the water or on the land; but some have adopted the air as their home, while others have taken to life underground, though always near the surface.

Air and water are ever changing; the lands are also changing, though more slowly; and plants and animals are varying in their relation to air, ocean, and land. These changes have a profound effect on man, and it is therefore important to study about them.

Such a study is known as **Physical Geography, which may be defined as the study of the physical features of the earth and their influence on man.**

NEW PHYSICAL GEOGRAPHY.

CHAPTER I.

THE EARTH AS A PLANET.

1. Shape of the Earth. — When we look at the full moon we see clearly that it is a sphere in the heavens (Fig. 2). If we could stand on the moon and look at the earth, we would see that it, too, is a sphere. But the earth is a much larger sphere than the moon (Fig. 3).

FIG. 2.—The moon.

Over two thousand years ago it was known that the earth was a sphere; but this was later forgotten, and for a long time the earth was believed to be flat. Before the time of Columbus, navigators imagined all sorts of terrors at the edge of a flat earth; and Columbus had difficulty in finding sailors who were willing to face these imaginary terrors. Columbus's voyage helped to bring into prominence the old proofs that the earth is a sphere.

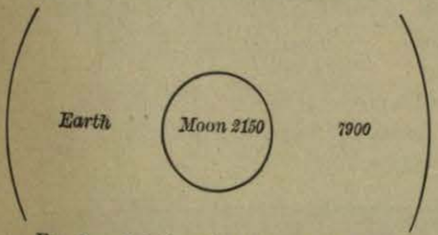

FIG. 3.—Relative size of earth and moon. The figures are the diameters in miles.

No matter where one may stand on the seashore, or on a vessel in the open ocean, he may find proof that the earth's surface is curved (Fig. 4). The sails and smoke of distant ships are seen while the hulls are hidden behind the curvature of the earth (Fig. 6). As the ship comes nearer, more and more of it is seen. This does not prove that the earth is a sphere, for other curved bodies, such as an egg-shaped one, would produce the same effect.

FIG. 4. — The curved ocean surface.

That the earth is spherical is now proved, and its size and exact form have been measured by scientists. Travelers have gone around it in various directions, and it is known how far one must travel to return to the starting point. Among the proofs that the earth is a sphere, and one known to the ancient Greeks, is that furnished by eclipses of the moon. Such an eclipse is caused by the earth's shadow thrown on the moon when the earth comes between the sun and moon. This shadow is always bounded by part of a circle (Fig. 5). If the earth were not a sphere this could not be so, for in some positions its outline would be certain to show the true form.

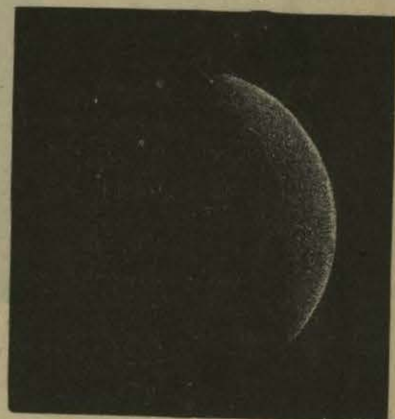

FIG. 5. — Curved shadow of the earth during an eclipse of the moon.

FIG. 6. — To show why part of a distant ship is hidden. The straight line is the line along which a man on the deck of the sailing vessel would look.

The earth is not an exact sphere, for the diameter at the equator is 7926 miles, and at the poles 7899. This difference in the two diameters is due to a slight flattening at the poles. Such a slightly flattened sphere is called an *oblate spheroid*. Compared to the earth as a whole this flattening is so slight that it cannot be shown on an ordinary globe.

