Glencoe Science
Chapter Resources

Stars and Galaxies

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Reproducible Student Pages

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Hands-On Activities
Observing Star Patterns

Procedure
1. On a clear night, go outside after dark and study the stars. Take an adult with you.
2. Let your imagination flow to find patterns of stars that look like something familiar.
3. Draw the stars you see, note their positions, and include a drawing of what you think each star pattern resembles.

Data and Observations

Analysis
1. Which of your constellations match those observed by your classmates?
2. How can recognizing star patterns be useful?
Measuring Distance in Space

**Procedure**

1. On a large sheet of **paper**, draw an overhead view of the Milky Way. If necessary, refer to **Figure 16** in your textbook. Choose a scale to show distance in light-years.
2. Mark the approximate location of the solar system, which is about two thirds of the way out on one of the spiral arms.
3. Now, draw a side view of the Milky Way Galaxy. Mark the position of the solar system.

**Analysis**

1. What scale did you use to represent distance on your model of the Milky Way?

2. The Andromeda Galaxy is about 2.9 million light-years from Earth. What scale distance would this represent?
Lab Preview
Directions: Answer these questions before you begin the Lab.

1. What safety cautions are needed for this lab?

2. Why do sunspots appear to move?

Sunspots can be observed moving across the face of the Sun as it rotates. Measure the movement of sunspots, and use your data to determine the Sun’s period of rotation.

Real-World Question
Can sunspot motion be used to determine the Sun’s period of rotation?

Materials
several books
piece of cardboard
drawing paper
refracting telescope

Goals
■ Observe sunspots and estimate their size.
■ Estimate the rate at which sunspots move across the face of the Sun.

Safety Precautions
WARNING: Handle scissors with care.

Procedure
1. Find a location where the Sun can be viewed at the same time of the day for a minimum of five days. WARNING: Do not look directly at the Sun. Do not look through the telescope at the Sun. You could damage your eyes.
2. If the telescope has a small finder scope attached, remove it or keep it covered.
3. Set up the telescope with the eyepiece facing away from the Sun, as shown. Align the telescope so that the shadow it casts on the ground is the smallest size possible. Cut and attach the cardboard as shown in Figure 1.
4. Use books to prop the clipboard upright. Point the eyepiece at the drawing paper.
5. Move the clipboard back and forth until you have the largest image of the Sun on the paper. Adjust the telescope to form a clear image. Trace the outline of the Sun on the paper.
6. Trace any sunspots that appear as dark areas on the Sun’s image. Repeat this step at the same time each day for a week.
7. Using the Sun’s diameter (approximately 1,390,000 km), estimate the size of the largest sunspots that you observed.

8. Calculate how many kilometers the sunspots move each day.

9. Predict how many days it will take for the same group of sunspots to return to the same position in which they appeared on day 1.

Data and Observations

<table>
<thead>
<tr>
<th>Sunspot Descriptions</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Sunspots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size Estimate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclude and Apply

1. What was the estimated size and rate of motion of the largest sunspots?

__________________________________________________________________________

2. Infer how sunspots can be used to determine that the Sun’s surface is not solid like Earth’s surface.

__________________________________________________________________________

__________________________________________________________________________

Communicating Your Data

Compare your conclusions with those of other students in your class. For more help, refer to the Science Skill Handbook.
Lab Preview

Directions: Answer these questions before you begin the Lab.

1. Why is the safety symbol for eye protection used in this lab?

2. What is parallax?

Parallax is the apparent shift in the position of an object when viewed from two locations.

Real-World Question

How can you build a model to show the relationship between distance and parallax?

Form a Hypothesis

State a hypothesis about how parallax varies with distance.

Possible Materials

- meterstick
- masking tape
- metric ruler
- pencil

Goals

- **Design** a model to show how the distance from an observer to an object affects the object's parallax shift.
- **Describe** how parallax can be used to determine the distance to a star.

Safety Precautions

**WARNING:** Be sure to wear goggles to protect your eyes.

Test Your Hypothesis

Make a Plan

1. As a group, agree upon and write your hypothesis statement.
2. **List** the steps you need to take to build your model. Be specific, describing exactly what you will do at each step.
3. **Devise** a method to test how distance from an observer to an object, such as a pencil, affects the parallax of the object.
4. **List** the steps you will take to test your hypothesis. Be specific, describing exactly what you will do at each step.
5. Read over your plan for the model to be used in this experiment.
6. How will you determine changes in observed parallax? Remember, these changes should occur when the distance from the observer to the object is changed.
7. **You should measure shifts in parallax from several different positions. How will these positions differ?**
8. **How will you measure distances accurately and compare relative position shift?**

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. **Construct** the model your team has planned.
3. Carry out the experiment as planned.
4. While conducting the experiment, record any observations that you or other members of your group make in the Data and Observations section.
Data and Observations

Analyze Your Data
1. Compare what happened to the object when it was viewed with one eye closed, then the other.

2. At what distance from the observer did the object appear to shift the most?

3. At what distance did it appear to shift the least?

Conclude and Apply
1. Infer what happened to the apparent shift of the object’s location as the distance from the observer was increased or decreased.

2. Describe how astronomers might use parallax to study stars.

Communicating Your Data
Prepare a chart showing the results of your experiment. Share the chart with members of your class. For more help, refer to the Science Skill Handbook.
The apparent magnitude of a star, or how much light is received on Earth, can be confusing to an astronomer trying to measure the distance a star is from Earth. Apparent magnitude is much different from the absolute magnitude, which is the true measure of how much light the star emits. These two variables control the brightness of the stars we see in our night sky. The absolute magnitude is not the same for every star. It is determined by the amount of light it gives off. The second variable is the amount of light received on Earth. The mixing of these two variables can lead to misunderstanding about the size and distance of a star. That is why it is important to understand the characteristics of stars and light to be able to correctly determine what we see in the night sky.

