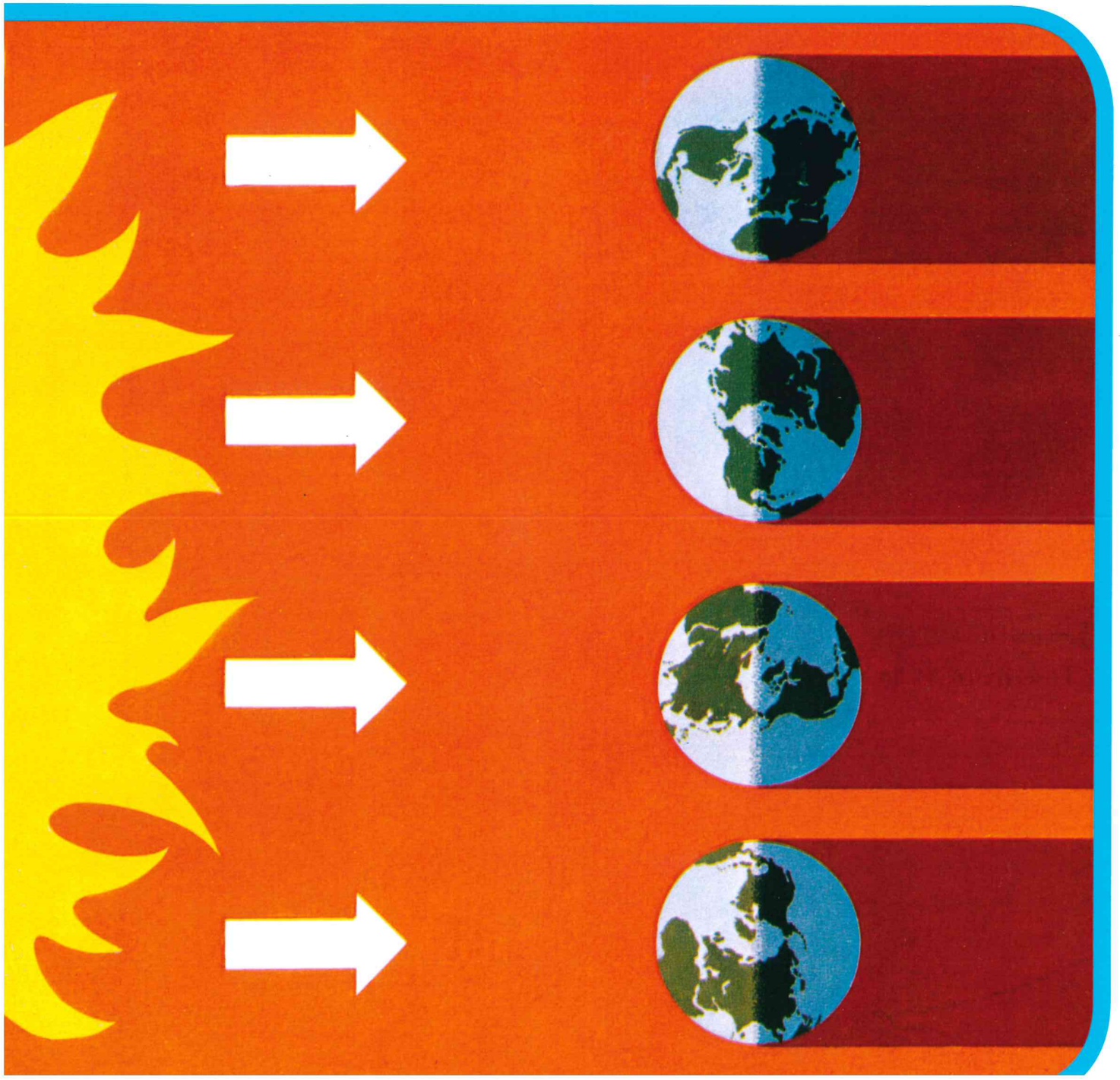
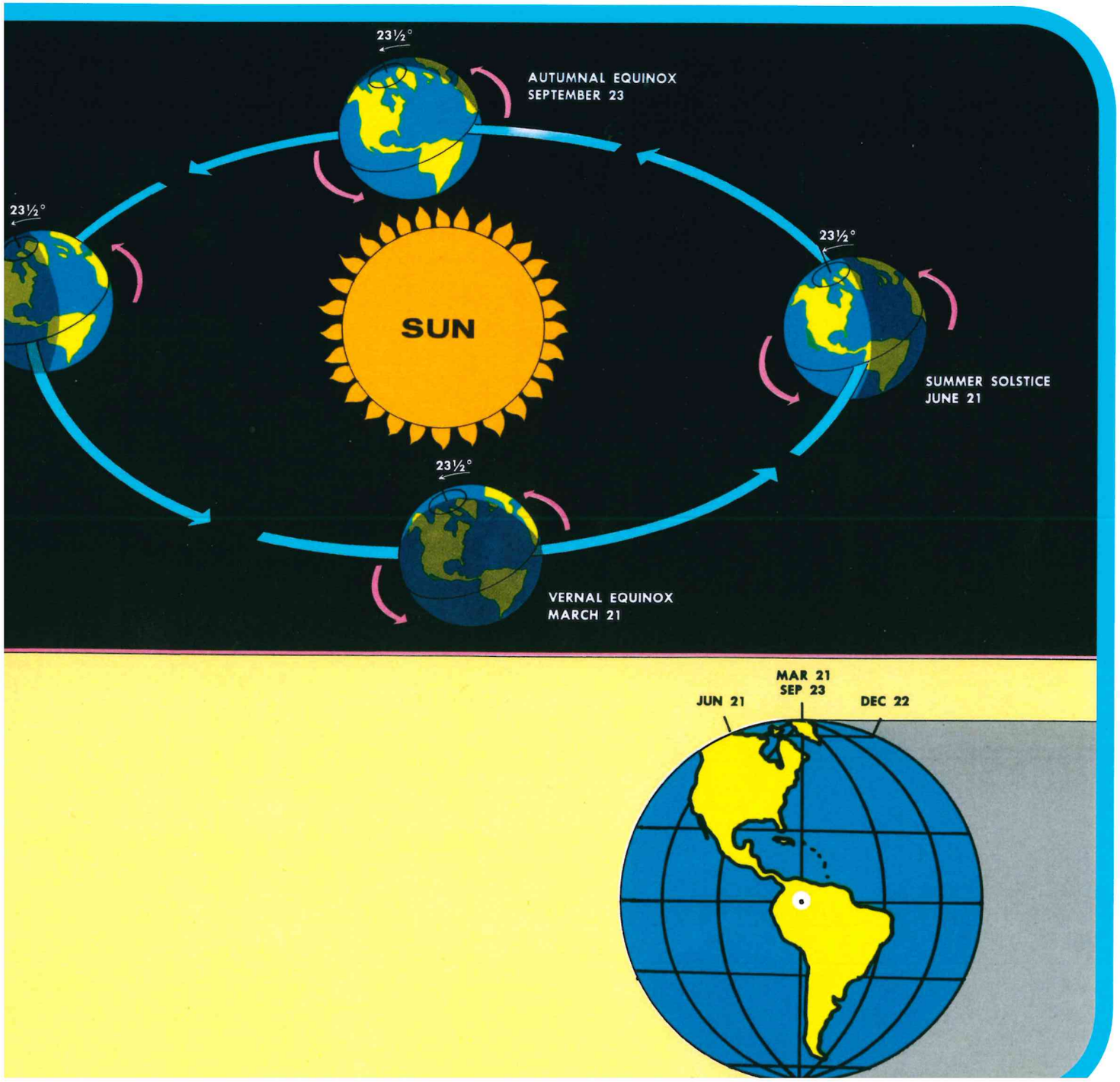


Day and Night

On the surface of the Earth, day and night are described in terms of the *apparent* movement of the sun. Day begins when the sun appears to rise over the eastern horizon, and lasts until the sun sets in the west and night begins. Can you describe the true or *actual* movement of the Earth and sun?