Summary. — *The earth is a slightly flattened sphere, or oblate spheroid. Its curved surface can be seen on the ocean; eclipses of the moon prove that it is a sphere; its size and shape have been measured; and the distance around it in all directions is known.*

2. Other Spheres. — The earth is only one of a great number of spheres in space. The nearest of these is the moon, whose average distance is about 240,000 miles. All the stars are also spheres, far larger than the moon, and billions of miles away. At the rate of an express train it would take tens of thousands of years to reach the nearest star. These stars are all fiery hot; but the moon is a cold mass of rock.

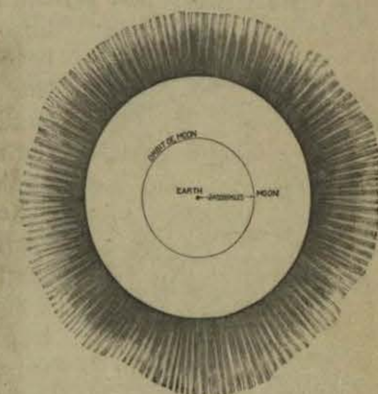

FIG. 7. — To show the great size of the sun. The earth, moon, and orbit of the moon could all be placed inside the sun, as shown.

The huge sun, another sphere, is a star with a diameter of 860,000 miles (Fig. 7). Its average distance from the earth is 92,750,000 miles, and yet it is so hot that heat and light from it cross that distance, making life on the earth possible.

The sun is the center of a family of spheres which form the ***solar system***. In this system there are eight large spheres called ***planets***, of which the earth is one. The sun and stars shine by their own light; but the planets merely reflect sunlight, as the moon does. The bright evening and morning "stars" are planets, like the earth. From one of them the earth would be seen to have the same steady, bright light that they show to us.

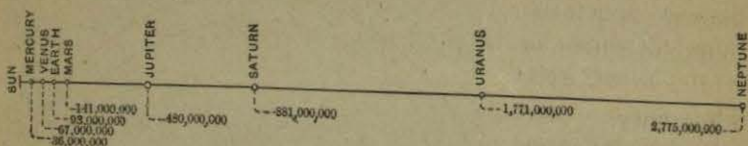

FIG. 8. — The distances from the sun to the different planets. The figures are distances in miles.

Some of the planets are far more distant than the sun (Fig. 8), Neptune, the most distant of all, being over 2,700,000,000 miles. How distant that is may perhaps be understood by the following illustration. If an express train could have started toward Neptune in the time of Christ, and have traveled steadily onward day and night at the rate of sixty miles an hour, it would not yet be halfway there.

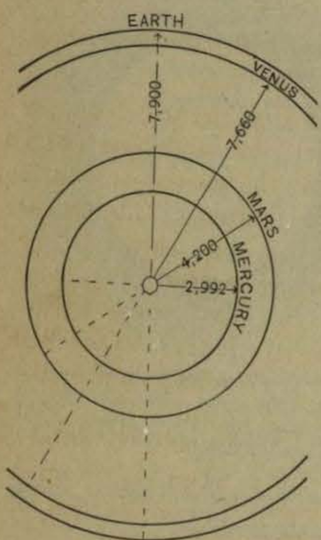

Fig. 9. — To show the relative size of the four smaller planets. The figures are diameters in miles.

Not only are the planets far away, but some of them are very large (Figs. 9, 10). Jupiter, the largest, is 86,000 miles in diameter. In the space between Mars and Jupiter there are also a number of very small spheres, called *asteroids*. The largest is about 500 miles in diameter.

Summary. — *Other spheres besides the earth are the stars, sun, moon, planets, and asteroids. The moon and planets are cold, and shine by reflected light; the stars and sun are fiery hot. In the solar system, which includes the sun, moon, planets, and asteroids, the largest sphere is the sun, the largest planet Jupiter, and the most distant planet Neptune.*

3. Movements of the Spheres. — Little is known about the motions of the distant stars. But all the planets whose movements are known have been found to turn, or *rotate*, on an axis. The earth takes one day for *rotation*; the sun over 25 days; Jupiter 9 hours, 55 minutes; the moon $27\frac{1}{3}$ days.

