CHAPTER

3 Outer Space

15 Understanding Distances in Space

SC.8.E.5.1; SC.8.E.5.2; SC.8.E.5.3

Getting the Idea

Key Words
galaxy
Milky Way galaxy
light-year
universe

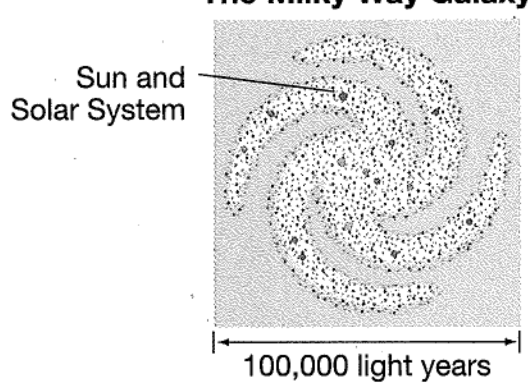
The universe contains countless stars and other objects. The stars are not scattered evenly through the universe, even though it may seem that way as you gaze into the night sky. The stars are actually organized into very large groups. In this lesson, you will explore these star groups and learn how the large distances between individual stars and star groups are measured.

The Milky Way Galaxy

Earth is part of a solar system that revolves around one star—the sun. However, the sun is not a lone star. The sun is a member of a family of stars called a galaxy. A **galaxy** is a large group of stars, space dust, and gases that are held together by gravity. Galaxies are classified into three types, according to their shape: spiral, elliptical, and irregular. No matter what their shape, an individual galaxy may contain billions or even trillions of stars.

The galaxy to which the sun belongs, the **Milky Way galaxy**, has a spiral shape. A spiral galaxy has "arms" that wind outward from the center, resembling a pinwheel. Many spiral galaxies have a "bar" of stars in the center. Scientists think that the Milky Way is a barred spiral galaxy.

The Milky Way Galaxy



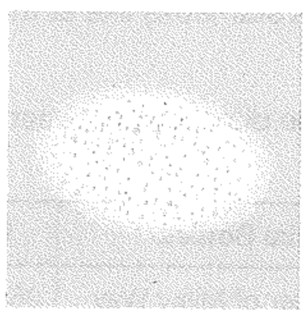
Our sun is only one average-sized star in the Milky Way galaxy. Many scientists estimate that there are between 100 and 300 billion stars in this galaxy. If you were able to view the Milky Way from above, you would see its spiral shape. You cannot see the spiral shape of the Milky Way from Earth because of your position within it. That position gives you a view of the galaxy from near its edge. In other words, you are looking across, or through the diameter of the galaxy. This side view produces the band of light that crosses the night sky. It is within the milky band of light that most of the stars of our galaxy are located.

The Milky Way galaxy is very large. In fact, it is so large that Earth is located nearly 26,000 light-years away from its center. You will learn more about light-years later in this lesson. Our solar system is located closer to the outer edge of the galaxy than it is to the center.

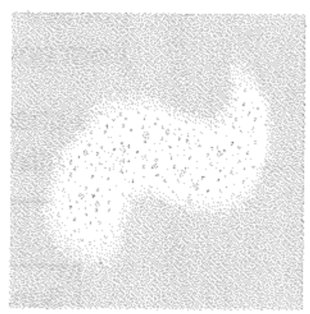
Other Types of Galaxies

An elliptical galaxy has an oval or near-spherical shape. Elliptical galaxies can have billions of stars, but these galaxies have little gas and dust. They are typically filled with older stars because, without gas and dust, new stars do not form.

Irregular galaxies are galaxies that do not fit into the other two groups. They have many different shapes and are typically smaller than the others. They tend to have bright, young stars and lots of dust and gas to form new stars.



Elliptical galaxy



Irregular galaxy

Measuring Distances in Space

Astronomers use different techniques to measure distances between stars and galaxies. One way is by measuring the apparent shift in the position of an object when you look at it from two different places.

You can model this idea by closing your left eye and holding your thumb up in front of your face. Block your view of something in your classroom. Without moving your thumb, open your left eye and close your right eye. You will notice that the object appears to move. Scientists look at stars from different points in Earth's orbit. They also look at how much the star appears to move against a background of stars farther away. By measuring the apparent change in position, a scientist can determine the object's distance from Earth.

Units of Measurement in Space

When you measure distances on Earth, you typically use units like meters or kilometers. The distance to most stars, however, is so large that these units are not practical. Instead, scientists use a unit called a light-year to measure distances in space. A **light-year** is the distance that light travels in one year. In space, light travels at a speed of nearly 300,000 kilometers per second, or almost 9.5 trillion kilometers per year. A light-year is thus equal to about 9.5 trillion kilometers.