If you could stand high above the Earth's North Pole, you would see clearly the difference between day and night. You would see the Earth turning slowly in a counter-clockwise direction. The sun would be shining on one side of the Earth and the other side of the Earth would be dark. As the Earth turned, you could watch one location, a city for example, emerge from the darkness into the light. That is, you would see it emerge from night into day. Later, the city would pass from the lighted side of the Earth to the dark side. In other words, the city would pass from day into night.

You can see from the illustration at the left that places east or west of each other have different "solar" times. That is, *solar noon* does not occur at the same moment in both places. Yet "clock time" may be the same for several hundred miles east or west of a given point. Different places have the same clock time because of the establishment of *standard time zones*. The boundaries of the time zones run approximately north and south, and each time zone is about 15° wide. Are the imaginary lines that separate time zones actually straight lines? If they are not, can you give some reasons why they aren't? Standard time differs by one hour from one time zone to the next. Why do you think standard time zones were established? Why are they about 15° wide on the average, instead of 25° or 30°?



The Seasons

The climate north and south of the equator undergoes seasonal changes because of the "tilt" of the earth's axis. The axis through the earth's poles forms an angle of 23 ½° with the plane of its orbit around the sun. As a result of this "tilt," would the sun shine longer and more directly on places north of the equator during one part of the year?

The start of spring, summer, autumn and winter occurs at specific moments during Earth's yearly orbit around the sun. When spring and autumn start, what is the position of the Earth in regard to the sun? Can you explain why there is a precise 12 hour daylight period at all latitudes at these two times in the year? These moments in time are called the *equinoxes*, meaning "equal day and night." Can you give the date of the *vernal equinox*? The *autumnal equinox*?

Summer and winter start when the Earth's shadow-line falls at the maximum distance from the north and south poles. The unequal lighting represents the year's longest daylight period in one hemisphere, and the shortest in the other. These moments in time are called *solstices*. What are their dates?

You know that summer starts about halfway between the beginning of spring and the beginning of autumn. Carefully study the position of the Earth in its orbit at the instants when the equinoxes and solstices occur. Then describe how long it takes for the Earth to travel from one point to the next, and compare the times. Remember that the equinoxes and solstices are not whole days, but only moments that occur on the days indicated.

Notice that the Earth's shadow falls at its maximum distance from the poles at the summer and winter solstices. Explain how the periods of day and night there are considerably different than the periods at other latitudes during these times of the year.

From what you understand about how seasons are caused, explain why the area at the Earth's equator has little seasonal change in comparison to an area at, for example, 40° north latitude.

The Planets

The planets that orbit the sun are among the most interesting objects in the universe. They are tiny objects and are not very numerous when you compare them to the billions of stars just within our own galaxy. How many planets have so far been discovered in our solar system? Name each of them, beginning with the one closest to the sun out to the farthest planet.

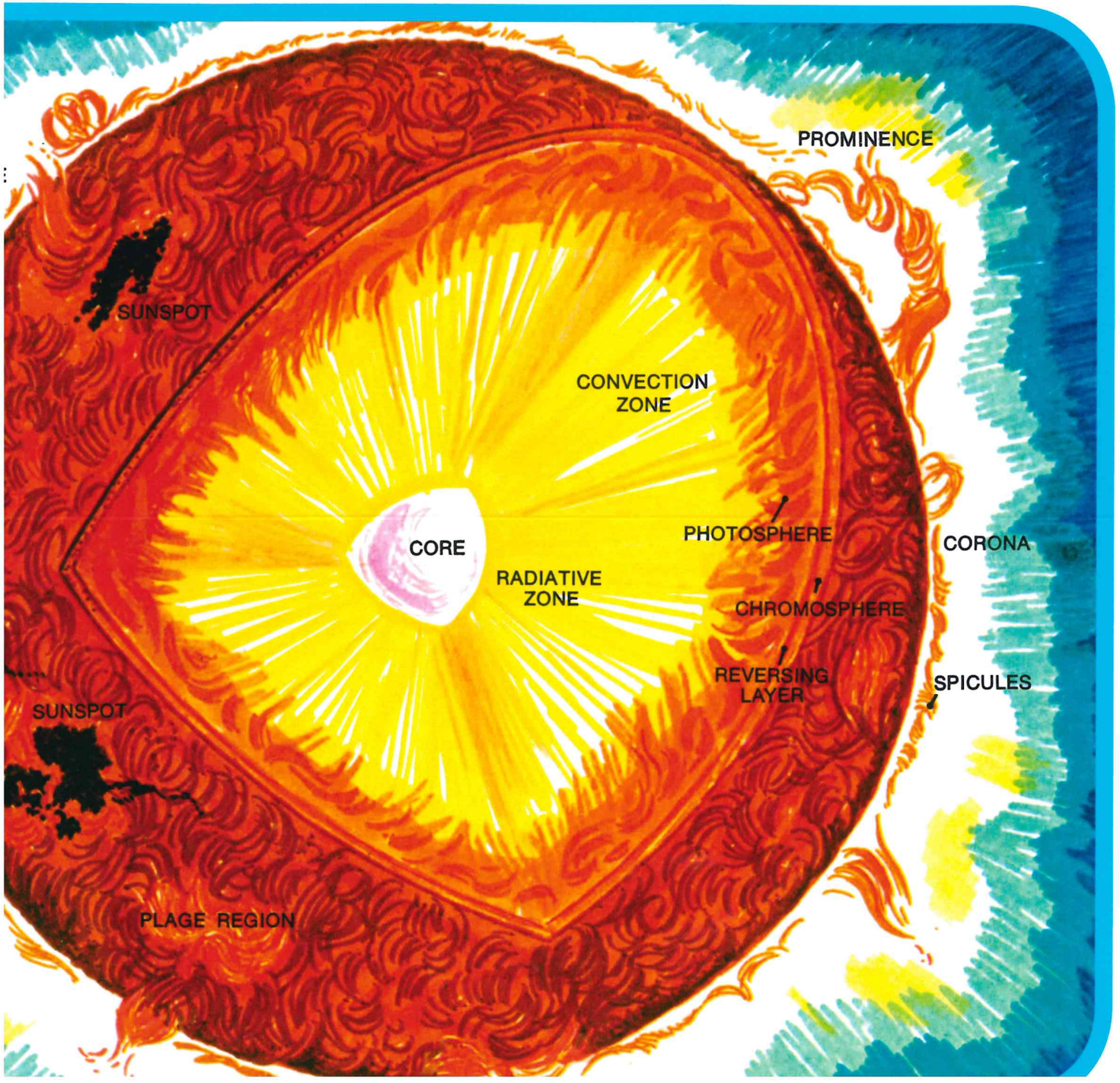
Astronomers have always been very interested in our sun's planets. Many believe they are similar to other planets that probably exist in orbit around other stars in the universe. Each of our planets is unique, however, and has distinct features. Can you name one unique feature for each planet?

The planets in our solar system travel in *elliptical* orbits around the sun, and their orbits lie in almost the same plane. Can you describe the difference between an ellipse and a circle?

