Astronomy 6

Blackline Masters

Access a PDF file from which to print copies with better graphics at the

Science Center's "Teacher Resource" web page (accessed via sciencecenter.ocmboces.org)

Revised June 2010 **OCM BOCES Science Center**
Oct 2011: mod. graphic pg. S
May 2013: cover – remove PW info

Sunrise and Sunset Data Charts

http://aa.usno.navy.mil/data/docs/RS_OneYear.html

New York City, New York Eastern Standard Time

Date	Sunrise Time	Sunset Time	Hours of Daylight (Rounded off)	Hours of Nighttime
September 21	5:42 AM	5:54 PM		
October 21	6:14 AM	5:06 PM		
November 21	6:50 AM	4:33 PM		
December 21	7:16 AM	4:32 PM		
January 21	7:15 AM	5:00 PM		
February 21	6:42 AM	5:38 PM		
March 21	5:58 AM	6:09 PM		
April 21	5:08 AM	6:41 PM		
May 21	4:33 AM	7:11 PM		
June 21	4:25 AM	7:30 PM		
July 21	4:42 AM	7:77 PM		
August 21	5:12 AM	6:45 PM		

How would you calculate the "Hours of Nighttime" for each of the months?

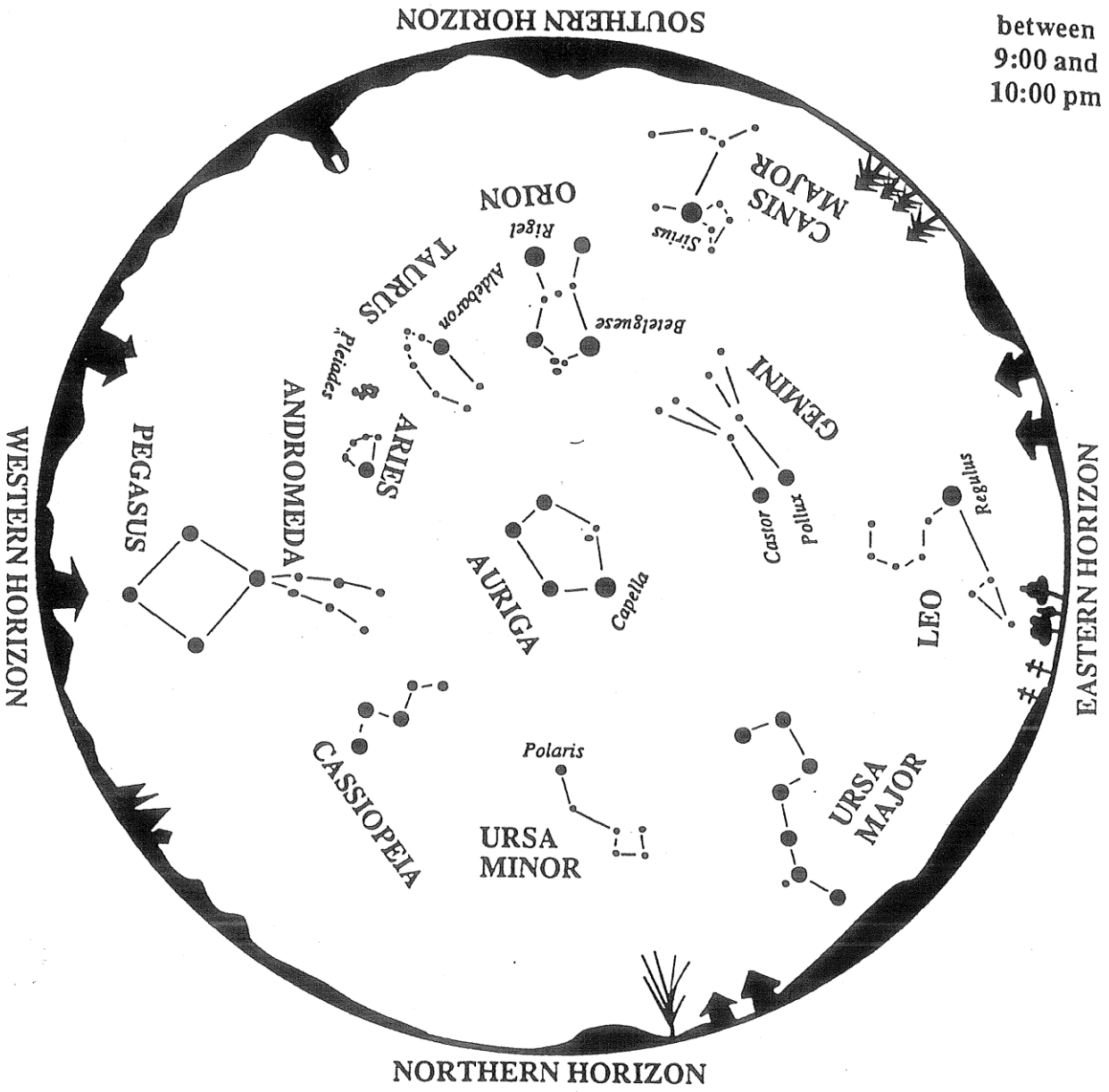
Barrow, Alaska Alaska Standard Time

Date	Sunrise Time	Sunset Time	Hours of Daylight (Rounded off)	Hours of Nighttime
September 21	7:04 AM	7:34 PM		
October 21	9:18 AM	5:04 PM		
November 21	----	----		
December 21	----	----		
January 21	----	----		
February 21	9:40 AM	5:43 PM		
March 21	7:20 AM	7:51 PM		
April 21	4:38 AM	10:18 PM		
May 21	****	****		
June 21	****	****		
July 21	****	****		
August 21	4:40 AM	10:16 PM		

---- sun is continuously below the horizon (continuous nighttime)
**** sun is continuously above the horizon (continuous daylight)

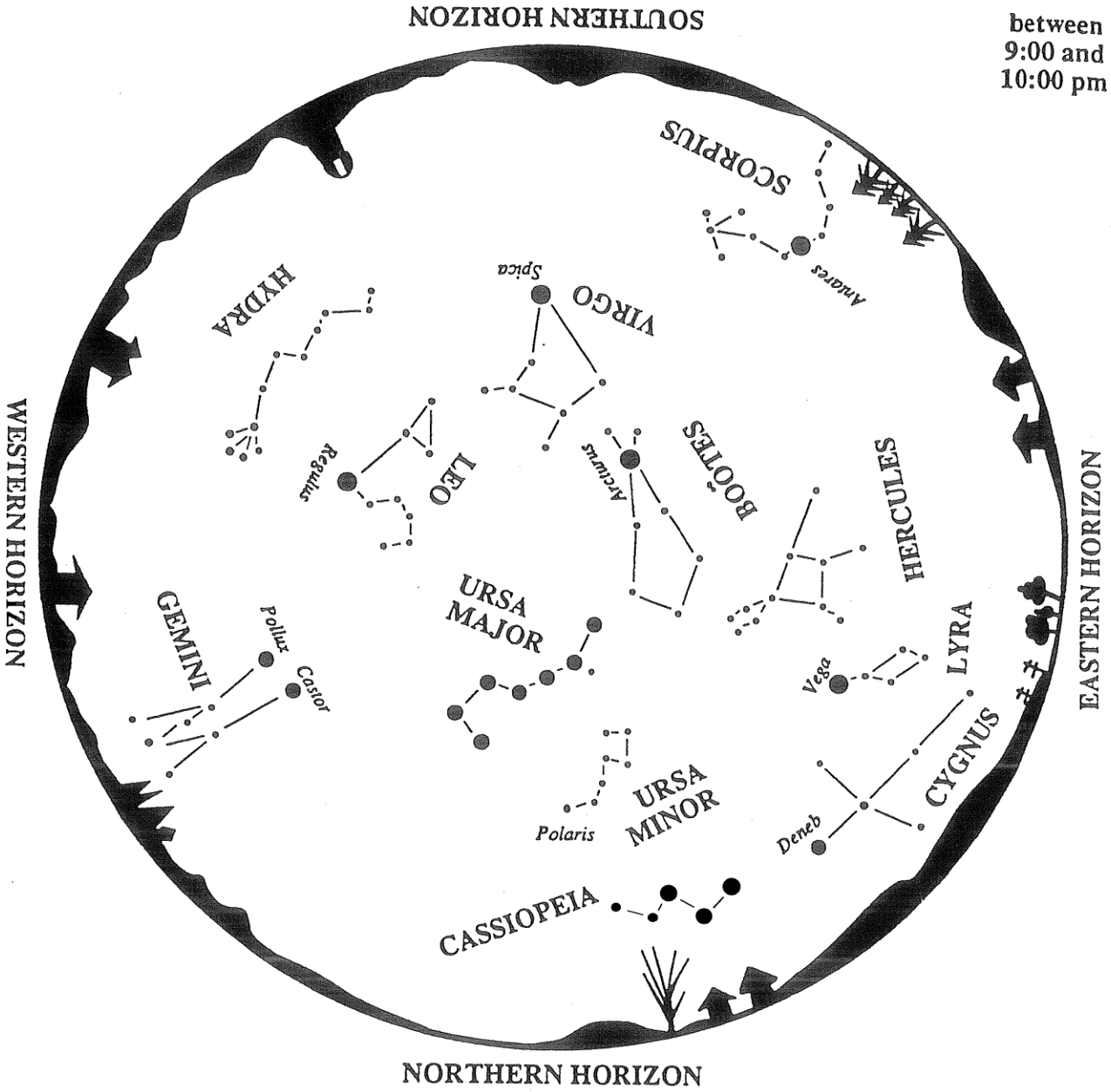
What is the major reason for Alaska to have 24 hours of night and 24 hours of daylight?

Evening Star Map for January - February



To use map:
Turn the map so the direction you are facing is on the bottom.
The constellations in the sky will match the contstellations on the map.