After our sun, the nearest star to Earth is Proxima Centauri. This star is a little more than 4.2 light-years (40 trillion kilometers) away. The distance to a star or galaxy in light-years is equal to the number of years needed for the light from that object to reach an observer on Earth. Light from Proxima Centauri takes a little more than 4.2 years to reach Earth. If you observe this star tonight, you would see Proxima Centauri as it looked 4.2 years ago. You will not see what this star looks like at this very moment until 4.2 years from now.

The chart lists the distances between some other structures in the universe.

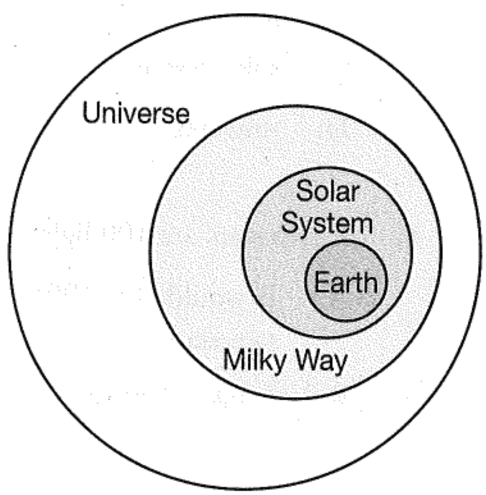
Celestial Bodies	Distance Between Them
Sun and center of Milky Way galaxy	26,000–27,000 light-years
Milky Way galaxy and Andromeda spiral galaxy	2.3 million light-years or 22 million, trillion kilometers
Earth and the edge of the universe	More than 13 billion light-years

Relationships within the Universe

The **universe** is a vast place made up of all the matter and energy that exists. When you try to understand this concept, it is helpful to examine the relationships among the different structures that the universe includes. For example, you know that Earth is one of the planets in our solar system. The solar system is composed of the eight planets and their moons, comets, asteroids, and many other objects that orbit our sun. The solar system of which Earth is a part is only one of a vast number of solar systems that exist throughout the universe.

The sun is only one of the billions of stars in the Milky Way galaxy. The Milky Way galaxy in turn is only one of the countless number of galaxies that make up the universe. Like the Milky Way, each of these other galaxies contains its own millions or even billions of stars. Each of these individual galaxies can be thousands of light-years across and be located millions of light years away from each other.

To study large amounts of information, scientists often find it helpful to organize information in a simplified concept map. The diagram below can help you visualize the hierarchal relationship among the different groups and bodies that make up the universe. Notice that this concept map is arranged from body containing the largest number of objects—the universe—to that containing the fewest objects—in this case, a single planet—Earth.



DISCUSSION QUESTION

When you look up into the sky, you can see stars that no longer exist. How do you explain this?

Test Tips . . .

When an answer includes numbers and units of measure, be sure to read all the answer options carefully before making your selection. Answers that look similar at first may differ slightly in the position of a decimal point or a unit of measure.

LESSON REVIEW

1. What does a group of stars, dust, and gas held together by gravity form?

   A. a star system

   B. a solar system

   C. a galaxy

   D. a constellation

2. Which type of galaxy contains mostly new stars because it has lots of dust and gas?

   A. irregular

   B. spiral

   C. elliptical

   D. regular

3. Which of these is largest?

   A. the sun

   B. galaxy

   C. solar system

   D. universe

4. If two stars are 100 light-years apart, what does this mean?

   A. It would take 100 years for a spaceship to travel between these two stars.

   B. It takes 100 years for light to travel from one star to the other.

   C. One of the stars formed 100 years before the other.

   D. The stars are 100 million kilometers from each other.

16 Properties of Stars

SC.8.E.5.5

Getting the Idea

Key Words
star
apparent magnitude
absolute magnitude
Hertzsprung-Russell (H-R) diagram
nebula
protostar
nuclear fusion
luminosity
white dwarf
black dwarf
red giant
planetary nebula
supergiant
supernova
neutron star
black hole

Our sun is only one of countless billions of other stars. Stars have similar compositions, but different ages and characteristics. By studying many different stars at different stages of development, scientists have gained an understanding of the star life cycle.

Properties of Stars

A **star** is a massive ball of hot gases that gives off its own light. All stars are made mostly of hydrogen and helium. However, stars vary in size, temperature, color, brightness, age, and distance from our solar system.

The sun is the nearest star to Earth. Recall from the last lesson that Proxima Centauri, the second nearest star to Earth, is about 4.2 light-years from our sun. Polaris (the North Star) is 390 light-years from the sun.

The Sun

Characteristic	Data
Age	4.5 billion years
Diameter	1.4 million kilometers
Average Surface Temperature	5,510°C
Color	Yellow
Mass	1.99×1030 kilograms

The table above lists some characteristics of our sun. Our sun is a medium-sized star in terms of both mass and diameter. Small, hot stars can be as small as Earth. Large, cooler stars can be many times larger than the sun.

