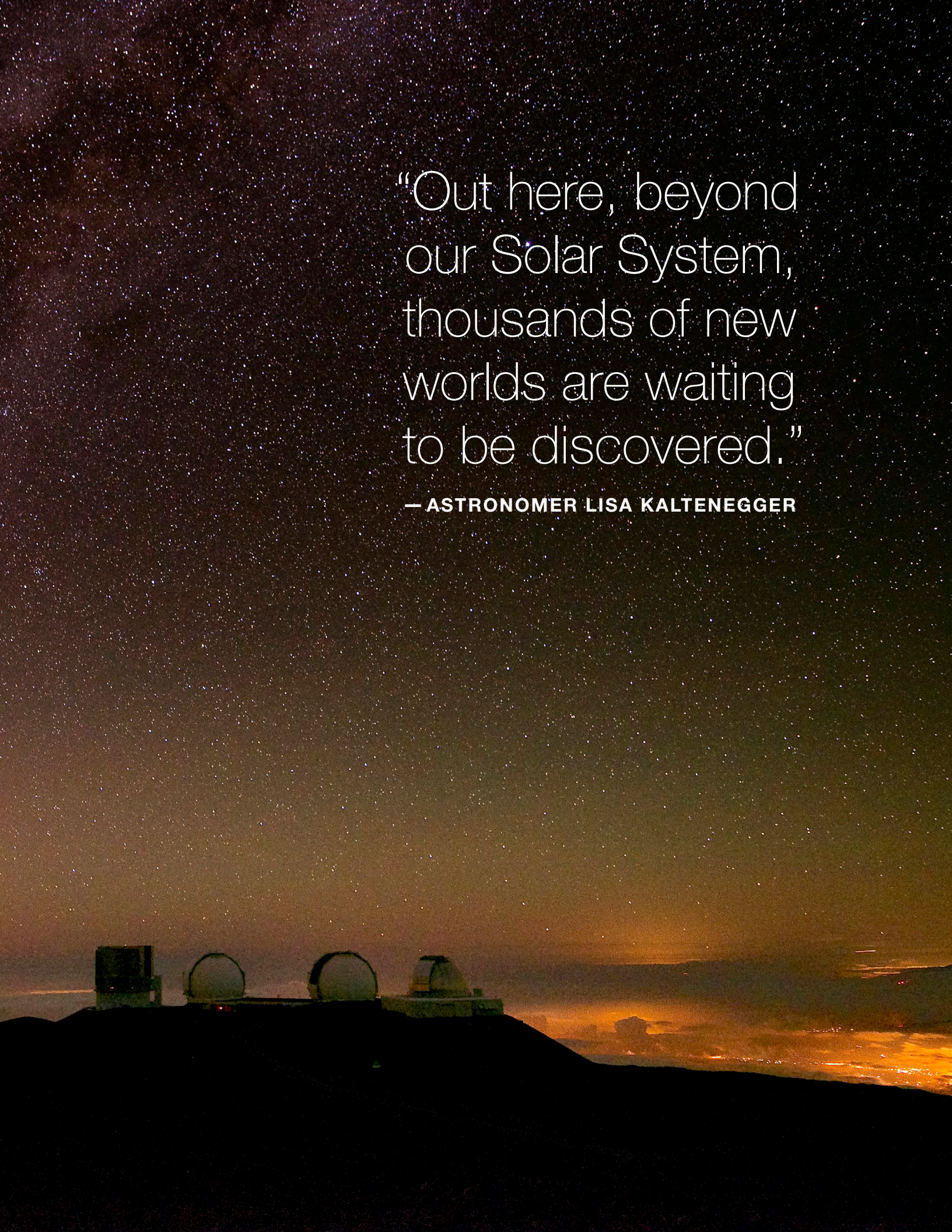

THE SEARCH FOR
LIFE
IN
SPACE
EDUCATOR GUIDE


“Out here, beyond our Solar System, thousands of new worlds are waiting to be discovered.”
—ASTRONOMER LISA KALTENEGGER

CONTENTS

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This study guide was produced by ATOM (Australian Teachers of Media) and adapted for U.S. curriculum standards by the Great Lakes Science Center in Cleveland, OH.

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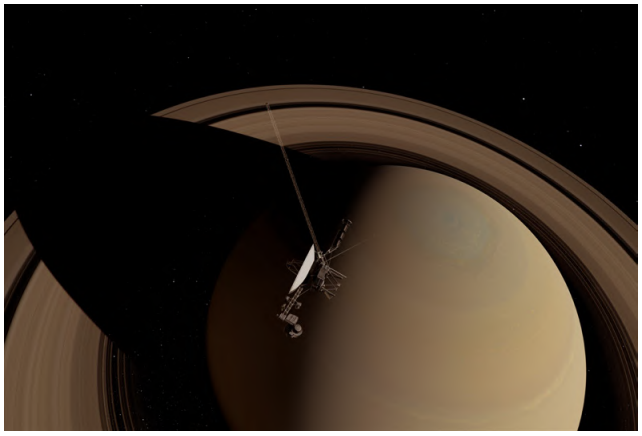


The Search for Life in Space is a 32-minute documentary that reviews current knowledge and ideas about astrobiology, the scientific study of life elsewhere in the solar system and beyond. Explorations on Earth and by space probes on other planets and moons are increasing the likelihood of finding life forms other than those on Earth, but as yet we do not know what these might be. The film presents current knowledge on the question: Are we alone in the universe? This contemporary topic is an excellent way to incorporate critical and creative thinking, ethics, English, science as a field of human endeavour (SHE) and concepts from biology, chemistry, physics and space science into science projects.

Introduction

There is one planet that we currently know of that supports life: Earth. Life is found all over the surface of Earth in all conditions, even in the most inhospitable places. Most life on Earth requires access to water, oxygen and a source of energy. In this film, astrobiologists explore the globe's extremes for signs of life and how life forms adapt to different conditions, from the volcanic lava flows of Hawaii to the driest deserts and the ocean depths. Even in the harshest of conditions, there are organizms that can survive. When there is water, oxygen and energy available, there will almost certainly be life. What about other parts of our solar system, our galaxy and the universe? What conditions are necessary for life to exist? How can we find out? This film presents the current state of scientific explorations by astrobiologists exploring the nature of life and conditions that can support what we know of as life. The study of a number of extremophiles on Earth has extended what we think might be the 'habitable zone.'

The history of space probe discoveries shows that we still have a lot to learn about our near neighbors in the solar system—and beyond, in the far reaches of our galaxy and others.

Humans have a desire to explore their world and ask questions about possibilities, including the possibility of other life 'out there'. In this documentary, many questions are raised about how we may discover exo-life on one or more of the many planets now identified outside our solar system. The viewer is left in no doubt that scientists believe the chances are improving that we might find other life in both the solar system and beyond; if it's there, then it is just a matter of time as refinements continue to be made in technologies used in the search.

THE FILM AT A GLANCE

Running time: 32 minutes

Credits: *The Search for Life in Space* is a December Media film developed and produced with the assistance of Film Victoria and Swinburne University of Technology

Director/Producer: Stephen Amezdroz

Executive Producers: Tony Wright and Stuart Menzies

Writer: Klaus Toft

Astronomer: Lisa Kaltenegger

Editor: Wayne Hyett

Narrated: Malcolm McDowell

Original Music: Dale Cornelius

Suitability: Grades 2–9, with particularly strong links to Middle School

Learn more: wwwSearchForLifeInSpace.com

GLOSSARY OF SCIENCE CONTENT

Note: In this film, the terms 'astrobiology' and 'off-Earth' are used rather than reference to 'extraterrestrial life', which is an older term often used in storytelling and science fiction about alien life.

Astrobiology

Astrobiology can be described as 'biogeochemistry,' which is an amalgam of the sciences of biology, geology and chemistry.

Astrobiology can be seen as incorporating all core STEM science and technology disciplines:
Astronomy (planetary science and cosmochemistry / chemical cosmology);
Biology (microbiology and evolution);
Chemistry (precursor to life chemistry and biochemistry);
Physics (thermodynamics and atmospheric physics);
Geology (the history of the carbon cycle); and
Engineering (space systems engineering).
Reference: saganet.org/page/whatisastrobiology

Extremophiles:

Extremophiles are living things that live at the limits of what we understand life's chemistry to be able to tolerate, such as extreme heat, pressure and lack of sunlight. Logically the reasoning is that as extremophile organisms on Earth can evolve and thrive in these extreme conditions, then it is possible that similar extreme conditions on other worlds might also support life as we know it on Earth.

The Pillars of Creation:

The Pillars of Creation are an astronomical feature in the Eagle Nebula 'star factory.'
'Pillars of Creation' is a photograph taken by the Hubble Space Telescope of columns of interstellar gas and dust in the Eagle Nebula, some 7,000 light-years from Earth.