Evening Star Map for May - June



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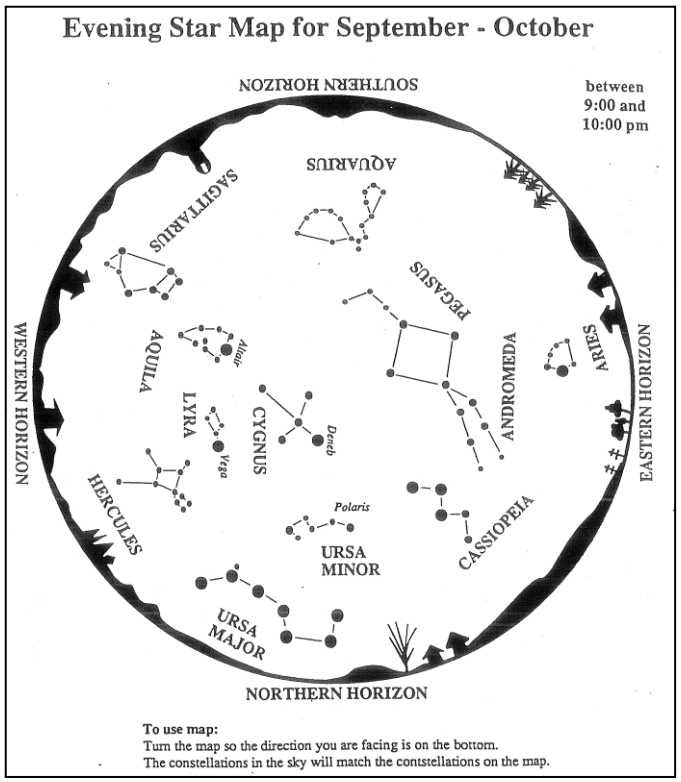
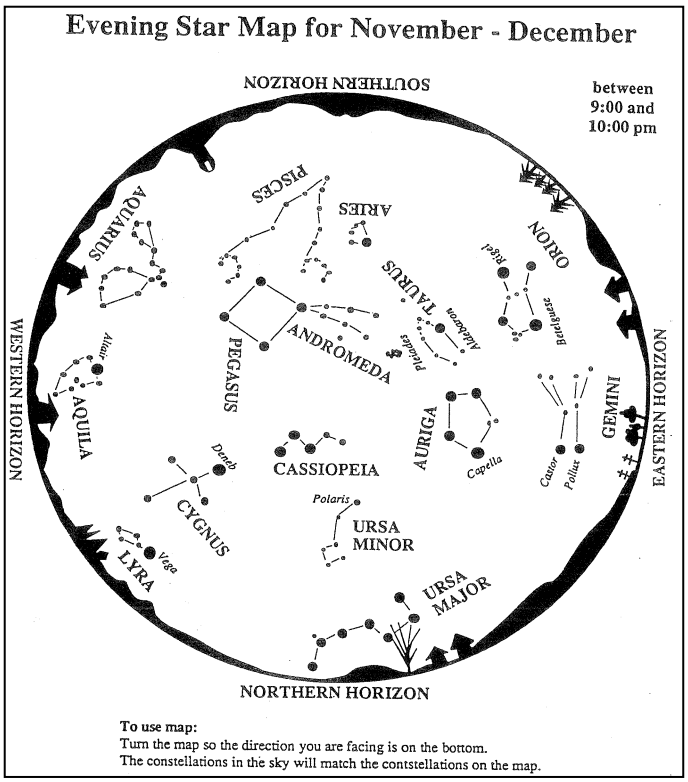
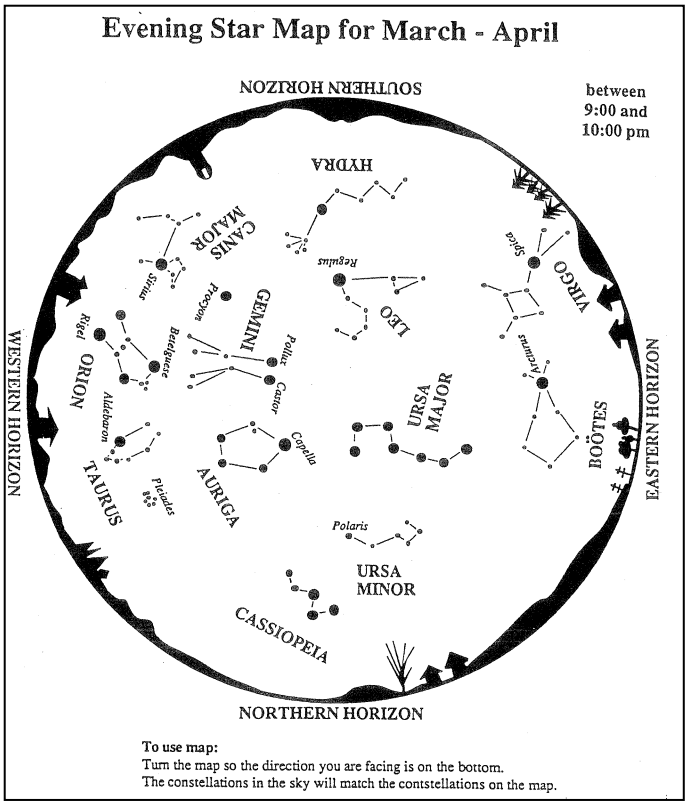
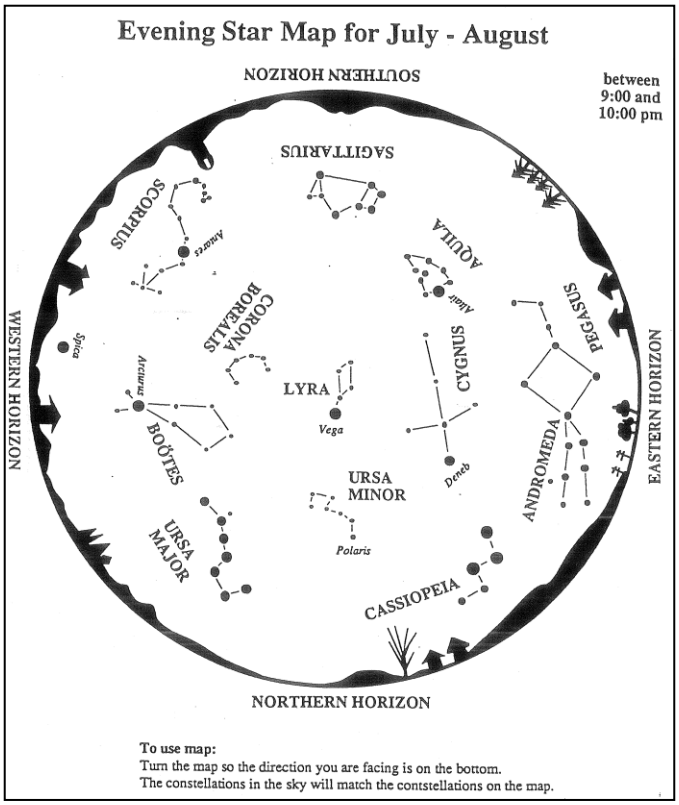
Evening Star Maps

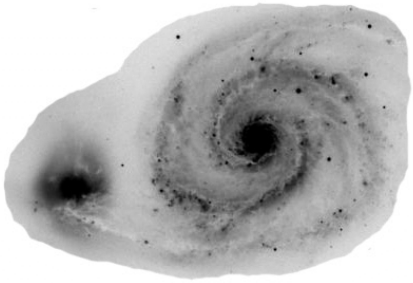








COSMIC SURVEY



What are your ideas about The Universe?

How big?

How far?

How old?

Produced for NASA's Office of Space Science by the
Structure and Evolution of the Universe Education Forum

60 Garden Street, Cambridge, MA 02138
http://cfa-www.harvard.edu/seuforum

Cosmic Survey: What are your ideas about the Universe?

Introduction

Many people, adults and students alike, are familiar with the names of objects in space, but have an incomplete mental model of WHERE those objects are in space, their relative size and scale, and how they fit into the cosmic scheme of things. Understanding the sizes and distances of celestial objects can be tricky, since in our everyday experience, the stars all seem the same distance away, and the moon can appear close or far away depending on whether you observe it near the horizon or higher in the sky. And of course most people's knowledge of dim and distant objects such as nebulae and galaxies comes mainly from images in books, where all the images are about the same size with no indication of scale.

In this activity, a three-part questionnaire launches your students on discussions about where objects in space are located, and when they formed — an introduction to the concepts of structure and evolution of the universe. By physically manipulating images of objects in space, students represent their own mental models of space and time.

When you lead discussions with your students, please keep in mind that ideas and insights about the three-dimensional organization of the universe develop gradually. Getting the "right answer" is not as important as the critical thinking skills that students develop as they confront the questions that arise as they struggle with their mental models of the Universe.

This survey can serve as a great pre-unit assessment activity for you to find out how your students think about the Universe, and you can use it to help design follow-up activities that help students to improve their understanding. The Universe! Education Forum has been using this survey as a research tool to help inform future curricula, and we would love to have your feedback. Email us at: seuforum@cfa.harvard.edu.

Time Frame

Part 1: What are your ideas about the Universe?	30 minutes
Part 2: Discussion	30 minutes

Materials Needed

For each student:
- 1 set of 7 different images cut from a copy of the Cosmic Survey Classroom Master
- a pair of scissors
- 1 copy each of the 3 "What are your ideas about the Universe" survey data sheets (How Big? How Far? How Old?)

For the class:
- 8 sets of the 3 "What are your ideas about the Universe" survey data sheets (or use the All-in-One data sheet)

Getting Ready

- Make enough copies of the Cosmic Survey Classroom Master image sheets to have 1 set of 7 images for each student. (There are small sets as well as the large set in case you need to save paper).

Part 1: What are your ideas?

1. Hand out copies of the All-In-One survey data sheets and the sets of images. Ask students to cut out the 7 separate images; put their names at the top of the data sheets; and then have them work to answer the survey questions in the following order: How Big? How Far? How Old? (This order represents increasing levels of conceptual difficulty for most students). Collect the students' papers so you can look over their ideas later.
2. Organize the class into eight discussion groups of three to five students per group. Give each group a set of 3 survey data sheets. Explain that each team is to discuss the three survey questions and come to an agreement, if possible, on the best order of images for each question. One member of each team should write down and keep track of questions that arise as they order the images.
3. Circulate among the groups of students, encouraging them to discuss any disagreements fully and to write down arguments in support of their answers.

Part 2: Discussion

1. Lead the class in a discussion about the 3 different survey questions. Play the role of moderator, requiring each group to explain why they chose that order. (Ensure that students are also comfortable saying, "we really didn't know about these objects…") Look below for a discussion of "correct" answers vs. frequent student ideas.
2. After discussing each question, poll the students on the alternative orders of images suggested. Do not announce the correct order at this time; students should be encouraged to think for themselves.
3. After getting a class consensus on all three questions, let students know the correct answers according to measurements and observations of astronomers.
4. You can try this activity again with your students as a post-astronomy unit assessment, to see if their ideas have changed.

Possible classroom follow-up activities could include:
• researching size and distances, and calculating and making scale models of different objects in the universe
• activities measuring distances using angular diameter
• investigating how astronomers can find out about distant objects: what can you learn from light

Thanks to GEMS Earth, Moon, & Stars for the format of this activity.

