Astraviator

SPACE WORKBOOK

UNIT 6 OF 8

Stars, Constellations & Galaxies

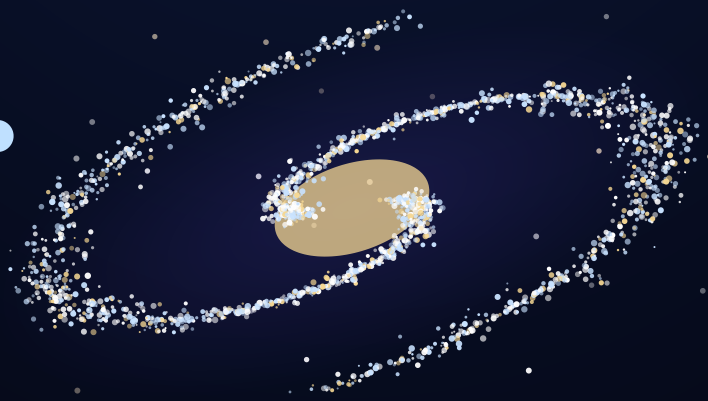
Light-years · Star maps · Galaxies · Black holes

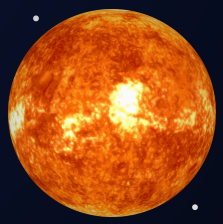
Puzzles · Dot-to-dot · Cut-out cards · Star lab

Ages 9–14 · three levels · answer key included

★ Explorer · ★★ Navigator · ★★★ Commander







astraviator.com | Solar System Explorer Simulator

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: Stars All Around ★ EXPLORER

Every star you see at night is a Sun, a giant ball of hot gas that makes its own light. They look tiny only because they are **very** far away.

Light-year

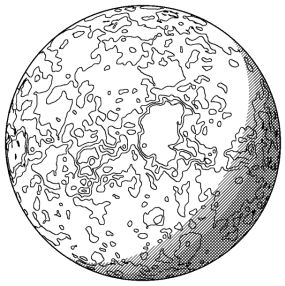
Space is so big that miles are too small. Astronomers use the **light-year**: the distance light travels in one year, about **5.88 trillion miles**. Light moves at 186,282 miles per second!

Constellations

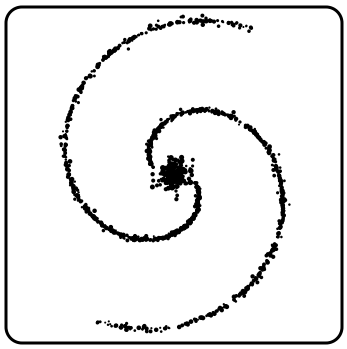
A **constellation** is a pattern of stars that people imagined as a picture: a hunter, a swan, a cross. The stars in a pattern are usually *not* near each other; they only look close from Earth.

Galaxies

A **galaxy** is a huge family of stars, gas and dust held together by gravity. Our Sun lives in the **Milky Way**, which has 100 to 400 billion stars.



Our Sun, the nearest star



A spiral galaxy like the Milky Way

Star	Distance	Light takes
Sun	93 million miles	8.3 minutes
Proxima Centauri	4.24 light-years	4.24 years
Sirius	8.6 light-years	8.6 years
Betelgeuse	~550 light-years	~550 years

Life Story of a Star

★ EXPLORER ★★ NAVIGATOR cut-out

Stars are born, live and die. A small star like the Sun and a massive star have very different endings. Cut out the cards, sort them into two paths, and glue them in order from left to right.

Path 1 · A small star like the Sun

1	2	3	4	5	6

Path 2 · A massive star

1	2	3	4	5	6

1 · A planetary nebula: the outer layers drift away

1 · A white dwarf: a hot, tiny core that slowly cools

1 · A main-sequence star burns hydrogen for billions of years

1 · A cloud of gas and dust (nebula)

1 · A red giant swells up as hydrogen runs out

1 · A protostar: the cloud collapses and heats up

2 · A neutron star or a black hole is left behind

2 · A cloud of gas and dust (nebula)

2 · A massive star shines blue-white and burns fast

2 · A red supergiant swells to hundreds of times the Sun

2 · A supernova: the star explodes!