Some planets appear in the sky for only a short time just after sundown or before sunrise. In your "mind's eye" hold the Earth in one position in its orbit, and imagine the other planets revolving around the sun. Which planets can be seen from Earth in the middle of the night? Which ones can be seen only near the sun at dusk or sunrise?

The distance from the Earth to any other planet changes as both planets revolve around the sun. When is another planet closest to the Earth? When is it farthest away? Can all the planets be seen without using a telescope?

As the planets revolve around the sun, their location in the sky continually changes. When does a planet appear largest in the sky? When does it appear smallest? When is the full lighted disk of the planet visible from the Earth?



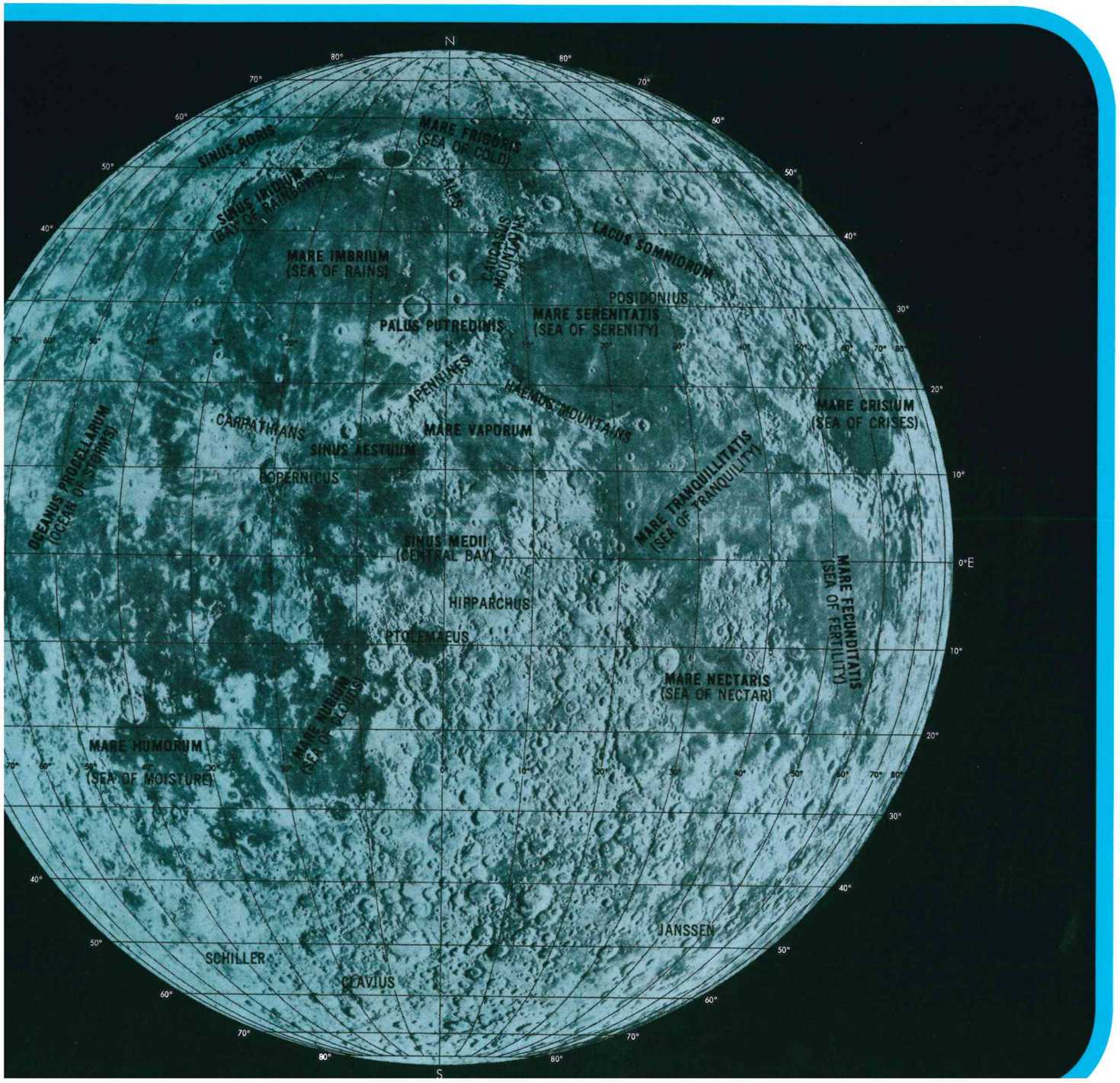
The Sun

The sun is a star and has a complex structure that is difficult to study from Earth. The illustration at the left shows the most important features that astronomers have been able to discover about the composition of the sun. Also shown are various phenomena (or actions) that occur on the sun.

The surface of the sun visible from Earth, is called the *photosphere*. The most familiar features on the photosphere are the dark *sunspots*. Why do they appear darker than the area around them? The entire photosphere contains an enormous number of *granules*, somewhat similar in appearance to the cells in a beehive. The granules are thought to consist of hot gases rising in the center, with cooler gases sinking down into the sun along the edges. *Spicules* appear to be jets of hot gases that rise momentarily from the granules. Larger eruptions from the photosphere are called *solar flares*.

The sun also has an "atmosphere" that surrounds the photosphere. The inner region of the sun's atmosphere is the *chromosphere*. The innermost part of the chromosphere is called the *reversing layer*. It absorbs some of the sun's light and sends it out in different directions. The outer layer of the sun's atmosphere is called the *corona*. It extends millions of miles into space. Does the corona appear to be a region of violent activity? The corona becomes visible only when the photosphere is completely hidden from view during a total solar eclipse. Bright *solar prominences* are solar phenomena that originate in the corona. Describe the differences between a prominence and a solar flare. Places of unusual solar activity are also generally accompanied by *plage regions* that emit the light characteristic of the spectrum of calcium.

The interior regions of the sun include the *core*, the *radiative zone* and the *convection zone*. The core is, in a way, the sun's "furnace." Can you describe what occurs in the sun's core? What happens in the radiative zone? In the convection zone?



The Moon

This view of the moon shows much more detail than you can see when you look at the moon without the aid of a telescope. The moon has been assigned latitude and longitude lines to provide a reference system for locating points on the surface. What are some types of physical features of the lunar surface shown and identified here?

Many features on the moon's surface have Latin names, because they were named during the time when Latin was the language used by astronomers. The *maria* (singular: *mare*), or seas, were first thought to be similar to oceans on earth. What is the difference between a *mare* and a *sinus*?

