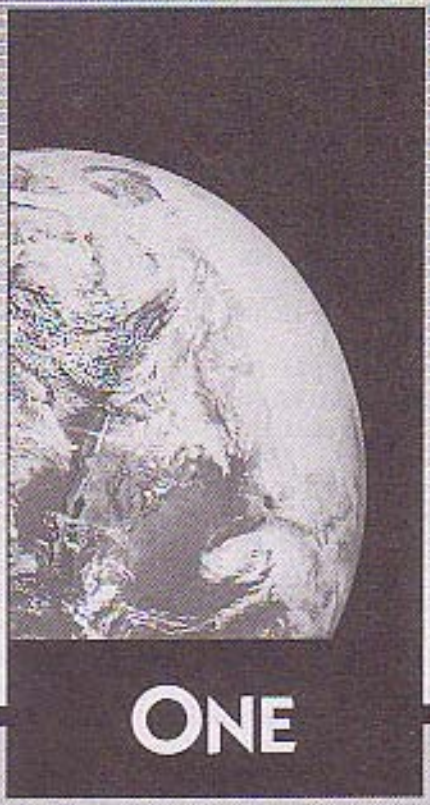
Activity 1
Bulletin board idea:
Contrast the points of the geocentric and heliocentric theories, and/or list names of important men under each theory.



NASA photograph of earth

THE EARTH'S MOTIONS

ONE

Begin with a discussion of optical illusions. Information is in most encyclopedias. Make sure that students understand that while observation is the key to science investigations, our senses sometimes fool us and lead us to wrong conclusions. Remind them that this is the limitation of science which states that "science is fallible." See transparency master 1-a from the visuals packet.

Use transparency master 1-b with its overlay from the visuals packet to demonstrate this illusion of a star dome.

1A–Does the Earth Move?

Does the earth move? The ground under your feet seems solidly immovable. You feel no sensation of movement. But when you ride in a good car at a steady speed, movement is also difficult to feel. How do you know that the car is moving? You observe movement by looking at your surroundings. In the same way, the earth's surroundings—the heavens—can show whether the earth is moving.

The Geocentric Theory

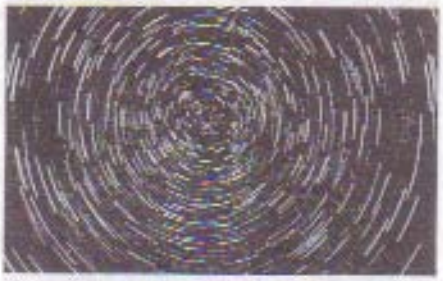
When you stand outside looking at the night sky, you may get the impression that you are at the center of a large dome. All the stars seem to be attached to the dome. As you watch the sky for a time, the dome appears to be turning. When you come back the following night and look again, the sky seems to have made one complete turn and come back

2

Objectives—Chapter 1A-1

- Identify the main tenets of the geocentric theory.
- List the early proponents of the geocentric theory.
- Explain several problems associated with the geocentric theory.

to the position where you saw it the previous night. You may decide that the sky is not just a dome but is a whole sphere (like the inside of a hollow ball) that surrounds you. Ancient observers drew this conclusion. From such observations they reasoned that the earth is stationary and that the sky turns around it.



1A-1 *In this time exposure, the stars appear to move counterclockwise around the North Star.*

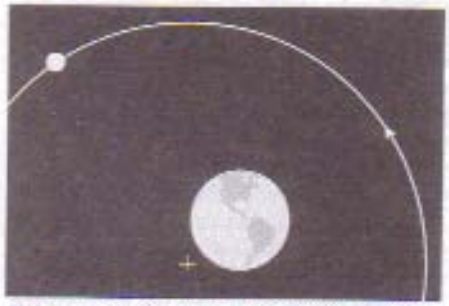
Yet early star watchers noticed that seven heavenly bodies were different from the others. These seven bodies were the sun, the moon, and five planets: Mercury, Venus, Mars, Jupiter, and Saturn. When the ancients observed these bodies over several weeks, they saw them move slowly among the stars. How could these objects move among the stars if they were attached to the same sphere as the stars? Early astronomers decided that each heavenly body must be turning on its own separate sphere. The spheres must be hollow shells, they reasoned, made of something transparent such as glass so that they would not hide the sky.