Discussion Notes for Cosmic Survey: Frequent student ideas compared with astronomers' measurements

Question 1: How Big?

The correct order for the 7 images, from smallest to largest is:

Telescope	40 feet long	(~12 meters)
Moon	2 thousand miles diameter	(~3,200 kilometers)
Saturn	75 thousand miles diameter	(~121,000 kilometers)
Sun	875 thousand miles diameter	(~1,408,000 kilometers)
Pleiades	60 trillion miles across the cluster	(~1 x 10^{14} kilometers)
Galaxy	600 thousand trillion miles across	(~1 x 10^{18} kilometers)
Hubble galaxies	600 million trillion miles across the cluster	(~1 x 10^{21} kilometers)

Students answering this question sometimes wonder whether Saturn is larger than the Sun (since they may know it as a "giant" planet). They also wonder if, in the image of the Pleiades, "are we talking about the sizes of the individual stars, or all the stars in the picture?" You may need to explain that for this picture (and the Hubble galaxies), the challenge of the survey is to figure out the relative size of the "field of view" — all the stars (or galaxies) in the cluster.

Some notes: It's hard to tell the size of objects from many of the images we see, since they look about the same size in the pictures. But the Sun is much larger than Saturn or any of the planets. In fact, a million earths would fit inside the Sun.

Size counts in nature. Objects much larger than Saturn or Jupiter are destined to turn into stars such as our Sun: They collapse under their own weight and grow fiercely hot as their nuclear fires are kindled. At each scale in the Universe, gravity helps shape the structures we see.

Question 2: How Far?

The correct order for the 7 images, from closest to Earth to farthest, is:

Telescope	350 miles above surface of Earth	(~560 kilometers)
Moon	250 thousand miles	(~402,000 kilometers)
Sun	93 million miles	(~1.5 x 10^{8} kilometers)
Saturn	790 million miles (at its closest)	(~1.3 x 10^{9} kilometers)
Pleiades	2400 trillion miles	(~4 x 10^{15} kilometers)
Galaxy	200 million trillion miles	(~3 x 10^{20} kilometers)
Hubble view of galaxies	30 billion trillion miles	(~5 x 10^{22} kilometers)

In this survey question, students often struggle with

1. the distance of the Hubble space telescope (after all, it takes images of very distant objects…and while NASA has sent some spacecraft out deep into the solar system, the space telescope orbits fairly close to earth's surface).
2. The relative distances of the Sun and Saturn — figuring this out requires knowledge about the relative orbits of the planets
3. Depending on how much astronomy background students have had, the Pleiades may be placed inside the solar system, or as the farthest objects in space. In general, most students (and adults) have a hard time understanding the relative distances of the last 3 objects.

Some notes: How far away is that Hubble Space telescope? Many people believe that it is beyond the orbit of the Moon...but it's actually only 350 miles high. That's high enough for a clear view above the Earth's atmosphere...but low enough to enable it to be serviced by the astronauts aboard the space shuttle.

Many people think the beautiful Pleiades cluster of stars must be further away than a cluster of galaxies, because they look smaller. But all the stars we see in the night sky are much closer than even the nearest galaxy.

A galaxy is a "city" of many billions of stars. Galaxies are so far away that we can't make out the individual stars in them. In fact, the roughly 5000 stars we can see with our naked eyes (including the Pleiades) are just among the closest of the billions of stars in our own galaxy, the Milky Way.

Question 3: How Old?

For this question, the correct order for the 7 images is actually somewhat ambiguous, and the subject of much current astronomical research! A "best response" (one that most astronomers—but not all—might give) is:

Telescope	a few years (1990)
Pleiades	80 million years
Moon	~4.5 billion years
Saturn	~4.5 billion years
Sun	~4.5 billion years
Galaxy	~10 billion years?
Hubble galaxies	~10 billion years?

In confronting this seemingly simple survey question, students are grappling with the big ideas of formation of the solar system, life cycles of stars, and evolution of the universe!

Some notes: Almost all students will grab the Sun, Moon and Saturn pictures together, demonstrating that they, like most astronomers, have a theory about solar system formation. But which is the exact order of age? Current theories of moon formation suggest it was formed by a collision of a Mars-sized object with the Earth, making it slightly younger than the Earth and planets. On the other hand, an astronomer reviewing this activity noted that our picture of Saturn shows well defined rings, which would have formed much more recently than our moon...

We tend to think of stars as having been around for a very long time. In fact our Sun is billions of years old. But new generations of stars, like those in the Pleiades, are continually being born. Most people are surprised to learn the Pleiades stars are only about 80 million years old. If the first dinosaurs ever gazed at the night sky...they wouldn't have seen the Pleiades, which hadn't been born yet!

What's older, sun or Hubble galaxies? Depends on what you mean by "age." The Sun is about 4.5 billion years old. But the Hubble "deep-field" galaxies are among the most ancient and distant objects we can see in the sky. The light from them has taken about 10 billion years to reach us. So they were born long before the Sun. On the other hand, the Hubble deep field galaxies are young! Because light takes time to travel, telescope images of far-away objects let us look back in time. This image shows these galaxies as they were when they formed only a few billion years after the Big Bang...so many of the stars in these galaxies may be younger than our Sun. We're looking at an "old" image of young objects!

UNIVERSE!

Cosmic Survey: What are your ideas about the Universe?

For more information on cosmic structure and evolution, try these web sites:

Universe! Education Forum:
http://cfa-www.harvard.edu/seuforum
This site, hosted by the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, contains information and educational activities related to NASA's space science research into the Structure and Evolution of the Universe.

Imagine the Universe:
http://imagine.gsfc.nasa.gov
This site, from astrophysicists at NASA's Goddard Space Flight Center, offers "a glimpse into the mysteries of our universe...what we know about it, how it's evolving, and the kinds of objects it contains."

Powers of Ten:
http://powersof10.com
From the same folks who created the famous film by this name, this site offers a great introduction to size and scale in the universe.

Chandra X-ray Observatory:
http://chandra.harvard.edu
Chandra is NASA's flagship mission for X-ray astronomy, and one of the "Great Observatories." Find out about black holes and other high-energy regions of our universe.

NASA Probe Studies the Big Bang:
http://map.gsfc.nasa.gov
NASA's WMAP satellite (Wilkinson Microwave Anisotropy Probe) has made the first detailed full-sky picture of the oldest light in the universe. Find out what this image tells us about the Big Bang.

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Reviewers: Roy Gould, Adam Contos, Judith Peritz, Sandra Field-Daly, Freeman Deutsch, Philip Sadler, and members of the Thursday Science Panel at the Harvard-Smithsonian Center for Astrophysics.

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Cosmic Survey: What are your ideas about the Universe?

Question 1: How big?

You have been provided with images of seven different objects in space. Try arranging the pictures side by side in a row, **in order of actual size** of the object (or field of objects) pictured. Order the objects so that the smallest is on the left, largest on the right. Write down and keep track of questions that arise as you order the images.

When you are satisfied that you have the best order, record the names of the objects in the spaces below.

Objects Ordered by Actual Size

1.	2.	3.	4.	5.	6.	7.

Smallest in Actual Size — Largest in Actual Size

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Cosmic Survey: What are your ideas about the Universe?

Question 2: How far?

You have been provided with images of seven different objects in space. Try arranging the pictures side by side in a row, **in order of distance** of the object from Earth. Order the objects so that the object closest to Earth is on the left, farthest on the right. Write down and keep track of questions that arise as you order the images.

When you are satisfied that you have the best order, record the names of the objects in the spaces below.

Objects Ordered by Distance from Earth

1.	2.	3.	4.	5.	6.	7.

Closest to Earth — Farthest from Earth

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Cosmic Survey: What are your ideas about the Universe?

Question 3: How old?

You have been provided with images of seven different objects in space. Try arranging the pictures side by side in a row, **in order of age**, beginning with the youngest (most recently formed) object, and moving in order to the oldest. Write down and keep track of questions that arise as you order the images.

When you are satisfied that you have the best order, record the names of the objects in the spaces below.

Objects Ordered by Age

N

1.	2.	3.	4.	5.	6.	7.
_____	_____	_____	_____	_____	_____	_____

Youngest (Most Recently Formed) Oldest

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Cosmic Survey: What are your ideas about the Universe?

All-in-One Data Sheet: How big? How far? How old?

Objects Ordered by Actual Size

_____ _____ _____ _____ _____ _____ _____

1. 2. 3. 4. 5. 6. 7.

Smallest in Actual Size — Largest in Actual Size

Objects Ordered by Distance from Earth

_____ _____ _____ _____ _____ _____ _____

1. 2. 3. 4. 5. 6. 7.

Closest to Earth — Farthest from Earth

Objects Ordered by Age

_____ _____ _____ _____ _____ _____ _____

1. 2. 3. 4. 5. 6. 7.

Youngest (most recently formed) — Oldest

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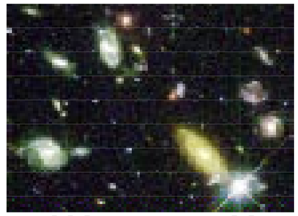
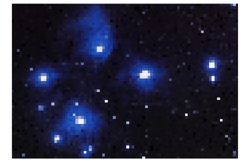
Moon

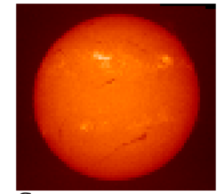

Whirlpool Galaxy


Hubble Deep Field Galaxies

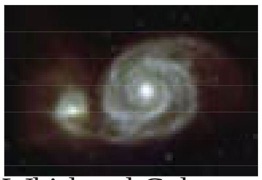

Hubble Space Telescope

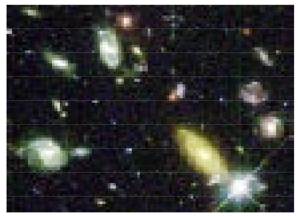

Pleiades Star Cluster


Saturn


Sun


Moon


Whirlpool Galaxy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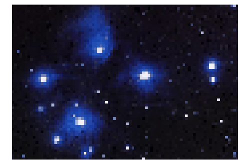
Hubble Space Telescope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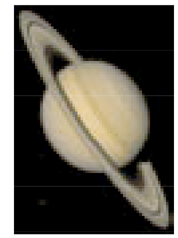
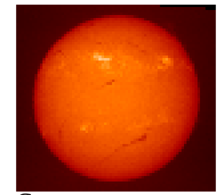
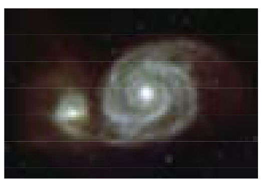
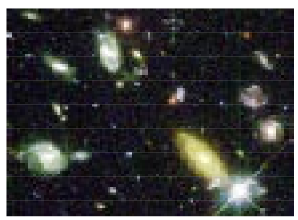
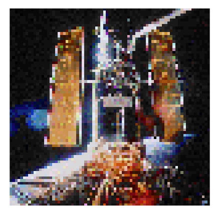