Stars vary widely in their surface temperatures. The coolest stars have surface temperatures as low as 3,000°C, while the hottest stars have surface temperatures ten times higher. The temperature of a star determines its color—from cool, red stars to hot, blue ones. The table below shows how temperature and star color are related. Recall that the sun is a medium-temperature yellow star.

Star Color and Temperature

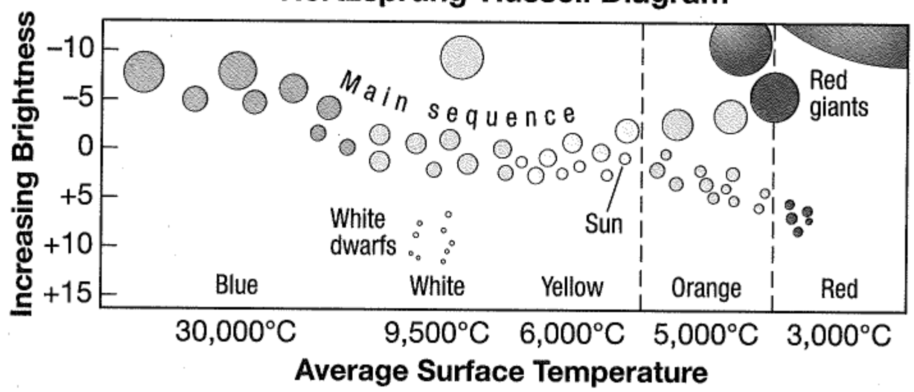
Color	Average Surface Temperature
Blue	30,000°C
White	9,500°C
Yellow	6,000°C
Orange	5,000°C
Red	3,000°C

The term *magnitude* is used to describe the brightness of a star. **Apparent magnitude** is the brightness of a star as it appears from Earth. This brightness depends partly on how far away the star is. **Absolute magnitude** describes the actual brightness of a star without considering its distance from the observer. The absolute magnitude of stars is measured on a scale from about −15 to +15. On this scale, negative numbers correspond to brighter stars.

Around 1910, Ejnar Hertzsprung and Daniel Russell independently developed means for showing how a star's magnitude relates to its surface temperature. Their findings were later combined into a graph called the **Hertzsprung-Russell (H-R) diagram**. This graph displays the relationship between a star's average surface temperature and its brightness.

On the H-R diagram, most stars, including the sun, fall within a diagonal band of stars called the *main sequence*. Main-sequence stars show a direct relationship between temperature and brightness: hotter stars burn brighter. Note that the cool red giants in the upper right burn brightly because of their enormous size. The hot white dwarfs near the center have low brightness because they are so small.

Hertzsprung-Russell Diagram



Life Cycles of Stars

Stars exist for billions of years. A star begins forming when gravity pulls together the gas and dust that make up a **nebula**. As the particles pull together, they form a dense, rotating sphere. This rotating sphere becomes hot, due to friction caused by the collisions of its particles. This glowing, hot, condensed sphere of dust and gas is a beginning star, called a **protostar**.

Stars form when the temperature in a protostar becomes hot enough to start the process of nuclear fusion. **Nuclear fusion** is the joining of the nuclei of light atoms to form a heavier atomic nucleus. This process releases enormous amounts of energy. In young stars, hydrogen undergoes fusion and becomes helium.

The mass of a star determines its temperature, its luminosity, and its diameter. **Luminosity** is a measure of the energy released each second from the surface of a star. The brightness of a star depends on its luminosity and its distance from observers on Earth.

Did You Know?

A star named Betelgeuse (pronounced "beetle-juice"), located in the Orion constellation, is a supergiant. It has a diameter several hundred times larger than the sun.

The mass of a star determines the different changes it will go through. For example, mass determines if a star will expand and become larger or contract and get smaller.

Most stars enter the main-sequence phase a few million years after they begin to form. Most stars in the main-sequence stage are medium-mass stars,which are stars with masses similar to the sun. Medium-mass stars use hydrogen in their cores for nuclear fusion. The fusion process continues until the hydrogen runs out.

After the hydrogen is gone, the star's mass determines which phase of its life cycle it enters. Low-mass stars collapse and become white dwarfs. **White dwarfs** are small, hot, dense stars that can radiate heat for billions of years. Eventually, a white dwarf cools and becomes a **black dwarf**.

Medium-sized stars enter a period of expansion and contraction. The core shrinks as the hydrogen burns away, but the star itself expands because gravity can no longer hold the outer layers in tightly. The star becomes a **red giant**, a large, bright, cool star.

After another billion years or so, the outer layers of a red giant expand to form a glowing cloud of gas called a **planetary nebula**. The remaining core of the star collapses into a white dwarf that eventually cools into a black dwarf.