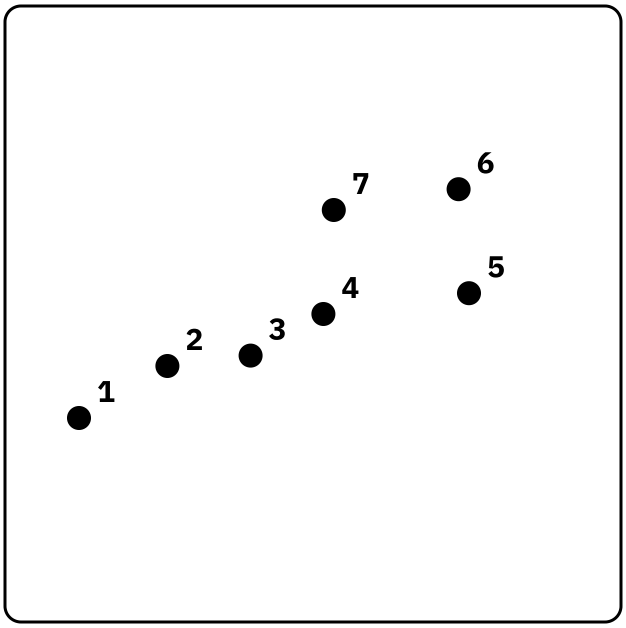
2 · A protostar: the cloud collapses and heats up

1 Which stage do both paths share at the beginning? _____

2 Our Sun is about 4.6 billion years old and will live about 10 billion in total. How many billion years does it have left? _____

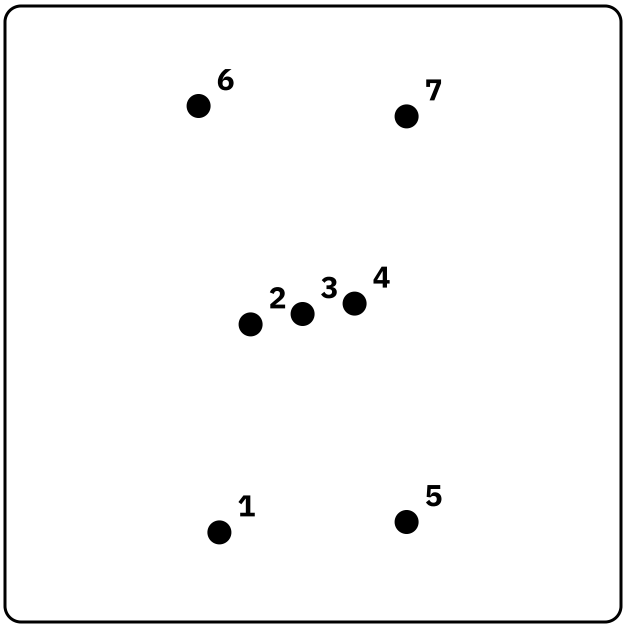
Connect the Dots: Star Patterns ★ EXPLORER

Join the stars to reveal the constellation. Follow the instructions under each picture.



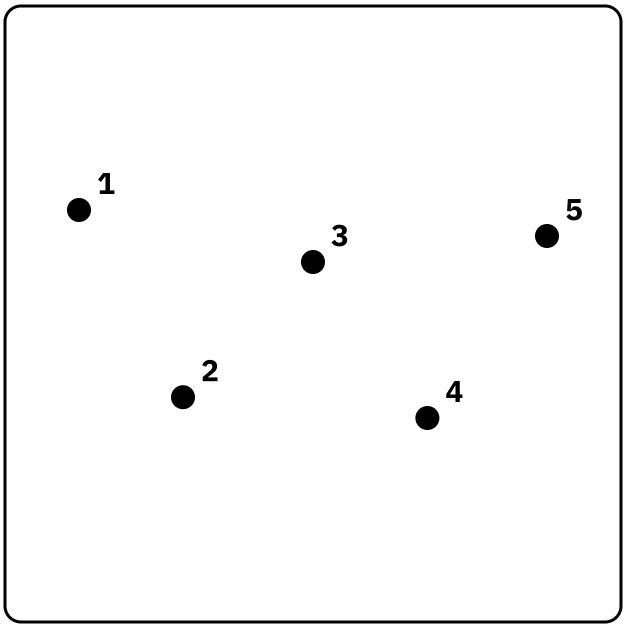
Big Dipper

Join 1→2→3→4→5→6→7, then 7→4.