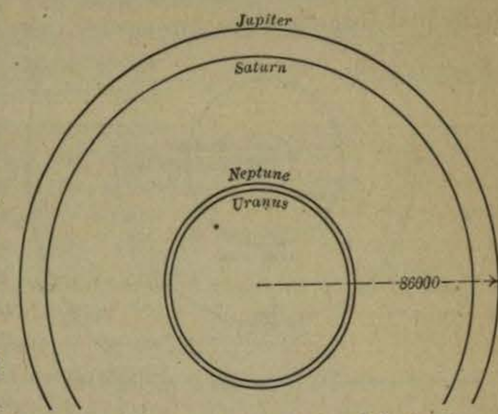

FIG. 10. — To show the relative size of the four larger planets.

All members of the solar system also travel, or *revolve*, around the sun. This *revolution*[1] is along a nearly circular path, or *orbit*. The orbit is not an exact circle, but an *ellipse* (Fig. 11), and the sun, instead of being at the center, is a little to one side, at one of the *foci* of the ellipse. This causes the earth to be nearer the sun at one season (over 91,000,000 miles) than in the opposite (over 94,000,000 miles), when it reaches the other end of the ellipse. The earth requires a little over 365 days, or one year, to make a complete revolution around the sun.

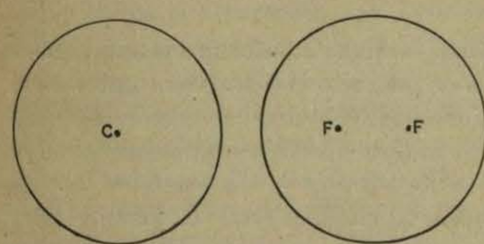

FIG. 11. — A circle (on left) and ellipse (on right). Find the center of the circle (*C*) and the foci of the ellipse (*FF*).

[1] For fuller treatment of revolution, see Appendix A.

Mercury, the smallest and nearest of the planets (Figs. 8, 9), requires only 88 days for a single revolution. What is the time required by the other planets (Fig. 12)?

Several of the planets have moons. The word *satellite*, meaning follower, is given to these smaller spheres because they follow their planets in their revolution around the sun. The earth has one moon; no moons have been discovered for Mercury or Venus; but Saturn has eight. It is believed that each satellite rotates on an axis and revolves in an ellipse around its planet. The moon makes one revolution around the earth in about 27⅓ days.

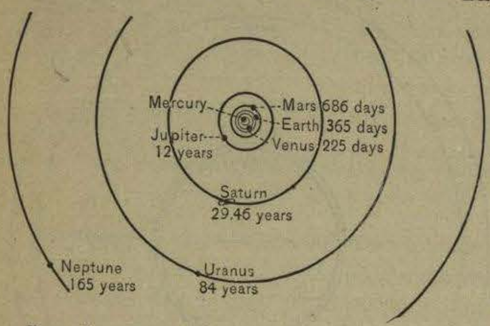

FIG. 12. — Time of revolution of the planets.

Summary. — *So far as known, all the planets rotate on axes, and all revolve around the sun in elliptical orbits. The periods of rotation and revolution differ. Satellites accompany several of the planets.*

4. Rotation of the Earth. — Many uninformed people believe that the sun rises, passes through the heavens, and sets in the west. Our own ancestors, centuries ago, held the same belief. We still use their terms, ***sunrise*** and ***sunset***, though we well know that it is the turning of the earth on its axis that makes the sun appear to rise and set. In looking from the window of a train it sometimes seems as if objects were passing by, while it is really you yourself that is moving. In the same way, as the earth turns with us toward the east, the sun seems to travel in the opposite direction.

The rising and setting of the moon, and the apparent movements of the stars at night, are also due to the earth's rotation.

