plants in photosynthesis
Water – essential for life
Carbon monoxide (one carbon + one oxygen) – a poisonous gas
Methane – a greenhouse gas produced by some rocks and lifeforms, used as a fuel

Dataset 2:
Definitely no life here: 1, 3, 4, 6, 8, 9
Unlikely to support life: 2, 7, 10
Exoplanet most likely to support life: 5

Questions for the Class
• What is an exoplanet?
• Why are we interested in exoplanets?
ACTIVITY 5.2
DATA DETECTIVE
From Chapter Five of the Deep Space Diary
discoverydiaries.org/activities/data-detective/

LEARNING LEVEL
KS2, P5-7, Y4-6

CURRICULUM LINKS & DIFFERENTIATION IDEAS
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discoverydiaries.org/resources/teacher-toolkit/

Additional Challenges / Extension Activities
For a simple challenge, students can research the four gases, giving reasons for how each affects life.

Students can research how Webb will work with TESS (the Transiting Exoplanet Survey Satellite, which was launch in 2018) to study exoplanets.

Can students, individually or in groups, research an exoplanet? How was it located? Which telescope found it? Where is it located? Is it likely to support life? Why? See Useful Links for resources to support this activity.

Ideas for Differentiation
Support:
• Give students fact files for water, carbon dioxide and carbon monoxide, to support their initial research.

Challenge:
• Allow independent research.
• Justify each exoplanet’s likely to support life, with reasons. Can students use scientific evidence to justify their answers?

Useful Links
This image show how spectroscopy is used to study the atmospheres of Earth, Mars and Venus:
https://webbtelescope.org/contents/media/images/2018/05/4183-Image

NASA’s information about exoplanets and how we locate them, written for young readers:
https://spaceplace.nasa.gov/all-about-exoplanets/en/

NASA animated clip for children about how we search for exoplanets: http://bit.ly/2UDLt1o

Animated clip about how we use Webb to study the atmospheres of exoplanets. This clip is more suitable for older viewers: http://bit.ly/2OTC2p6

Animated clip about how space telescopes capture images and spectra, so we can study exoplanets: https://youtu.be/ZoaklEFPHIg

This booklet contains nine practical activities about exoplanets, developed for KS2 (or equivalent) by ESERO-UK: https://www.stem.org.uk/resources/elibrary/resource/417024/are-we-alone-search-planets-beyond-our-solar-system

‘Activity 1.1: Signs of Life’ from the Mars Diary is a good introductory for educators wishing to revise indicators of life on planets: https://discoverydiaries.org/activities/signs-of-life/

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**Learning Objective**
To research, plan, create and evaluate a scientific poster.

**Resources Required**
- Smartphone/device or computer to access Zap code (optional)
- Resources for poster creation
- Reference materials for research
- Desktop publishing tools (optional)

**Background to this Activity**
Representing scientific findings and data visually is one way to quickly and effectively communicate and is therefore an important scientific skill. While we often encounter visual representations of data in everyday life, like graphs about our household energy usage or charts about the weather, scientists have a special way of sharing data visually in what’s called an academic poster.

The purpose of an academic poster is to summarise the key information arising from research. It should be clear and attractive, so that it generates interest and encourages discussion. It is often used to support a talk or presentation but should also stand alone without verbal explanation, if it is displayed.

The most successful posters:
- have a short, compelling title
- have a total word count of 300-800 words
- use headings, bullet points and numbered lists to make it easy to read and follow
- use colour graphs, charts, infographics and other visual representations of data to communicate
- have a clean and consistent design and layout.

This activity challenges students to create an academic poster, using findings from work they’ve already completed in their Deep Space Diary. This may include information about new galaxies identified by Webb’s infrared cameras (see Activity 5.1: First Findings: discoverydiaries.org/activities/first-findings/), new planets and their atmospheres (see Activity 5.2: Data Detective: discoverydiaries.org/activities/data-detective/) or even information about the James Webb Space Telescope itself.

**Running the Activity**
This is a largely open-ended task which will fit in well with various areas of focus within the Space topic. Prior to planning their own posters, students should be given lots of time to study examples of scientific posters, noting particular features which set them apart from other types of expository writing. This task would fit nicely into a unit of work on expository writing.

**Exposure to the Genre**
Remember that students are unlikely to have significant experience of scientific posters, but will be very familiar with posters more generally (e.g. adverts, signage etc). Relate this task to prior learning, both in terms of poster design and presentational devices.

Allow the class to explore examples of scientific posters. Some examples with a space theme can be found at:
- https://mars.nasa.gov/classroom/pdfs/EarthMars_poster_front.pdf

This is a very relevant example of an informational poster on ‘big telescopes’. Please note and point out to student that this poster includes an outdated launch date for the James Webb Space Telescope: https://stfc.ukri.org/files/educational-publications/big-telescopes/

It may be useful to look at other topic areas:
Identifying Features

Show students examples which demonstrate the standard of poster you expect from them.

Identify those features which students will include in their own posters. This will vary depending on the age and ability of the class but may include the following:

- title
- subtitles
- paragraphs around themes
- graphs
- tables
- photographs
- captions
- bold/italic text
- definitions
- a careful balance between images and text.

Research

Following this familiarisation with the writing genre, students will be ready to carry out research into their chosen area of focus. This could be related specifically to something they’ve learnt during their Deep Space Diary work, or another aspect of the Universe which they are interested in. Encourage them to use note-taking, book and e-research to compile information.

Planning/Design

Students should use the information they have gathered to draft a plan for their poster. They can be encouraged to evaluate and edit their plans. This is a nice opportunity for teacher, self or peer-led formative assessment.

Writing

Allow several sessions for the poster creation. Students could produce their poster on large sheets of card or could use desktop publishing software if appropriate.

Presentation/Assessment

Depending on age/ability it may be appropriate for the class to present their posters to their peer group or another class. Encourage constructive peer feedback in line with current practices in your school.

Questions for the Class

- Where have you seen posters before? What have they been used for? What is their purpose?
- What are the main features of the scientific posters you have looked at?
- What makes scientific posters different/similar to other posters you have seen?
- What is your area of focus going to be?
- How will you find out more about that?
- How can you present this information on your poster?
- What worked well in the poster and what could be improved?

Additional Challenges / Extension Activities

Have more-able students complete a related scientific experiment and present their findings in poster form. Students could build models and/or present their work in a semi-permanent display for parents/other students to visit.

Ideas for Differentiation

Support:

- You may decide to use different strategies depending on the needs of the class. Consider voice-recordings as a way to engage reluctant writers at the planning stage.
ACTIVITY 5.3
VISUALISING THE UNIVERSE
From Chapter Five of the Deep Space Diary discoverydiaries.org/activities/visualising-the-universe/

LEARNING LEVEL
KS2, P5-7, Y4-6

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- Consider the assistive technology available at your school to support dyslexic students. Typically, these students have lots of fantastic ideas, knowledge and understanding but may struggle with reading extended pieces of text or with organising their thoughts and ideas so they may be understood by others.

Challenge:
- Digital tools such as the Pic Collage app or MS Publisher could be used to extend more able students and enhance ICT skills.

Useful Links
Example of an excellent academic poster produced as part of NASA's JWST art competition:
https://c1.staticflickr.com/1/773/32826923170_64226d3e3c_o.jpg

This webpage includes an academic poster about the development of space telescopes over the ages:
https://apd440.gsfc.nasa.gov/tech_about.html

This NASA site provides tips and information about creating academic posters:
http://www.waspacegrant.org/for_students/student_internships/wsgc_internships/posterdesign.html

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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 extend 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/

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**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/