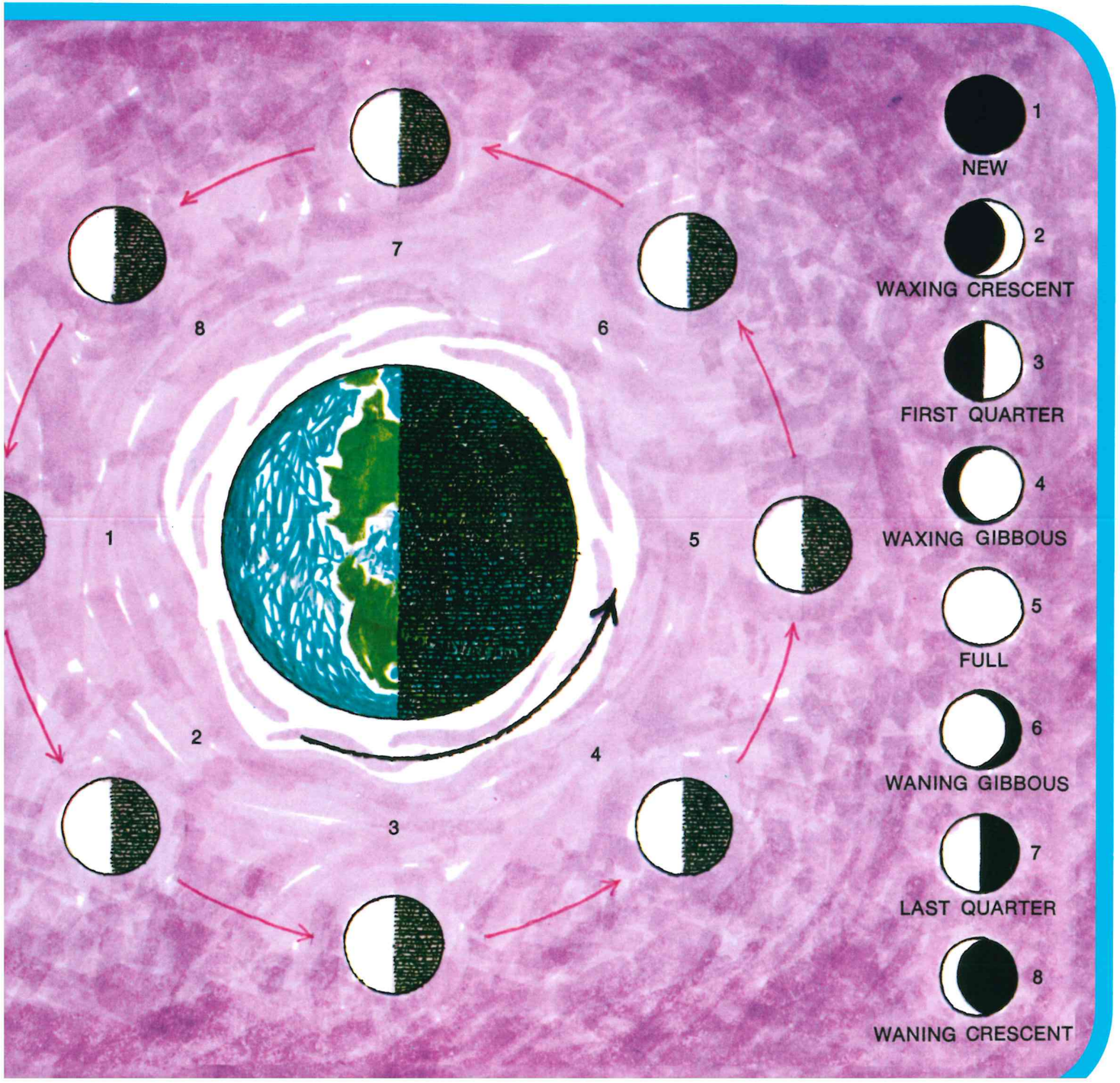
The craters of the moon are very striking physical features. The largest have been named for famous astronomers, such as Copernicus and Ptolemy. How do you think the craters were caused?

Notice that many craters overlap one another. For example, a set of three overlapping craters can be seen at about 40° S. latitude, 0° longitude. Which of these craters do you think is the oldest? Which is the youngest? How can you tell? Look carefully at the lunar surface for other overlapping craters, and try to determine which are the oldest.

Notice also that many craters have a point in the center. A good example is located at about 15° N latitude, 23° E longitude. Is the central point higher or lower than the rest of the crater floor? How can you tell?

The maria are almost completely without craters. Can you think of possible reasons for the absence of visible craters? In working out an explanation, try to take into account how the craters were formed, how surface conditions on the moon could affect their formation, and how lighting conditions might affect the visibility of craters.

Can you locate the landing sites of Apollo 11 and Apollo 12? Why do you think these sites were chosen?



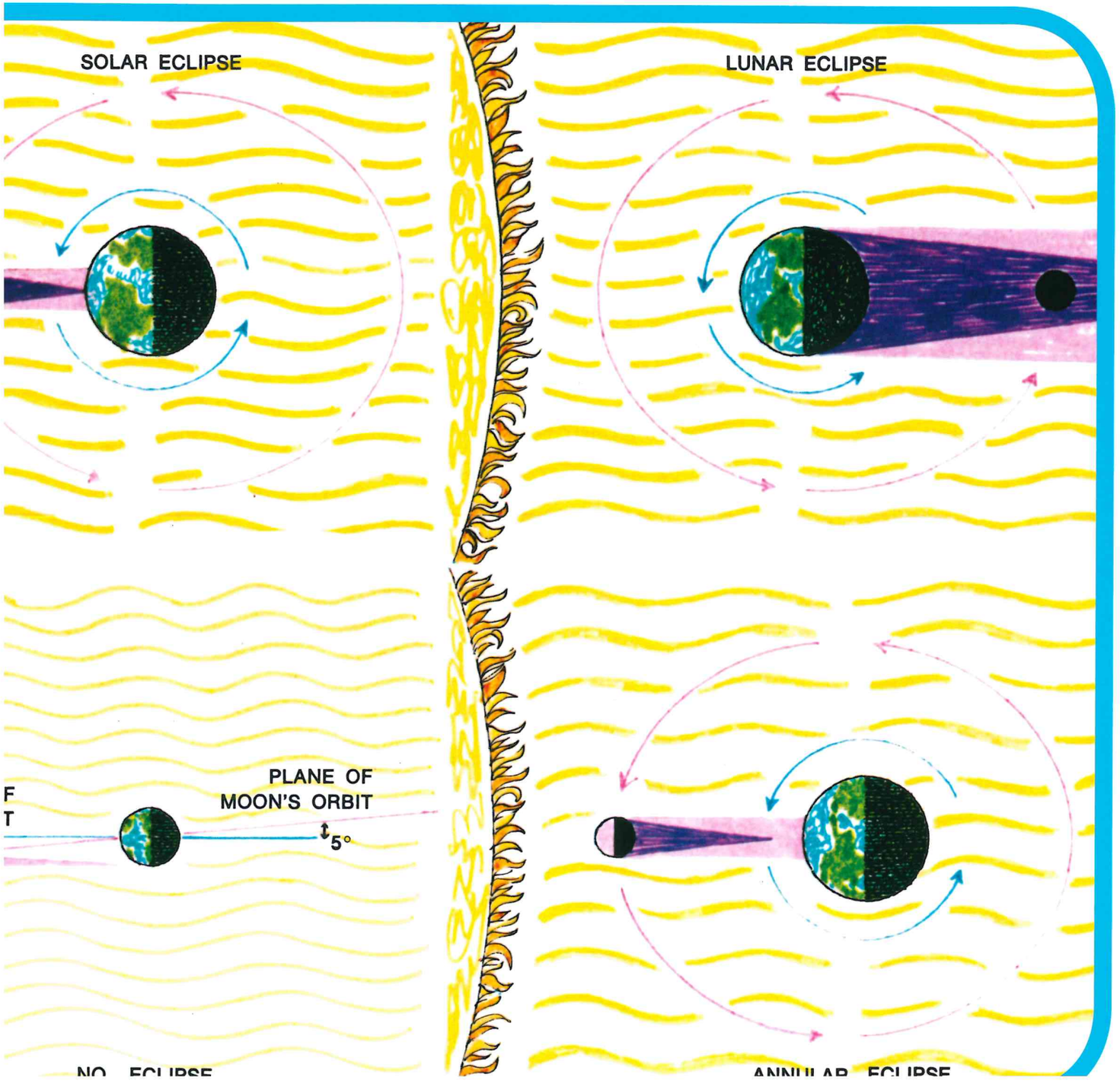
Phases of the Moon

One of the first things a person notices about the moon is that throughout the month it seems to keep changing its shape in the sky. The different appearances of the moon are called its *phases*. The sun lights only half of the moon. The sun does the same to Earth which is the cause of day and night on our planet. The side of the moon away from the sun is in darkness. As the moon revolves around the Earth, different portions of the lighted half become visible from Earth. Why do we only see certain portions of the lighted half? Can you demonstrate this?