Very massive stars become **supergiants**—huge, cool, red stars that burn helium in the core. When the helium is gone, the core contracts again. When a massive star dies, the huge explosion that results is a **supernova**. If a supergiant is massive enough, it will collapse into a **neutron star**, an extremely dense object that consists mainly of closely-packed neutrons. The most massive stars, however, collapse into black holes. A **black hole** is a small, extremely dense object. The pull of gravity from a black hole is so strong that not even light can escape from it.

A star may release some of its gases at different stages in its life cycle. These gases then become the material from which new stars form.

Test Tips . . .

Remember to stay positive. Don't get upset if you don't know the answer to a question right away. Just move on and come back to it later. You may remember the answer once you relax!

DISCUSSION QUESTION

Imagine that you could watch our sun undergo its own life cycle. What would you see happen?

LESSON REVIEW

1. Which of the following is MOST important in determining a star's life cycle?

A. its mass

B. its diameter

C. its color

D. its brightness

2. What fuel does a main-sequence star use for nuclear fusion?

A. oxygen

B. petroleum

C. helium

D. hydrogen

3. What phase takes place after the most massive of stars is already a supernova?

A. a planetary nebula

B. a black hole

C. a white dwarf

D. a black dwarf

Lesson

17 Applications of the Electromagnetic Spectrum

SC.8.E.5.10; SC.8.E.5.11

Getting the Idea

Key Words

electromagnetic spectrum
wavelength
frequency
electromagnetic radiation
telescope
optical telescope
spectroscope
satellite

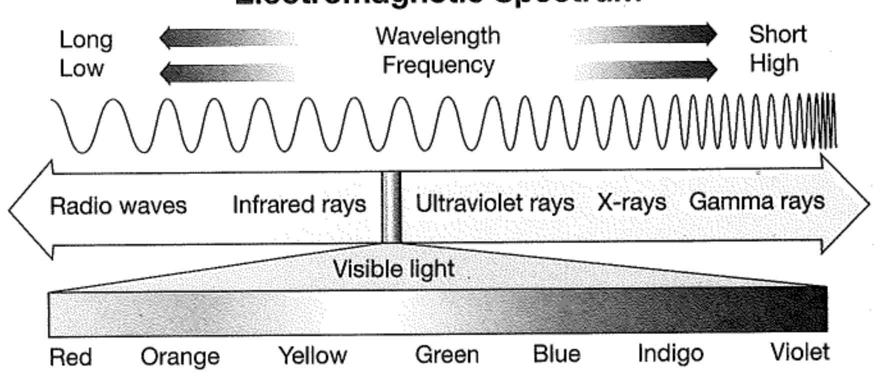
Light is a form of energy. Light travels in waves. However, visible light is only one type of a large spectrum of energy that travels in the same way. These other types of energy affect you in many different ways. In this lesson, you will learn about these different kinds of energy waves.

The Electromagnetic Spectrum

The **electromagnetic spectrum** is the range of all possible waves that transfer energy through an electric and a magnetic field that are perpendicular to each other. Electromagnetic (EM) waves can travel through empty space. All EM waves travel at the same speed—about 300,000 km per second in a vacuum. However, the waves of the EM spectrum vary widely in wavelength and frequency. **Wavelength** is the distance between a point on one wave and its corresponding point on the next wave. **Frequency** is the number of waves produced in a given amount of time.

Energy transmitted by electromagnetic waves is called **electromagnetic radiation**. EM waves are categorized by their wavelengths. As you look at the diagram below, notice that wavelength and frequency are inversely proportional. As one value increases, the other decreases.

Electromagnetic Spectrum



There are different categories of electromagnetic waves. The chart below describes each category of EM wave and identifies some of its uses:

Types of Electromagnetic Waves

Name	Description
Gamma Rays	• highest energy, highest frequency • waves about the size of an atom's nucleus • produced by the sun and other stars • very damaging to cells • used to sterilize medical equipment by destroying germs
X-rays	• waves about the size of atoms • can travel through skin and muscle, but not through hard bone; used for imaging • Repeated exposure can damage cells • used in security checks to find any hidden objects
Ultraviolet (UV) Light	• higher energy and higher frequency compared to visible light • waves about the size of molecules • UV rays from the sun can tan or burn skin • can make certain minerals glow • Prolonged exposure can damage cells
Visible Light	• longest wavelengths of visible light is red and the shortest is violet • waves about the size of bacteria • the only part of the EM spectrum humans can see • includes the visible spectrum (rainbow)
Infrared Waves	• Heat from the sun travels to Earth in this form. • waves about the size of a needle point • not seen by humans but can be felt as heat • Night vision goggles use infrared sensors • Some toaster ovens also produce these waves to toast the bread
Microwaves	• shorter wavelengths and higher frequency compared to radio waves • waves the size of an adult person • used to heat foods in microwave ovens • used to send cell phone signals • Radars also use these waves
Radio Waves	• lowest energy • waves range from the the size of people to the size of tall buildings • transmit radio and television signals • used in items such as cell phones, radios, and televisions, and in radar • TVs and FM radio use shorter wavelengths, AM radio uses longer wavelengths

Telescopes

Telescopes are among the most common instruments used to study space. **Telescopes** are devices that detect the various forms of energy in the electromagnetic spectrum. As objects in space emit electromagnetic radiation, telescopes collect and focus these energy waves. Scientists then use the focused waves to learn about their source.