Saturn

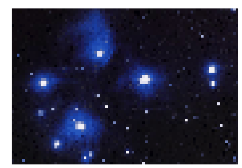

Sun


Moon

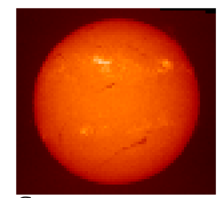

Whirlpool Galaxy


Hubble Deep Field Galaxies

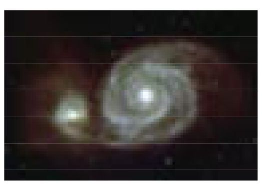

Hubble Space Telescope

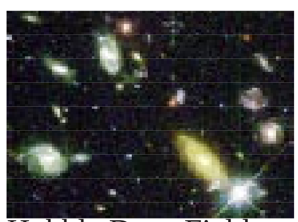

Pleiades Star Cluster


Saturn


Sun


Moon


Whirlpool Galaxy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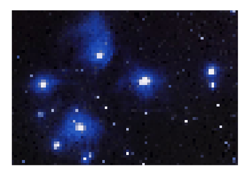
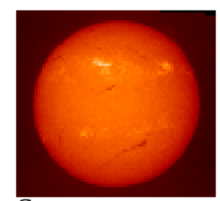

Pleiades Star Cluster

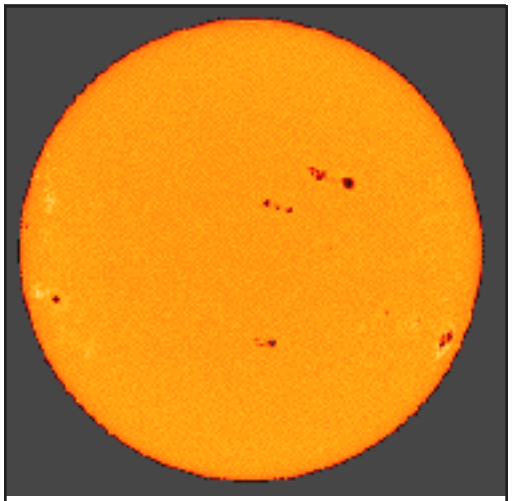

Saturn


Sun

Images courtesy of NASA; Isaac Newton Telescope; Smithsonian Astrophysical Observatory

COSMIC SURVEY IMAGES

Deep Field Galaxies



Sun

Saturn

Pleiades Stars

Moon

Whirlpool Galaxy

Hubble Space Telescope

Name _____

Planet Clue Cards

Planet Clue Card 1

These are your clues to help solve the group's problem. Read them to the group, but do not show them to anyone.

Arrange the nine planets in order based on their relative distance from the Sun.

Clue

- The Five planets nearest the Sun are Earth, Jupiter, Mercury, Venus, and Mars, not necessarily in that order.

Planet Clue Card 2

These are your clues to help solve the group's problem. Read them to the group, but do not show them to anyone.

Arrange the nine planets in order based on their relative distance from the Sun.

Clues

- Early astronomers knew that Venus and Mercury were the only two planets closer to the Sun than our planet Earth.
- Saturn is nearer Earth than Neptune.

Planet Clue Card 3

These are your clues to help solve the group's problem. Read them to the group, but do not show them to anyone.

Arrange the nine planets in order based on their relative distance from the Sun.

Clues

- The four planets farther from the Sun are Uranus, Neptune, Jupiter, and Saturn, not necessarily in that order.
- These four outer planets are much larger than the other four planets, but have a lower density.

Planet Clue Card 4

These are your clues to help solve the group's problem. Read them to the group, but do not show them to anyone.

Arrange the nine planets in order based on their relative distance from the Sun.

Clues

- Mercury and Neptune have six planets between them.
- There is just one planet beyond Uranus .

Planet Clue Card 5

These are your clues to help solve the group's problem. Read them to the group, but do not show them to anyone.

Arrange the nine planets in order based on their relative distance from the Sun.

Clues

- Uranus is between Saturn and Neptune.
- The four terrestrial or earthlike planets are Earth, Venus, Mars and Mercury.

Planet Clue Card 6

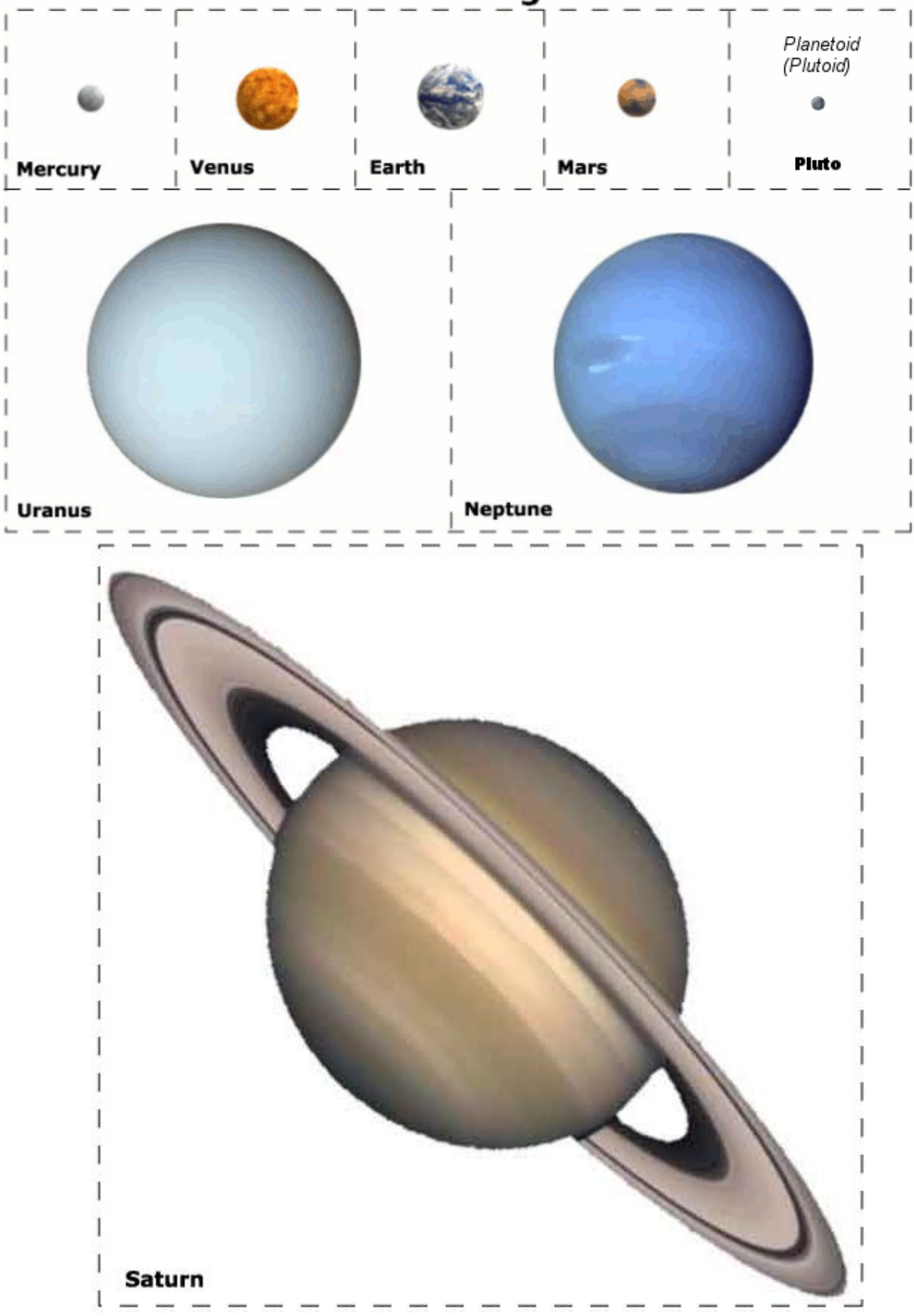
These are your clues to help solve the group's problem. Read them to the group, but do not show them to anyone.

Arrange the nine planets in order based on their relative distance from the Sun.

Clues

- Copernicus in the 16th century knew of six planets: Earth, Mars, Mercury, Jupiter, Saturn, and Venus. These are the six planets closest to the Sun.
- Earth is 93 million miles from the Sun.

09 - Planet Image Cards



Jupiter Image Card

Jupiter

Measures of the Planets

Larger Scale Model							***USE*** → **Small Scale Model**		
Planet	**True Diameter** in miles	**Diameter** in inches	**True Distance to the Sun** in miles	**Distance to Sun** in sheets* (50,653 miles/sheet)	**Distance to Sun** in inches (11,255 miles/inch)	**Distance to Sun** in feet (135,060 miles/foot)	**Distance to Sun** in sheets* (18,709,074 miles/sheet)	**Distance to Sun** in inches (18,709,074 miles/4.5 in)	**Distance to Sun** in feet (18,709,074 miles/.25 ft)
Mercury	3,032	0.267	35,983,610	710	3,197	266	1.9	8.7	0.7
Venus	7,521	0.664	67,232,360	1,327	5,973	498	3.6	16.2	1.3
Earth	7,926	0.699	92,957,100	1,835	8,258	688	5.0	22.4	1.9
Mars	4,222	0.371	141,635,300	2,796	12,583	1,049	7.6	34.0	2.8
Jupiter	88,846	7.658	483,632,000	9,548	42,966	3,580	25.9	116.3	9.7
Saturn	74,898	6.391	888,188,000	17,535	78,906	6,576	47.5	213.6	17.8
Uranus	31,763	2.576	1,783,950,000	35,219	158,486	13,207	95.4	429.1	35.8
Neptune	30,778	2.494	2,798,842,000	55,255	248,648	20,721	150.0	673.2	56.1
~~**Pluto**~~	1413	0.124	3,674,491,000	72,542	326,441	27,203	196.4	883.8	73.7
The Sun's diameter in inches (at this scale) is 76.7 in *** Sheets = sheets of toilet paper (one sheet of toilet paper is a 4.5" piece of paper tape, yarn or string)**							**The Sun's diameter in inches (at this scale) is 0.208 in**		

Important Note: The order of the planets given here is based on the planets' average distances from the Sun. Because Pluto's orbit is quite elliptical in shape, at times Pluto travels closer to the Sun than Neptune's orbit. This was the case from January 1979 through February 1999, when Neptune was the farthest planet from the Sun.

