Astraviator

SPACE WORKBOOK

UNIT 7 OF 8

Life Beyond Earth

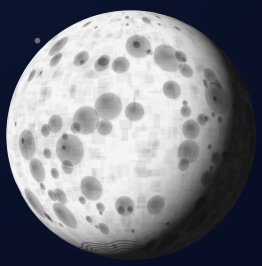
Habitable zones · Extremophiles · Exoplanets · Signals

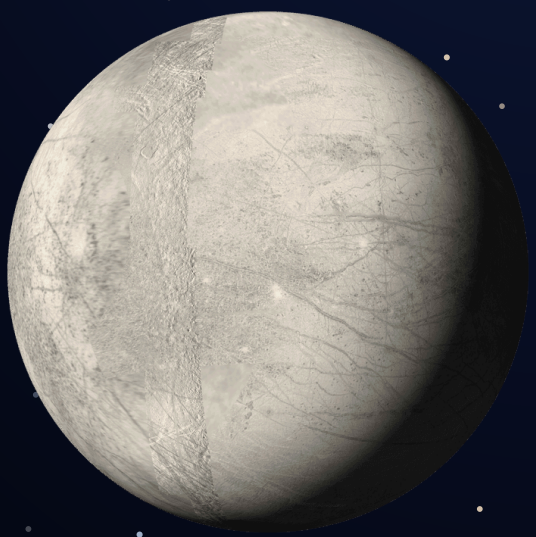
Puzzles · Cut-out cards · Experiments · Alien design

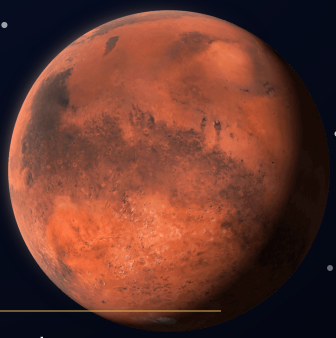
Ages 9–14 · three levels · answer key included

★ Explorer ★★ Navigator ★★★ Commander









Print at 100% · black & white pages, color cover · Imagery rendered from NASA / USGS data and Solar System Scope textures (CC BY 4.0)

FREE SIMULATOR

Scan to fly to the Moon

SOLAR SYSTEM EXPLORER

astraviator.com/explore

Assemble the rocket, launch, cross to the Moon and explore real space data. Play the free simulator in your browser, on a phone, tablet or computer: no install, no account.

SAFETY FIRST Children should do the experiments with an adult, using ordinary household materials and eye protection when asked. Never look directly at the Sun, never cap a bottle that fizzes, and do not point anything at people or pets. Adults are responsible for supervision and for deciding whether an activity is suitable for the child.

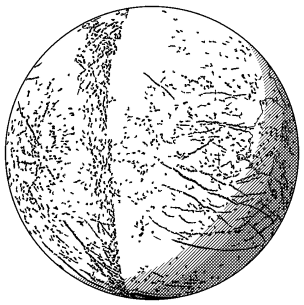
Point your phone’s camera at the code and tap the link.

Mission Briefing: Is Anybody Out There? ★ EXPLORER

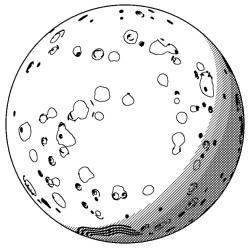
So far, Earth is the only place where we know life exists. But scientists search for it on other worlds. What do they look for?

Ingredients for life

1. **Liquid water**: it lets chemicals mix and move.
2. **Energy**: sunlight, heat from inside a planet, or chemical reactions.
3. **Building blocks**: carbon, nitrogen, hydrogen, oxygen and more.
4. **Time**: life on Earth took hundreds of millions of years to appear.



Europa



Enceladus

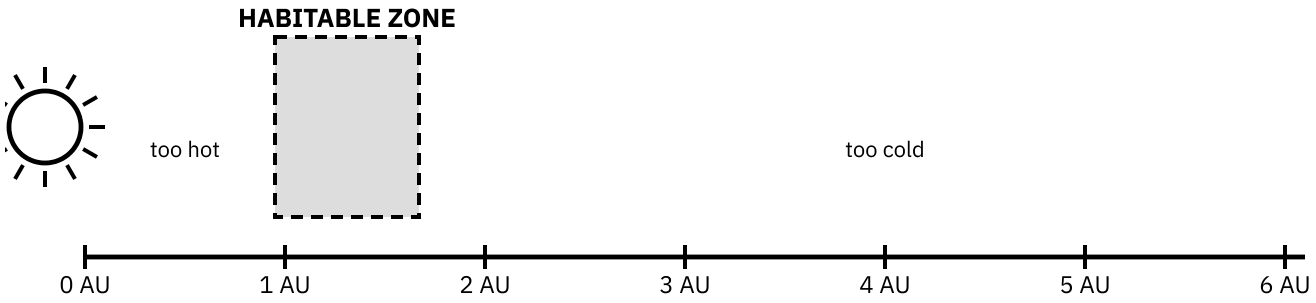
Where do we look?