The telescopes you are most familiar with are optical telescopes. An **optical telescope** is a device that uses lenses or a combination of lenses and mirrors to gather visible light from space. Visible light is the only type of electromagnetic radiation you can see. The lenses, or lenses and mirrors, in an optical telescope work to make distant objects appear closer and brighter.

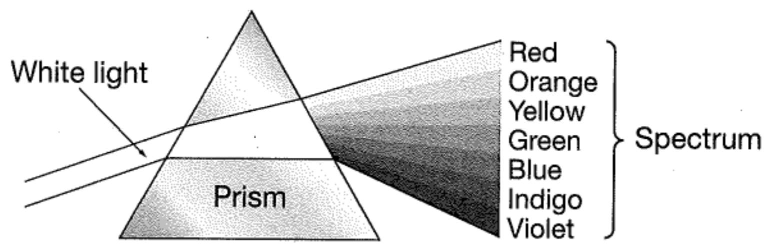
Many other telescopes gather invisible radiation from space. The invisible radiation may include infrared (heat) radiation, ultraviolet radiation, X-ray radiation, and radio waves. The table below describes some common types of telescopes.

Types of Telescopes

Type of Telescope	Type of Radiation	Source of Radiation	Function
Optical	Visible light	Most stars, planets	Detects and enhances visible light
Radio	Radio waves	Galactic centers, stars, black holes	Detects radio waves
Ultraviolet	Ultraviolet	Distant stars, clouds of dust, and gas	Maps sources, analyzes composition
Infrared	Infrared (heat)	Stars, galaxies	Finds new objects in space

Spectroscopes

A **spectroscope** is a special telescope that can analyze visible light by acting like a prism. As shown below, a prism is an optical device that separates visible light into its component colors (or spectrum). For example, a prism will separate white light from a flashlight into bands of red, orange, yellow, green, blue, indigo, and violet.



A prism separates white light into the colors of the spectrum.

Substances, such as those in stars, give off light when heated. Many elements produce their own distinct spectral "fingerprints." These fingerprints are composed of bands of color of specific patterns and widths. Scientists can use these patterns to study a star's composition by comparing the patterns to those produced by starlight that passes through a spectroscope.

Satellites

A **satellite** is a natural or artificial object that revolves around another object in space. The moon is Earth's natural satellite. Artificial satellites are built on Earth. They are put into orbit around Earth by rockets or the space shuttle. For example, in 1990 scientists sent the Hubble Space Telescope into orbit around Earth to study objects both in and beyond our solar system.

Thousands of artificial satellites orbit Earth. Some of these gather scientific data from outer space. Others are used to track weather and climate changes on Earth, to transmit television and radio signals around Earth, to help ships and land vehicles navigate on Earth, and for military purposes.

DISCUSSION QUESTION

A student turns on the radio to listen to music. Then she cooks a bag of popcorn in the microwave as she checks text messages on her phone. What different types of electromagnetic waves are involved in this scenario?

LESSON REVIEW

1. Which of the following correctly lists electromagnetic waves in order from highest to lowest frequency?

   A. X-rays, gamma rays, visible light, microwaves, radiation

   B. microwaves, infrared radiation, ultraviolet, gamma rays

   C. gamma rays, ultraviolet, visible light, microwaves, radio waves

   D. radio waves, visible light, ultraviolet, X-rays, gamma rays

2. Which type of telescope uses visible light emitted by a star to make it appear closer?

   A. radio

   B. ultraviolet

   C. optical

   D. infrared

3. Which tool would an astronomer MOST LIKELY use to collect information about the chemical composition of a star?

   A. infrared telescope

   B. radio telescope

   C. satellite

   D. spectroscope

18 Technology and Its Contributions to Astronomy

SC.8.E.5.10, SC. 8.E.5.11

Getting the Idea

Key Words
- technology
- model
- National Aeronautics and Space Administration (NASA)
- space shuttle
- International Space Station (ISS)
- space probe
- telescope

Galileo first used a telescope to study the night sky in the 1600s. Since that time, scientists have continued to develop more advanced tools for collecting information about space. In the last lesson, you read about how scientists use spectroscopes, satellites, and different types of telescopes to study space. In this lesson, you will examine other forms of technology scientists use to study space.

What Is Technology?