**Strategy**
You will observe how light behaves over distance.
You will predict how two stars that are different in size and far away from each other may appear in the night sky.

**Materials**
- black construction paper
- rubber bands
- scissors
- medium sized nail
- small flashlight
- tape
- measuring tape or meterstick
- white correction fluid
- *chalk
- * markers
- * Alternate materials

**Procedure**
1. Students will work in groups of three to four. Use your scissors to cut a piece of black construction paper large enough to comfortably cover the light end of the flashlight.
2. Cover the end of the flashlight with the paper and secure it in place with a rubber band. Take the sharp end of the nail and carefully poke a single hole in the center of the paper covering. The smaller the hole the better.
3. Find a wall or hard surface on which you can tape a background of more black construction paper. An area about one meter square would be best for the experiment. An alternate choice would be to use the black- or white-board in the classroom. If you do use a wall, write only with the appropriate materials, such as chalk or erasable marker.
4. At a distance of two meters or six feet from the wall, mark a spot with tape on the ground. Then mark the next interval at 1.3 meters or four feet. The last mark is at 0.6 meters or two feet.
5. Ask your instructor to darken the room as much as possible. One student will stand at the six foot mark and turn on the flashlight. The other students will mark the edges of the diameter of the circle of light made by the flashlight with correction fluid, chalk, or markers. Be sure to notice the intensity of the inner and outer regions of the circle of light. You will record this in the data table provided.
6. Repeat this procedure at the closer interval. Then repeat one more time at the closest interval. Look at the intensity of the light instead. When is it most intense and where is it very diffuse? Record these observations in your table.

7. Observe the behavior of light at different intervals. Try to account for what you observe by what you know. For instance, you know the amount of light exiting the flashlight has not changed at all during the experiment. So what is happening to the dispersal of light? Record your hypothesis in the space marked “Hypothesis for the dispersal of light.”

Data and Observations

Table 1

<table>
<thead>
<tr>
<th>Diameter of Light Circle (cm)</th>
<th>Observations about Intensity of Light (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td></td>
</tr>
<tr>
<td>Trial 2</td>
<td></td>
</tr>
<tr>
<td>Trial 3</td>
<td></td>
</tr>
</tbody>
</table>
Laboratory Activity 1 (continued)

According to your experiment, your circle of light changed in size as you got closer to the wall. The intensity, or brightness, also changed. How would you account for this? Write your hypothesis in the space below.

Hypothesis for the dispersal of light:

Questions and Conclusions
1. The circle of light produced by your flashlight on the wall was larger when you were farther away from the wall. Was the light more or less intense? How do you account for this?

2. The circle of light got smaller as you approached the wall. Was the light more or less intense? How do you account for this?

3. As a result of your experiment, would you expect a star to appear brighter when closer to or farther from the Earth? Explain your answer.

4. If you used a bigger and brighter flashlight and repeated the same experiment, what would you expect your results to be like? Explain your answer.
5. Suppose you were going to perform the experiment with two students: One holds a weak flashlight; the other a strong flashlight. How would you place the students so that the circles of light on the wall were exactly the same size? Explain your answer in terms of magnitude.

6. How would you model the difference in absolute magnitude between the two flashlights?

7. Predict what an astronomer would look for if he or she wanted to determine the size and heat of a star and its distance from the Earth. Would it be a good idea to watch the star over a long period?

**Strategy Check**

_____ Can you observe how light behaves over distance?

_____ Can you predict how two stars that are different in size and far away from each other may appear in the night sky?
The photograph of the spectrum of a star, sorted by color across a plate, will reveal spectral lines upon close examination. The lines are produced by elements in a star at high temperature. These lines represent the chemical composition of the star. Each element has its own “fingerprint.” To analyze the spectra of stars, scientists collected spectra of all the known elements. If we compare the spectral lines of an unknown star with the spectral lines of elements, we can determine the chemical composition of the star. More recently, we have discovered not only the composition of the stars but also their temperatures, their rotational rate, and their relative motion with regard to Earth.

**Strategy**
You will construct a simple spectral analyzer.
You will determine the composition of a star using the spectral analyzer.
You will determine other characteristics of a star by comparing the spectral lines with a standard.

**Materials**
scissors

**Procedure**
1. Turn to the third page of this lab. Cut out the pull tab card; the spectroscope fingerprints card; and Stars B, C, and D along the dashed lines.
2. Make five slits along the dashed lines A, B, C, D, and E on the fingerprints card.
3. From left to right, insert “Pull Tab Out” up through slit E, down through slit D, up through slit C, down through slit B, and up through slit A.
4. Compare the lines of each known element with the lines of Star A. If lines match, then that element is present in Star A. Record your findings in Table 1.
5. Star B, Star C, and Star D are provided for further study and comparison. Each can be placed over Star A.