When the moon is between the Earth and the sun, we cannot see the lighted half of the moon. What is this moon phase called? After the moon moves a short way in its orbit, only a thin, curved sliver of the lighted half can be seen. What is this phase called? As the lighted portion becomes visible from the Earth, the moon is said to be *waxing* (becoming larger). The *first quarter* phase appears when half the lighted part can be seen. When more than half the lighted part can be seen, the moon is entering another phase. What is this called? The moon finally reaches a position in its orbit where the entire lighted portion can be seen. What is this phase called?

As the moon continues in its orbit, less of the lighted half can be seen from the Earth, and the moon is said to be *waning* (becoming smaller). All the phases repeat in the reverse order. Identify them in this reverse order. When the moon reaches the new moon phase again, the cycle is complete. The time from one new moon to the next is 29 ½ days.

The illustration uses the numbers 1 through 8 to show the eight major phases of the moon; each one revealing the moon's location in relation to the sun and Earth. A separate panel shows how the moon would appear to a person on Earth at each of these phases.



Eclipses

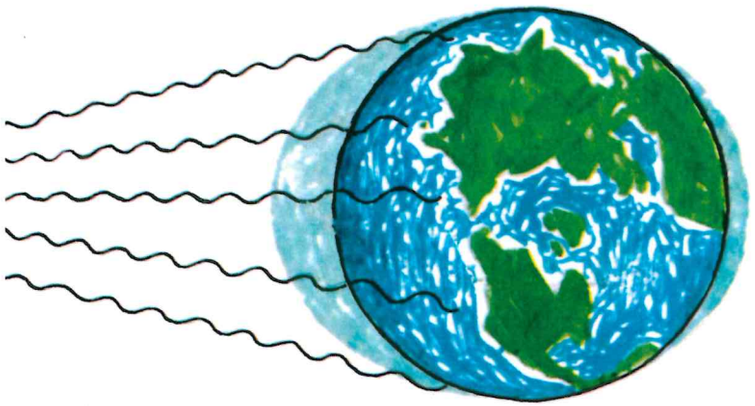
There are two basic types of eclipses that can be seen from the Earth: an eclipse of the moon and an eclipse of the sun. Describe the positions of the Earth, sun, and moon during these two eclipses. Eclipses, however, only occur at certain times and they are not frequent. Use the panel which illustrates the plane of the moon's orbit to help you explain why this is so.

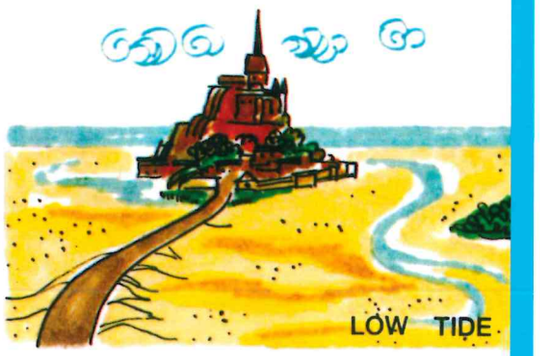
A *lunar eclipse* occurs when the moon passes through the earth's shadow. What phase is the moon at when this happens? The shadow of the Earth extends away from the Earth toward the moon. The sun is so large that the shadow has two parts, each in the shape of a cone. The darkest part of the shadow is the region where the sunlight to the moon is completely blocked by Earth. What is this part of the shadow called? What is the lighter shadow region called?

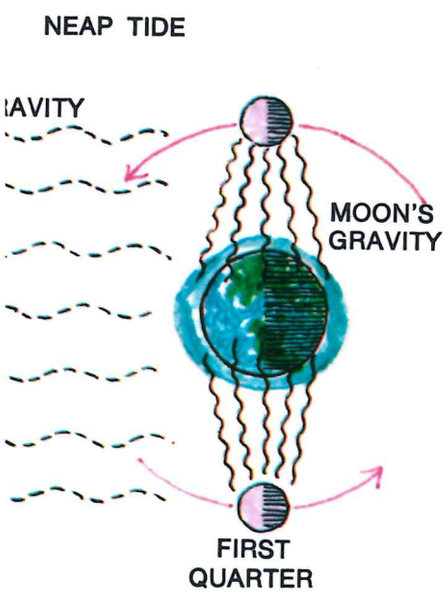
If the entire moon passes through the umbra, the eclipse is *total*. If only part of the moon passes through the umbra, or the moon passes only through the penumbra, the eclipse is *partial*. A *solar eclipse* occurs when the shadow of the moon falls on the surface of Earth. Like the Earth's shadow, the shadow of the moon consists of a dark central region and a lighter region around it. The umbra is only a few miles in diameter at the place where it falls on Earth's surface. To see a total solar eclipse, you must be at a point within the path of the umbra as it sweeps across the Earth. If you are within the penumbra region, you will only see a partial eclipse. The penumbra is much wider and a partial solar eclipse can be seen from a large area on either side of the path of the umbra.

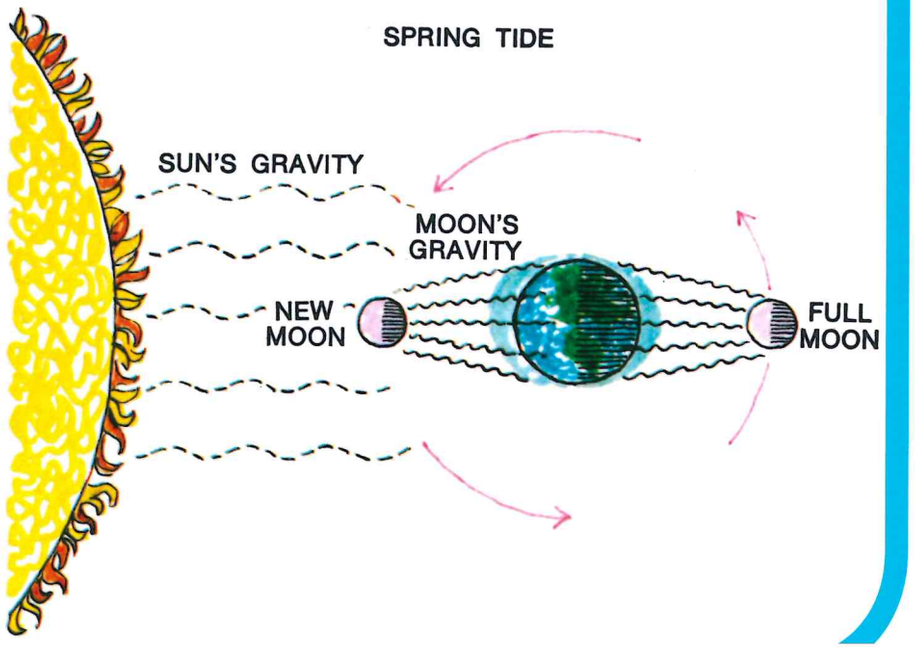
A type of solar eclipse is called *an annular eclipse*. Using the panel at the left which illustrates this, describe the difference between an annular and a regular solar eclipse.