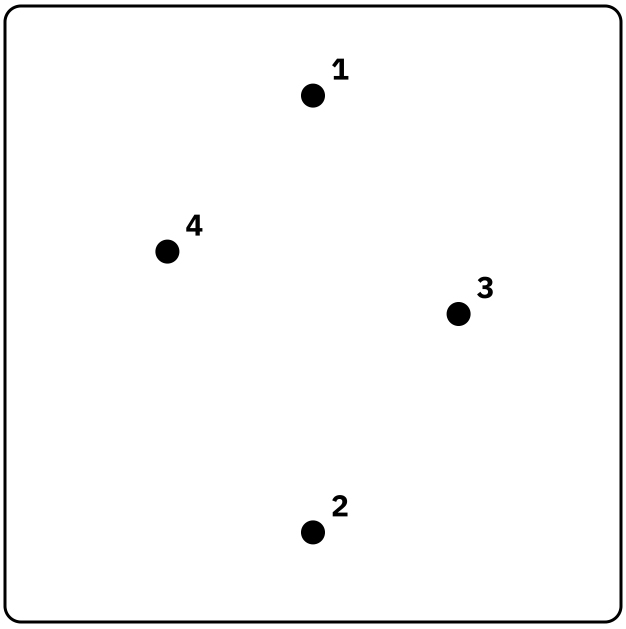
Orion

Join 1→2→3→4→5, then 6→2, 7→4 and 6→7.



Cassiopeia

Join 1→2→3→4→5. It makes a big W!



Southern Cross

Join 1→2 and 3→4. Only visible south of the equator.

Orion has a red star, **Betelgeuse** (6), and a blue star, **Rigel** (5). Color them lightly with a red and a blue pencil. The Southern Cross points to the south, and the Big Dipper points to Polaris, the North Star.

Math Lab · Light and Distance ★★ NAVIGATOR ★★★ COMMANDER

Use a calculator. 1 light-year = 5,878,000,000,000 miles. Light speed = 186,282 miles per second.

1. **Sunlight.** The Sun is 93,000,000 miles away. Time = distance ÷ speed = _____ seconds = _____ minutes.

2. **Moonlight.** The Moon is 238,855 miles away. How many seconds does its light take to reach us? _____

3. **Looking into the past.** Sirius is 8.6 light-years away. You see it as it was _____ years ago. If you are 11 years old, in which year of your life was this light leaving Sirius? Age _____

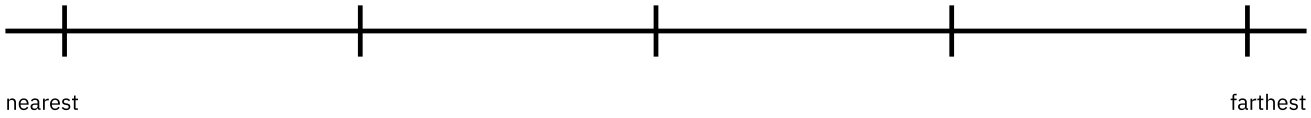
4. **Miles to Proxima.** Proxima Centauri is 4.24 light-years away. 4.24 × 5,878,000,000,000 = _____ miles (about _____ trillion).

5. **The long trip.** The fastest probe, New Horizons, left Earth at 36,373 mph. About how many years would it take to reach Proxima? Hours = _____ ; ÷ 8,766 hours per year = _____ years.

6. **Compare.** About how many human generations (25 years each) is your answer to question 5? _____

Number line · Which light left first?

Place the stars on the line by their distance in light-years: Sun (0.0000158), Proxima (4.24), Sirius (8.6), Vega (25), Betelgeuse (550). The line is not to scale: write each name above its tick and its distance below.



nearest farthest

Star Colors and Temperatures ★★ NAVIGATOR

A star's color tells its surface temperature. Blue stars are the hottest and red stars are the coolest, like a flame: the blue part of a candle flame is hotter than the orange tip. Astronomers sort stars into classes **O, B, A, F, G, K, M** (remember: *"Oh, Be A Fine Girl, Kiss Me!"*).