Science and technology are different, but related, fields. Science is the search for answers to questions about the natural world. **Technology** is the application of science to everyday life. Thus, technology involves applying scientific knowledge to solve problems or to fill needs that arise.

Almost all science inquiry relies on some form of technology. Use of technology helps scientists work more efficiently. Scientists who study outer space use technology in the following ways:

- to access outer space and other remote locations
- for sample collection
- to make measurements and computations
- for data collection and storage
- to communicate information

Much of the research done by scientists involves the use of tools. All of these tools are products of technology. Some tools such as the optical telescope devised by Galileo to study the night sky are fairly simple in design. Others, such as the remote-controlled rovers NASA scientists have sent to Mars to photograph the surface and collect and analyze Martian soil samples, are more precise and sophisticated.

Use of Computers

Over the last 50 years, the computer has become an essential tool for science research. One use of computers is for data collection and storage. They are also used to carry out mathematical calculations, analyze data, and create visual displays of these data. Scientists use computers to communicate with one another as well as with the various forms of technology that are sent into outer space to investigate planets and stars more closely.

Recall that a **model** is a representation of an object, process, or phenomenon. Models are important investigative tools for space scientists. Computer simulations, mathematical models, and computer models are all used to study space. Such tools have been used to investigate star formation, black holes, gravitational interactions within galaxies, and the formation of the universe.

Space scientists input data or conditions into their models until the results closely match observations they have made about an object, process, or phenomenon. The models can be used to reconstruct how galaxies and other features in space formed. Simulations and models are also used to predict what galaxies and stars will look like in the future.

Travel in Space

In the United States, most exploration and research of space is carried out by the **National Aeronautics and Space Administration (NASA)**. NASA is an agency of the United States government established in 1958. NASA is responsible for the nation's public space program. Eleven years after it was established, NASA succeeded in developing the technology and spacecraft needed to place astronauts on the surface of the moon.

Astronauts landed on the moon on six separate occasions. These astronauts walked on the moon's surface, collected rock and soil samples, conducted demonstrations and experiments, and gathered large amounts of data. The information they gathered was about subjects such as magnetic fields, mineral compositions, and meteor impacts on the moon's surface. Scientists used technology to return all of this information to Earth for analysis.

Did You Know?

The last man to set foot on the moon was part of the Apollo 17 mission in December of 1972. NASA planned three more Apollo lunar landing missions, Apollo 18 through Apollo 20. However, NASA cancelled these missions to make funds available for the development of the space shuttle.

In the 1970s, NASA developed a new type of spacecraft commonly called the space shuttle. The **space shuttle** is the first reusable spacecraft that is capable of carrying astronauts into orbit around Earth. The space shuttle also has a large cargo bay that carries equipment into space, including satellites that have been placed into orbit around Earth.

In recent years, the space shuttles carried astronauts and equipment to the International Space Station (ISS). The **International Space Station** is a satellite that orbits Earth in which astronauts from different nations live and work together for months at a time.

Space Probes

More recently, scientists developed technology that allows them to send objects rather than humans into space to gather information. **Space probes** are unmanned spacecrafts used to gather information about parts of the solar system and relay that data back to Earth. Each probe contains scientific instruments that collect data or perform experiments.

Telescopes

Earth-based radio telescopes and space-based telescopes provide valuable information about many space objects, processes, and phenomena. A **telescope** is a device that detects the various forms of energy in the EM spectrum.

Many optical telescopes are in use throughout the United States. The Very Large Array in New Mexico is a series of linked radio telescopes used to study radio waves from space. Telescopes for other types of electromagnetic radiation must be launched into space because Earth's atmosphere blocks some gamma rays, X-rays, ultraviolet radiation, and infrared radiation. NASA has launched several telescopes into orbit around Earth. It has also launched telescopes beyond Earth's atmosphere. These include the Hubble Space Telescope, the Far Ultraviolet Spectroscopic Explorer, the Chandra X-ray Observatory, and the Compton Gamma Ray Observatory.

DISCUSSION QUESTION

Using information gathered by space probes, scientists found evidence that water may have once flowed over the surface of Mars. Why is this discovery significant?

LESSON REVIEW

1. Which of these BEST describes a space probe?

A. a spacecraft in which astronauts can travel

B. a tool that makes distant objects appear closer

C. an unmanned spacecraft used to collect data from the solar system

D. an object that revolves around Earth, collecting data about the planet's weather

2. Which form of technology are space scientists MOST LIKELY to use to calculate the distance to a newly-discovered planet?

A. computer

B. space shuttle

C. space probe

D. radio telescope

3. Which force, coupled with inertia, keeps satellites orbiting Earth?

A. Earth's gravity

B. the sun's gravity

C. the moon's gravity

D. Earth's magnetic field

19 Space Exploration and Its Effects on Florida

SC.8.E.5.12

Getting the Idea

Key Word
spinoff

Two of the most challenging questions in science deal with how the universe began and how long it will exist. The U.S. government established NASA to help answer these types of questions through space exploration. Since NASA was established, the state of Florida has played a very important role in our nation's space program.