Comets	Asteroids
Drawing	Drawing

Star Light, Star Bright: Exploring How Stars are Classified

LP _____ **Date** _____

Objectives:

- Students will work in small groups to organize stars into different categories based on observations of properties for a collection of stars.

Materials:

- One set of colored and laminated stars per 4 students: Star Set (pdf)

Procedure:

1. Ensure that students understand what type of information is known about each star by examining the sun as a class.
2. Make sure children notice each star has a name, a color, a temperature and a luminosity value.
3. Make sure they understand the luminosity is compared to the sun's luminosity such that a value greater than 1 means it is that many times the sun's luminosity. A value less than one means it is that fraction of the sun's value.
4. Allow time for the groups to become familiar with the stars and encourage the groups to write down what they are noticing.
5. Encourage the children to spread the stars out on their tables to examine them more easily
6. Each group should report some of their findings as the teacher starts to record these on the board.
7. When all groups have reported on their findings ask the class to summarize conclusions from these observations.

Data: **Table 1: Star Arrangement #1**

We arranged our stars according to:	
List at least 4 observations about this arrangement:	
1.	
2.	
3.	
4.	
5.	
6.	

http://www.middleschoolscience.com 2003 - Worksheet to be used with "Star Light, Star Bright" activity by Joanne DeMizio located at: http://www.scienceteacherprogram.org/astronomy/DeMizio02.html

Table 2: Star Arrangement #2

We arranged our stars according to:	
List at least 4 observations about this arrangement:	
1.	
2.	
3.	
4.	
5.	
6.	

Table 3: Star Arrangement #3

We arranged our stars according to:	
List at least 4 observations about this arrangement:	
1.	
2.	
3.	
4.	
5.	
6.	

Table 4: Star Arrangement #4

We arranged our stars according to:	
List at least 4 observations about this arrangement:	
1.	
2.	
3.	
4.	
5.	
6.	

http://www.middleschoolscience.com 2003 - Worksheet to be used with "Star Light, Star Bright" activity
by Joanne DeMizio located at: http://www.scienceteacherprogram.org/astronomy/DeMizio02.html

Star Light, Star Bright
Analysis:

1. Pick a star size (small, medium, large) and, from your data observations, write a general statement about that star type? _____