The ancient description of the universe is called the **geocentric*** (JEE oh SEN trik) **theory.** According to this theory, the earth is at the center; the moon occupies the innermost crystal sphere; Mercury, the second sphere; and Venus, the third, followed by the sun, Mars, Jupiter, and Saturn in consecutive spheres. The stars occupy the outermost

1A-2 *A model of the geocentric theory of the solar system. The ancients, not knowing the true sizes of the objects, pictured an oversized earth. The objects circling the earth are the moon, Mercury, Venus, the sun, Mars, Jupiter, and Saturn. Ancient astronomers were not aware of the existence of Uranus, Neptune, or Pluto.*

sphere. In modern terminology we call this a **model** of the universe. A model is a simplified picture that a scientist uses to represent what he is studying.

Ancient astronomers thought that the sun's sphere turned once each day. The other spheres turned nearly once each day. The moon's sphere, they explained, turned much slower than the others, allowing the moon to change its position rapidly among the stars. This explained why the moon rises about fifty minutes later each night. The planets' spheres



1A-3 *An attempt to make the geocentric model "work." Because a planet sometimes appears closer and other times farther away, it was suggested that perhaps the earth is not at the very center of a planet's circular orbit.*

geocentric: geo- (Gk. GE, earth) + -centric (Gk. KENTRON, center)

Have an interested student photograph the night sky. On a clear night prop a camera capable of taking long exposures in the direction of the North Star. Make an exposure of several minutes with the camera focused on infinity. A sensitive film such as High Speed Ektachrome (color) or Tri-X (black and white) will work best. Experiment with exposure times from about three minutes up to half an hour or more. The star trails should look similar to the photograph in figure 1A-1.

Use transparency master 1-c from the visuals packet to demonstrate the geocentric theory.

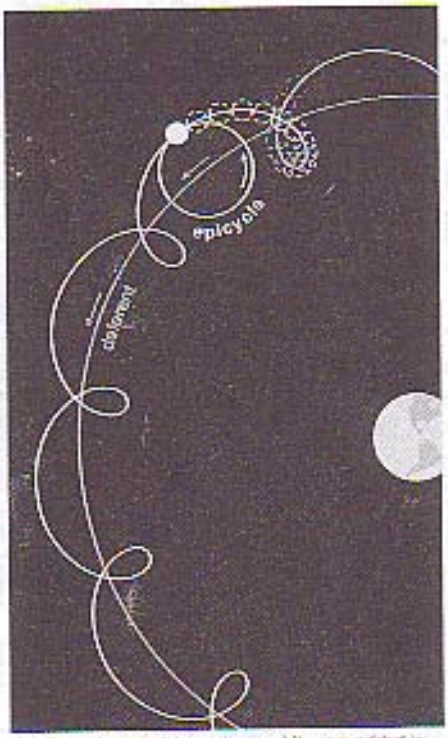
It is generally better not to ask students to memorize the geocentric order, since it makes it difficult for them to learn the correct order later.

turned at slightly different rates, explaining their independent paths among the stars.

Different Greek philosophers and astronomers of several centuries contributed to the geocentric view of the universe. Most notable were Hipparchus (hih PAR kus) in the second century B.C. and Ptolemy (TOLE uh mee) in the second century A.D. Ptolemy played such a large role in attempting to improve the geocentric theory that it is sometimes called the **Ptolemaic theory.**

Several problems with the geocentric model bothered the ancient astronomers. One is that the planets sometimes appear to be large, bright, and close; at other times they seem smaller, dimmer, and farther away. Ptolemy tried to solve this problem by shifting each planet's sphere so that the earth was no longer at its center. Such an off-center circle is called **eccentric.*** This would make the planet on the sphere closer to the earth at times and farther from the earth at other times. This solution offended the ancient sense of beauty because it was not symmetrical, but it helped to make the model closer to reality.

Another problem with the geocentric view is that the planets sometimes slow down in their motion among the stars, stop, and then back up. After tracing out a backward loop, they resume their forward motion. How could the model explain these variations in motion? Could the crystal spheres slow down, stop, and reverse their motion? They could, but that would make the heavens seem somewhat disorderly. Ptolemy preferred to think that the spheres turned at a constant rate. He imagined that the planets moved around small circles called **epicycles*** while each epicycle went around the earth on the crystal sphere. He then called the crystal sphere the **deferent** (DEF ur unt) to distinguish it from the epicycles. With this approach he could explain a backward loop as the planet's moving rapidly backward in its epicycle as the epicycle itself was moving slowly forward around the deferent.



