Name Date

Topic 4.3 Highlights

How has technology expanded our knowledge and understanding of the universe?

Use with textbook pages 320–349.

Telescopes

Instruments such as telescopes have greatly improved our ability to see the universe. Since Galileo's time, optical telescopes have collected visible light for brighter, more distant images of space. Objects in space give off many forms of electromagnetic radiation, not just visible light. Radio telescopes detect radio waves even through clouds, so they can be located on Earth. Other wavelengths are partially blocked by Earth's atmosphere, so some telescopes are sent into space to detect X-rays, infrared, and ultraviolet radiation. The Hubble Space Telescope detects visible, infrared, and ultraviolet wavelengths for its images.

The Milky Way and Other Galaxies

A white, fuzzy band seen across the night sky far from city lights is really our own Milky Way galaxy. A **galaxy** is a collection of many billions of stars, gas, and dust. Gravity holds galaxies together.

Galaxies can be classified based on their basic shapes. Galaxy shapes can be spiral, elliptical, and irregular. Each category has different numbers and ages of stars. Most galaxies, including the Milky Way, are spiral galaxies; they look like flattened pinwheels with a dense central bulge of old stars, and younger stars on their arms. Our Sun is located along one of these arms. Galaxies also have smaller groups of stars within them called **star clusters**. Open clusters have fewer stars, while globular clusters have up to one million stars. Each type of star cluster is found in different regions of a galaxy. The Andromeda galaxy is our nearest neighbouring galaxy in space. It looks like a fuzzy smudge to the unaided eye. It is the most distant object we can see with only our eyes.

Distances in Space: The Light Year

Fairly small distances in space, such as those between objects in our solar system, can be measured in astronomical units (AU). The AU is based on the distance between Earth and the Sun. This distance is 1 AU.

For objects beyond the solar system, a much larger unit of distance is needed. A **light-year** (ly) is the distance that light travels in a year, which is about 10 trillion km. Proxima Centauri, our next closest star to the Sun, is about 4 ly away. The North Star (Polaris) is 400 ly away. Light from Proxima Centauri has taken about 4 years to travel to Earth. Light from Polaris has taken about 400 years. When we observe objects in space, including the Sun, we are really seeing them as they were in the past.

One method used to calculate the huge distances to stars involves geometry. *Parallax*

and *triangulation* use small changes in a star's position against a fixed background of other stars.

Stars and Their Characteristics

Each star has its own unique brightness, colour, temperature, and mass. Stars vary greatly in all of these characteristics. The luminosity, or brightness, of stars shows how much energy is given off per second. Compared to the Sun, some stars are more faint and much less luminous; others are tens of thousands of times more luminous. Absolute magnitude compares how bright stars would look if they were all at a common standard distance from Earth.

Colours of stars indicate their temperature. They range from the hottest blue stars through average-temperature yellow stars like the Sun, all the way to cooler, reddish ones. The mass of stars also varies. Some stars have only a small fraction of the Sun's mass, while others are over 100 times more massive.

A **Hertzsprung-Russell (H-R) diagram** shows how the brightness, colour, and size of a star are related to its mass. After plotting thousands of stars on the graph, it was found that almost all stars fit in the central band, called the **main sequence**. This region runs diagonally from the top left bluish, bright stars to the bottom right reddish, cool stars. Our yellow Sun lies in the middle of the main sequence with an average mass, temperature, and brightness. Red giant and supergiant stars are not on the main sequence, since they are very cool but very bright due to their size. The types of stars that are not found on the main sequence are clues to changes that happen to stars during their lifetimes.

How Stars Evolve

Stars do change over time, but very, very slowly. They emit light and other radiation wavelengths by using huge amounts of energy, but eventually the hydrogen they use for fusion is used up. Stars end their lives either as white dwarfs, neutron stars, or black holes. The type they become in their final stages depends on the mass of the star. Stars like the Sun will expand to become a red giant when their hydrogen is nearly used up; next, they become a planetary nebula, and then finally a cool white dwarf, found off the H-R diagram's main sequence. The whole process for such stars takes about 10 billion years. Cool, reddish stars consume their hydrogen slowly, and may live up to 100 billion years.

More massive and hotter blue stars use up their fuel much faster. They become a red supergiant near their end, and then explode as a **supernova**. Heavier elements such as those found in all life, including carbon, oxygen, and nitrogen, are produced and given off from supernovas. Following a supernova, this type of star may then end its days as an incredibly dense **neutron star**, sending out pulses of energy as it spins. The most massive stars end as black holes. **Black holes** have huge masses compressed into no volume, causing their gravity to be so strong that even light cannot escape it. They cannot be seen in space. They are detected only by the intense radiation they emit and how their gravity affects nearby objects. There is a black hole at the centre of the Milky Way galaxy as well as most other galaxies.

Telescopes in Space

Use with textbook pages 322-323.

1. Check Your Understanding

As you read the paragraph under the heading "Telescopes in Space" on page 323 of the textbook, stop and reread any parts that you do not understand. Write down any sentences that help you understand the concepts better.

2. Summarizing

Summarizing means restating the main ideas in your own words. A summary can be in point form or in sentence form. Read the paragraph about telescopes in space on page 323. Complete the following table by using point form to summarize the main ideas in the paragraph. Write a summary sentence. Compare your table and points with a partner's. (Remember that you can use this same technique to help you summarize any paragraph or group of paragraphs in any other part of your textbook.)

Section of the Textbook	Main Topic	What the Text Says About the Main Topic	Supporting Details
Page 323, "Telescopes in Space"			

Summary Sentence:

_____

3. Interpreting Diagrams

A diagram is a type of visual that includes labels to better communicate information about the visual and how to interpret it. Refer to Figure 4.18 on page 322 in the textbook. Read the caption beside Figure 4.18 to understand the main idea of the diagram.

a) Analyze Figure 4.18. Based on the lengths of the vertical arrows in different regions, explain why certain types of telescopes can be located on Earth.

_____

b) From Figure 4.18, which types of electromagnetic radiation do not reach Earth's surface according to the arrows?

_____

c) How do radiation wavelengths affect the placement of telescopes designed to detect them?

_____

The Shape of Galaxies

Use with textbook page 327.

The Milky Way is our home galaxy. When using our eyes to look at the night sky, all the stars we can see are part of the Milky Way. Using telescopes, we recognize that there are billions of other galaxies in the universe, far beyond our own. Are they similar to the Milky Way, or are they different? Is our galaxy an average one, or is it unusual? What do other galaxies look like?

Use textbook page 327 to answer the following questions.

1. Complete the table below.

Comparing Different Types of Galaxies

Characteristics	Elliptical Galaxies	Spiral Galaxies	Irregular Galaxies
Description of shape			
Sketch of shape			
Ages and locations of their stars			
Gas and dust information			
Other general information			
Percentage of total galaxies we can see			

2. a) How are galaxies formed?

_____

b) Which type of galaxy is the Milky Way?

_____

3. Compare spiral and barred spiral galaxies.

a) How are they similar? _____

b) How are they different? _____