**Data and Observations**

**Table 1**

<table>
<thead>
<tr>
<th>Star</th>
<th>Chemical Composition</th>
<th>Other Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions and Conclusions

1. When you hear someone say that neon lights look beautiful, what color comes to mind? What color is suggested by the “fingerprints” of neon?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

2. Did any of the stars have the same chemical composition? Look at the table.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

3. Sometimes scientists see spectral lines that do not fit the usual pattern. The lines might be shifted from their usual positions. This may suggest that the star is moving either toward the observer (shift toward the blue) or away from the observer (shift toward the red). Look at the spectral lines for Star B and Star D. Star B is the standard for comparison. How is Star D different? What is a possible explanation for the difference?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

4. If the scientist sees the spectral lines wider than usual, he or she relates this spectral broadening to either rotational speed (the broader the faster), temperature (the broader the hotter), or pressure (the broader the greater pressure). Look at the spectral lines for Star B and Star C. Star B is the standard. How is Star C different? What could be a possible explanation?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

Strategy Check

_____ Can you construct a simple spectral analyzer?

_____ Can you determine the composition of a star using the spectral analyzer?

_____ Can you determine other characteristics of a star by comparing the spectral lines with a standard?
Laboratory Activity 2 (continued)

Spectrogram of unknown star

Identify the elements in the star

Sodium doublet

Star A

Left hand film

Star B

Right hand film

Star C

Star D

SPECTROSCOPE "Fingerprints"
Stars and Galaxies

Directions: Use this page to label your Foldable at the beginning of the chapter.

Stars

Galaxies

Universe

It can become a giant, a supergiant, or white dwarf.

It is a large group of stars, gas, and dust held together by gravity.

It is accepted that this started with the Big Bang.

Magnitude is a measure of its brightness.

We live in the Milky Way.
Meeting Individual Needs
**Overview**

**Stars and Galaxies**

**Directions:** Unscramble each term to complete the concept map below.

1. ___________

2. ___________

3. ___________

4. ___________

5. ___________

6. ___________

**Directions:** Use the terms from the concept map to complete the sentences below.

7. Most stars are __________________________ stars.

8. In the late stages of their life cycle, stars can expand to become __________________________ or __________________________.

9. A __________________________ is a star that has contracted after using its supply of helium.

10. __________________________ are large groups of stars, gas, and dust held together by gravity.
Directions: Circle the term that correctly completes each sentence.

1. Patterns of stars in the sky are called (galaxies/constellations).
2. Constellations that circle Polaris are (circumpolar/binary).
3. Scientists use (telescopes/spectographs) to break visible light from a star into its component colors.
4. Distances in space are measured in (light-years/CMEs).
5. The absolute (magnitude/brightness) of a star is a measure of the amount of light it gives off.
6. A measure of the amount of light received on Earth is called the (absolute/apparent) magnitude.

Directions: Identify the following parts of the Sun in the spaces provided.

prominence  surface  sunspot

7. ___________
8. ___________
9. ___________
Section 3 ■ Evolution of Stars

Section 4 ■ Galaxies and the Universe

Directions: Identify the stages in the life cycle of an average star. Use the words below to fill in the blanks.

white dwarf    nebula    giant    main sequence

1. Star begins in a clouds of gas and dust. ___________________

2. Star continues to use hydrogen for energy; heat from fusion causes pressure that balances the pull of gravity. ___________________

3. Star’s core is exhausted of hydrogen; its outer layers expand and cool. _________

4. Star’s core is exhausted of helium; its outer layers escape into space leaving only the core; the core contracts, or gets smaller. ___________________

Directions: Identify the type of galaxy shown in each illustration. Use the words to fill in the blanks below.

irregular    spiral    elliptical

5. ___________________ 6. ____________________ 7. ___________________

Directions: Answer the questions below on the lines provided.

8. In which galaxy is our solar system? ____________________________

9. What is the name for the change in a star’s spectrum when it moves away from Earth? ____________________________

10. What is the theory that explains how the universe began with an enormous explosion? ____________________________
Key Terms
Stars and Galaxies

Directions: Write the letter of the term that correctly completes each sentence in the space at the left.

1. ______ is a measure of the amount of light a star actually gives off.
   a. Apparent magnitude   b. Absolute magnitude

2. A ______ is a large group of stars, gas, and dust held together by gravity.
   a. solar system   b. galaxy

3. The largest layer of the Sun’s atmosphere is the ______.
   a. chromosphere   b. corona

4. Distances between stars and galaxies are measured in ______.
   a. light-years   b. millions of kilometers

5. An object so dense that nothing can escape its gravity field is a ______.
   a. white dwarf   b. black hole

6. A ______ is a group of stars that form a pattern in the sky.
   a. constellation   b. flare

7. A star beginning as a large cloud of gas and dust is called a ______.
   a. nebula   b. neptune

8. The Milky Way is a(n) ______ galaxy.
   a. spiral   b. elliptical

9. Areas of the Sun’s surface that appear dark because they are cooler than surrounding areas are called ______.
   a. CMEs   b. sunspots

10. The collapsed core of a supernova that contains only neutrons is ______.
    a. neutron star   b. super giant
Instrucciones: Decifra cada término para completar el siguiente mapa de conceptos.

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________

Instrucciones: Utiliza los términos del mapa de conceptos para completar las siguientes oraciones.

7. La mayoría de las estrellas son estrellas __________________________.
8. En las etapas tardías de sus ciclos de vida, las estrellas pueden expandirse y convertirse en __________________________ ó __________________________.
9. Un(a) __________________________ es una estrella que se ha contraído después de agotar su provisión de helio.
10. Las __________________________ son grandes grupos de estrellas, gas y polvo que se mantienen juntos gracias a la gravedad.
Instrucciones: Encierra en un círculo el término que complete correctamente cada oración.