NASA and the Kennedy Space Center

As you learned in Lesson 18, NASA was established in 1958. Within two years, NASA began operating within the state of Florida as part of the Cape Canaveral Air Force Station. In 1963, the parts of the Cape Canaveral facility dedicated to space exploration were renamed the John F. Kennedy Space Center in honor of the late president.

The Kennedy Space Center is one of more than a dozen NASA centers in the United States. It is located near the center of the state, close to the Atlantic coast of Florida. The temperate climate of the region is suited to the Kennedy Space Center's service as the primary launch center for spacecraft.

Space Exploration and Florida

As a Floridian, you are certainly affected by space exploration. These effects result largely from having the Kennedy Space Center located within your home state.

Space exploration has many effects on the economy of Florida. One way this occurs is through the jobs the Kennedy Space Center provides to residents of Florida. At present, the space center employs about 15,000 people. These jobs include people who work in science and technology, tour guides, food service workers, maintenance staff, and construction workers, among others.

In addition to the people it employs directly, NASA and the space center also provide an economic benefit to people living outside of Florida. Some of these benefits come directly from employment of people at NASA facilities located in other parts of the country. Other economic benefits are provided through employers who help provide NASA with the technologies and services that allow space exploration to occur.

The Kennedy Space Center also provides money to the state through tourism. Some of this money comes from admission tickets, food, and souvenir sales from visitors to the space center. Additional money is made by hotels, motels, restaurants, gift shops, and other service providers that cater to tourists.

Not all of the effects of the space program are economic. Space exploration also affects the culture of Florida. For example, NASA missions play a major role in history, technology, and education. Some historical and technological achievements of NASA include placing the first human on the moon and developing the world's first reusable spacecraft, the space shuttle.

NASA plays a role in education by sharing much of the information it gathers with the public. In many cases, people can view new data and pictures of bodies in space almost immediately by visiting NASA's Web site. NASA also offers many programs to students including opportunities to speak with astronauts.

One educational opportunity provided only by the Kennedy Space Center is the ability to view a launch first-hand. Tickets for many launches are available through the space center. In addition, NASA provides information about how to view launches from a distance at various off-site locations.

Technological Contributions of NASA

One of the most interesting contributions of the space program is in the area of spinoffs. A **spinoff** is a technology developed for a specific use in science or industry that becomes useful for other purposes in everyday life.

Technologies originally developed by NASA for space exploration have become common in everyday life. For example, NASA developed cordless tools powered by rechargeable batteries for astronauts in space to use. Astronauts used some of these tools during construction of the International Space Station (ISS).

Today, many people use cordless tools such as drills, saws, hedge trimmers, and blowers to do repairs or maintenance in their homes.

Scientists developed cameras that use infrared technology. These hand-held cameras study the heat emitted from objects in space. Today, firefighters use similar technology to help them identify people, objects, and hot spots within burning buildings.

DISCUSSION QUESTION

The money needed to carry out space exploration through NASA is provided by tax dollars. A single mission can cost many millions or even billions of dollars to carry out. Do you think the technologies and knowledge that result from such exploration are worthy of such funding. Explain your response.

LESSON REVIEW

1. Which of these is an economic effect of space exploration in Florida?

- **A.** improved education
- **B.** people viewing launches
- **C.** increased tourism dollars
- **D.** its well-documented temperate climate

2. Which correctly defines a spinoff?

- **A.** the launching of a spacecraft
- **B.** use of a technology created for a specific purpose for that purpose
- **C.** money generated by tourism dollars
- **D.** a technology developed for a specific use that becomes useful for other purposes in everyday life

3 Review

1. Which tool travels through the solar system relaying information back to Earth?

   A. telescope

   B. satellite

   C. space probe

   D. spectroscope

2. A light-year is a unit of measurement that would MOST appropriately be used to measure which of the following distances?

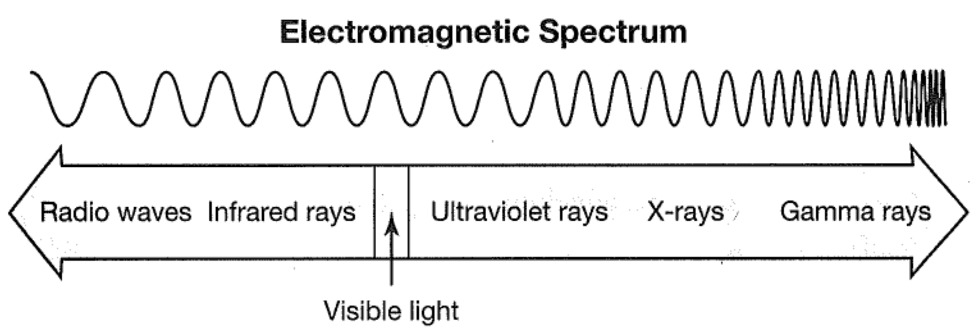
   A. Earth to the sun

   B. the Milky Way to the next nearest galaxy

   C. Earth to Jupiter

   D. the sun to Pluto

Use the diagram below to answer questions 3 and 4.