Mars once had rivers and lakes. **Europa** and **Enceladus** hide salty oceans under their ice. **Titan** has lakes of liquid methane. Beyond our solar system, telescopes have found more than 5,000 **exoplanets**, planets around other stars.

World	Liquid water?	Where
Earth	Yes, surface oceans	–
Mars	Ice and briny water underground; past lakes	Jezero Crater (ancient lake)
Europa	Ocean under an ice shell 10–15 mi thick	Moon of Jupiter
Enceladus	Ocean under ice; geysers	Moon of Saturn

The Goldilocks Zone ★ EXPLORER ★★ NAVIGATOR

A planet that is too close to its star is too hot and its water boils away. Too far, and the water freezes. The area in between, where liquid water can exist on a planet's surface, is called the **habitable zone** (the "Goldilocks zone"). Distances are measured in **AU**: 1 AU = Earth's distance from the Sun = 93 million miles.



1. **Place the planets.** Draw a circle on the line at each distance and write its name above: Venus 0.72 AU · Earth 1 AU · Mars 1.52 AU · Jupiter 5.2 AU.

2. Which planets are inside the habitable zone (0.95 to 1.67 AU)? _____

3. How many miles is Mars from the Sun? 1.52 × 93,000,000 = _____ miles

4. **Red dwarf stars** are small and cool, so their habitable zone is very close in. Proxima Centauri's zone is about 0.05 AU. How many miles is that? _____ Is that closer to its star than Mercury (0.39 AU) is to the Sun? _____

5. Why might Europa and Enceladus have liquid water even though they are far outside the habitable zone?

_____

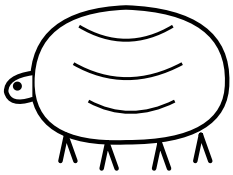
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Extremophile Trading Cards

★ EXPLORER cut-out & color

Extremophiles are living things that thrive in extreme places. If life can survive there on Earth, maybe it can survive on other worlds. Cut out, color and play: pick a category and compare with a friend's card. Two blank cards are for your own creature!

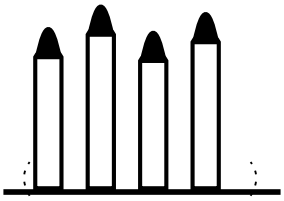
TARDIGRADE



Size	**0.02 in**
Lives	**Moss, water drops**
Survives	**Vacuum, radiation, −458 °F to 300 °F**
Space test	**Flew outside the ISS**

★ **Nicknamed "water bear"**

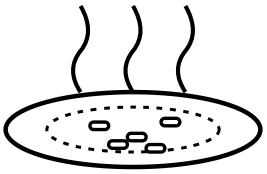
GIANT TUBE WORM



Size	**Up to 8 ft**
Lives	**Deep-sea vents**
Energy	**Chemicals, not sunlight**
Space link	**Hints for Europa's ocean floor**

★ **Lives with no sunlight at all**

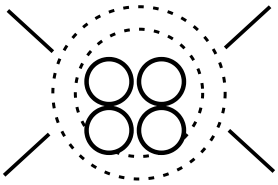
HOT-SPRING MICROBES



Size	**Microscopic**
Lives	**Yellowstone hot springs**
Survives	**Water above 160 °F**
Space link	**Models for hot places on Mars**

★ **Some enzymes made from them are used in labs**

RADIATION-PROOF BACTERIUM



Name	**Deinococcus radiodurans**
Lives	**Soil, dry places**
Survives	**Radiation 1,000× a human's limit**
Space link	**Could survive on Mars' surface?**