1. Los patrones de estrellas en el firmamento se llaman (galaxias/constelaciones).
2. Las constelaciones alrededor de Polaris se llaman (circunpolares/binarias).
3. Los científicos usan (telescopios/espectrógrafos) para separar la luz proveniente de una estrella en los colores que la componen.
4. Las distancias en el espacio se miden en (años luz/CMEs).
5. El (la) (magnitud/brillo) absolut(a) de una estrella es una medida de la cantidad de luz que despide.
6. Una medida de la cantidad de luz que recibe la Tierra se llama magnitud (absoluta/aparente).

Instrucciones: Identifica las siguientes partes del Sol en el diagrama.

prominencia superficie mancha solar

7. ________

8. ________

9. ________
Instrucciones: Identifica las etapas del ciclo de vida de una estrella promedio. Usa los siguientes términos para llenar los espacios en blanco.

<table>
<thead>
<tr>
<th>enanas blancas</th>
<th>nebulosa</th>
<th>gigante</th>
<th>serie principal</th>
</tr>
</thead>
</table>

1. Una estrella comienza como una nube de gas y polvo. _______________

2. La estrella comienza a usar hidrógeno como combustible; el calor de la fusión causa presión que equilibra la fuerza de gravedad. _______________

3. El núcleo de la estrella agota el oxígeno; sus capas exteriores se expanden y se enfrian. _______

4. El núcleo de la estrella agota el helio; sus capas exteriores escapan al espacio dejando sólo el núcleo; el núcleo se hace más pequeño. _______________

Instrucciones: Identifica el tipo de galaxia de cada ilustración. Usa los términos para llenar los espacios en blanco.

irregular en espiral elíptica

5. _______________ 6. _______________ 7. _______________

Instrucciones: Contesta las preguntas en el espacio dado.

8. ¿En cuál galaxia está nuestro sistema solar? __________________________.

9. ¿Qué nombre recibe el cambio en el espectro de una estrella, a medida que se aleja de la Tierra? ____________________________________________________________.

10. ¿Cuál es la teoría que explica el comienzo del universo como una enorme explosión?
**Términos claves**

**Estrellas y galaxias**

**Instrucciones:** Escribe en el espacio a la izquierda la letra del término que complete correctamente cada oración.

1. La ______ es una medida de la cantidad de luz que emite una estrella.
   a. Magnitud aparente  
   b. Magnitud absoluta

2. Un(a) ______ es un grupo grande de estrellas, gas y polvo que se mantienen unidos gracias a la gravedad.
   a. sistema solar  
   b. galaxia

3. La capa más grande de la atmósfera del Sol es la ______.
   a. cromosfera  
   b. corona

4. Las distancias entre las estrellas y las galaxias se miden en ______.
   a. años luz  
   b. millones de kilómetros

5. Un astro cuya gravedad es tan fuerte que nada escapa de su campo de gravedad es un(a)______.
   a. enana blanca  
   b. agujero negro

6. Una ______ es un grupo de estrellas que forman un patrón en el cielo.
   a. constelación  
   b. llamada

7. Una estrella que comienza como una gran nube de gas y polvo se llama ______.
   a. nebulosa  
   b. neptuno

8. La Vía Láctea es una galaxia ______.
   a. espiral  
   b. elíptica

9. Las áreas que se ven oscuras en la superficie del Sol porque son más frías que las áreas circundantes se llaman ______.
   a. CMEs  
   b. manchas solares

10. El núcleo colapsado de una supernova que contiene solamente neutrones es una ______.
    a. estrella de neutrones  
    b. super gigante
**Stars**

**Directions:** Use the clues provided to solve the crossword puzzle.

**Across**

3. The Big Dipper is part of this constellation. (2 words)

5. This is the amount of starlight received on Earth. (2 words)

7. Our Sun is a star of this color.

10. This is the actual amount of light that a star gives off. (2 words)

13. This is another name for the North Star.

14. These are groups of stars that form patterns.

**Down**

1. The North Star is in this constellation. (2 words)

2. This is the apparent shift in position of an object when viewed from two different places.

4. Relatively cool stars look either orange or this color.

6. This is the brightest star in the sky.

8. This is the distance of about 9.5 trillion kilometers that light travels in one year. (2 words)

9. Astronomers study these to learn about the properties of stars.

11. This constellation, named after a mythical hunter, includes the star Betelgeuse.

12. Even though this star has an absolute magnitude greater than that of Sirius, it looks dimmer from Earth since it’s 100 times farther away.
The Sun

Directions: The diagram shows interior and outer features of the Sun. Write the name of each feature on the lines provided in the diagram.

1. ______________________
2. ______________________
3. ______________________
4. ______________________

5. ______________________
6. ______________________

Meeting Individual Needs

7. How can the Sun be classified?

8. How is the energy of the Sun produced?

9. How does our Sun differ from most other main sequence stars?

10. How do CMEs (coronal mass ejections) affect Earth?

11. How are sunspots related to prominences and solar flares?
Evolution of Stars

Directions: Circle the term in the puzzle that fits each clue. Then write the term on the line. In the puzzle, the terms read across or down.