3. The diagram shows the electromagnetic spectrum. Which type of wave has the the LEAST amount of energy?

   A. gamma

   B. ultraviolet

   C. infrared

   D. radio

4. What type of telescope collects radiation from waves that are shorter than visible light?

A. ultraviolet telescope

B. infrared telescope

C. optical telescope

D. radio telescope

5. Which statement is correct?

A. The sun is the only star in the Milky Way.

B. The Milky Way is part of the solar system.

C. The Milky Way is a galaxy far from the solar system.

D. The sun is one of billions of stars in the Milky Way.

6. Explain why scientists use telescopes that detect types of electromagnetic radiation, in addition to visible light, to study objects in space.

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7. Which choice orders the average size of these star groups from smallest to largest?

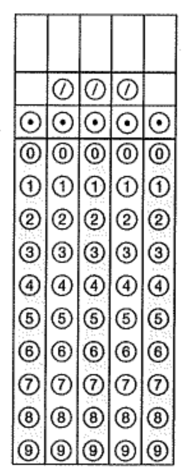
A. white dwarf, main sequence, red giant

B. main sequence, white dwarf, red giant

C. red giant, main sequence, white dwarf

D. white dwarf, red giant, main sequence

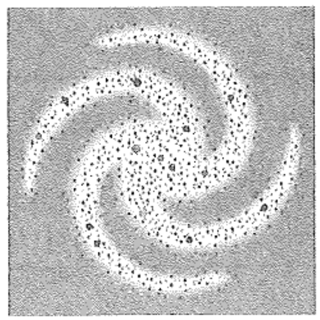
8. A light-year is the distance light travels in one year, about 9.5 trillion kilometers. If it takes 5 years for light from a star to reach you, how many trillions of kilometers away from you is that star?



9. Which of the following astronomical tools uses a prism to separate light into its characteristic colors?

- **A.** radio telescope
- **B.** reflecting telescope
- **C.** spectroscope
- **D.** satellite

10. What type of galaxy is shown below?



- **A.** irregular
- **B.** spiral
- **C.** elliptical
- **D.** regular

11. What is a space probe and what are the advantages of using space probes to explore objects in the solar system?

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12. Which of the following shows the correct order for systems in space from smallest to largest?

A. solar system → galaxy → universe

B. universe → solar system → galaxy

C. space probe → universe → solar system

D. galaxy → solar system → universe

13. A light-year is the distance light travels in a year, or 9.5 trillion kilometers. If a star is 8 light-years from Earth, how far away is it?

A. 7.6 kilometers

B. 1.2 trillion kilometers

C. 76 trillion kilometers

D. 1.5 trillion kilometers

14. Which of the following BEST describes a galaxy?

A. a huge body of interstellar gas and dust

B. an irregularly shaped rocky object in space

C. a group of billions of stars, space dust, and gases held together by gravity

D. an attractive force that works to pull objects together

15. Identify and describe one effect of space exploration on the culture and economy of Florida.

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16. Which of the following is an example of a spinoff resulting from the space program?

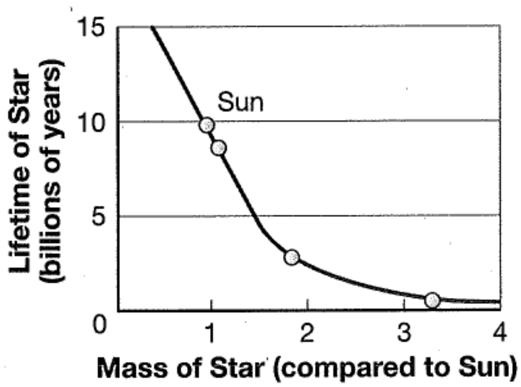
A. space probe

B. space shuttle

C. telescope

D. cordless tools

17. The graph compares star mass and lifetime. Based on the graph, which statement is TRUE?



A. The lifetime of a star is inversely proportional to its mass.

B. Stars with greater mass generally live longer than less massive stars.

C. Stars that are two to three times the mass of the sun are younger.

D. The relationship between the lifetime of a star and its mass is linear.

18. Which property of a star does absolute magnitude describe?

A. color

B. temperature

C. age

D. brightness

19. Which of these is largest?

A. the sun

B. solar system

C. universe

D. galaxy

CHAPTER

4 Properties of Matter