Find the North Star by following the pointers on the outer side of the Great Dipper (Fig. 13). Notice that it does not move at night, but that the Dipper and other stars seem to swing around it. The farther a star is from the North Star the greater the circle through which it swings, those far away rising in the east and setting in the west. It used to be thought that the sky was a great dome with stars set in it, a few miles from the earth, and that it slowly swung around the earth. We now know that the earth's axis points toward the North Star and that, as the earth turns, it causes the stars to appear to swing round the North Star.

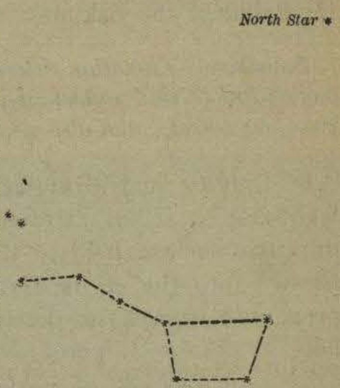

FIG. 13. — The Great Dipper and North Star.

Summary. — *It was formerly thought that the sun, moon, and stars moved; we now know that these apparent movements are caused by the earth's rotation. The axis of the earth points toward the North Star; therefore the other stars seem to circle round it.*

5. Effects of Revolution and Rotation. — Rotation of the earth has given the basis for our computation of time. Thus we reckon a day as the period required for one rotation (24 hours). The day is divided into hours, each hour being the time required for the sun's rays to advance 15° over the curved surface of the rotating earth. By rotation, also, the day is divided into a period of light and one of darkness. Name some habits of plants, animals, and men that are determined by this effect of rotation.

Revolution of the earth is also a matter of the highest importance. By it another standard of time, the year, is fixed. Revolution also causes an apparent movement of the sun, by which it rises and sets farther north or south at different times. These changes in the sun's position, which cause the seasons, have determined some of man's most characteristic habits. Name some ways in which revolution affects you,—your home, clothes, foods, and games. Recall from your study of geography how revolution affects the habits of the Eskimos.

Summary. — *Rotation determines the length of our day, causes day and night, and influences our habits. Revolution gives us our year, our seasons, and also profoundly affects our habits.*

6. Gravity and Gravitation. — The earth exerts on all bodies upon it an attraction which we call *gravity*. By gravity men are held to the surface of the earth; a stone thrown into the air is drawn back to the earth; the air is prevented from flying away into space; and the oceans are held in place. It gives to the ocean a curved surface, because each particle of water is attracted toward the center of the sphere. Each part of this curved surface, or *sea level*, is at right angles to a line leading toward the earth's center.

Bodies in space also exert an attraction on other spheres. For example, the moon exerts an attraction upon the earth, and the earth upon the moon; but the earth, being larger, has the stronger effect. This attraction of bodies in space is called the *attraction of gravitation*.

Gravitation is the bond that holds the earth and other planets to the orbits along which they travel about the sun. If it could be possible for the sun to lose its attraction of gravitation, the earth would fly off into space, as a stone whirled by a string flies away if the string breaks. Gravitation also holds the moon so firmly that it swings around the earth with such regularity that its position a thousand years from now can be accurately foretold. The law of gravitation was discovered over two centuries ago by Sir Isaac Newton; yet even now no one knows exactly what causes it nor why it operates in the universe.

Held by gravitation, the earth is able to travel along its orbit of 600,000,000 miles each year at a rate of over 1000 miles a minute. At the same time, it is whirling on its axis so rapidly that a person on the equator is moving at the rate of 17 miles a minute. We are not aware of these rapid movements, because the land, water, and air go with us. Even when traveling on a noisy railway train, we sometimes forget that we are moving. But the earth moves without jar or noise, and there are no near-by objects for us to swiftly pass; therefore, for many generations men did not even suspect that they were moving at all.