Planet:

In the traditional model of solar systems, a planet is a celestial body larger than an asteroid or comet.
The definition of a planet set in Prague in 2006 by the International Astronomical Union (IAU) states that, in the solar system, a planet is a celestial body which: is in orbit around the Sun, has sufficient mass to assume hydrostatic equilibrium (a nearly round shape) and has cleared the space around its orbit.
Technically, there was never a scientific definition of the term 'planet' before 2006.
Reference: www.iau.org/public/themes/pluto/

CURRICULUM AND EDUCATION SUITABILITY

Reference: Next Generation Science Standards
www.nextgenscience.org

Level: Grades 2–9 as presented in this guide. Highly recommended for Grade 5 through Middle School. This film centers on how scientists might look for life beyond the limits of Earth. It is most suitable for students who have already come to accepted scientific understandings of the nature of the solar system and our place in it, and have a basic knowledge of conditions on the various planets of the solar system. The search for life in extreme environments can help focus attention on basic requirements of life, including water, oxygen and suitable temperatures. It is recommended that teachers review students' basic factual knowledge on the planets of the solar system, using a pre-test quiz prior to watching, e.g. see www.space.com/quizzes/.

Exobiology provides a contemporary context in which students can study science concepts associated with each of the disciplines: biology, physics, chemistry and earth science. Using current issues and recent research enhances understanding of science in the world, motivates and excites students.

Summary Learning Areas

Disciplines: Life Science, Physical Science, Earth and Space Science
Science and Engineering Practices
Crosscutting Concepts
Arts: Media Arts

DETAILED CONTENT DESCRIPTIONS

Discipline

Grade 2

Life sciences

Make observations of plants and animals to compare the diversity of life in different habitats. **(2-LS4-1)**

Grade 3

Life sciences

Construct an argument that some animals form groups that help members survive.
(3-LS2-1)

Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. **(3-LS4-3)**

Grade 4

Life sciences

Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. **(4-LS1-1)**

Grade 5

Life sciences

Support an argument that plants get the materials they need for growth chiefly from air and water. **(5-LS1-1)**

Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. **(5-LS2-1)**

Earth and space sciences

Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky**. (5-ESS1-2)**

Middle School

Life sciences

Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships**. (MS-LS4-2)**

Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. **(MS-LS1-1)**

Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. **(MS-LS1-3)**

Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. **(MS-LS1-5)**

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. **(MS-LS2-3)**

Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. **(MS-LS4-6)**

Physical Science
Develop models to describe the atomic composition of simple molecules and extended structures. **(MS-PS1-1)**

Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. **(MS-PS1-2)**

Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. **(MS-PS3-4)**

Earth and Space Science
Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. **(MS-ESS1-1)**

Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. **(MS-ESS1-2)**

Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. **(MS-ESS2-1)**

Science and Engineering Practices

Grades 2–3
Asking Questions and Defining Problems

Grades 4-5
Analyzing and Interpreting Data
Constructing Explanations and Designing Solutions

Middle School
Engaging in Argument from Evidence
Analysing and Interpreting Data
Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts

Grades 2–5
Patterns
Cause and Effect
Systems and System Models

Middle School
Interdependence of Science, Engineering and Technology

Influence of Engineering, Technology and Science on Society and the Natural World

Arts: Media Arts

Grades 2-5
Choose ideas to create plans and models for media arts productions. **(MA:Cr2.1.2)**

Conceive of original artistic goals for media artworks using a variety of creative methods, such as brainstorming and modeling. **(MA:Cr1.1.4)**

Middle School
Formulate variations of goals and solutions for media artworks by practicing chosen creative processes, such as sketching, improvising and brainstorming. **(MA:Cr1.1.6)**

Organize, propose, and evaluate artistic ideas, plans, prototypes, and production processes for media arts productions, considering purposeful intent. **(MA:Cr2.1.6)**

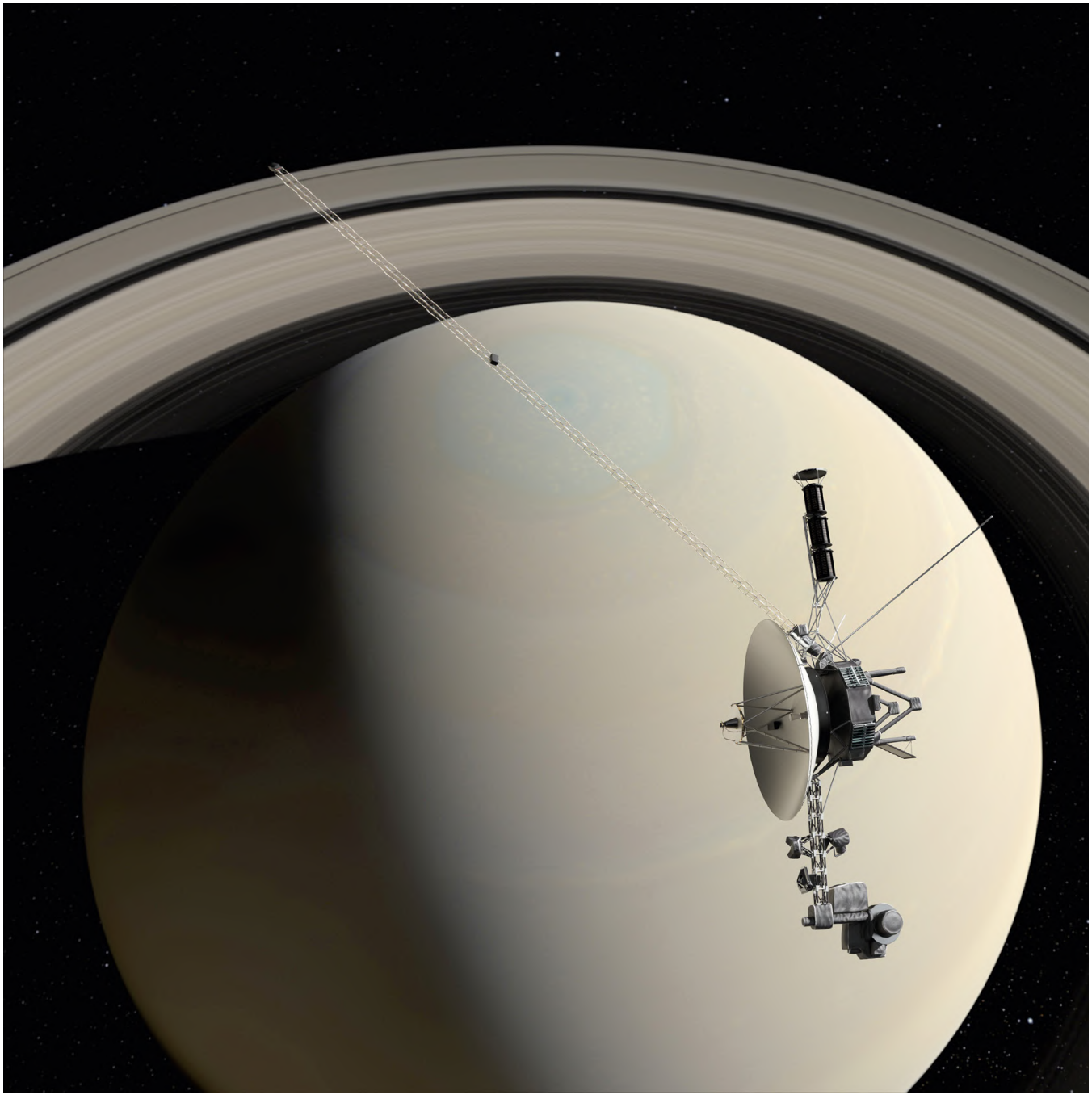
Source: nationalartsstandards.org/

SYNOPSIS

When we look out into space, we wonder about how life came to be here. People have long wondered about whether there is life on other planets or in other parts of the universe. What might these off-Earth, extraterrestrial, alien life forms be like? Indeed this search leads to the basic questions: 'What is life?', and, 'What conditions are necessary for life to evolve?'

The Search for Life in Space illuminates the intricate web of connections between the physical world and living things. Astrobiologists study the requirements for life in Earth's extreme environments to help them better understand the very nature of 'life' itself, and where in the universe it may occur and evolve. This 32-minute documentary follows scientists searching for deeper knowledge of what makes life possible on Earth, to help inform our understandings of possible exobiology. *The Search for Life in Space* reveals the interdisciplinary efforts to develop scientific understanding about the possibilities of life on other worlds. If life can exist in extreme environments, what does that say about where we might search for life beyond the confines of our planet Earth?

As the film concludes, the audience comes to the realization that the key to understanding life, including that on Earth, is not to make assumptions about what is possible from what is seen most or in our own biology.