★ **Repairs its own DNA**

Extremophile Cards: Create & Compare ★★ NAVIGATOR

YOUR EXTREMOPHILE

Draw it here

Name	_____
Lives in	_____
Survives	_____
Space link	_____

YOUR EXTREMOPHILE

Draw it here

Name	_____
Lives in	_____
Survives	_____
Space link	_____

1 Which extremophile survives the most extreme temperature range? _____

2 The tube worm lives where there is no sunlight. Why does that make scientists more hopeful about life on Europa?

_____

_____

3 Temperature conversion: 160 °F − 32 = _____ ; × 5 ÷ 9 = _____ °C. Water boils at 212 °F. How many degrees below boiling is 160 °F? _____

4 Design a creature that could live on Titan (−290 °F, methane lakes, orange haze). Describe it here:

_____

_____

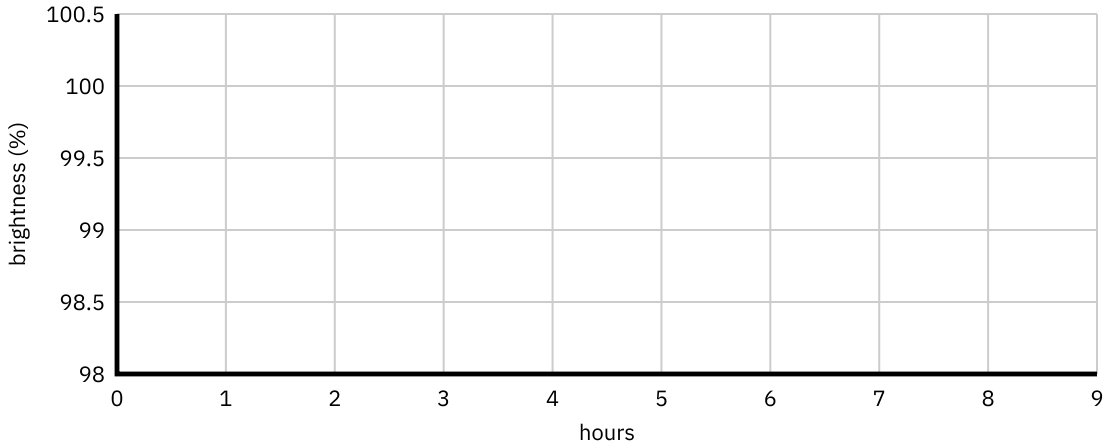
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Planet Hunter · The Transit Method ★★★ COMMANDER

How do we find planets around other stars? When a planet passes in front of its star, it blocks a little light, and the star gets slightly **dimmer**. This is a **transit**. Telescopes like **Kepler** and **TESS** look for these tiny dips.

Hour	0	1	2	3	4	5	6	7	8	9
Brightness (%)	100	100	100	99	99	99	99	100	100	100

Plot the table on the graph and join the dots.



1. How many hours did the transit last (from the first dip to the end)? _____

2. By how much did the star dim? _____ % That is 1/100 of its light.

3. **Planet size.** The dip equals (planet radius ÷ star radius)². If the dip is 0.01, then planet radius ÷ star radius = _____. The star is a Sun twin with a radius of 432,000 miles, so the planet's radius is _____ miles.

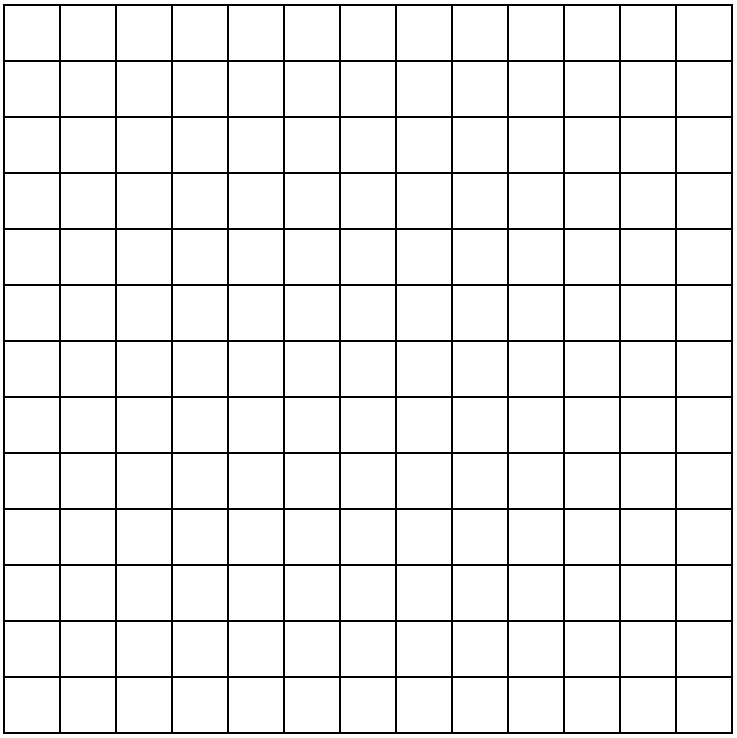
4. Compare it: Jupiter's radius is 43,400 miles and Earth's is 3,959. Is this planet more like _____ (Jupiter / Earth)?