Class	Color	Surface temperature	Color it
O	Blue	> 53,500 °F	
B	Blue-white	17,500–53,500 °F	
A	White	12,000–17,500 °F	
F	Yellow-white	9,700–12,000 °F	
G	Yellow	8,400–9,700 °F	
K	Orange	6,200–8,400 °F	
M	Red	< 6,200 °F	

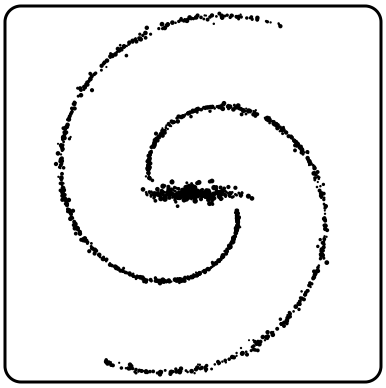
1 **Match each star with its class** using the clues: Sun, Rigel, Betelgeuse, Sirius, Aldebaran, Proxima Centauri, Spica, Procyon.

Star	Clue	Class
Sun	Our star: yellow, about 9,900 °F	_____
Rigel	The blue-white hunter's foot in Orion	_____
Betelgeuse	The red shoulder of Orion	_____
Sirius	The brightest star in the night sky, white	_____
Aldebaran	The orange eye of the Bull	_____
Proxima Centauri	The closest star after the Sun, a small red dwarf	_____
Spica	Blue-white star of Virgo	_____
Procyon	Yellow-white, in the Little Dog	_____

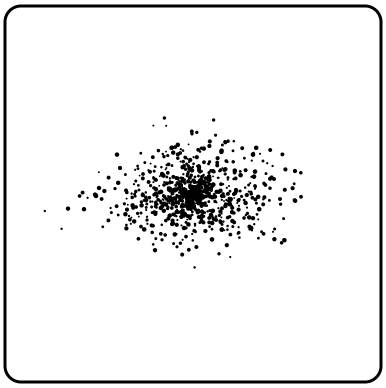
2 Is the Sun's surface hotter or cooler than Rigel's? _____

Galaxy Zoo ★ EXPLORER ★★ NAVIGATOR

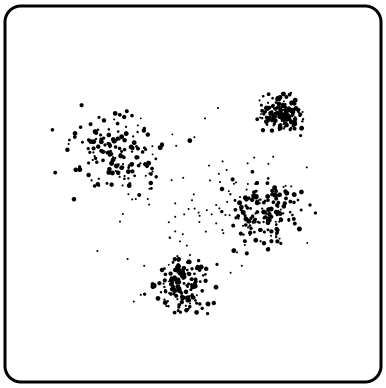
Galaxies come in different shapes. Look at each drawing, read the clues, and write its type.



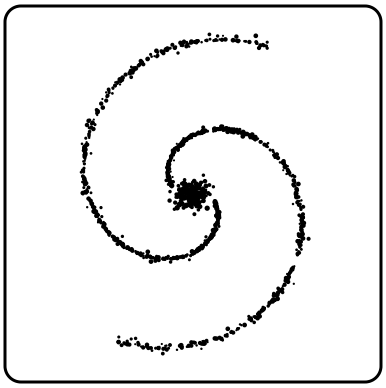
A _____



B _____



C _____



D _____

Spiral · Barred spiral · Elliptical · Irregular

1. Round or oval ball of old, reddish stars with no arms.
2. A flat disk with curved arms of young blue stars. Our Milky Way is one.
3. A spiral whose arms start from a straight bar of stars in the middle.
4. No clear shape: messy clumps, often after a collision.

1 Write the number of the clue that matches each drawing: A ____ B ____ C ____ D ____

2 The Milky Way is about 100,000 light-years wide, and our Sun is about 26,000 light-years from its center. About what fraction of the way from the center to the edge is that? (26,000 ÷ 50,000) _____

3 The Andromeda galaxy is 2.5 million light-years away. Its light left when no humans yet existed on Earth. About how many times farther is it than Betelgeuse (550 ly)? _____

Star Word Search ★ EXPLORER

Find the 14 words. They can go in any direction, even backward.