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

1. A ________________ is a large cloud of dust and gas that becomes a star.
2. A graph that shows the relationship between a star’s absolute magnitude and temperature is an ________________.
3. A star that is a ________________ has exhausted its supply of hydrogen.
4. The ________________ of atoms powers the Sun and other stars.
5. The temperature and brightness of stars are indicated by their ________________.
6. About 90 percent of the stars, including our Sun, are ________________ stars.
7. A ________________ is produced when the outer core of a star explodes after the core collapses.
8. The hottest, brightest stars are ________________ and white.
9. Medium hot and bright stars like our Sun are ________________ in color.
10. When a star has no fuel left and its outer layers escape into space, it is a ________________.
11. As heavier elements are formed by fusion, a massive star expands into a ________________.
12. When a collapsed core becomes so dense only neutrons can exist there, a ________________ is formed.
13. A ________________ is so dense that nothing, including light, can escape its gravity field.
14. Write the remaining letters in the puzzle in the order in which they appear to reveal a famous scientist’s theory.
1. The two types of ____________________________ galaxies are barred and normal.
2. A ____________________________ is a group of galaxies.
3. ____________________________ galaxies have many different shapes and are usually smaller and less common than other types of galaxies.
4. An elliptical galaxy about 2.9 million light-years away is in the constellation of ______________________________.
5. Galaxies shaped like footballs are ____________________________ galaxies.
6. Two irregular galaxies called the ____________________________ orbit the Milky Way.
7. A ____________________________ is a large group of stars, gas, and dust held together by gravity.
8. The ____________________________ is an explanation for the formation of the universe.
9. The solar system in which we live is in the ____________________________ Galaxy.
10. The Milky Way Galaxy may contain ____________________________.
11. The Andromeda Galaxy is a member of the ____________________________.
12. The ____________________________ causes changes in the light coming from distant stars and galaxies.
13. One model of the origin of the universe is the ____________________________, which proposes that the universe was always as it is now.
14. Another model of the origin of the universe is the ____________________________, which believes that the universe expands and contracts in a regular pattern.
Comparing Apparent Magnitudes

Directions: Study the following tables and then answer the questions below. Table 1 identifies the apparent magnitudes of objects that can be seen in the sky. The naked-eye limit and the telescope limit indicate the minimum magnitude of sky objects that can be seen. Table 2 identifies the differences in apparent magnitude and the ratio of light that is emitted based on the differences.

### Table 1

<table>
<thead>
<tr>
<th>Object</th>
<th>Apparent Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>-26.5</td>
</tr>
<tr>
<td>Full moon</td>
<td>-12.5</td>
</tr>
<tr>
<td>Venus (at its brightest)</td>
<td>-4.0</td>
</tr>
<tr>
<td>Jupiter, Mars (at their brightest)</td>
<td>-2.0</td>
</tr>
<tr>
<td>Sirius</td>
<td>-1.5</td>
</tr>
<tr>
<td>Naked-eye limit</td>
<td>6.5</td>
</tr>
<tr>
<td>15-cm telescope limit</td>
<td>13.0</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Difference in Apparent Magnitude</th>
<th>Ratio of Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1:1</td>
</tr>
<tr>
<td>1.0</td>
<td>2.5:1</td>
</tr>
<tr>
<td>2.0</td>
<td>6.3:1</td>
</tr>
<tr>
<td>3.0</td>
<td>16:1</td>
</tr>
<tr>
<td>4.0</td>
<td>40:1</td>
</tr>
<tr>
<td>5.0</td>
<td>100:1</td>
</tr>
<tr>
<td>10.0</td>
<td>10 000:1</td>
</tr>
<tr>
<td>15.0</td>
<td>1 000 000:1</td>
</tr>
<tr>
<td>20.0</td>
<td>100 000 000:1</td>
</tr>
<tr>
<td>25.0</td>
<td>10 000 000 000:1</td>
</tr>
<tr>
<td>30.0</td>
<td>1 000 000 000 000:1</td>
</tr>
</tbody>
</table>

1. What is the apparent magnitude of the Sun? ___________________________
2. What is the apparent magnitude of Sirius? ___________________________
3. What is the difference in the magnitudes of the Sun and Sirius? ________________
4. How much more light does the Sun provide than Sirius? ____________________
5. What is the difference in the Sun's apparent magnitude from that of the full Moon? ________________
6. About how much more light does the Sun provide than the full Moon? ________________
7. What is the greatest apparent magnitude that can be viewed by the naked eye? ________________
8. What is the difference in the apparent magnitude of the Sun and an object with the greatest apparent magnitude that can be viewed by the naked eye? ________________
9. How much more light does the Sun give off than an object with the least apparent magnitude that can be viewed by the naked eye? ________________
10. If a star has an apparent magnitude of 7.5, would you be able to see it with the aid of a 15 cm telescope? ________________
11. What is the difference in magnitudes between Venus and Mars at their brightest? ________________
12. What is the ratio of light of Venus and Mars at their brightest? ________________
Humans cannot travel outside a spaceship without protection. They must be protected from the extreme cold of space and the lack of air pressure. The condition of weightlessness combined with a lack of atmospheric pressure places the human body in a life-threatening position. One of the most dangerous problems humans encounter in space, however, is the exposure to high levels of radiation streaming from the Sun. The Sun produces many types of radiation including gamma rays and X rays.

**Barriers to Radiation**

Normally, the atmosphere of Earth protects us from most of the Sun's radiation. We receive some degree of ultraviolet light and other forms of high energy waves, but most of these dangerous waves are turned away by the atmosphere and the magnetic field surrounding our planet. In space, however, the human body is exposed to all of the Sun's harmful emissions. Scientists have addressed this dangerous problem by designing super protective spacesuits. These spacesuits are made of special fabrics and act as barriers to most radiation. The unique face masks are coated with resistant chemical barriers and act like huge sunglasses.

Even so it is best if astronauts only expose themselves to the Sun's radiation for a few hours.

**New Use for Spacesuits**

One amazing use for these suits has been discovered right here on Earth. Some children are born with a condition in which they cannot tolerate any light or ultraviolet radiation. This condition is called xeroderma pigmentosum, or XP for short. Children born with this condition cannot tolerate any exposure to the Sun. In the past, these children were forced to stay indoors and away from windows or bright lights.