5. This planet transits every 3 days. How many transits would the telescope see in 30 days? _____

Message to the Stars: Color by Code ★ EXPLORER ★★ NAVIGATOR

In 1974, scientists beamed the **Arecibo message** toward a star cluster 25,000 light-years away. It was a string of 1,679 ones and zeros that, arranged in a grid, made a picture. Try it yourself! Each row below is a code: **1 = color the square**, **0 = leave it white**. What picture appears?

1	1000000000001
2	0100000000010
3	0011111111100
4	0111111111110
5	1111111111111
6	1100111110011
7	1100111110011
8	1111111111111
9	0111111111110
10	0011111111100
11	0001110111000
12	0000111110000
13	0000011100000



1. What does the picture show? _____

2. Count the ones in row 5 (**1111111111111**): _____ . How many squares are colored in the whole picture? _____

3. **Your turn.** On the back of this page (or on grid paper), design a 9 × 9 picture and write its code, row by row, for a friend to decode. If a friend 25,000 light-years away received your message, how many years would it take to arrive? _____

Mission Planner Puzzle ★★ NAVIGATOR ★★★ COMMANDER

Four life-hunting probes launch on four different days, one to each world. Use the clues to find which world each day's probe visits. Write the world in the table.

Monday	
Tuesday	
Wednesday	
Thursday	

Mars · Europa · Enceladus · Titan

Clues

1. The Europa probe does not launch on Monday.
2. The Titan probe launches after the Enceladus probe.
3. The Mars probe launches the day right before the Europa probe.
4. The Titan probe launches last.
5. The Enceladus probe does not launch on Monday.

1 Which probe launches on Wednesday? _____

2 **Your turn.** Write three clues for a new puzzle with these worlds on three days.

_____

_____

_____

Alive or Not? Sorting Cards

★ EXPLORER cut-out

Scientists say something is **alive** if it grows, uses energy, reacts to its surroundings, makes copies of itself, and is made of cells. Cut out the cards and sort them into three groups: **ALIVE**, **NOT ALIVE** and **TRICKY** (scientists disagree!). Glue them in the boxes.

ALIVE	NOT ALIVE	TRICKY

Fire	**Oak tree**	**Mars rover**	**Cloud**
Bacteria	**Car**	**Dog**	**Virus**
Robot	**Seed**	**Crystal**	**Mushroom**

1. Fire grows, moves and uses energy. Why is it **not** alive?

2. If a rover found a rock on Mars that “grew” over time, how could you tell whether it was alive?

Lab · Does Salt Stop Ice? ★★ NAVIGATOR

SAFETY Do this with an adult. Do not taste the salty water. Frozen cups can be very cold: let an adult take them out and do not hold the ice against your skin.

On Mars, water can stay liquid at freezing temperatures if it is full of salt (**brine**). Scientists think Europa's ocean is salty too. Test how salt changes freezing!

You need

- 3 small cups
- 1½ cups of water
- Table salt
- A marker and a spoon
- A freezer

Steps

1. Put ½ cup of water in each cup.
2. Cup A: no salt. Cup B: 1 teaspoon of salt. Cup C: 4 teaspoons of salt. Stir until dissolved. Label the cups.
3. Place all cups in the freezer. Check every hour for 4 hours.

My prediction: _____

	Cup A (no salt)	Cup B (1 tsp)	Cup C (4 tsp)
Hour 1			
Hour 2			
Hour 3			
Hour 4			

Write: liquid, slushy or solid.

1 Which cup froze first? _____ Which stayed liquid longest? _____

2 Explain why salty water could stay liquid on cold Mars.

_____

_____

Math Lab · How Many Alien Worlds? ★★ NAVIGATOR ★★★ COMMANDER

Scientist **Frank Drake** proposed a chain of guesses to estimate how many civilizations might exist in the galaxy. Let's try a simple version. Each step uses a fraction of the previous number. These are *guesses*, not facts!