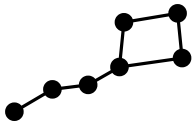
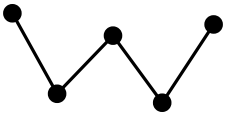
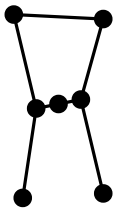
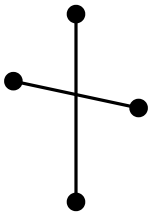
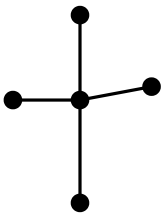
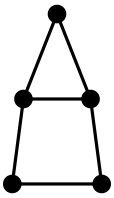
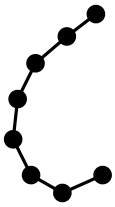
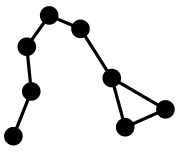
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S V G T R O H T M C B F Y V Z
U X R D J G A L U B E N V E U
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R C O N S T E L L A T I O N V
I G D Z J O R Q A C R J E O X
S P O L A R I S Q Z J L L R O
S X P Z X C A N V O L I O I B
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Y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

- ☐ ANDROMEDA
- ☐ BETELGEUSE
- ☐ BLACKHOLE
- ☐ CONSTELLATION
- ☐ DWARF
- ☐ GALAXY
- ☐ LIGHTYEAR
- ☐ NEBULA
- ☐ ORION
- ☐ POLARIS
- ☐ PROXIMA
- ☐ PULSAR
- ☐ SIRIUS
- ☐ SUPERNOVA

Constellation Memory Game

★ EXPLORER cut-out

Cut out the 16 cards, mix them face down, and take turns flipping two. Match each star pattern with its name. The player with the most pairs wins.

	**Big Dipper**		**Cassiopeia**
	**Orion**		**Southern Cross**
	**Cygnus (Swan)**		**Lyra**
	**Scorpius**		**Leo**

Only some constellations can be seen from every place: the Big Dipper and Cassiopeia from the north, the Southern Cross from the south. Orion, Leo and Scorpius are visible from almost everywhere on Earth.

Star Chart: Brightness vs. Color ★★★ COMMANDER

Astronomers plot stars on a chart of **color class** (hot → cool, left to right) and **brightness** (bottom to top). Most stars fall along a band called the **main sequence**. Plot each star as a dot and write its name beside it.

Star	Class	Brightness (1–5)
Sun	G	3
Rigel	B	5
Betelgeuse	M	5
Proxima	M	1
Sirius B	A	1
Aldebaran	K	4
Spica	B	4
Altair	A	3

Brightness	O	B	A	F	G	K	M
Brilliant							
High							
Medium							
Low							
Dim							

1. Draw a line that follows most of the dots from the upper left to the lower right. This is the **main sequence**. Which stars are far from it? _____

2. Betelgeuse is cool but very bright: it must be very _____ (small / huge). Sirius B is hot but dim: it must be very _____ .

Star Code Breakers ★★ NAVIGATOR

A **Caesar cipher** shifts each letter forward in the alphabet. Use the code wheel strip: the top row is the real letter, the bottom row is the secret one. Find the real letters.

Message 1 · shift 3

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

top row = real letter · bottom row = coded letter

V W D U V D U H V X Q V

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Message 2 · shift 7

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

top row = real letter · bottom row = coded letter

A O L T P S R F D H F O H Z

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

I P S S P V U Z V M Z A H Y Z

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Message 3 · you decide!

Write a secret message about a star or galaxy, pick a shift, and write the coded version. Swap with a friend.

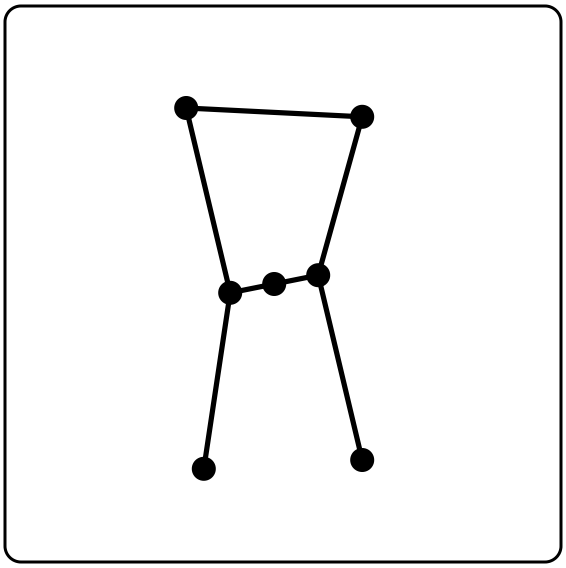
___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Star Lab · Pinhole Planetarium ★ EXPLORER ★★ NAVIGATOR

SAFETY An adult makes the holes with the pin or thumbtack. **Never point the tube at the Sun** or look at it through the tube. Use a flashlight only.