During a solar eclipse, you should never look directly at the sun because of the damage it could do to your eyes. Can you think of other ways to view a solar eclipse?









Day and Night

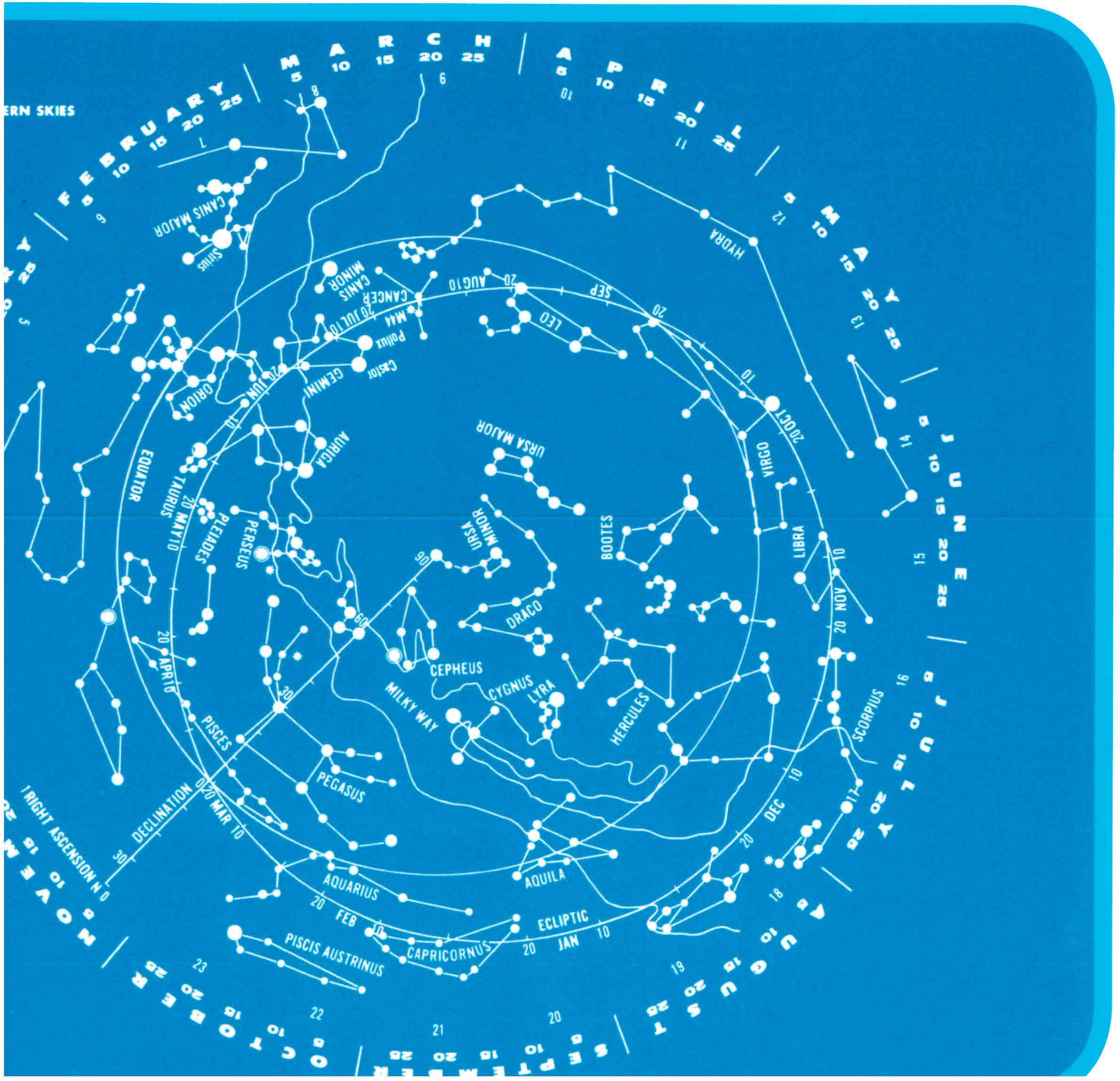
The rhythmic rise and fall of the ocean tides is a result of the rotation of the Earth and the gravitational pull of the moon and sun. The ocean covers almost three-fourths of the total surface of the Earth. Because water can easily change its shape, the pull of the moon and sun cause "tidal bulges" in the ocean.

The moon's effect is greater than that of the sun. Why would this be so? The pull of the moon is stronger on the near-side of the Earth than on the far-side, and therefore pulls the water on the near-side toward it. A bulge of the water on the far-side is also created because the moon's gravitational force also pulls the land away from the water on the far-side of Earth. This would create what kind of tide on the near and far sides of the Earth? In areas midway between the near-side and far-side, what kind of tide would be caused?

When the Earth, sun and moon are lined up in a straight line, the gravitational pull on the Earth is the strongest. The result is a larger than normal rise and fall of the tides. What are these large tides called? How often each month do they occur? When the sun and moon pull in directions 90° from each other, the resulting high tides are smaller than normal, and the low tides are higher than average. What are these tides called?

As the Earth turns, each point on the seacoast passes through both tidal bulges every day. Thus, the tide rises twice a day and falls twice a day. The time between tides is not exactly six hours because the moon moves slightly faster in its orbit than the earth rotates. The full time between a high tide and low tide is about six hours and 15 minutes.

Do spring tides have any relation to the season of spring on Earth? Small lakes, rivers and streams do not have noticeable tides. Can you explain why?



Star Chart (North)

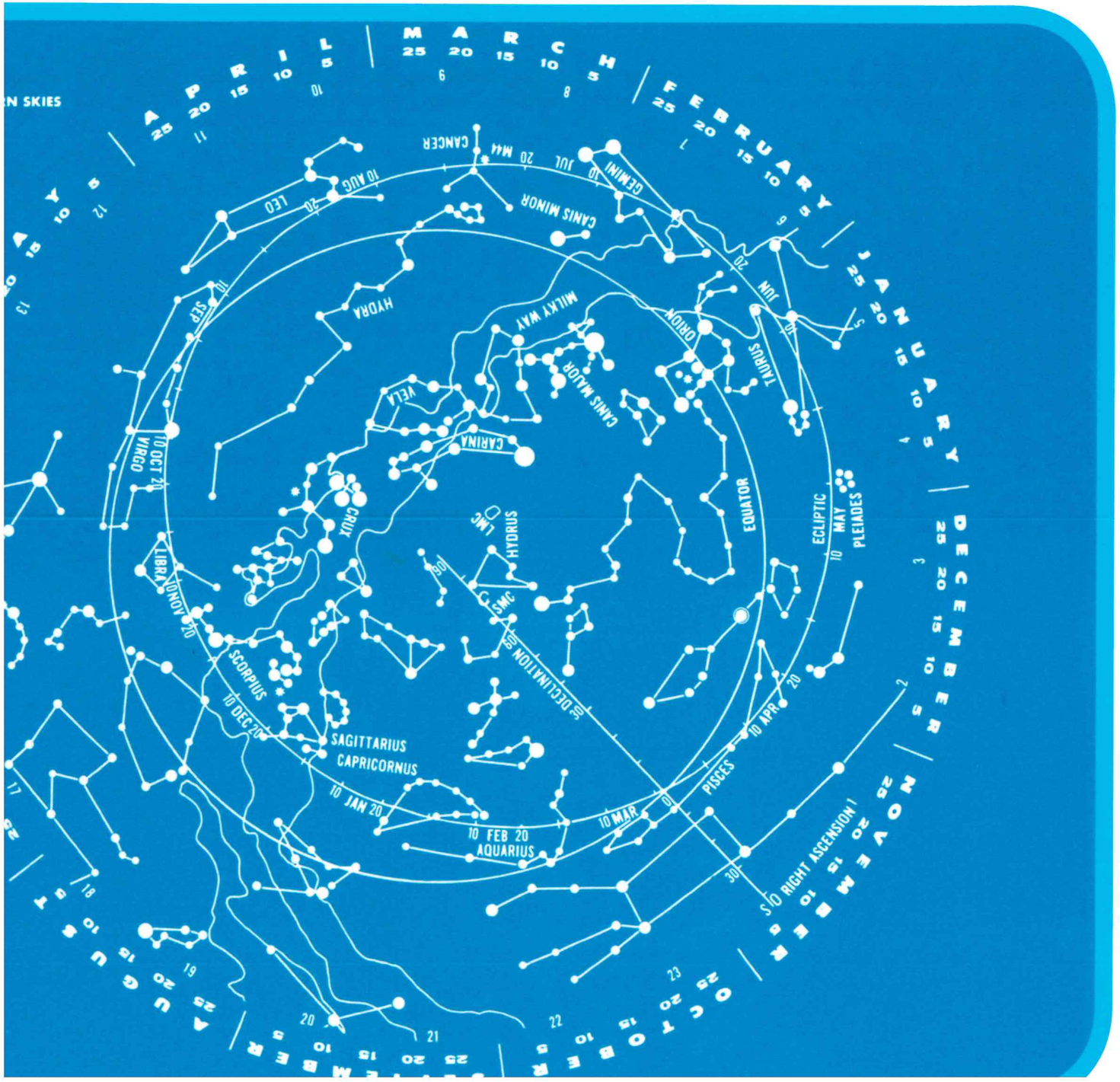
This star chart shows the entire Northern skies, visible throughout the year from 40° North latitude. All of these stars, of course, cannot be seen on a particular date.