Scientists at the National Aeronautics and Space Administration (NASA) recognized that their astronaut apparel could benefit people with XP. The scientists designed suits for two little girls and in 1999, the children were able to come out into the sunlight for the very first time wearing their special spacesuits. Most spacesuits are white to repel some of the Sun's emissions, but the girls have asked for colors for their special outfits. Don't be surprised if, someday, you see an astronaut wearing a green or yellow spacesuit.

1. What is one of the most dangerous problems for astronauts in space?

2. Why do humans on earth not experience the same problems as astronauts in space?

3. What are two features of spacesuits that help protect astronauts?

4. What other use did NASA find for its spacesuits?
More About Black Holes

Scientists believe black holes to be places where matter is so dense that the gravitational field is so strong, not even light can escape its pull. This is how the black holes get their names. All we see is the absence of light. So how can we identify something we can’t see? We cannot make them in the laboratory. We cannot actually see them in space. How do we know they might exist?

Event Horizon

There are a number of possible explanations. A black hole has a surface where some particles are sucked into the hole and others might still escape. This is called the event horizon. The inside of a black hole is called a singularity. At the horizon it might be possible for two particles to come very close to each other and exchange energy. When this happens one particle becomes negatively charged and the other becomes positively charged. It is most likely that the negative particle will be pulled into the black hole first.

When this occurs, the brief moment of energy exchange will shoot the positive particle away from the negative and out into space. It escapes the black hole. This constant shooting out of high energy particles creates radiation. Scientists have detected radiation coming from black spaces in the universe. This might be evidence of a black hole.

X Rays as Evidence

One large source of X rays comes from an irregular galaxy that is just 180,000 light years from Earth, making it a Milky Way neighbor. Labeled LMC X–1, for Large Magellanic Cloud, the source appears to be a binary star system with a compact star so massive and so dense that it would be like putting five of our Sun into a space the size of Earth. Scientists believe that this compact star may be a black hole. The gravity is so great that this compact star appears to be ripping the gases from the nearby star. The result is an emission of X rays that helps scientists to detect black holes.

1. What is one problem with trying to learn about what goes on in black holes?

2. What is one piece of information scientists have found that support the idea of a black hole?

3. What is the surface of a black hole called? What is the inside called?

4. If scientists cannot see black holes and do not know for certain that they exist, why might studying them be important?
Searching for the Age of the Universe

In spite of the development of the Hubble Space Telescope and the building of two space stations, scientists still are no closer to agreeing on one of the central questions of astronomy: How old is the universe? From time to time, announcements are made by different research teams who think they have found the answer, but soon there is always a great deal of disagreement from other research teams. Astronomers might not yet be able to definitively state the age of the universe, but they have identified several clues that might one day settle the question.

How old are you now?

What types of clues tell about the age of the universe? One key to estimating age is to estimate distance. Because many scientists believe the universe began with the Big Bang and is continuing to expand, measuring distance can give researchers a relative idea of how old objects in space are. However, because no one knows for sure whether the rate of expansion is increasing or decreasing, measurement methods vary. The Hubble Space Telescope has provided more accurate measurements in some cases, but results about the age of the universe based on an eight-year study are still considered controversial. That study stated that the universe is around 12 billion years old. A later NASA study also used the Hubble Space Telescope.

This study looked in one galaxy at Cepheid variables, which emit light in pulses. The rate of pulsation is related to the brightness of the variables, and so by measuring the brightness of the galaxy, researchers can calculate how far it is from Earth. This type of measurement, however, is claimed by some to overestimate galaxy distances, significantly throwing off calculations of the age of the universe.

The Oldest Stars in the Galaxy

Yet another study used masers for its measurements. Masers are the microwave version of lasers. They are located near an apparent black hole near the center of the universe. Another clue to the age of the beginning of the universe might lie in star clusters. In the Milky Way there are clusters of stars thought to have formed just after the Big Bang, making them the oldest stars in the galaxy. The groupings of these stars are called globular clusters. In this case, scientists study white dwarf stars in a cluster and calculate the mass and temperature of the stars. These calculations allow scientists to determine the distance and, therefore, the age of the cluster. Since these are the oldest stars, knowing their age can help researchers calculate the age of the universe. However, because no one has yet proved results to be infallible, the quest for discovering the age of the universe continues.

1. Why does measuring distance help scientists measure the age of stars?

2. Why are these measurements controversial?

3. What are two methods scientists have used to try to determine the age of the universe?
Section 1  Stars

A. Patterns of stars—_______________________
   1. Ancient cultures used _____________ or everyday items to name constellations
   2. Modern astronomy studies __________ constellations
   3. Some constellations are not _____________ all year because Earth revolves around the Sun
   4. ____________________________ in the northern sky appear to circle around Polaris and are visible all year

B. Star __________________
   1. ________________—measure of the amount of light a star actually gives off
   2. ________________—measure of the amount of a star’s light received on Earth

C. Space __________________
   1. Astronomers measure a star’s _________________—shift in its position when viewed from two different angles
   2. Distance is measured in ____________________—the distance light travels in a year

D. Star ___________________
   1. Color indicates ____________________
      a. Hot stars are ____________________
      b. Cool stars look ____________________
      c. ______ stars like the Sun are medium temperature
   2. A spectroscope breaks the visible light from a star into a ________________
      a. Spectrum indicates ________________ in the star’s atmosphere