Step	Question	Fraction	Result
1	Stars in the Milky Way	–	100,000,000,000
2	Stars with planets	1/2	_____
3	…with a habitable planet	1/5	_____
4	…where life appears	1/1,000	_____
5	…and becomes intelligent	1/1,000	_____

1. Fill in the Result column. How many planets with simple life are there in the Milky Way (step 4)?
   _____

2. **What if?** Change the step 4 fraction to 1/1,000,000. How many planets with life now?
   _____

3. Would you say life in the universe is common or rare? Explain with your numbers.

   _____

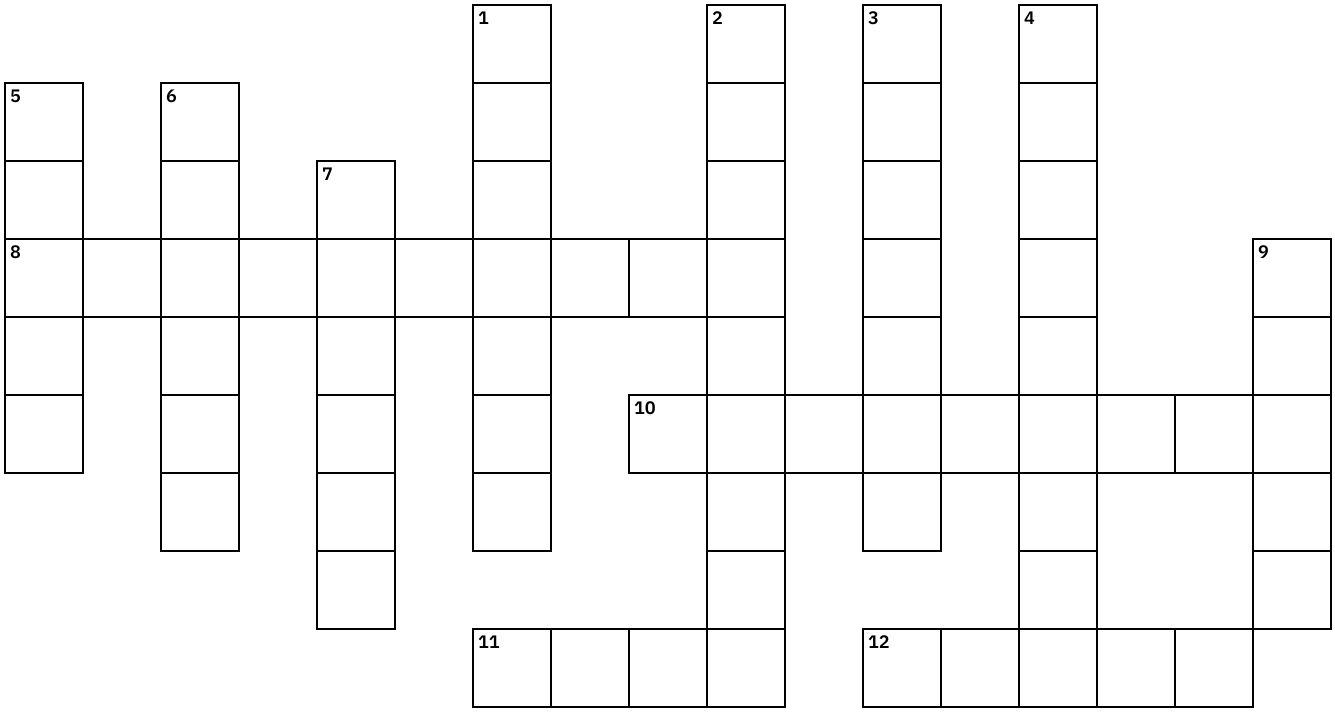
   _____

4. **Radio talk.** A radio signal travels at the speed of light. If a signal takes 4.24 years to reach Proxima Centauri, how long would a conversation take (one question and one reply)? _____ years

5. The first radio signals from Earth began about 100 years ago. Up to how many light-years have they traveled? _____

Astrobiology Crossword ★★ NAVIGATOR

Every answer is a word from this unit.