As the earth revolves around the sun, the positions of the stars in the night sky change according to the Earth's position in its orbit, and the hour of observation. Why would the position of the stars be different at midnight than at 9 p.m. on a specific date?

The sun is so bright that it blots out the stars on the daylight side of the earth. On the night side, the full circle of stars comes into view as the Earth progresses in its orbit around the sun. If it were possible to see the stars around the sun, you would see that the sun's position among the stars continually changes during the year as the earth moves around the sun. The apparent path of the sun through the stars is called the *ecliptic*. Point out the ecliptic on the star chart. The dates along the ecliptic show the sun's position against the background of stars on that day. The circle that represents the *celestial equator* shows the stars that lie in the plane of the earth's equator. Stars that are outside the celestial equator are located in the southern celestial hemisphere. A few can be seen by looking south from 40° North latitude but most are not visible to people viewing the skies from Earth's northern hemisphere. They could not be seen at all from the North Pole.

If you observed the stars from the North Pole, Polaris would appear directly overhead. If you observed the stars from a point on the equator, the stars along the celestial equator on the star chart would pass directly overhead. Which stars do you think will pass directly overhead if you observe them from 40° N. latitude? Indicate these stars on the star chart.

Point out some of the familiar constellations. Can you find the 12 constellations of the Zodiac? How do they relate to each other?



Star Chart (South)

The stars visible in Earth's southern hemisphere are different than those visible in the northern hemisphere. This star chart shows the entire southern celestial hemisphere that can be seen at night at 40° South latitude. Why do you think different stars are visible in the southern hemisphere?

Polaris is at the center of the northern celestial hemisphere. Is there a star at the center of the southern celestial hemisphere?

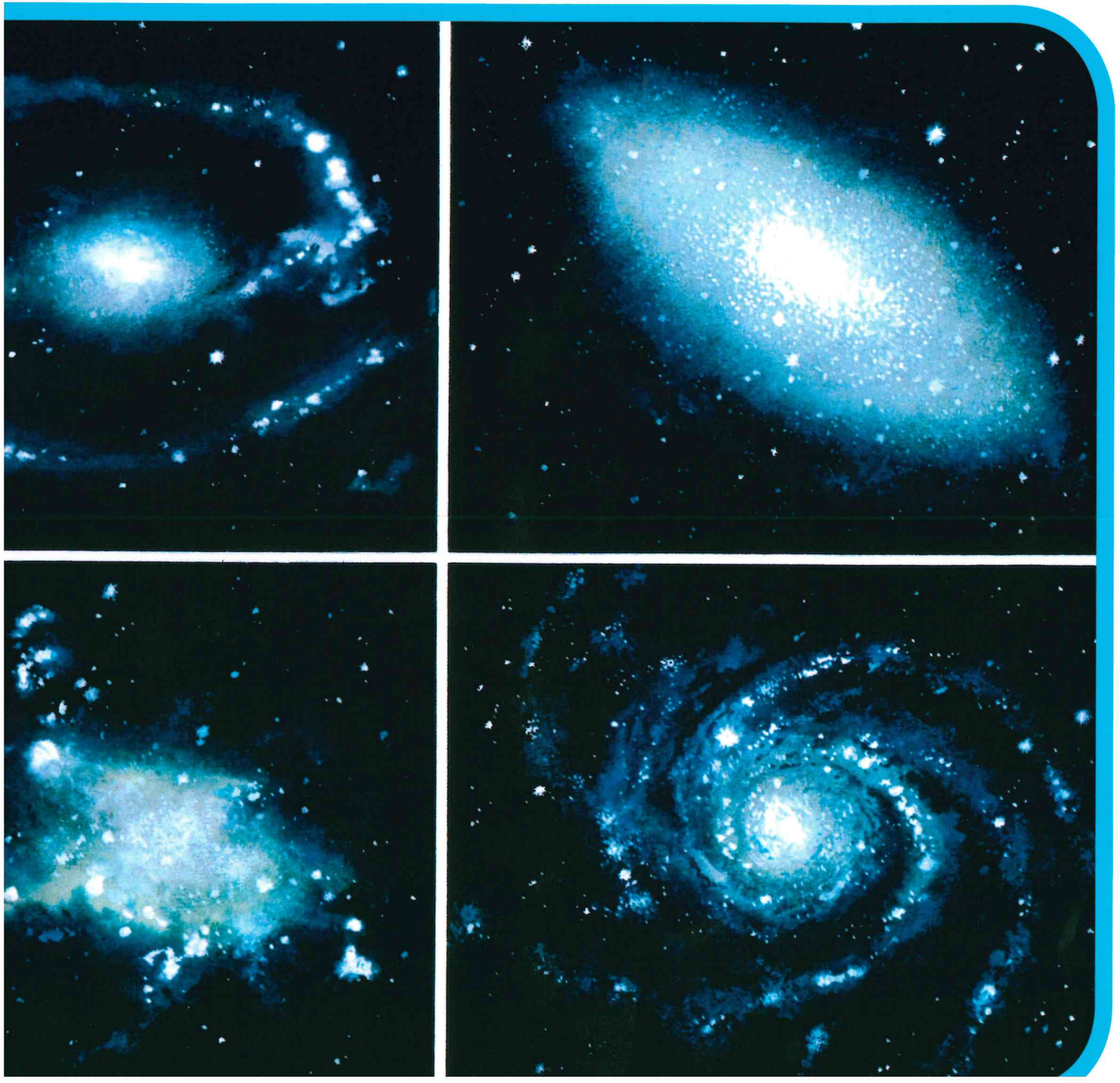
If it were possible to see the stars around the sun, you would see that the sun's position among the stars continually changes during the year as the Earth moves around the sun. The apparent path of the sun through the stars is called the *ecliptic*. It is shown here as well as on the star chart of the northern skies. The dates along the ecliptic show the progression of the sun throughout the year.