BEFORE-VIEWING ACTIVITIES

Activity 1
Life in the Universe

Grades 2–5

Materials: Worksheet 1a (What is Life?)—see page 21

Purpose: To establish student interest in and common knowledge about concepts of Biology and Astrobiology, and to raise their own questions about scientific study of extraterrestrial life **prior to watching the film**.

Topic focus: Scientific ideas about the nature of life and the conditions that make it possible (on and off Earth).

Focus questions: What do you think is the difference between living and non-living things? What would you name as the basic requirements of life?

Disciplinary Core Ideas: Life Science
LS1A-Structure and Function
LS1B-Growth and Development of Organisms

Time allocation: 30 minutes

Teaching strategy: Think/Pair/Share

What to do:

Working as a class

Understanding and using definitions: How would you define life? What makes something 'living'? What do you think might be some of the basic requirements of living things? What is living versus non-living? What would you list as the basic conditions needed for life to exist on Earth? What do scientists explore about life on Earth? Where is life on Earth found?

Working individually and then pairs

Reflecting on understandings: Hand out and go through **Worksheet 1a: What is life and what are its needs?** Ask students to record their initial ideas by completing the worksheet individually in preparation for sharing with a partner.

Working as a class

Using science: Discuss student ideas: How important is water to life? Could life exist without water? Why do living things need energy?

Drawing conclusions: Do you think there might be life elsewhere in the universe? How would we know? Begin a class PowerPoint listing the students' questions about biology and astrobiology.

Extension: *The Search for Life in Space* describes one area that is at the frontier of science: discuss with students their ideas on what areas of knowledge being explored in science they find most interesting at this time.

Middle School

Materials: Worksheet 1b (Astrobiology—Are We Alone in the Universe?)—see page 22

Purpose: To establish student interest in and common knowledge about astrobiology by encouraging students to explore their own prior assumptions, knowledge, thoughts and questions about extraterrestrial life, prior to watching the film.

Topic focus: For students to consider scientific ideas about the nature of life and the conditions that make it possible (on and off Earth) and raise interest on the topic of the film by asking students to record what they currently know, think and wonder about the topic.

Focus questions: What do you think is the main reason we search for life in space? How important is this search to you? What do you think are the possibilities of life elsewhere in the universe (and should we be searching

for it)? What would you describe as the necessary conditions for life to exist and survive?

Disciplinary Core Ideas: Life Science
LS2B-Cycles of Matter and Energy Transfer in Ecosystems
Earth and Space Sciences
ESS1B-Earth and the Solar System

Time allocation: 30 minutes

Teaching strategy: Sharing prior knowledge using Think/Know/Wonder to raise student questions.

What to do:

Working as a class

Hand out and go through the task for Worksheet 1b. Ask students to offer their initial ideas about:

a. What is life? How would you define it? What makes something 'living'?

b. What are the basic conditions needed for life to exist?

c. What are the chemical signatures of life? Where might these be found 'off Earth'?

d. What do you think are the chances that we are alone in the universe? Do you think it is important to search?

e. Why do we want to search for off-Earth life? Introduce and define the term 'astrobiology.'

Working in groups

Students complete Worksheet 1b in preparation for sharing and discussing as a class. Encourage question-raising about how scientists might explore these ideas and where students have learned about this in their schooling and everyday life.

Discuss students' ideas about three requirements of life listed in the film. How important is water to life? Could life exist without oxygen? Why do living things need energy?

Discuss with students their ideas on what areas of knowledge are suitable for exploration in science. Ask:

a. What are some of the major areas of science that you think are important to pursue?

b. How much do we know about life on Earth?

c. Do you think there might be life elsewhere in the universe? How would we know?

Discuss responses to Question 4 on the worksheet to share students' current ideas about the topic of the film, to identify pre-existing areas of interest and share questions raised in preparation for watching.

Begin a class PowerPoint listing the students' questions about astrobiology and the search for life in space, which will be added to after watching the film. If students have little knowledge of space probes and their findings you might want to have the groups explore the NASA and ESA websites prior to watching the film.

Extension: Science fiction 'aliens.' Links to English and Media Arts outcomes.

Questions and Discussion Starters

The following is a list of possible discussion starters that teachers can consider using depending on their study focus. The questions are divided into four groups, corresponding to one of the four labelled sections of the film. These starters link directly to the activities that follow in this study guide.

Curriculum focus:
Life Sciences, Earth and Space Science.

These questions could be given as a handout along with **Worksheet 2: What I Understand About the Search for Life in Space** for students to record responses after viewing.

Part 1
How, where and why do we search for extraterrestrial life?

1. Why do you think we search for extraterrestrial life?
2. What did the Voyager and Cassini probes find about the solar system's worlds?

3. What do astrobiologists understand as the basic requirements of life?
4. What are some of the 'surprises' that life comes up with?
5. How do you think the Hawaiian islands were colonised by life?

Part 2
What are the basic requirements of life?

1. What is the importance of water for life?
2. How do planets form?
3. What are some ways that living things gain water, energy and nutrients at extremes?
4. What evidence is there for life on Enceladus, Mars and the moons of Jupiter?
5. What is the likelihood of water on Mars, and how do we know?

Part 3
How are exobiologists searching for possibilities of life off Earth?

1. What are the basic requirements of life?
2. How do water bears (tardigrades) survive extremes?
3. How common do you think life in our solar system might be?
4. Would you be surprised if we found life somewhere else in our solar system?
5. Why are the possibilities more exciting beyond our solar system?

Part 4
What technologies are used by scientists to search for life inside and outside our solar system?

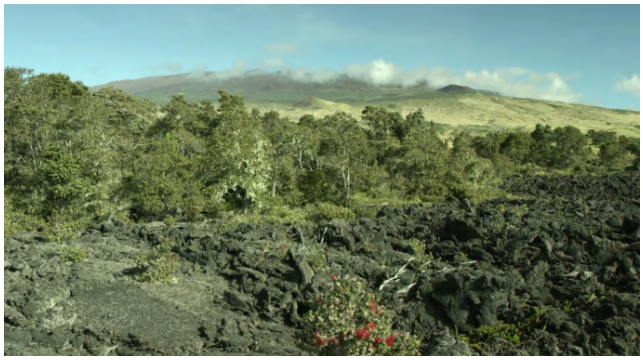
1. How can exoplanets be identified?
2. How does the Kepler space observatory identify planets?
3. What do exobiologists look for on exoplanets once they are discovered?
4. What are the biosignatures of Earth-like life?
5. How might space probes and telescopes help increase knowledge of possibilities of life on Mars and other worlds?

AFTER-VIEWING ACTIVITIES

Activity 2: What I Understand About the Search for Life in Space

Grades 2–5:

The task: Review the main ideas about the nature of life, its basic requirements and where it might be found (as covered in *The Search for Life in Space* and students' responses/reactions/ideas while watching the film).



Teaching Strategy: Whole class discussion (using selected questions as prompts).

What to do:

Before teaching, make a selection of the questions listed on Page 11.

Working as a class
Discuss each of the four sections of the film. Record students' ideas and questions raised as part of a class discussion.

Part 1 How, where and why do we search for extra-terrestrial life?

Part 2 What are the basic requirements of life?

Part 3 How are exobiologists searching for possibilities of life off Earth?

Part 4 What technologies are used by scientists to search for life inside and outside our solar system?

Have students select or create one or more questions to research further.

Middle School

Focus questions: What do we now know? What do we want to know?

Materials: Worksheet 2 (What I Understand About the Search for Life in Space)—see page 23

What to do:

Working as a class
Ask students what they think are the main ideas of astrobiology. What was shown in the film about what astrobiologists are most interested in exploring today?

Working in groups
Hand out Worksheet 2. Have students record what they know, think or feel about the content relating to the nature of 'life' in each of the four sections of the film:

Part 1 How, where and why do we search for extra-terrestrial life?

Part 2 What are the basic requirements of life?

Part 3 How are exobiologists searching for possibilities of life off Earth?

Part 4 What technologies are used by scientists to search for life inside and outside our solar system?

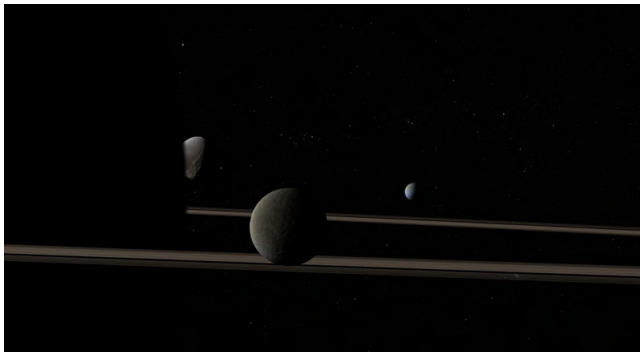
Working as a class
After recording their ideas on Worksheet 2, ask students to share in class discussion and add to the class ideas PowerPoint about what was covered in each of the four sections of the film (see Questions and Discussion Starters, page 11), and what they now think and feel about the topics covered.