   _____

2. Name a star that is:

   cool and dim - _____ temp.:_____ lumen.: _____

   cool and bright - _____ temp.:_____ lumen.: _____

   hot and dim - _____ temp.:_____ lumen.: _____

   hot and bright - _____ temp.:_____ lumen.: _____

3. What do you think temperature tells us about luminosity?

   _____

   _____

4. What do you think size tells us about luminosity?

   _____

   _____

5. Conclusion: Write 2 – 3 sentences telling what you learned from this activity.

_____

_____

_____

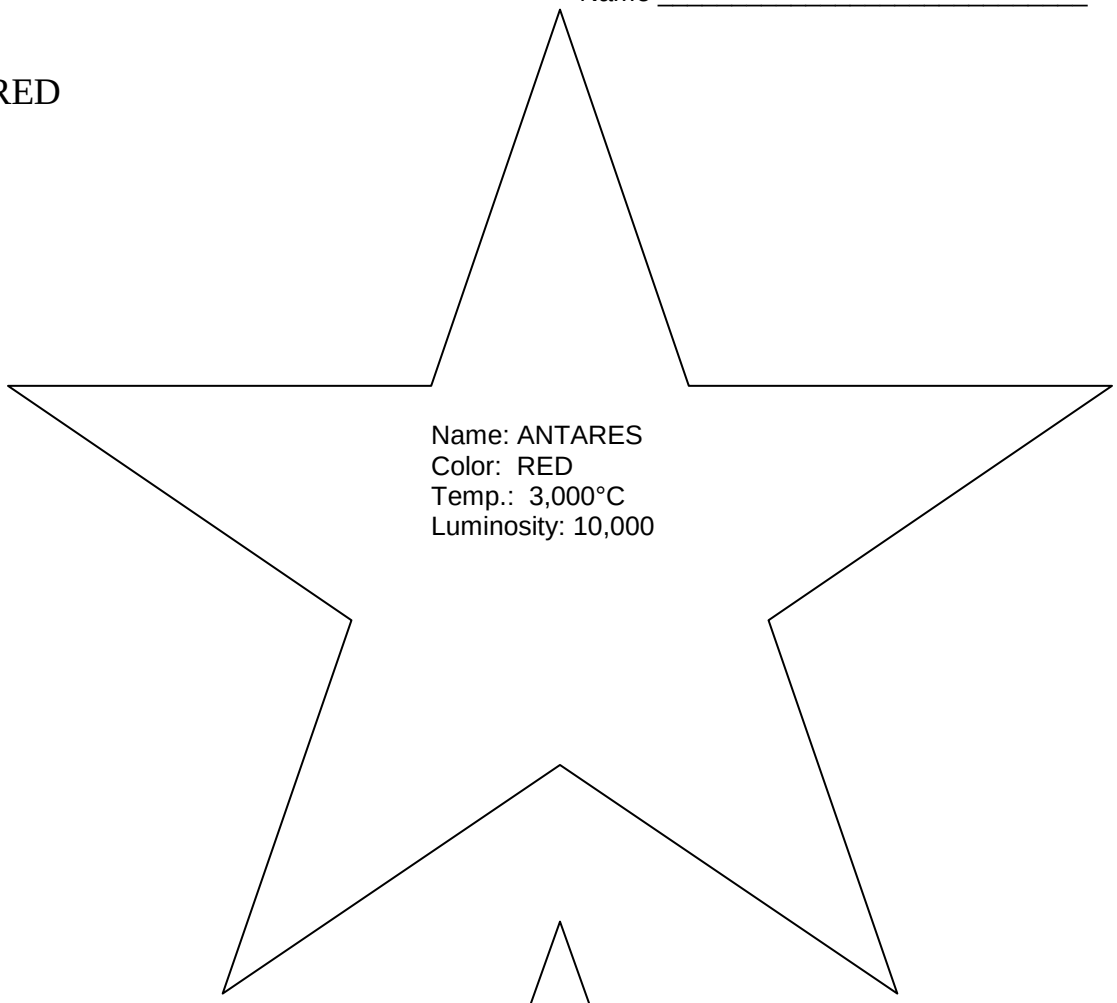
_____

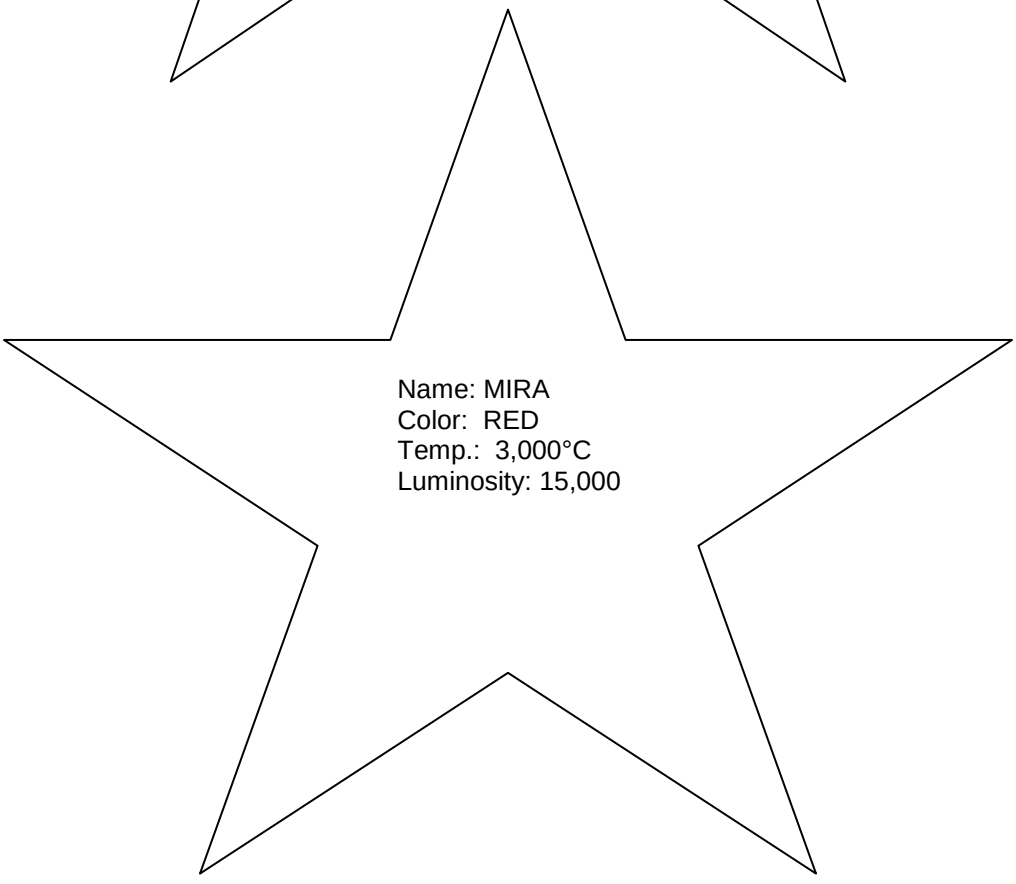
_____

_____

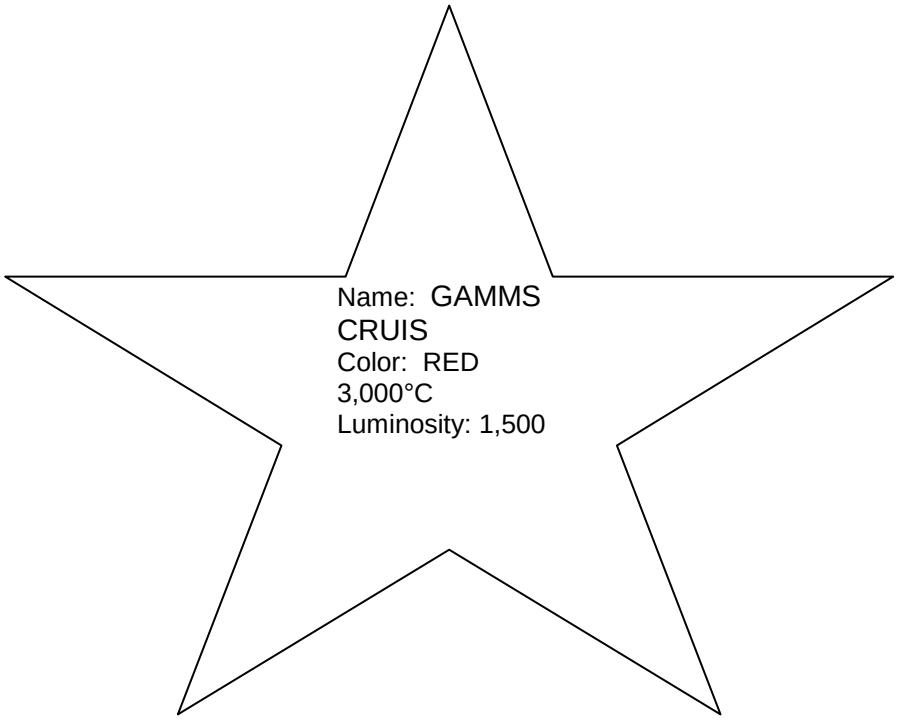
Name _____

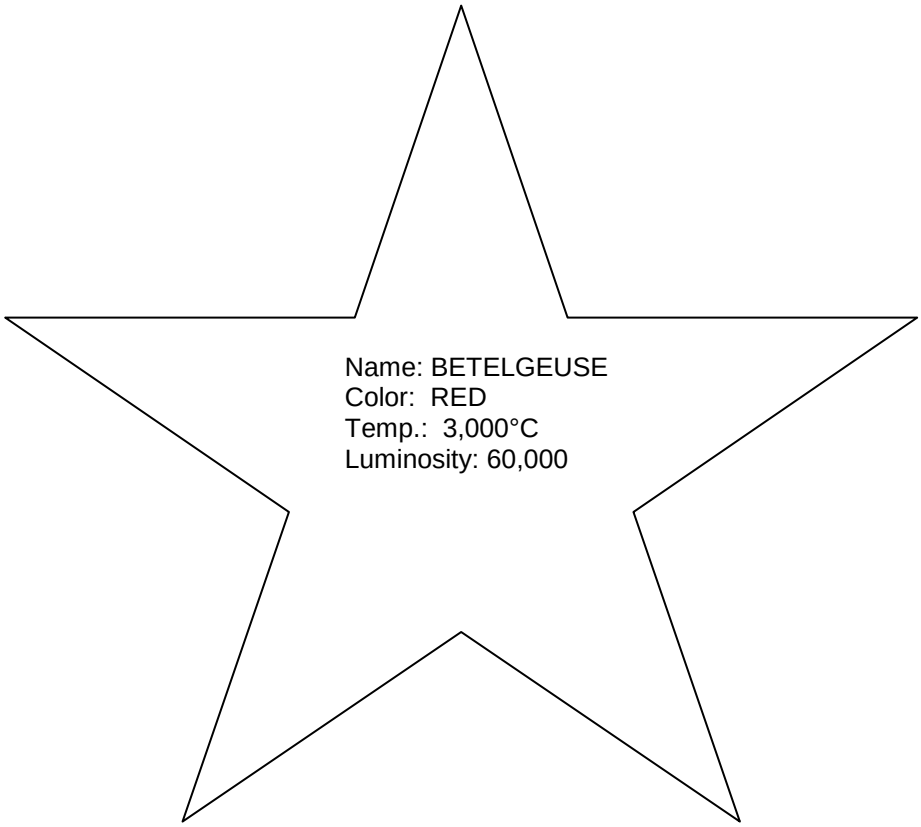
Star Page
COLOR: RED





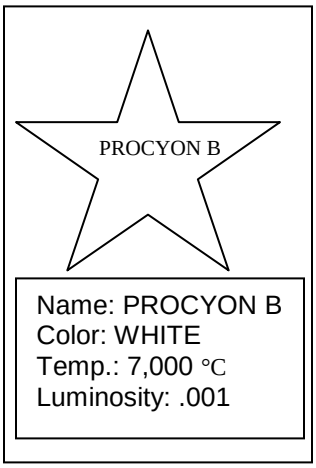
Star Page
COLOR: RED



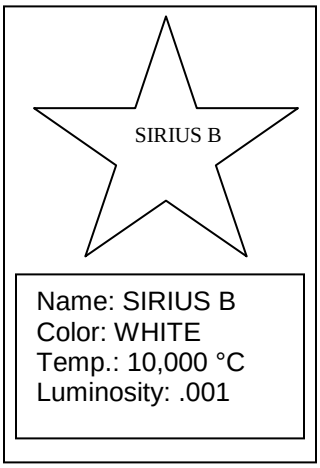


Star Page
COLOR: WHITE

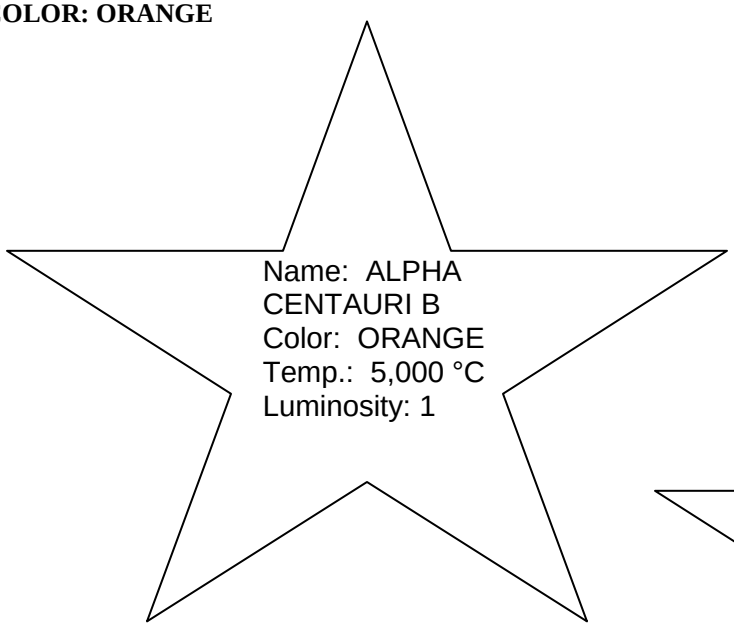
Name: ALCOR
Color: WHITE
Temp.: 15,000°C
Luminosity: 10

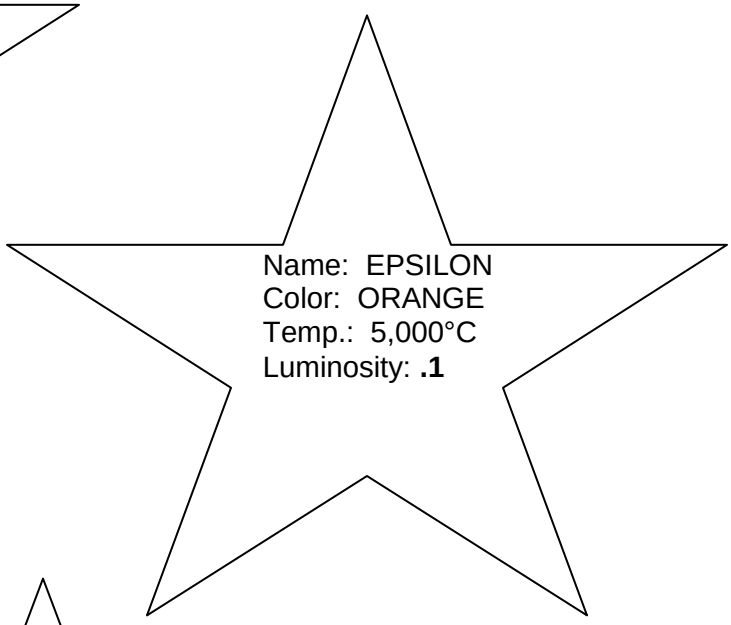


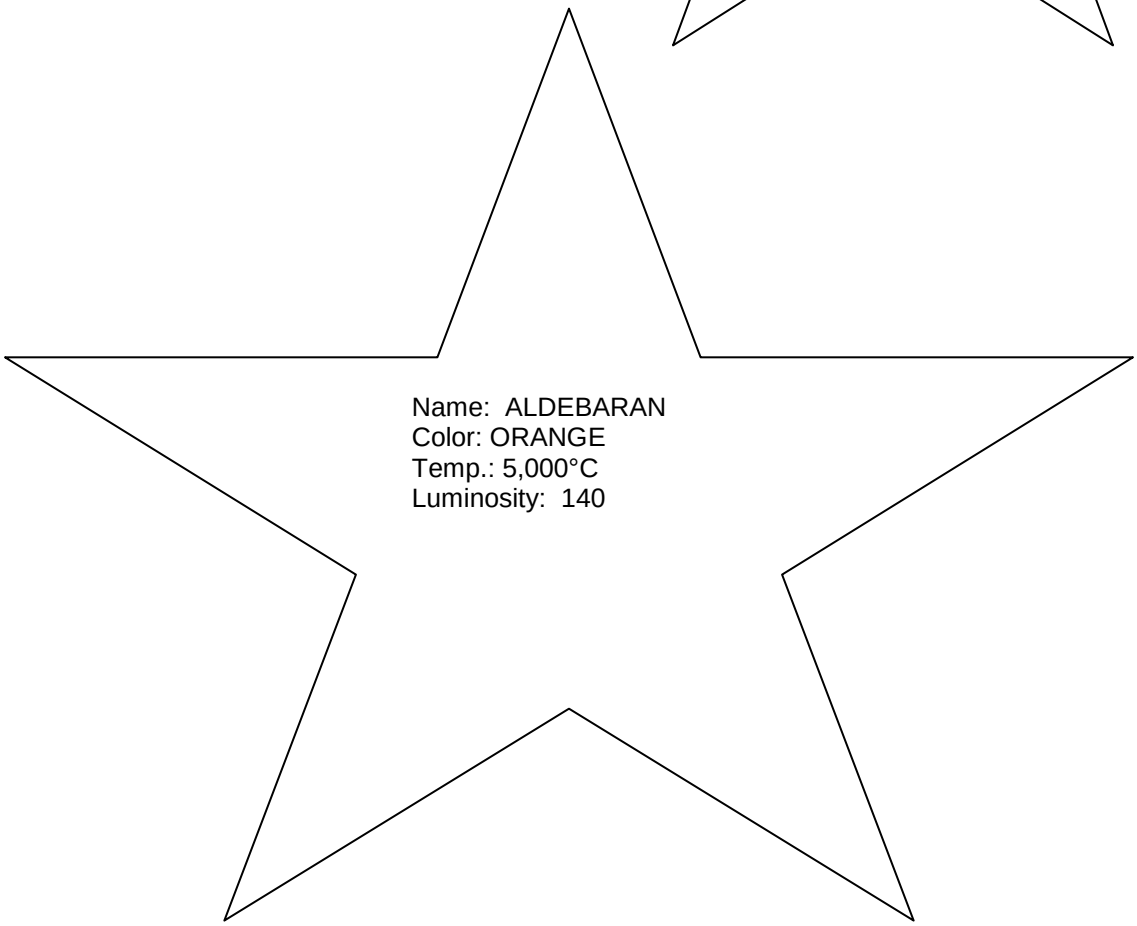
Name: SIRIUS
Color: WHITE
Temp.: 15,000°C
Luminosity: 26