Section 2  The Sun

A. Sun’s ______________—energy created in the core moves outward through the radiation zone and the convection zone and into the Sun’s atmosphere
B. Sun’s __________________
   1. __________—lowest layer gives off light and is about 6,000 K
   2. __________ is the next layer about 2000 km above the photosphere
   3. Extending millions of km into space, the 2 million K __________ releases charged particles as solar wind

C. Surface ________________
   1. ______—dark areas cooler than their surroundings
      a. _______ features which come and go over days, weeks, or months
      b. Increase and decrease in a 10 to 11 year pattern called __________________ cycle
   2. Sunspots are related to ________________________________
      a. Magnetic fields may cause ______________—huge, arching gas columns
      b. Violent eruptions near a sunspot are called __________________________
   3. Bright ____________________________ (CMEs) appear as a halo around the Sun when emitted in the Earth’s direction
      a. Highly charged ____________________________ can disrupt radio signals
      b. Near Earth’s polar areas solar wind material can create light called an __________

D. Sun is mostly ________________
   1. ______—aged star
   2. Typical ____________________________ with yellow light
   3. Unusual—Sun is _________________ of a multiple star system or cluster

Section 3   Evolution of Stars
A. Classifying stars—Ejnar Hertzsprung and Henry Russell ________________ stars by temperature and absolute magnitude in a H-R diagram
   1. __________—diagonal band on H-R diagram
      a. Upper left—hot, ____________, bright stars
      b. Lower right—______, red, dim stars
      c. Middle—average ____________ stars like the Sun
   2. ________________—the ten percent of stars that don’t fall in the main sequence
B. ________ of hydrogen occurs in star cores releasing huge amounts of energy

C. ________ of stars

1. A ______________ contracts and breaks apart from the instability caused by gravity
   a. __________ in each nebula chunk increase as particles move closer together
   b. At 10 million K __________ begins and energy from a new star radiates into space

2. The new main sequence star ________________ pressure from fusion heat with gravity
   a. Balance is lost when core hydrogen fuel is ________________
   b. Core contracts and heats up causing outer layers to ___________ and cool
   c. Star becomes a ______________ as it expands and outer layers cool
   d. Helium nuclei fuse to form core of ________________

3. A _______________ forms from the giant star
   a. Helium is exhausted and outer layers escape into space
   b. Core contracts into hot, dense, small star

4. In massive stars fusion causes higher temperatures and greater expansion
   into a ________________
   a. Eventually fusion stops as iron is formed
   b. The core crashes inward causing the outer part to explode as an incredibly
      bright ________________

5. The collapsed core of a supernova may form a ________________ of extremely high
   density

6. The mass of a tremendously big supernova core can collapse to a point, forming a
   ________________
   a. ________ is so strong not even light can escape
   b. Beyond a black hole’s ________________ gravity operates as it would before the
      mass collapsed

7. Matter emitted by a star over its life time is recycled and can become part of
   a new ________________
Section 4 Galaxies and the Universe

A. ______—gravity holds together a large collection of stars, gas, and dust
   1. Earth's galaxy is Milky Way which is part of a galaxy cluster named the
      ______________________
   2. _____________________—spiral arms wind out from inner section; some have barred spirals with
      stars and gas in a central bar
   3. ______________________—large, three-dimensional ellipses; most common shape
   4. ______________________—smaller, less common galaxies with various different shapes

B. The Milky Way Galaxy—usually classified as a _______________________________
   1. May contain one ________________ stars
   2. About 100,000 light-years _____________
   3. Sun orbits galaxy's core every 225 million years

C. Theories on the _______________ of the universe
   1. ______________________—universe has always existed just as it is now
   2. ______________________—universe expands and contracts repeatedly over time

D. Universe is __________________
   1. ________________ light changes as it moves toward or away from an object
      a. Starlight moving toward Earth shifts to ____________________ end of spectrum
      b. Starlight moving away from Earth shifts to ____________ end of spectrum
   2. All galaxies outside the Local Group indicate a red shift in their spectra indicating they are
      moving __________________ Earth

E. ______________—holds that universe began 13.7 billion years ago with a huge explosion
   that caused expansion everywhere at the same time
   1. Galaxies more than 10 ________________ light-years away give information about a young
      universe
   2. Whether the universe may eventually ______________ expanding and begin
      _________________ is unknown
Assessment
Part A. Vocabulary Review