You need

- A cardboard tube or a paper cup
- A pin or thumbtack
- Black paper or foil
- A flashlight
- The Orion pattern below



Orion pattern. Copy it onto black paper.

Steps

1. Cut a circle of black paper to cover one end of the tube.
2. Place the pattern on it and poke a pin through each dot. Make Betelgeuse and Rigel a little bigger.
3. In a dark room, shine the flashlight through the open end and look at the wall.
4. Check your pattern against the real constellation on a clear night.

Hand measuring (outdoors)

Hold your arm straight. Your **fist** covers about 10° of sky, your **hand span** (thumb to pinky) about 20°, and your **pinky** about 1°. Measure these angles:

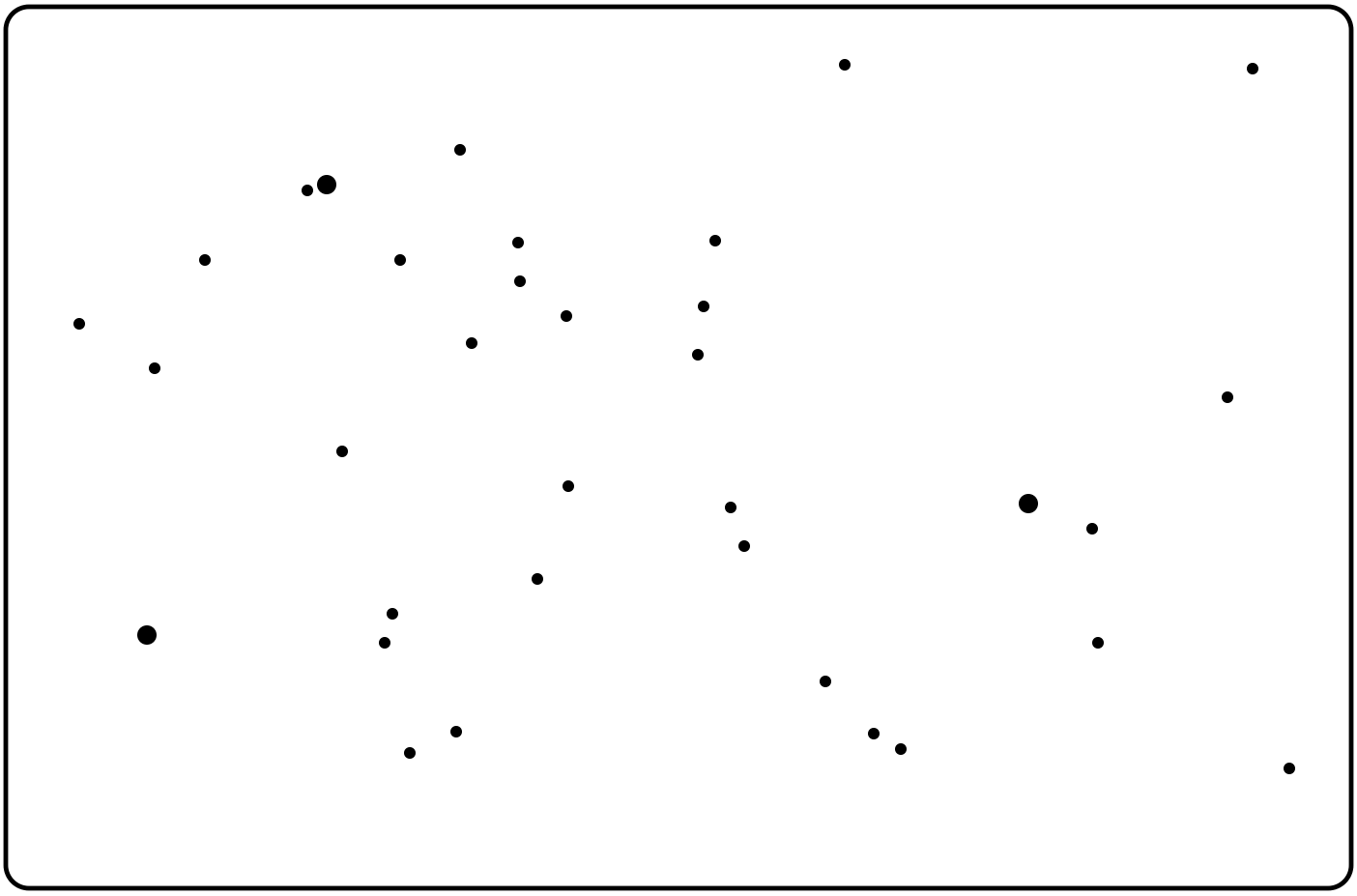
What I measured	Fists / spans	Angle
Orion's belt to Rigel		
Width of the Big Dipper (or Southern Cross)		
Moon to a bright star or planet		