Culmination/conclusions: Discuss student ideas and questions after they add to the class PowerPoint list of questions and ideas for further investigation. These might be used to guide students to develop their questions into projects and investigations. Display the class list of their ideas with their names next to their suggestions. As the work on the film progresses, tick off ideas that are covered in further activities, and add to and delete ideas as appropriate throughout the class study of the film as you review the activities covered.

Activity 3: Astrobiology of the Solar System: Missions and Findings

Grades 2–5

Materials: Worksheet 3a (Missions and Findings) and Worksheet 3 Information Sheet (Space Probes)—see pages 24 and 26



Note: This activity would be best used as a culminating activity, after watching the film and establishing shared definitions of life, biology and astrobiology. A number of websites and YouTube videos provide excellent information about specific missions and possible sites for life in the solar system. Some are listed in Resources on page 19. Students should be encouraged to use a range of websites when searching for information about space probes explored in *The Search for Life in Space*.

Purpose: To extend student knowledge of space missions to date, exploring the nature of the solar system and possibilities for life off Earth.

Focus question: What space probes have been sent by scientists that have helped in the search for life off Earth?

Task: To explore a space probe mission that has explored some part of the solar system searching for life off Earth.

Recommended teaching strategy: Negotiated cooperative group work project

What to do:

Class discussion: Discuss details on Worksheet 3 information sheet, which lists some details of the space probe missions that are explored in the film and have been collecting data about objects in our solar system.

Discuss major missions such as *Curiosity, Voyager, Kepler* and *Rosetta*. Note that those listed in Worksheet 3 information sheet and in the film cover just some of the missions that have been sent from Earth.

Focus the attention of students on how they can learn more about one of the space probes (and telescopes) using online sources. Consider:

- **Science:** What is this space probe looking for that indicates the possibility of life?
- **Technology:** How are probes designed? How do scientists on Earth learn the results of their findings?
- **Engineering:** How do probes conduct tests at their destinations? How do they reach their destinations? How do they move?
- **Mathematics:** What size is this probe? What are its dimensions? How far has it travelled?
- **Project groups:** Students search for and record information about a probe, its mission and findings.

Design and negotiate the project: Have students design a list of headings (and subheadings) to use in their project product, such as:

- When the probe/telescope launched
- Where it went
- What it has found
- Interesting features
- Questions
- Sources of information/References

Reporting: Negotiate a rubric for assessment of quality of projects, which might be based on the above list, STEM components, dimensions of scientific investigation processes or other criteria such as presentation, organization and content. Have students report on 'their mission' and assess using the agreed rubric/s. Students might be encouraged to self assess and/or peer assess their works.

A partially-completed example rubric is shown on page 14.

Reporting: Have students negotiate how they will add to a class display of their findings about space probes. Teacher could set up a class space probe timeline for display. Make sure only acceptible-quality final work is displayed.

Extension Activity: How might this mission have done things differently? Record your ideas for mission improvements.

Project Quality Assessment

Criterion	1 Star Requires improvements	2 Stars Developing	3 Stars Meets expectations	4 Stars Proficient	5 Stars Outstanding
Science					All basic requirements of life clearly outlined and discussed in relation to life off earth
Technology		Details of communications technologies outlined in brief			
Engineering				Excellent description of design features being put into practice	
Mathematics			Details of basic measurements and distances clearly shown		
Resources/ references	No websites or other resources listed				

Middle School

Materials: Worksheet 3b (Space Probes: Astrobiology of the Solar System) and Worksheet 3 Information Sheet (Space Probes)—see pages 25 and 26

Note: This activity is best completed after watching *The Search for Life in Space*, having students explore their own prior knowledge and interests in space exploration and the nature of life, and in particular, establishing a shared definition of astrobiology.

Purpose: To extend student knowledge of the missions to explore the nature of the solar system and possibilities for life off Earth.

Focus question: Where and how do scientists search for life off Earth?

Task: To explore some of the places life might be found and the probes that have been used to explore the solar system, which are described in this film.

Recommended teaching strategy: Group work and Jigsaw

Time allocation: 120 minutes

Groupings: Groups of four

Disciplines: Science: Life Sciences and Earth and Space sciences. Arts: Media Arts

What to do:

Hand out Worksheet 3b for groups to complete after watching the film. Note that the worksheet and film cover just some of the missions that have been sent from Earth. A number of websites and YouTube videos provide excellent information about specific missions and possible sites for life in the solar system. A number are listed in Resources on page 19 of this guide.

Prior to completion of worksheet:

Class discussion: Focus attention of students on how they can learn more about space probes and telescopes using online sources.

- What are space probes looking for that indicate the possibility of life?
- How are probes designed? How do probes reach their destinations?
- How do they conduct tests at their destinations and how do scientists on Earth learn the results?
- How do you think learning more about life at the extremes helps scientists in their search for off-Earth life and how it can 'make a living'?

Home groups: Have students in home groups of four complete the worksheet by having each member of the group select a mission and site in the solar system to explore in more detail, using the film and other sources. Record in the space provided:

- When the probe/telescope launched
- Where it went
- What it has found
- Interesting features
- Questions
- Sources of information / References

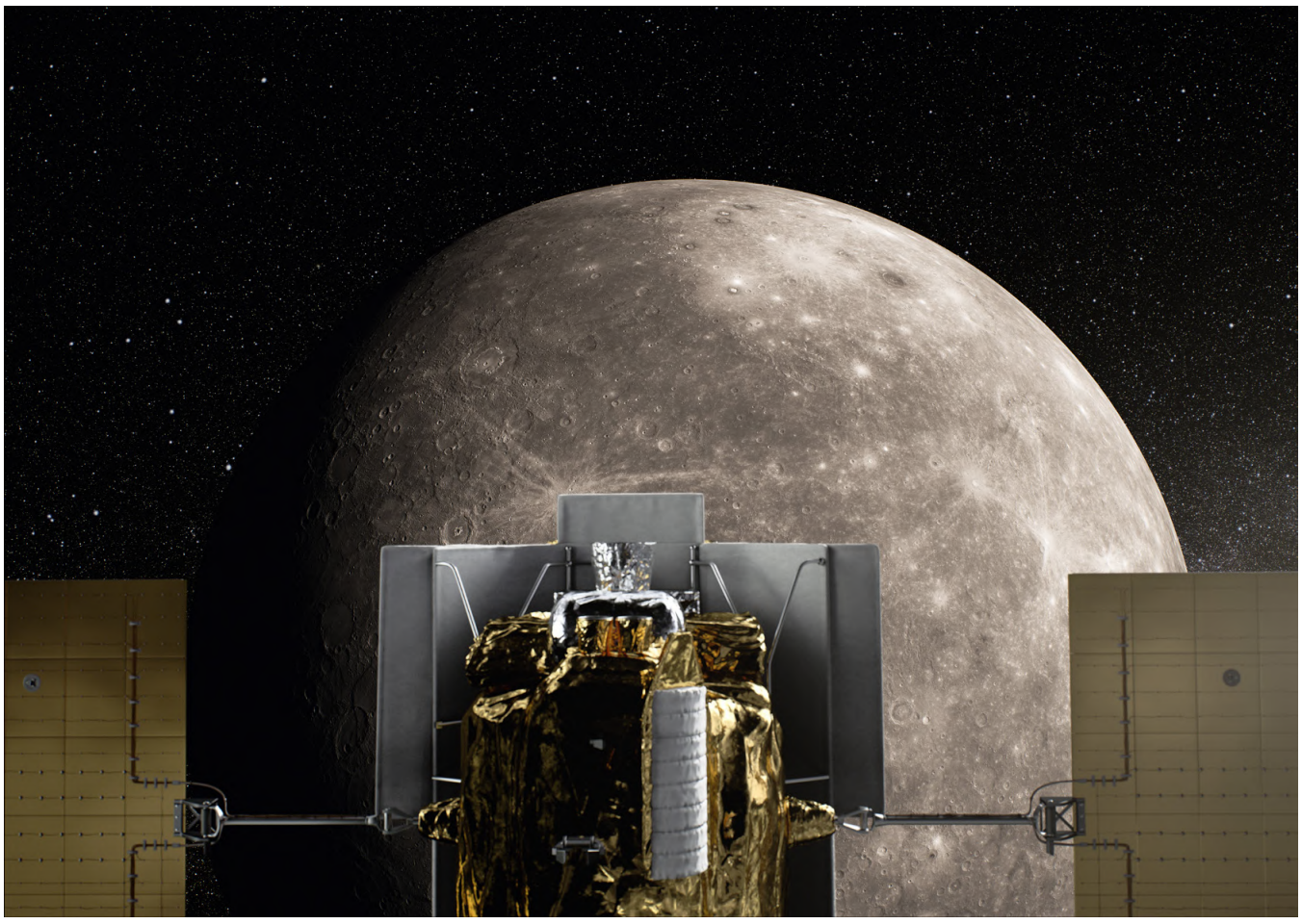
Jigsaw expert groups: Have students from the home groups move to four expert groups, one for each of the four 'missions' on the worksheet—*Curiosity*, *Voyager*, *Kepler* and *Rosetta*.