**Directions:** Match the terms in **Column I** with their descriptions in **Column II.** Write the letter of the correct description in the blank at the left.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. white dwarf</td>
<td>a. explanation for the beginning of the universe</td>
</tr>
<tr>
<td>2. absolute magnitude</td>
<td>b. relatively cool star that has expanded to more than 700 times as large as our sun</td>
</tr>
<tr>
<td>3. apparent magnitude</td>
<td>c. groups of stars whose positions in the sky seem to change as Earth moves</td>
</tr>
<tr>
<td>4. parallax</td>
<td>d. distance that light travels in one year</td>
</tr>
<tr>
<td>5. constellations</td>
<td>e. lowest layer of the Sun’s atmosphere that gives off light</td>
</tr>
<tr>
<td>6. main sequence</td>
<td>f. classification of about 90 percent of the stars</td>
</tr>
<tr>
<td>7. nebula</td>
<td>g. actual amount of light a star gives off</td>
</tr>
<tr>
<td>8. giant</td>
<td>h. two or more stars revolving around one another</td>
</tr>
<tr>
<td>9. light-year</td>
<td>i. produced from an explosion that occurs when a star’s core collapses</td>
</tr>
<tr>
<td>10. supergiant</td>
<td>j. star in which only neutrons can exist in its core</td>
</tr>
<tr>
<td>11. neutron star</td>
<td>k. earliest stage of a star’s formation</td>
</tr>
<tr>
<td>12. black hole</td>
<td>l. amount of a star’s light observed on Earth</td>
</tr>
<tr>
<td>13. sunspots</td>
<td>m. large, cool expanding star in which helium fuses to form carbon</td>
</tr>
<tr>
<td>14. chromosphere</td>
<td>n. object so dense that nothing, including light, can escape it</td>
</tr>
<tr>
<td>15. corona</td>
<td>o. layer of the sun’s atmosphere above the photosphere</td>
</tr>
<tr>
<td>16. supernova</td>
<td>p. large group of stars, gas, and dust held together by gravity</td>
</tr>
<tr>
<td>17. binary system</td>
<td>q. apparent shift in position of an object when viewed from different places; used to determine distances</td>
</tr>
<tr>
<td>18. photosphere</td>
<td>r. small, hot star consisting of a hot, dense core contracting under the force of gravity</td>
</tr>
<tr>
<td>19. galaxy</td>
<td>s. dark, cooler areas of the Sun’s surface</td>
</tr>
<tr>
<td>20. Big Bang theory</td>
<td>t. outer layer and largest part of the Sun’s atmosphere</td>
</tr>
</tbody>
</table>
Part B. Concept Review

1. Sequence the colors of stars by temperature, labeling the hottest star number 1.

   ______ blue
   ______ yellow
   ______ red

2. Identify the sequence of the evolution of stars by labeling the stages. Use 1 to label nebula.

   ______ nebula
   ______ white dwarf
   ______ giant
   ______ main sequence star

Directions: Write the word yes in front of any characteristic of the Milky Way. Write the word no in front of any characteristic that does not match the Milky Way.

   ______ 3. spiral galaxy
   ______ 4. member of the Local Group
   ______ 5. 5.8 million light-years from the galaxy in Andromeda
   ______ 6. more than 400 billion stars
   ______ 7. elliptical galaxy
   ______ 8. 100,000 light-years in diameter

Directions: Answer the following questions using complete sentences.

9. How is the Sun different from other stars? How is the Sun similar to other stars?

10. How is the Big Bang theory supported by the observed Doppler shift of galaxies?

11. How does the Sun produce energy?

12. Compare and contrast apparent magnitude and absolute magnitude.

13. How are sunspots, flares, and prominences related?
Transparency Activities
A Starry Night

On a clear night, if you are far away from city lights, you can see hundreds of stars.

1. What constellations can you identify where you live?
2. Make up your own constellations using the stars in this photograph. Name each constellation and explain what it represents.
3. Why might some stars look brighter than others?
A Hot Topic

Light isn’t the only thing that comes from the Sun; the solar wind, which consists mainly of charged particles, also flows from the Sun. These particles are the reason that the tails of comets point away from the Sun, and they are thought to play a role in the auroral light displays.

1. How does the Sun make life on Earth possible?
2. Describe the features of the Sun that you can see in the image above.
If conditions are right, a star can evolve into a pulsar. The name *pulsar* comes from the phrase “pulsating radio star.” Pulsars are so dense that if you could get a teaspoon full of pulsar matter, it would weigh roughly one billion *tons*!

1. Describe what you see in this image.
2. If this were a moving picture, you would see this star rotating. How would the beams of light appear as the star rotates?
While these dishes may appear to be separate instruments, they actually form one radio telescope named the Very Large Array (VLA). Scientists can adjust the VLA by moving the dishes along a Y-shaped railroad track.

1. How are optical telescopes used to study objects in the universe?
2. How is the VLA similar to an optical telescope?
3. There are 27 dishes in the VLA. Why might 27 dishes be better than a single dish?
Circumpolar Constellations

- Polaris
- Big Dipper
- Little Dipper
- Ursa Major
- Ursa Minor
- Draco
- Cassiopeia
- Cepheus
- Apparent motion
- Looking north
Teaching Transparency Activity (continued)

1. Polaris is almost directly above what point on Earth?

2. What is another name for Polaris?

3. Do the stars in the constellation Ursa Major appear to rotate clockwise or counterclockwise?

4. What star is located at the end of the Little Dipper?

5. The constellation Orion is visible in the northern hemisphere during what season of the year?

6. Draw the Little Dipper and the Big Dipper in relation to Ursa Minor.
Directions: Carefully review the table and answer the following questions.

<table>
<thead>
<tr>
<th>Color</th>
<th>Wavelength (nanometers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>380-450</td>
</tr>
<tr>
<td>Blue</td>
<td>450-490</td>
</tr>
<tr>
<td>Green</td>
<td>490-560</td>
</tr>
<tr>
<td>Yellow</td>
<td>560-590</td>
</tr>
<tr>
<td>Orange</td>
<td>590-630</td>
</tr>
<tr>
<td>Red</td>
<td>630-760</td>
</tr>
</tbody>
</table>

1. According to the table, what will be the color of a light wave with a wavelength of 500 nanometers?
   A. Violet  C. Green
   B. Blue    D. Yellow

2. In a clear sky, the Sun is bright yellow. What is the approximate wavelength of the light coming from the Sun?
   F. 380–340 nanometers  G. 450–490 nanometers
   H. 560–590 nanometers  J. 630–760 nanometers

3. The shorter the wavelength of a light wave, the greater its energy. A light wave of which of the colors listed below has the greatest energy?
   A. Red
   B. Orange
   C. Green
   D. Violet