Star Page
COLOR: ORANGE



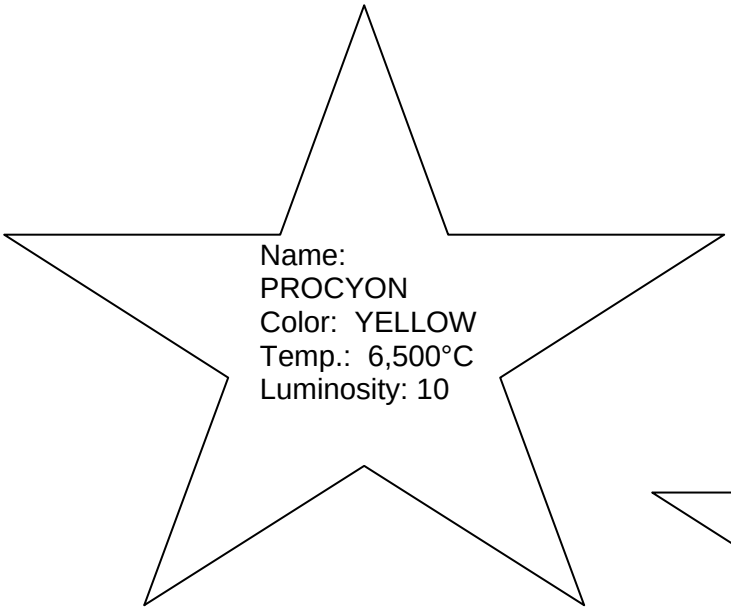


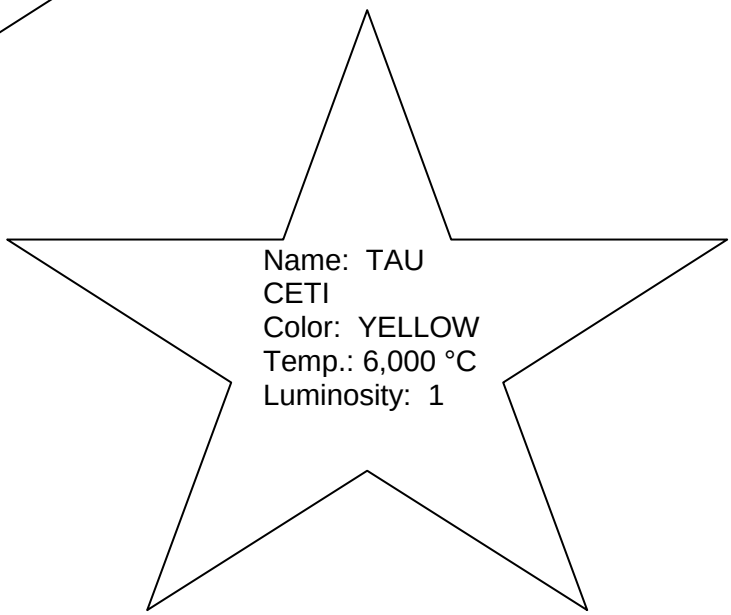


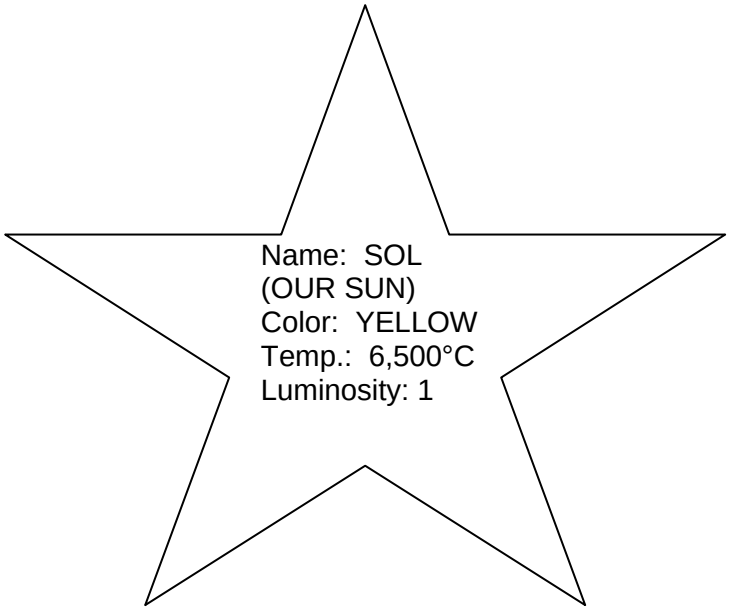
Name _____

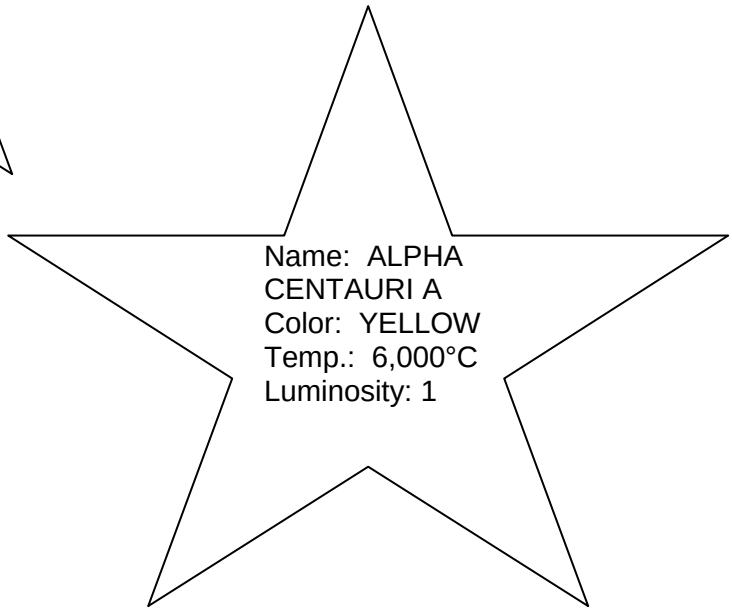
Star Page

COLOR: YELLOW



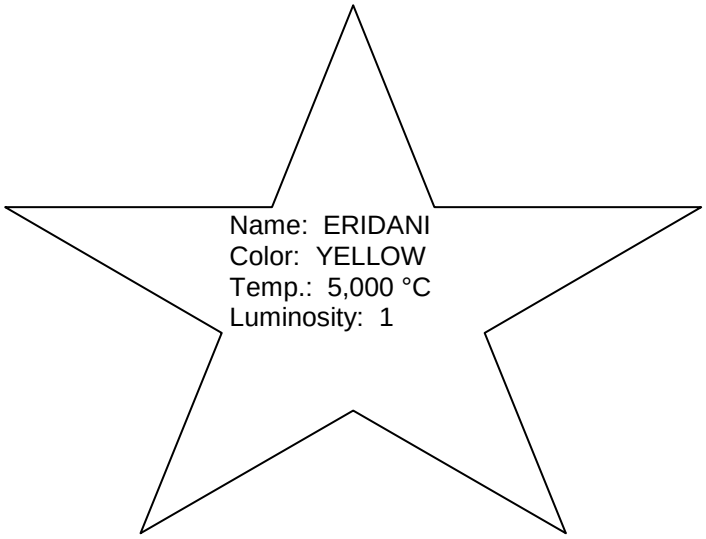


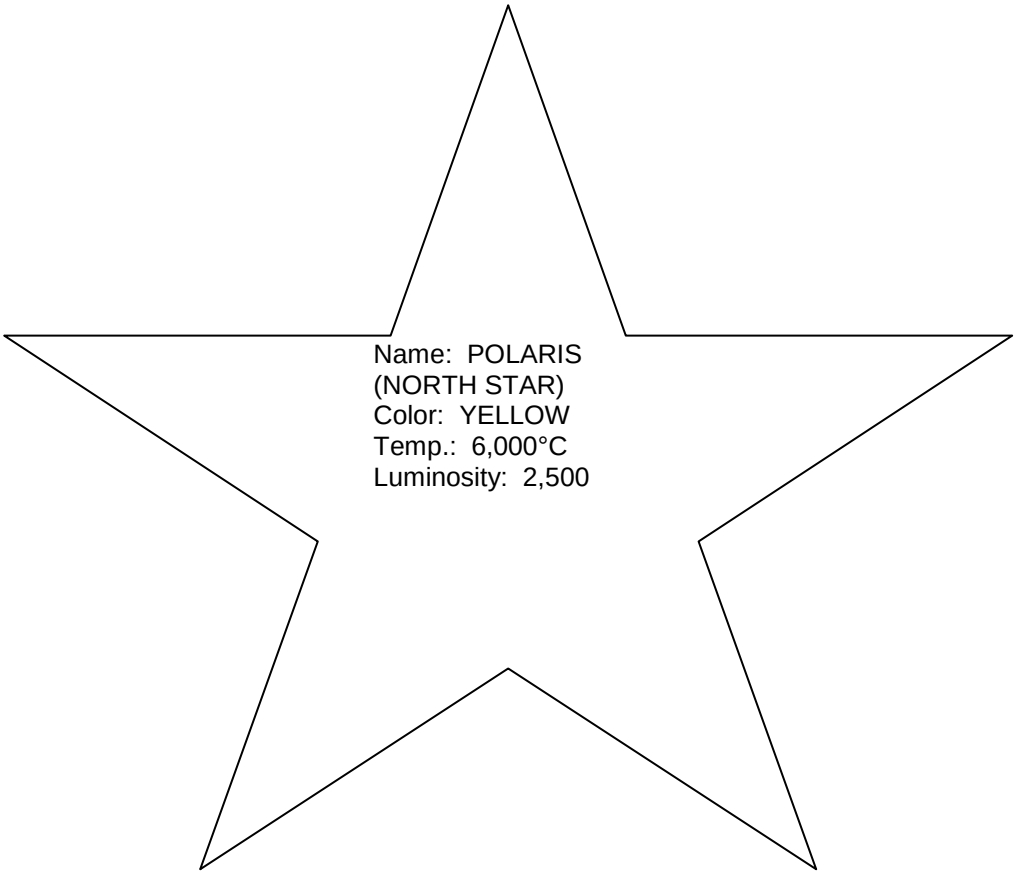




Star Page

COLOR: YELLOW

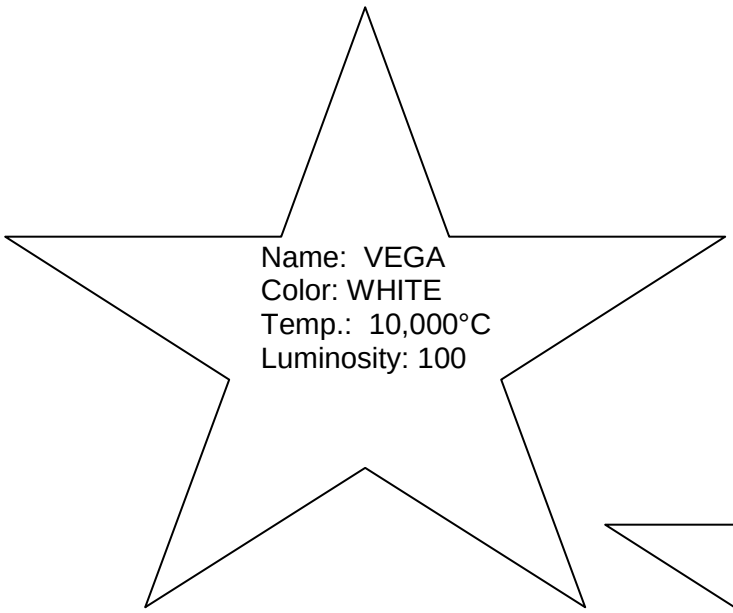


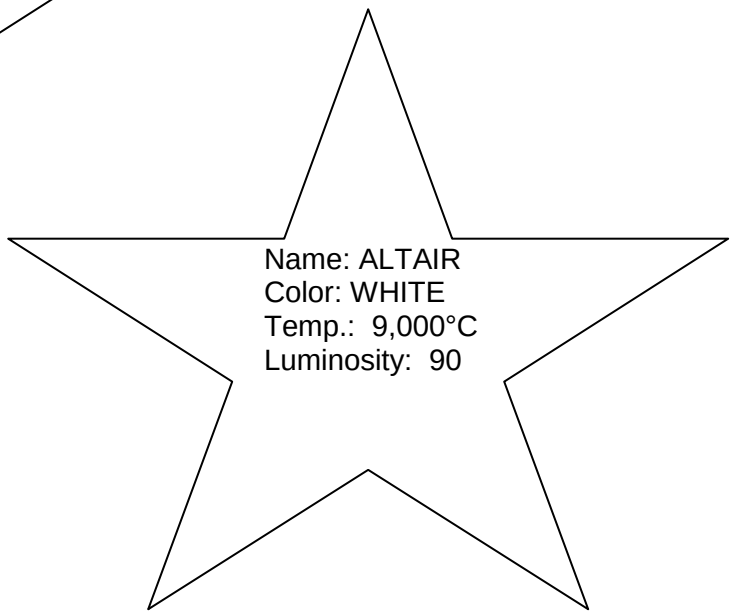


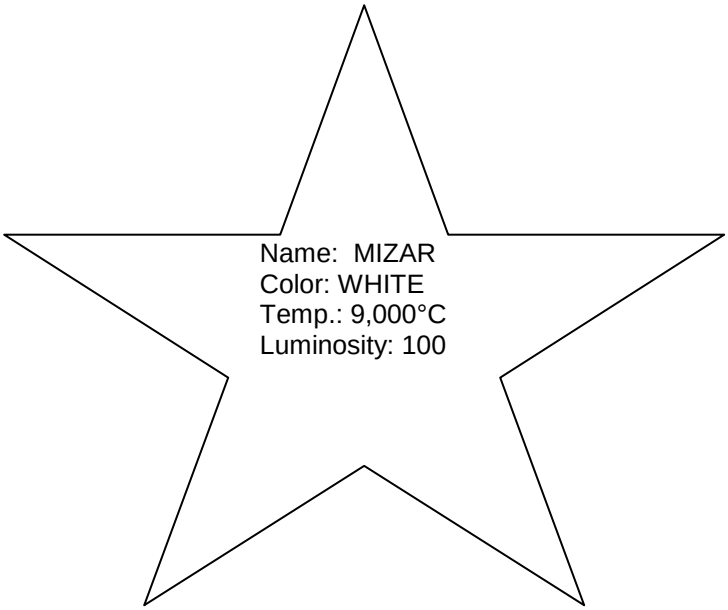