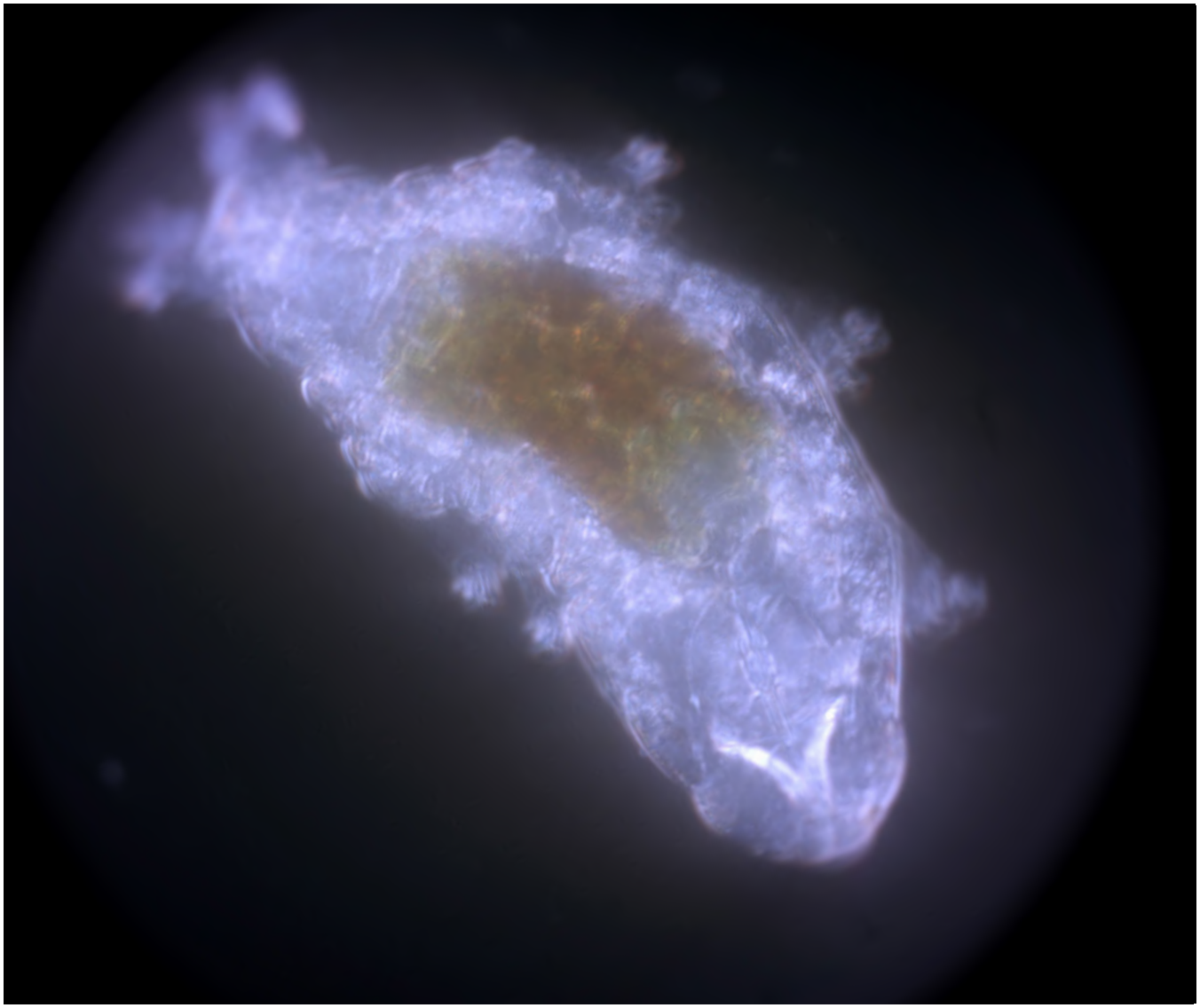
Ask students in expert groups to explain how they might organize themselves to efficiently search for and share more information online.

Home groups: Have students return to home groups and report on their mission.

Report writing: Have students negotiate how they will create a short display of their findings to share with the class. Negotiate assessment rubric for their display including dimensions such as content, organization, proofreading, layout, referencing and resources used.

Extension activity: Discuss: The key to understanding life, including that on Earth, is not to make assumptions about what is possible from what is seen most or in our own biology.





Activity 4:
Life at Extremes: Where Can Life Exist?

Grades 2–5 and Middle School

Materials: Worksheet 4 (Life at Extremes: Where Can Life Exist?)—see page 27

Grouping strategy: Whole-class discussion and groups (2–4)

Suggested class time allowance: 60 minutes

Discipline: Life Science; Arts: Media Arts

The task: Working in pairs, students review ideas of possibilities of finding life in extreme environments and how important they think the search is to understanding life off Earth. Then create and present a display.

What to do:

Prior to handing out worksheet
Discuss the idea of 'what is life?' How can we define life? (Note: This links to, and extends on, Worksheets 2 and 3).

Hand out Worksheet 4

After completing worksheet
Have students share their responses and discuss as a class.

Make a class list of ideas and terms that students wondered about as they worked on the sheet and their research, to assist their understanding of the content of the film.

Extension: The habitable zone
Develop a definition of the habitable zone and how this might relate to the presence of water.
(Ref: www.britannica.com/science/habitable-zone)

Activity 5:
Our Search for Exo-life Past and Future: Class Timeline Project

Purpose: To encourage student curiosity about space exploration and search for life off Earth.

Focus questions: What have we found and what do you think we will find with space probes in future? Given that Europa has a good chance of harboring life due the presence of liquid water oceans, do you think the planned 2022 NASA mission is a good use of resources?

Teaching strategy:
Grades 2–5: Whole-class, teacher-directed group display activity using student projects (Activity 3)
Middle School: Group self-directed research and communication for timeline displays and class performances, writing or debate.

What to do:

Grades 2–5:

Working as a class, discuss the format of the timelines they have found online during research and others they have seen. What format might work best for a class project display?

Ask students to contribute to details of timeline.

Have other students or adults come and see display, with students talking about their project with the visitors.

Extension activity: Future of the timeline: It is the year 2025. You are an astrobiologist working at NASA. What future mission would you like to see happen? Add your ideas to the class timeline.

Middle School

Materials: Worksheet 5 (Our Search for Exo-life Past and Future)

Hand out Worksheet 5 and discuss the future of astrobiology, and in particular the proposed NASA 2022 mission. Allow time for students to review space probe timelines. After students have had time to search for space probe timelines online, organize and display a range of examples of these timelines (of space travel and space probes) that were found by students in web searches to discuss the main probes and findings. Working as a class, discuss the format of the timelines they found online. What format works best? How might we create a timeline display of our own? Make choices as to how the class timeline will be displayed and organized, ideally as one whole-class display.

Allocate one or more of the steps of the agreed timeline format to each group to explore further and record information they find onto the class display. Limit the time for the task to one class session or less and establish agreed features of the display prior to students conducting research.

When the timeline entries are nearing completion, return to the class discussion of future missions. Discuss: The next proposed NASA mission is to land a probe on Europa. Do you think they will find life?

Ask students in their groups to also contribute to a future timeline by entering a proposed future mission. Discuss: What do you think should be the next steps in our search for life in space? What are some possible areas of interest that require further study, and what might these be? E.g. searching for liquid water on a moon, testing Martian subsoil for signs of life.

Ask students if they think working in this area would interest them. What ideas do they have for further exploration? Discuss: What role would you like to play in this? Discuss ideas about the stereotypes of who scientists are. See ‘draw-a-scientist’ tests and females in science blogs and on YouTube, e.g. The Myth of the Scientist: Crystal Dilworth at TEDxYouth@Caltech www.youtube.com/watch?v=w8Uo_OAbCSo

Consider how they might go about planning for writing an imaginative story or short role-play of either their preferred role in finding evidence of exo-biology or whether they think we should not be sending out probes or signals to outer space.

Extension
Life vs intelligent life: The Drake equation

'What do we need to know about to discover life in space?'—**Frank Drake, 1961**

The Drake Equation is a simple but effective tool for encouraging curiosity about the universe around us:

$$N = R^{*} \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

Key to terms

N = The number of technologically advanced civilizations in the Milky Way galaxy whose electromagnetic emissions are detectable.