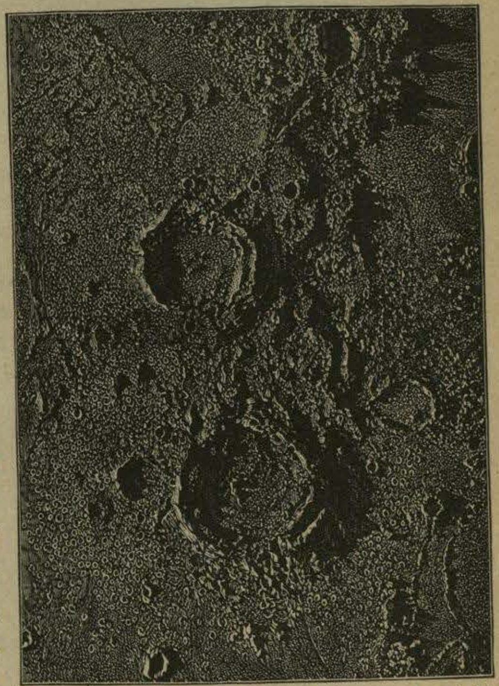

FIG. 14.—Craters on the moon, seeming to indicate former volcanic eruptions due to a heated condition of the interior.

Summary. — *Gravity is the attraction that holds objects to the earth; it causes the curved surface called sea level. Gravitation, discovered by Newton, is the attraction exerted on one another by bodies in space and by which the spheres are held to their orbits.*

7. Heat in the Solar System. — The sun is the only member of the solar system that is hot enough to glow; but in past ages the other members have apparently also been hot. Jupiter appears still to be so warm at the surface that the water rises in clouds of steam. The earth is cold at the surface, but hot within (p. 17); the small moon, though now cold, was apparently once hot within.

The heat of the sun is so great that even mineral substances exist in the form of gases. This white hot sun is slowly cooling by radiating its heat off into space; but a few small points, of which the earth is one (Fig. 15), intercept a minute portion of these rays, on which animal and plant life depend.

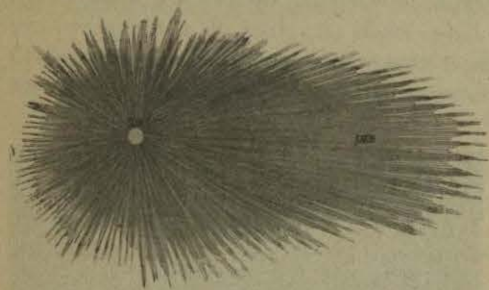

FIG. 15. — To illustrate the very small proportion of all the rays passing out from the sun that reach the earth.

With great speed these rays cross the 93,000,000 miles that separate us from the sun. They reach the earth in about 8 minutes, while, at the rate of a fast express train, 175 years would be required. The distant planet Neptune doubtless receives too little heat for life; Mercury is so near that it perhaps receives too much; but the earth is so favorably situated that it receives neither too much nor too little. As the sun cools down to a red heat, in some far-distant future age, life on the earth will no longer be possible.

Summary. — *The members of the solar system show signs of heat, either past or present. Heat, radiated from the white hot sun, passes rapidly across space; and some of it, reaching the earth, makes life possible.*

TOPICAL OUTLINE, QUESTIONS, AND SUGGESTIONS.

TOPICAL OUTLINE. — 1. **Shape of Earth.** — Former belief; proofs of roundness; exact shape; length of diameters.

2. **Other Spheres.** — The moon; stars; sun; solar system; relative size of planets; relative distance; asteroids.

3. **Movements of the Spheres.** — (*a*) Rotation: time required. (*b*) Revolution: nature of path; effect on distance from sun to earth; time required. (*c*) Satellites: meaning of name; number; movements.

4. **Rotation of the Earth.** — Apparent movement of sun, former belief; real explanation; movements of stars; explanation.

5. **Effects of Rotation and Revolution.** — (*a*) Rotation: effect on divisions of time; on day and night; on habits of man. (*b*) Revolution: effect on division of time; on seasons; on habits of man.