ACROSS →

8. Tiny “water bear” that survives space

10. A place where life could live

11. The Red Planet, once wetter

12. Moon with methane lakes

DOWN ↓

1. A living thing too small to see

2. Saturn moon with geysers

3. When a planet passes in front of its star

4. A planet around another star

5. The liquid life needs

6. Icy moon of Jupiter

7. A message sent by radio

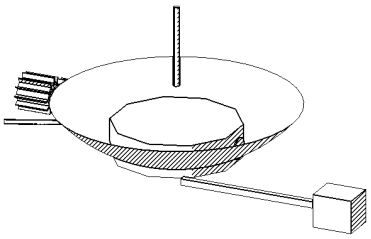
9. Europa and Enceladus hide one under the ice

Create · Your Golden Record

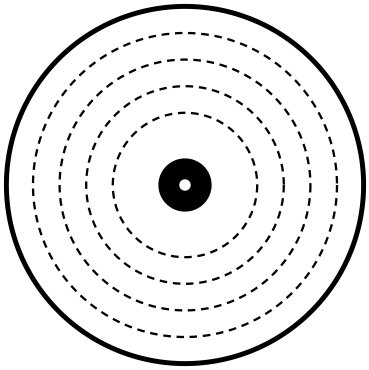
★ EXPLORER ★★ NAVIGATOR

In 1977, the **Voyager** probes each carried a **Golden Record** with sounds and pictures of Earth, in case someone finds it one day. Now you decide what to send. Choose **five** items from this list (or invent your own) and explain why.

- ☐ Sounds of rain and thunder
- ☐ A baby laughing
- ☐ Music by Bach
- ☐ A greeting in 55 languages
- ☐ A photo of a family
- ☐ A map of the solar system
- ☐ A drawing of a human
- ☐ A song of whales
- ☐ A recipe for pizza
- ☐ Photos of Earth's landscapes
- ☐ The sound of a heartbeat
- ☐ A children's song



Voyager carries the record



Decorate your record: draw 3 symbols

1. I choose: _____ because _____
2. I choose: _____ because _____
3. I choose: _____ because _____
4. I choose: _____ because _____
5. I choose: _____ because _____
6. Write a greeting for the aliens in one sentence:

_____

_____

Unit Review · Mission Check

★ EXPLORER ★★ NAVIGATOR ★★★ COMMANDER

1. **Match**: habitable zone ___ extremophile ___ exoplanet ___ transit ___

   A. a planet around another star · B. a living thing in extreme places · C. where liquid water can exist on the surface · D. a planet passing in front of its star

2. **List** three ingredients life needs:

3. **True or false?** a) Scientists have found life on Mars. T / F b) Europa may have an ocean under its ice. T / F c) A planet that is too close to its star is too cold. T / F

4. **Calculate.** A star dims by 4% during a transit. Its brightness drops from 100% to _____ %.

5. **Explain** why tardigrades interest astronomers.

6. **Order** from closest to farthest from the Sun: Europa · Mars · Earth · Enceladus:

7. **Argue.** Should we send a message to aliens? Give one reason for and one against.

8. **Predict.** Where in the solar system would you send the next life-detecting probe and why?

Mission Log ★ EXPLORER

Check the boxes when you can do each one. Color a star for each section you enjoyed.

☐ I can list what life needs to exist.

☐ I can explain the habitable zone.

☐ I can describe extremophiles and why they matter.

☐ I can explain how the transit method finds planets.

☐ I can decode a binary picture.

☐ I can solve a logic puzzle.

☐ I can tell alive from not alive.

☐ I can design a message for aliens.

My favorite activity was

Something new I learned

A question I still have about space

UNIT 7
LIFE BEYOND EARTH
★ ★ ★
MISSION COMPLETE

Signed: _____
Date: _____

The Space Workbook series

You have **Mission 7**. There are **8 missions** in all: each one is a complete set of puzzles, math labs, games and experiments, and each works on its own.

1	**Earth, Moon & Sun** Phases, time zones, seasons, eclipses, tides	☐
2	**Rocky Planets** Mercury, Venus, Earth and Mars	☐
3	**Giant Planets** Jupiter, Saturn, Uranus and Neptune	☐
4	**Moons, Dwarf Planets & Small Bodies** Pluto, Ceres, comets, asteroids and icy moons	☐
5	**Rockets, Orbits & Missions** SLS, orbits, Morse code, spacecraft	☐
6	**Stars, Constellations & Galaxies** Light-years, star maps, galaxies, black holes	☐
7	**Life Beyond Earth** Habitable zones, extremophiles, exoplanets	**★ YOU ARE HERE**
8	**Astronaut Life** Training, spacewalks, food, living in orbit	☐
+	**Field Guide** The 29 destinations of the Solar System Explorer	in the Complete Workbook

Want them all in one file? The Complete Space Workbook has all 8 missions, the Field Guide and every answer key. Download it free at **astraviator.com/explore**

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