R* = The rate of formation of stars suitable for the development of intelligent life.

fp = The fraction of those stars with planetary systems.

ne = The number of planets, per solar system, with an environment suitable for life.

fl = The fraction of suitable planets on which life actually appears.

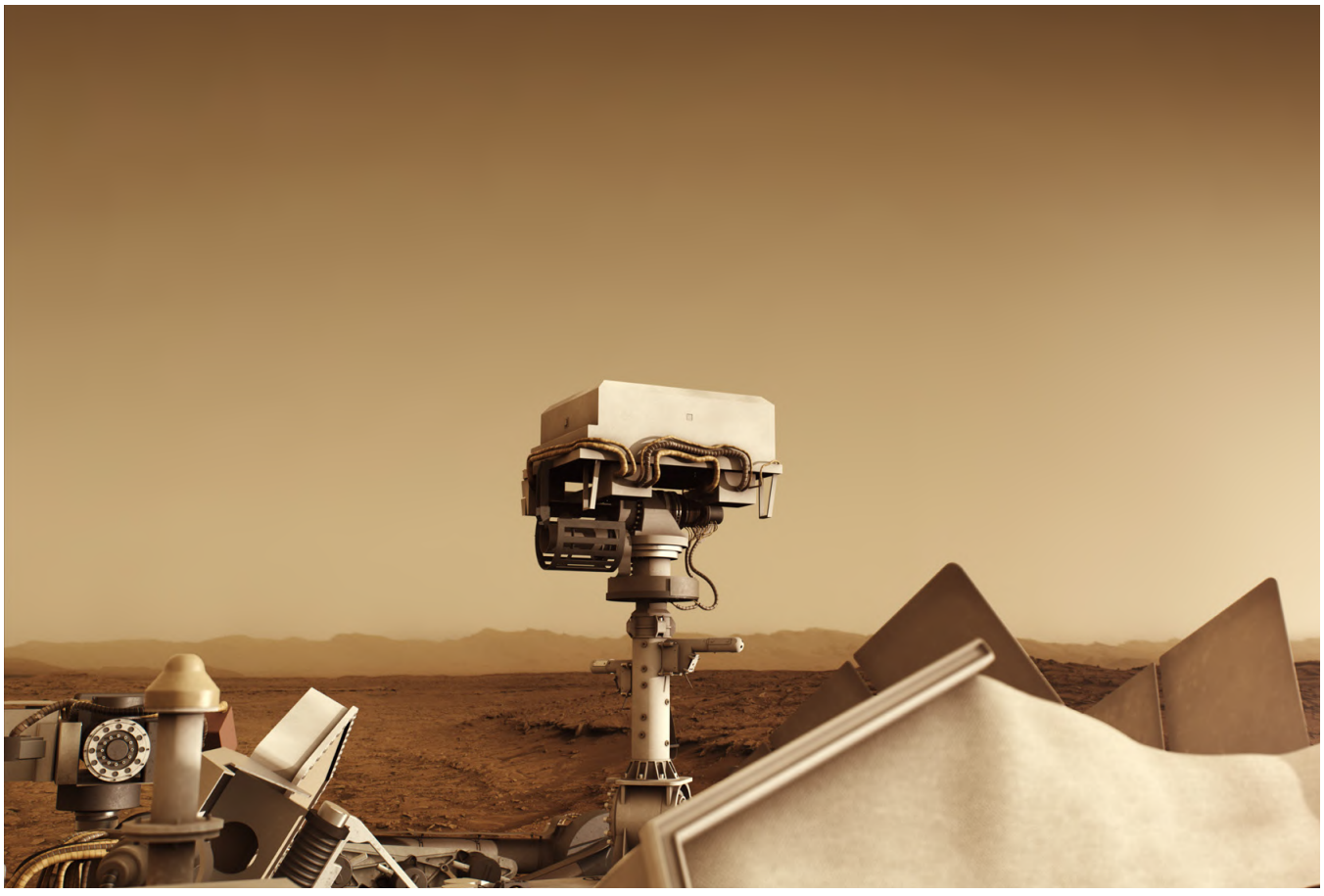
fi = The fraction of life-bearing planets on which intelligent life emerges.

fc = The fraction of civilizations that develop a technology that releases detectable signs of their existence into space.

L = The length of time such civilizations release detectable signals into space.

Dr Frank Drake—a radio astronomer at the National Radio Astronomy Observatory in Green Bank, West Virginia—came up with the above equation made up of terms involved in estimating the number of technological civilizations that may exist in our galaxy. This is now known as the Drake Equation. The equation names variables involved in the development of civilizations. There is no solution to this equation as yet. It is a tool used by scientists to think about the possibility of 'someone being out there.'
www.seti.org/drakeequation/

See as starting point: 'Why Aren't Aliens Calling Earth?' by Robert Scherrer, Vanderbilt University, Space.com, June 16, 2015.
www.space.com/29683-why-arent-aliens-calling-earth.html



RESOURCES

Pre-test space quizzes

www.space.com/quizzes/

Online resources for students and teachers

The Drake Equation—Frank Drake, 1961
www.seti.org/drakeequation/

Habitable zones—NASA classroom activities

Includes a number of classroom activity suggestions including conditions that are right for life, the habitable zone, and extremes that life can tolerate.
NASA JSC Astrobiology: Fingerprints of Life—It's Just Right, pp. 1–5
solarsystem.nasa.gov/docs/Its_Just_Right.pdf

Astrobiology in your classroom: Life on Earth … and elsewhere? Activity 4: What can life tolerate? pp. 37–48
download.searchforlifeinspace.com/AstrobiologyEd-Guide.pdf

The Sun's Habitable Zone—Life in Space: Part 2—Build Your Own Planet Temperature Calculator
www.astro.indiana.edu/~gsimonel/build.html
www.nasa.gov/pdf/562183main_LS3_HabitableZones_C5.pdf

International Astronomical Union

Definitions for a planet and other astronomical bodies
www.iau.org/static/resolutions/Resolution_GA26-5-6.pdf

What is science?

Exploring some of the problems with definitions of science, The Happy Scientist
www.youtube.com/watch?v=YwYEy5AXwlQ

Who are scientists?

The Myth of the Scientist: Crystal Dilworth at TEDxYouth@Caltech
www.youtube.com/watch?v=w8Uo_OAbCSo

Spacecraft and missions

All topics A–Z
www.nasa.gov/topics/

Voyager—Full information about *Voyager* missions
voyager.jpl.nasa.gov
www.nasa.gov/mission_pages/voyager/index.html

Curiosity and Mars missions
www.nasa.gov/mission_pages/msl/index.html

Rosetta and Philae

Earth Sky Magazine article about *Philae* data, which suggests organic compounds existed in the early solar system
earthsky.org/space/philae-lander-finds-life-ingredients-on-comet

'Surprising Comet Discoveries by Rosetta's Philae Lander Unveiled', Space.com article by Mike Wall, Space.com Senior Writer, July 30, 2015
www.space.com/30100-comet-landing-discoveries-rosetta-philae-lander.html

Kepler space observatory

www.seti.org/kepler
Astronomers meeting in Florida this week announced the 2015 results in the planet-hunting *Kepler* spacecraft's second-chance mission, dubbed K2. Deborah Byrd, 'Kepler is back! 100 new planets', EarthSky, earthsky.org/space/kepler-100-new-exoplanets-k2-jan-2015 , January 7, 2016.

Online Videos

Students can search on YouTube, Vimeo, and similar sites for terms such as:

- Space Race
- Mars
- Gale Crater
- *Voyager 2*
- *Opportunity* rover
- *Sputnik*
- *Curiosity* rover
- *Voyager 1*
- *Spirit* rover
- *Kepler Orrery 111*
- NASA's Jet Propulsion Laboratory

Teacher reference books—background reading

Space Science Projects, Science Reference Services, The Library of Congress, www.loc.gov/rr/scitech/tracer-bullets/spacesciencetb.html

Sharing the Universe: *Perspectives on Extraterrestrial Life*, Seth Shostak (foreword by Frank Drake), Berkeley Hills Books, 1998.

SETI 2020: *A Roadmap for the Search for Extraterrestrial Intelligence*, Ron Ekers, Kent Cullers, John Billingham, and Louis Scheffer (eds), SETI Press, 2002.
'Why Aren't Aliens Calling Earth?' Robert Scherrer, Vanderbilt University, Space.com, http://www.space.com/29683-why-arent-aliens-calling-earth.html , June 16, 2015.


“The true sign
of inteligence is
not knowledge,
but imagination.”
—ALBERT EINSTEIN

Worksheet 1a (Grades 2–5)

What Is Life and What Are Its Needs?

Work in groups of up to four.

Name(s):

_____

_____

_____

_____

Biology is defined as the study of life. Astrobiology is therefore … ?

Focus question: What is life and how are scientists searching for life elsewhere in our solar system?