1 Which was farther apart in the sky? _____ Does that mean the stars are really farther apart in space?

_____

Create Your Own Constellation ★ EXPLORER ★★ NAVIGATOR

Here is a patch of night sky. Connect some stars to make a picture: an animal, a hero, a machine, a monster… Draw it, name it, and write its story.



1. Name of my constellation: _____

2. Its story (who is it and why is it in the sky?):

_____

_____

_____

> Many cultures saw different pictures in the same stars. The Big Dipper is a plow, a wagon or a bear in different places!

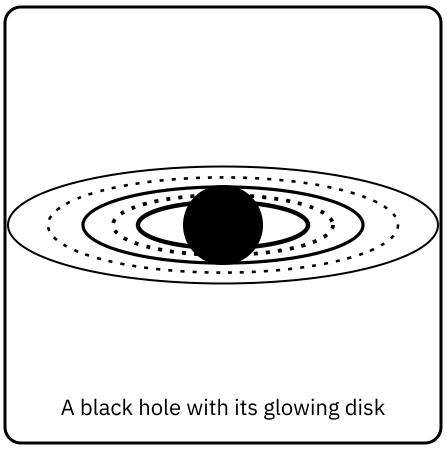
Reading: Black Holes

★★ NAVIGATOR ★★★ COMMANDER

When a very massive star dies in a supernova, its core can collapse into a **black hole**: a place where gravity is so strong that nothing, not even light, can escape once it gets too close. The boundary is called the **event horizon**.

A black hole is not a hole or a giant vacuum cleaner. If the Sun were replaced by a black hole of the same mass, Earth would keep orbiting just as it does now, only in the dark and the cold.

We cannot see a black hole, but we can see hot gas swirling around it. In 2019 and 2022, the Event Horizon Telescope made the first images: the black holes in the galaxy M87 and at the center of our own Milky Way, called **Sagittarius A***.



A black hole with its glowing disk

1. **True or false?** a) Nothing can escape a black hole's event horizon. T / F b) A black hole would suck in the whole solar system if it replaced the Sun. T / F c) We can see the gas around a black hole. T / F

2. In your own words, why is a black hole called "black"?

3. Name two things you could do to "see" something you cannot see directly.

Unit Review · Mission Check

★ EXPLORER ★★ NAVIGATOR ★★★ COMMANDER

1. **Match**: light-year ___ constellation ___ galaxy ___ supernova ___
   A. an exploding star · B. a pattern of stars that look like a picture · C. the distance light travels in a year · D. a huge family of stars, gas and dust

2. **Order** the star colors from hottest to coolest: red · blue · yellow · orange:
   _____

3. **Calculate.** A star is 20 light-years away. Its light left it _____ years ago.

4. **Decode** (shift 3 back): **VWDU** = _____

5. **Sequence** the life of a Sun-like star: white dwarf · nebula · red giant · main sequence · protostar:
   _____

6. **Which is true?** T / F The stars of a constellation are close together. T / F The Sun is a star. T / F A galaxy is a kind of star.

7. **Compare** a spiral galaxy and an elliptical galaxy.
   _____
   _____

8. **Explain** why Betelgeuse looks red and Rigel looks blue.
   _____
   _____

Mission Log ★ EXPLORER

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

☐ I can explain what a light-year is.

☐ I can calculate how long light takes to travel.

☐ I can find and draw constellations.

☐ I can sort stars by color and temperature.

☐ I can tell the life story of a star.

☐ I can name the main types of galaxies.

☐ I can decode a Caesar cipher.

☐ I can explain what a black hole is.

My favorite activity was

Something new I learned

A question I still have about space

UNIT 6
STARS & GALAXIES
★ ★ ★
MISSION COMPLETE

Signed: _____

Date: _____

The Space Workbook series

You have **Mission 6**. 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	**★ YOU ARE HERE**
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