Name _____

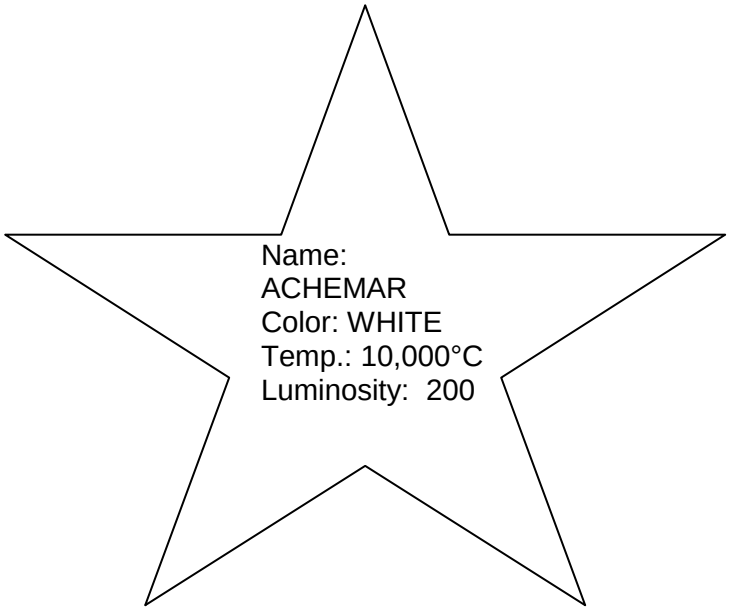
Star Page

COLOR: WHITE



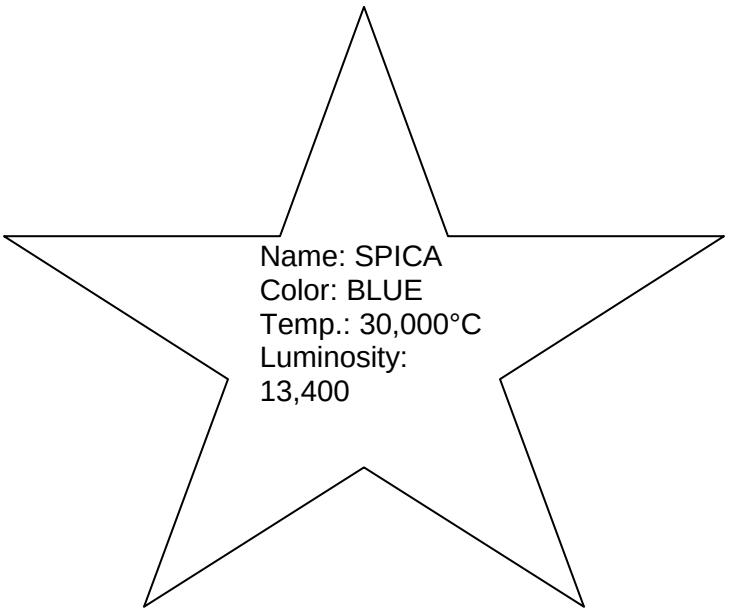


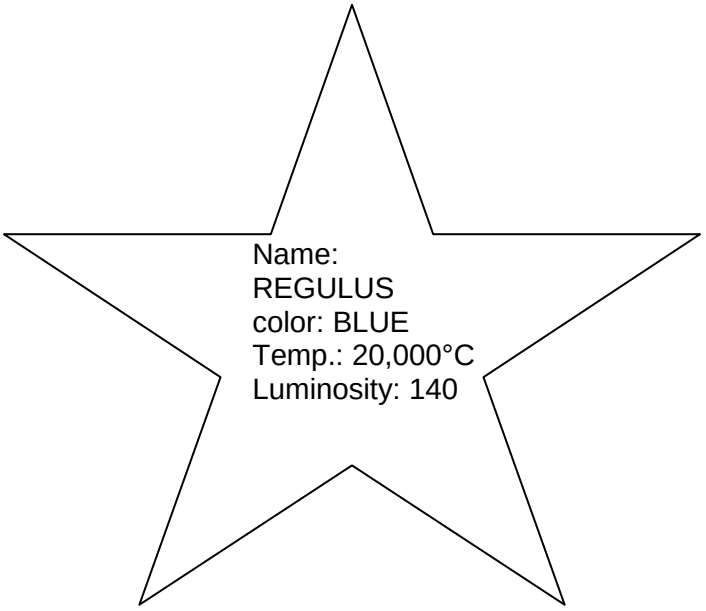


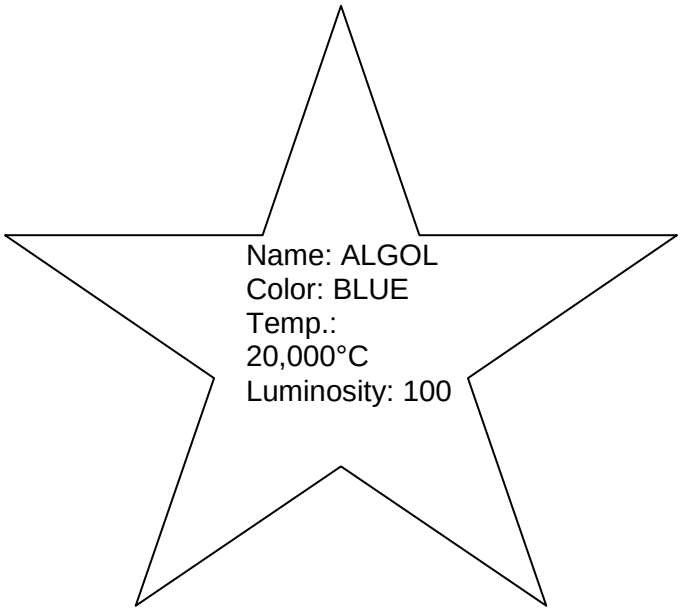


Star Page

COLOR: BLUE

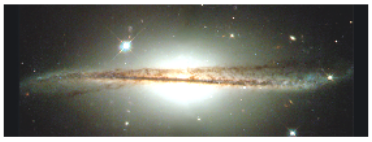






Graphic Organizer

Comparison of spiral, elliptical, and irregular galaxies

Spiral galaxies	Elliptical galaxies	Irregular galaxies
 Top view of a spiral galaxy  Side view of a spiral galaxy