Your task: Record what you know about the requirements of life and the possibilities that life exists elsewhere in the universe.

What to do: Working alone, record your ideas about each of the questions listed below and then pair up with a partner to discuss your ideas.

1. What is life? Using your own words write a definition of 'life'.
2. What are some major groups of living things and how would you recognize them?
3. Basic requirements for life to exist include water, oxygen, energy source and a suitable temperature. Complete the table showing what you know about these basic requirements.
4. Where do you think scientists might look for life in other parts of the solar system? Why?

Extension: Frontiers of science: How important or interesting is the scientific study of astrobiology to you? Discuss with students their ideas on what areas of knowledge being explored in science they find most interesting at this time.

Requirements of Life

Requirement	Why is it important?	How do you know?
Water		
Energy		
Oxygen		
Temperature		

Worksheet 1b (Middle School)
Astrobiology: Are We Alone in the Universe?

Work in groups of up to four.

Name(s):

_____

_____

_____

_____

Focus question: What do you think, know and wonder (TKW) about scientists searching for life elsewhere in the solar system and/or the universe?

Your task: Record your ideas about astrobiology and the possibilities that life exists elsewhere in the universe.

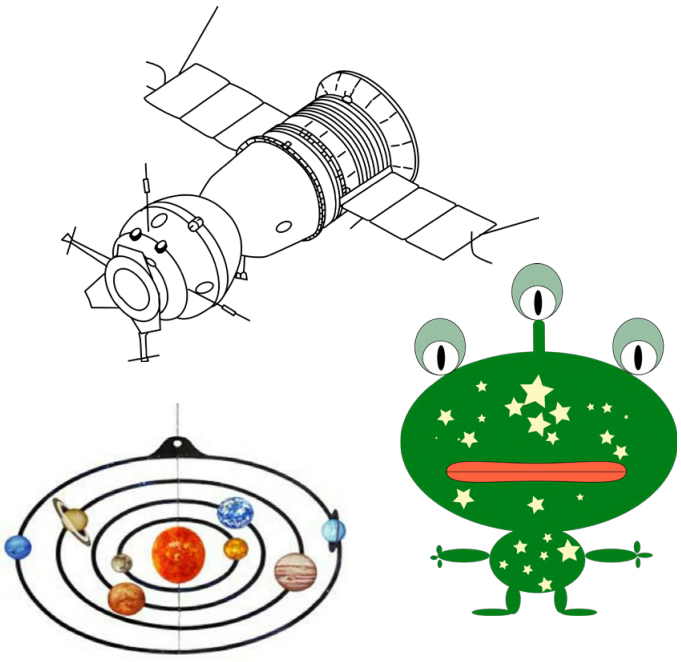
What to do: Working alone, think about each of the questions listed below. Then, in your group, discuss and record:

(a). one thing you think or know about the idea of the question; and

(b). one question you have about the idea.

1. Do you **think** there might be life elsewhere in the universe? How would we know?
   - **a.** We think …
   - **b.** We wonder …
2. How much do you **know** about scientific understandings of the requirement for life on Earth?
   - **a.** We know …
   - **b.** We wonder …
3. What do you think are the main reasons people think we should, or should not, search for life off Earth?

Example images:



4. Is this a topic you think is worthy of scientific investigation (and funding)? How does it rate for you compared with other major areas of science that you think are important to pursue?
   - **a.** We know/think …
   - **b.** We wonder …
5. What would you expect to see and learn about in a documentary called *The Search for Life in Space?* Do you often watch, or like to watch, documentaries? How about documentaries about life, or about space? What questions do you hope might be addressed or answered in this film?

   List two questions or ideas you think might be covered in the film to add to a class list for discussion as a class.

Extension: Explore 'aliens' presented in science fiction films and books. You might begin with HG Wells' *The War of the Worlds.*

	For (Positive)	Against (Negative)
a. We think ...		
b. What we would like to know...		

Worksheet 2 (Middle School)

What I Understand About the Search for Life in Space

Name(s):

_____

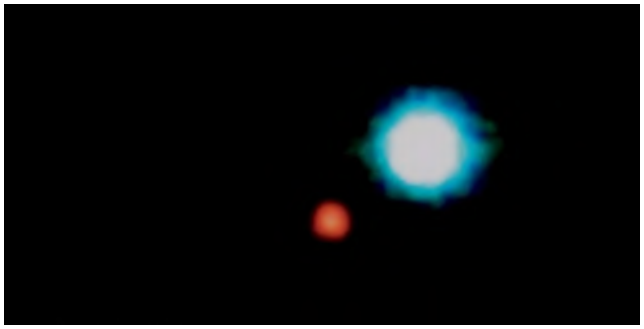
_____

_____

_____

The task: Review the main ideas about what life is, as covered in *The Search for Life in Space,* as well as your own responses, reactions and ideas while watching the film.

Focus question: Where can life exist and what are the basic requirements for life?



What to do: Respond to the ideas about the nature of life and where it might be found presented in each of the four sections of *The Search for Life in Space* by:

a) In column 2, writing your answer to the question;

b) Commenting in column 3 on what you **think** and **feel** about the ideas in that section of the film.

Further explorations: Add to a class list of **questions and activity ideas** relating to the nature of life you might be interested in exploring further:

Our Ideas
1.

2.

	How was the question answered:	What I/we think/feel:
Part 1 (00:50–10:00) How, where and why do we search for extraterrestrial life?		
Part 2 (10:00–18:00) What are the basic requirements of life?		
Part 3 (18:00–24:00) How are exobiologists searching for possibilities of life off Earth?		
Part 4 (24:00–31:00) What technologies are used by scientists to search for life inside and outside our solar system?		

Worksheet 3a (Grades 2–5)

Missions and Findings

Name(s):

_____

_____

_____

_____

Purpose: To extend student knowledge of space missions to date, exploring the nature of the solar system and possibilities for life off Earth.

Focus question: What space probes have been sent by scientists that have helped in the search for life off Earth?

Task: Group work negotiated project to explore and document a space probe mission that was sent to some part of the solar system searching for evidence of astrobiology (life 'off Earth').

What to do:
Choose one of the many probes that have been sent out into the solar system to investigate other worlds.

Design a poster or other format to write up a project on this probe that you can add to a class Space Mission Timeline.

How should your work be assessed?

Use a range of sources to find information about the mission, including:

Probe name:	
Probe details:	
When it launched:	
Where it went:	
What it has found:	
Interesting features:	
Your questions:	

NB: Make sure you keep records of your sources

Include details in your research of:

Science: What is this space probe looking for that indicates the possibility of life?	
Technology: How are probes designed? How do scientists on Earth learn the results?	
Engineering: How do they conduct tests at their destinations? How do probes reach their destinations?	
Mathematics: What size is this probe? What are its dimensions? How far has it travelled?	

Worksheet 3b (Middle School)

Space Probes: Astrobiology of the Solar System

Work in groups of up to four.

Name(s):

_____

_____

_____

_____

The search for life off Earth has been ongoing since the second half of the twentieth century. A number of bodies in the solar system have already been visited and explored for the possibility of life. We have landed missions on other planets including *Curiosity* on Mars, photographed planets and moons (including Ganymede and Europa) as space probes such as *Voyager 1* and *Voyager 2* flew by, and in 2015 have even successfully landed a probe, *Philae*, on a comet (Comet 67P/Churyumov-Gerasimenko). Space telescopes such as *Hubble* and *Kepler* have allowed us to locate planets orbiting stars other than our sun in other parts of the galaxy.

What to do:
Make notes on each of the items shown on this page based on what you can recall from watching the film *The Search for Life in Space.*

Planning for a Research project: Allocate one item on this page to each member of your group for them to explore in more detail using the worksheet 3 information sheet and other resources including online resources such as NASA, *National Geographic, Sky and Space Magazine.*

	***Curiosity* on Mars**	***Voyager* and Europa**	***Kepler* space observatory**	***Rosetta*/*Philae* at Comet 67P/ Churyumov-Gerasimenko**
Where is it currently located?				
What we have learnt from the mission?				
Could the places visited support life?				
Interesting facts:				
Further questions:				

Worksheet 3 Information Sheet: Space Probes

Voyager 1 and *Voyager 2*

The space probes known as the *Voyagers* were designed to conduct close-up studies of Jupiter and Saturn, Saturn's rings, and the larger moons of the two planets.