1A-4 *Epicycles, small loops in an orbit, were added in an attempt to correct the geocentric model.*

Although astronomers tried juggling the distances as well as the speeds in their model, the resulting system was still disappointingly inaccurate. In spite of a total of more than seventy separate motions for the seven bodies, a careful observer could find discrepancies between his observations and the model. Two major objections to the geocentric theory are its inaccuracy and complexity. The inaccuracy of the model hinders its ability to

eccentric: ec- (Gk. ek, out) + -centric (center)

epicycle: epi- (Gk. epi, on) + -cycle (Gk. kuklos, circle)

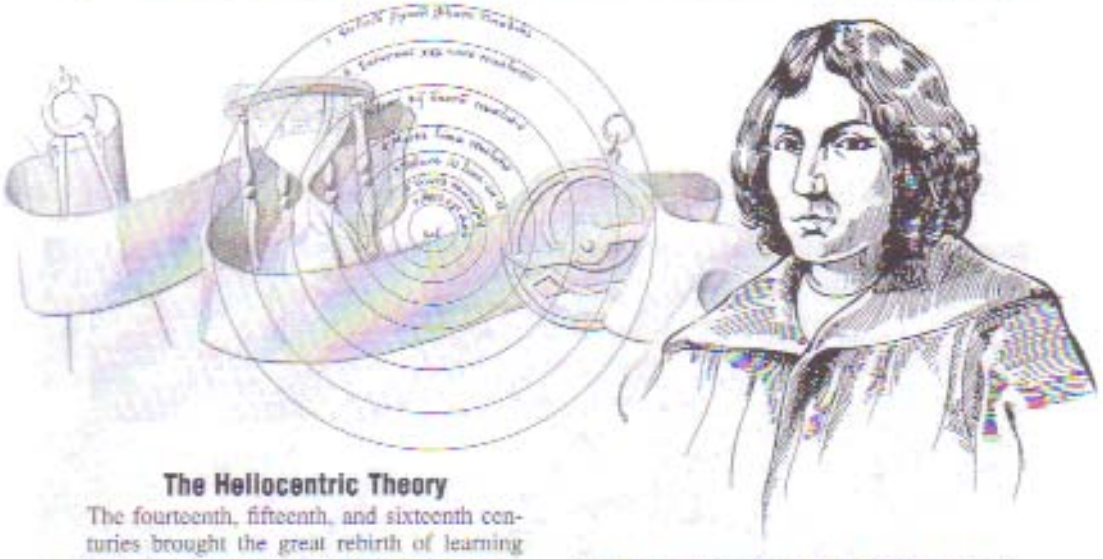
Activity 2: Demonstrate Epicycles
You can easily demonstrate epicycles by having a student slowly twirl a broom above his head as he walks around the room. Students will be able to grasp the concept clearly with this demonstration.

Activity 3
Have an interested student research the "International Flat Earth Society." One source is the Reader's Digest book *Strange Stories, Amazing Facts,* 1990 (ISBN 0-51769109-4). Use the information or have the student report to the class just after covering the section on the heliocentric theory. Emphasize how prejudice (limitations of science) influences scientific thought.

predict where the heavenly bodies would be at a given time, while the complexity of the model makes solving even simple problems time consuming. Complexity is undesirable in a scientific model because it reduces efficiency. However, if no simple explanation exists, a complex model is better than none. Some of God's creations are extremely complex, and oversimplification of them would be an error. So for centuries astronomers used the geocentric model because it was the only mathematical model available.

Section Review Questions 1A-1

1. Besides the stars, what seven heavenly bodies were ancient astronomers able to observe?
2. What is the name of the ancient theory of the universe that states that the earth is at the center and all heavenly bodies revolve around it?
3. What person in the second century A.D. is most noted for his work on improving and promoting the above theory?
4. What did the above astronomer call the transparent spheres in his theory?
5. Some astronomers believed the planets moved in circular loops within their spheres. What were these loops called?



1A-5 *The Copernican model of the solar system (left) is sun-centered. The planets are arranged outward from the sun in the following order: Mercury, Venus, Earth, Mars, Jupiter, and Saturn. Only the moon orbits the earth. Nicolaus Copernicus (right), a Polish astronomer, formulated this heliocentric theory.*

The Heliocentric Theory

The fourteenth, fifteenth, and sixteenth centuries brought the great rebirth of learning called the Renaissance. A renewed interest in every area of culture—art, literature, music, drama, geography, science, and medicine—swept across Europe. There was also a reawakening of interest in the Bible. With Gutenberg's movable-type printing process, the

Answers—Section Review Questions 1A-1

1. the sun, the moon, Mercury, Venus, Mars, Jupiter, and Saturn (p. 3)
2. the geocentric, or Ptolemaic, theory (pp. 3, 5)
3. Ptolemy (p. 4)
4. deferents (p. 4)
5. epicycles (p. 4)

Objectives—Chapter 1A-2

- Identify the main tenets of the heliocentric theory.
- List the early proponents of the heliocentric theory.
- Explain why early opponents of the heliocentric theory thought it was in error.
- List the evidences for the heliocentric theory.