The *celestial equator* shows the stars that lie in the plane of the Earth's equator. Stars that lie above, or north of, the equator are located in the northern celestial hemisphere. They cannot be seen at all from the South Pole.

The center of our galaxy, the *Milky Way*, is in the direction of the constellation *Sagittarius*. The sun passes through that spot in the sky on about December 21. How are the positions of the sun, the earth and the center of the galaxy related on that date?

On the same date, December 21, the stars that appear directly overhead at midnight when viewed from the equator are not part of the dense band of stars called the *Milky Way*. Can you figure out why? Which direction are you looking when you view these stars?

Name some of the well-known constellations in the southern skies.



Galaxies

Galaxies are huge collections of stars and clouds of gas in space. Our own galaxy contains about 100 billion stars, one of which is our sun. Astronomers also estimate that about 100 billion galaxies exist in the known universe. There are four major types of galaxies.

Normal spiral galaxies are the most common in the universe. They have a fiat, spiral shape with arms trailing off into space. Describe some of the characteristics of a normal spiral galaxy that are illustrated in the panel at the left.

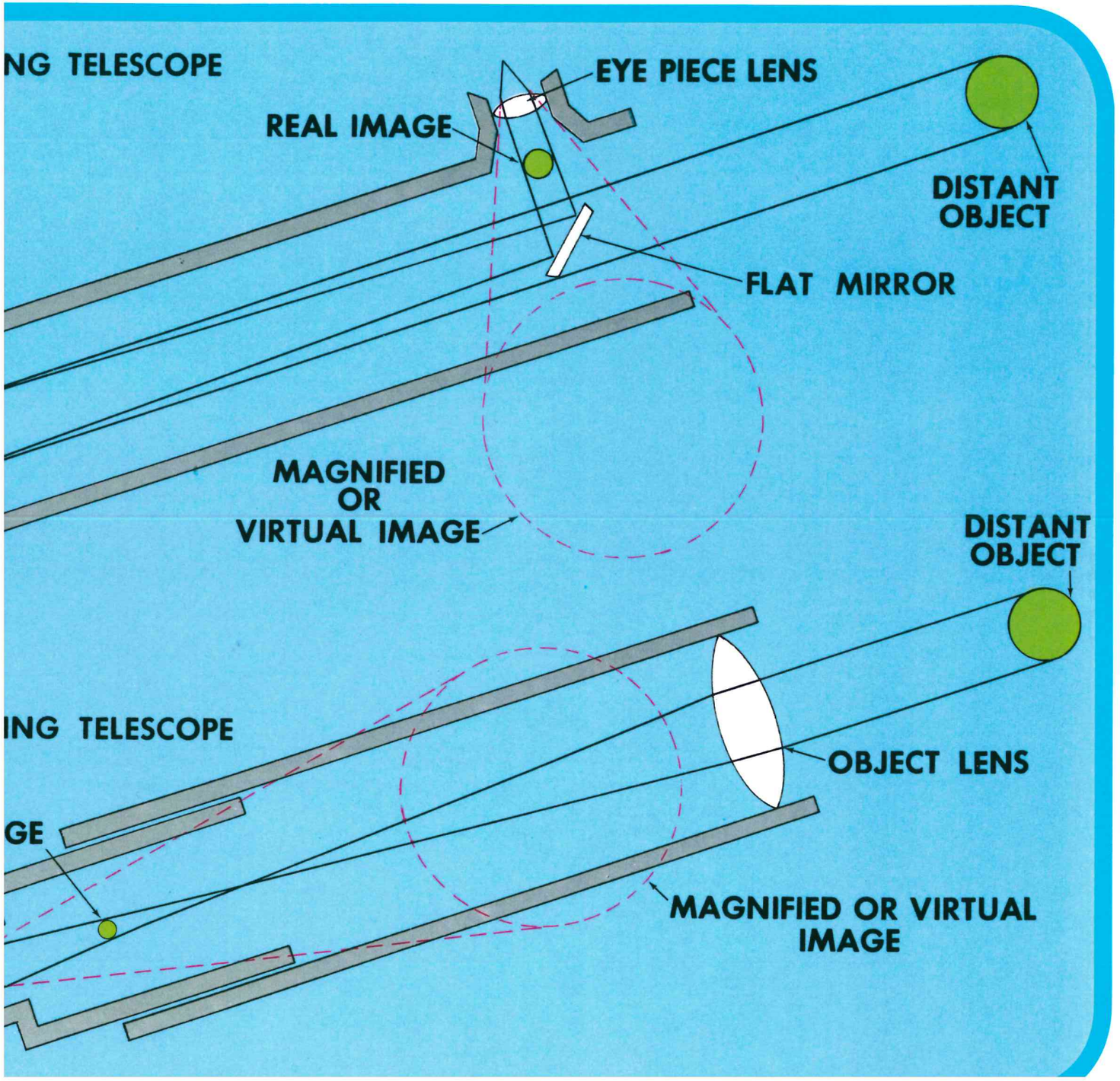
Barred spiral galaxies are another type of spiral galaxy. They have two curved arms extending from the ends of a central bar of gas and stars.

Elliptical galaxies make up about one-fifth of all galaxies. They are either round or somewhat flattened, without spiral arms. Elliptical galaxies generally contain older stars than spiral galaxies, and they contain little or no gas.

Irregular galaxies make up only about five percent of all galaxies. They have no identifiable shape. Irregular galaxies contain more gas clouds and more young stars than other types.

Many people have thought about the possibility that other intelligent beings may live on other planets in the universe. Suppose one star in 1000 has planets, and that among these stars, one in 1000 has a planet with conditions that could support life. Suppose further that among these planets, one in 1000 actually has intelligent life on it. If all these assumptions were correct, how many planets in the universe would have intelligent life?

Our galaxy is called the Milky Way. What type of galaxy is it? When you determine this, can you pinpoint the location of the sun in our galaxy on the proper illustration at the left?



The Telescope

There are two basic kinds of optical telescopes used in astronomy: *the reflector* and *the refractor.* Both form a real image, which is viewed through a magnifying eye-piece lens. And the viewer then sees an enlarged *virtual* image.

In the reflecting telescope, the real image is formed by reflection from a concave parabolic mirror. Light from a distant object is brought to a focus in front of the mirror. The mirror reflects the incoming light back to a small flat mirror. The viewer, looking in from the side, sees the virtual image from the small fiat mirror.

In the refracting telescope, the real image is formed by the *refraction* (bending) of light rays by an object lens mounted in one end of the telescope tube. An eye-piece lens is mounted in the opposite end of the tube. The viewer looks in the eyepiece-lens end of the telescope to see the magnified virtual image.

Which of the two types of telescopes is most widely used in astronomy? Do you think it would be easier to make an extremely large lens or an extremely large mirror?

The larger the diameter of the telescope, the more light it can gather. The largest reflecting telescopes are about 200 inches in diameter, about five times the diameter of the largest refracting telescopes. Since the light-gathering power depends on the area of the lens or mirror, a 200 inch reflecting telescope can gather about 25 times as much light as a 40 inch refractor.

What is another kind of telescope used in astronomy that is not optical? Can you describe how it gathers an "image"?

Telescopes have been sent into orbit around the Earth aboard satellites to observe the skies. Why can they observe the skies better than telescopes on Earth?