Launch dates: Voyager 1: September 5, 1977
Voyager 2: August 20, 1977

Launch site: From Cape Canaveral aboard a Titan-Centaur rocket

Closest approaches to Jupiter:
Voyager 1: March 5, 1979
Voyager 2: July 9, 1979

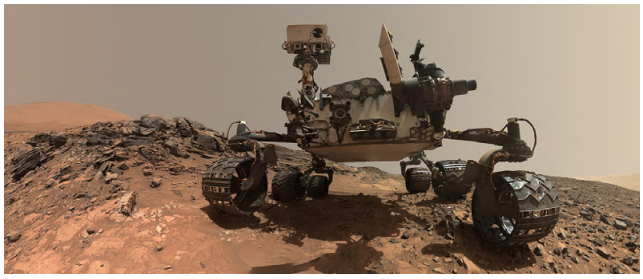
to Saturn
Voyager 1: November 12, 1980
Voyager 2: August 25, 1981

to Uranus
Voyager 2: January 24, 1986

to Neptune
Voyager 2: August 25, 1989

Voyager 1 and *Voyager 2* have now explored all the giant planets of our outer solar system—Jupiter, Saturn, Uranus and Neptune—and are leaving the solar system for deep space. They have also visited forty-eight of these planets' moons, and studied rings and magnetic fields of those planets from up closer than ever before.

voyager.jpl.nasa.gov/mission/
voyager.jpl.nasa.gov/news/factsheet.html



Curiosity

Curiosity is a car-sized robotic rover exploring Mars.

Launched: November 26, 2011 using Atlas V Rocket Operated and Manufactured by NASA as part of NASA's Mars Science Laboratory mission.

Current location (2016): Gale Crater since landing on August 6, 2012.

www.nasa.gov/mission_pages/msl/index.html

Rosetta and Philae

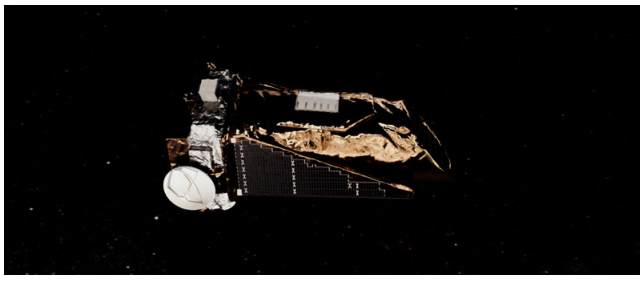
Launched: March 2, 2004

Operated by: European Space Agency (ESA)

Rosetta is a large aluminium box with dimensions 2.8 × 2.1 × 2.0 metres. The scientific instruments are mounted on the 'top' of the box. The lander Philae was commanded to self-eject from the main spacecraft and unfold its three legs, ready for a gentle touchdown at the end of the ballistic descent.

Location: After ten years in space it reached Comet 67P/Churyumov-Gerasimenko in 2014. Rosetta followed the comet as it orbited the Sun, and then sent out *Philae* to land on the surface. It was the first mission to land on a comet nucleus.

www.esa.int/Our_Activities/Space_Science/Rosetta/Why_Rosetta



Kepler mission

The *Kepler* Mission (NASA Discovery mission #10) is specifically designed to survey our region of the Milky Way galaxy to discover hundreds of Earth-sized and smaller planets in or near the habitable zone and determine the fraction of the hundreds of billions of stars in our galaxy that might have such planets.

www.nasa.gov/mission_pages/kepler/overview/index.html

Worksheet 4

Life at Extremes: Where Can Life Exist?

Your task: To create and present a display, as a cartoon strip or another agreed format, reporting on your research into life at extremes, emphasizing the ecology of life.

Focus question: Where can life exist?

What to do:

Working as a class

Record your ideas: What is life? How can we define what is living? Use a range of sources to agree on definition/s.

Review sections of *The Search for Life in Space* to revisit ideas about where life might be found:

a. Exploring the basic requirements for life: What are the three features that most life on Earth shares? (See 'Questions and Discussion Starters' on page 11.)

b. How finding water indicates life may be present: What is the importance of water for life?

c. How extremophiles satisfy basic requirements of life: What are some of the challenges the deep ocean, deserts and darkness present for life?

d. What exobiology or life in space might require: What are the biosignatures of Earth-like life?

Working in a group (max 4 students)

Choose one of the topics to investigate (or negotiate another topic of your own) to report on in more detail in an agreed format. The following questions could be used to get you started:

Extremophiles

Record details of the different research being conducted into life forms in extreme environments.

What is the importance of pioneering species in these environments and the development of ecosystems with diverse inhabitants?

Water and energy sources for living things

Discuss how surviving in low-water conditions or in the dark can help us appreciate where life might be found in space (and is increasing our understanding of our biota on Earth).

Biosignatures in space

In what ways or places might astrobiologists find signs of life?

Other (specify)

What other ideas could be explored?

Reporting back: Design a 'cartoon strip' of 6 to 12 panels explaining your findings.

Extension: The habitable zone
Earth is described as existing in the 'Goldilocks zone,' where temperatures are 'just right' for water to exist as solid, liquid and gas, and cycle through the atmosphere. Too close to the sun and all the water will evaporate away; too far away and it will freeze. How does the idea of the habitable zone help our understanding of where life might be found?

Cartoon Strip (panels explaining your findings)

Worksheet 5

Our Search for Exo-life Past and Future: Class Timeline Project

In January 2016, the U.S. government told NASA that its planned 2022 mission to Europa should not be a flyby but rather land on the surface of the moon (*New Scientist,* January 2, 2016, p.17). The budget is $175 million.

Another possible site for life is Saturn's moon Enceladus. The *Cassini* spacecraft made its last flyby in December 2015. Now two more missions are planned: LIFE (Life Investigation for Enceladus) and ELF (Enceladus Life Finder).

The field of astrobiology is one that fascinates many people. Others think that it is a waste of resources. What do you think? How interested are you in this area? What do you think would be a suitable way to proceed (if any)? Given that Europa has a good chance of harboring life due to the presence of liquid water oceans, do you think the planned mission is a good use of resources?

Your task: Contribute to a class display of a space probe timeline and future possible missions.

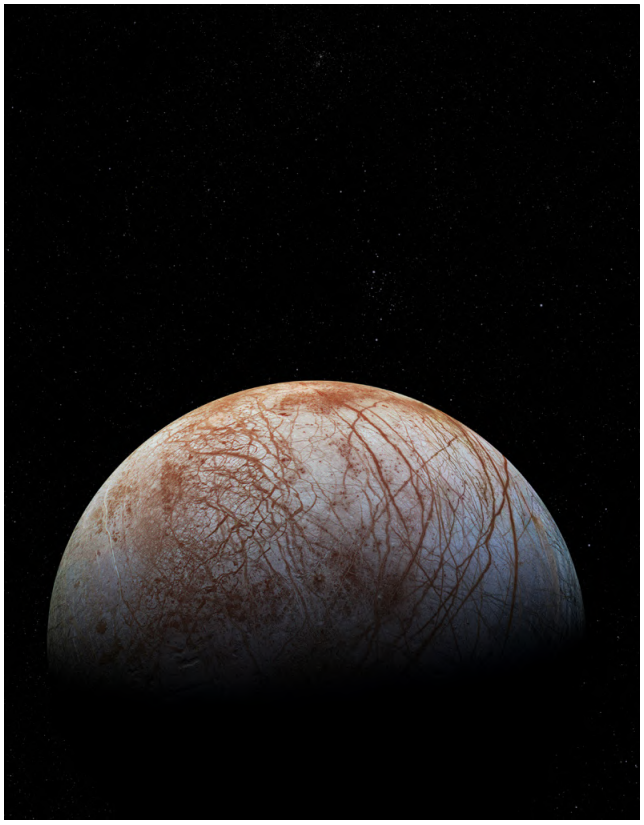
Focus questions: How have we been searching space for signs of life? What should our future searches for life in space be like?

What to do:

Discuss in your group: The next NASA mission is to land a probe on Europa. Do you think they will find life?

Conduct a web search for images showing timelines of past and proposed space travel and space probes. You might start with NASA: <nssdc.gsfc.nasa.gov/planetary/chronology.html>.

Choose one or more of these missions for your group to explore further and record information onto the class display. Remember to include the details of the references you use. Negotiate the time you can spend on the task and how it will be reported **before commencing.**



Imagine you are a NASA team member: Create a suggestion of a proposed future research project to add to the timeline. What do you think should be the next steps in our search for life in space? Be imaginative but realistic in choosing an aim.

What role would you like to play in this? Write an imaginative story or short role-play of your role in finding evidence of exobiology. Note: Think beyond stereotypes of who might be able to be involved.

Extension: The search for intelligent life: The Drake Equation.

Not all life is intelligent life. How can we estimate the number of technological civilizations that might exist among the stars? Explore the Drake equation for calculating the likelihood of there being other life in the universe and how much of that life could be expected to be 'intelligent life,' as well as how long it may be able to communicate.

www.seti.org/drakeequation

$$N = R^{*} \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

The Search for Life in Space is a December Media film produced in association with
Film Victoria and Swinburne University of Technology and distributed by MacGillivray Freeman Films.

www.searchforlifeinspace.com

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