6. **Gravity and Gravitation.** — (*a*) Gravity: nature; effects; nature of sea level. (*b*) Gravitation: nature; movements of moon and planets; discovery by Newton. (*c*) Rapid movements of earth.

7. **Heat in the Solar System.** — (*a*) Evidence of heat in the solar system. (*b*) Sun's heat: condition of sun; rate of passage of rays; proportion received by earth; other planets; effect of future cooling of sun.

QUESTIONS. — Section 1. What was formerly believed concerning the shape of the earth? What proof is there that the earth is spherical? What is its exact shape? Give its two diameters.

2. What other kinds of spheres are there? How do planets and stars differ? What is the solar system? What are asteroids? Give the distance from the sun to each of the planets (Fig. 8). Name the planets in the order of their size (Figs. 9 and 10).

3. What important movements have the planets? State the difference in time of rotation. Of revolution. What is the distance from earth to sun at opposite seasons? Why this difference? Give some facts about satellites.

4. What was formerly thought regarding the daily movement of the sun? What is now known to be the cause of it? Describe the movement of the stars, and explain them.

5. What are the important effects of rotation? Of revolution?

6. What is gravity? Give examples of its effects. What is the attraction of gravitation? What effect has this upon revolution? Why are the earth's movements not more noticeable?

7. What is the evidence of heat in the members of the solar system? What change is going on in the sun? What effect has that on the earth? Why is there probably no life on Neptune or Mercury? At what rate does sunlight travel?

SUGGESTIONS. — *These suggestions are made rather freely, though it is not expected that any school will find it feasible to carry out all, or even a majority. From among them, however, every teacher will find it possible to select some.* (1) Carefully examine the moon and note its roundness. If possible, look for the craters through a telescope or spyglass. (2) If an eclipse of the moon comes during the year, observe it and note the circular outline of the earth's shadow. (3) With a lamp, throw on the wall the shadow of a ball in various positions. Do the same with a cylinder; with a square. Which always shows one kind of outline? (4) A period devoted to the meaning of scale may be combined with a study of the size and distance of the members of the solar system. This can be done with profit by cutting disks out of brown paper to represent the planets (say on a scale of one inch for 5000 miles); and marking off distances in the school yard (say on a scale of one inch for 200,000 miles) to represent distances. (5) Take a string five feet long with a loop in the end. Put the loop over a nail driven in the floor. With a piece of chalk at the other end of the string draw a circle. Now drive another nail two inches from the first. Take a string ten feet long and tie the ends. Put it over the two nails, and with chalk held in the loop draw a figure as near a circle as you can. It will not be a circle, but an ellipse. If you put the two nails (the foci) farther apart, say six inches, the ellipse will be still less like a circle. (6) Rotate a globe or apple in front of a light to understand the cause of day and night. (7) Observe the stars of the Great Dipper and the North Star at 8, 9, and 10 o'clock. What changes do you notice? (8) Compare the movements of a planet in the heavens, say the evening "star," with that of a neighboring star. Why the difference? (9) With a telescope look for the moons of Jupiter and the rings of Saturn. (10) What are shooting stars and comets? (11) In some astronomy, read about the sun and the planets. (12) Find out what Aristotle, Magellan, and Galileo learned about the earth.

Reference Books. — *References to a few selected books are placed at the end of each chapter. Other reference books and magazines are listed in Appendix L.* NEWCOMB, *Elements of Astronomy*, American Book Co., New York, 1900, $1.00; YOUNG, *Manual of Astronomy*, Ginn & Co., Boston, 1902, $2.45; TODD, *New Astronomy*, American Book Co., New York, 1897, $1.30; LOCKYER, *The Chemistry of the Sun*, Macmillan Co., New York, 1887, $4.50.

CHAPTER II.

GENERAL FEATURES OF THE EARTH.[1]

THERE are three quite different parts of the earth: (1) the solid earth; (2) the liquid ocean which partially covers the solid earth; and (3) the gaseous envelope, or atmosphere.

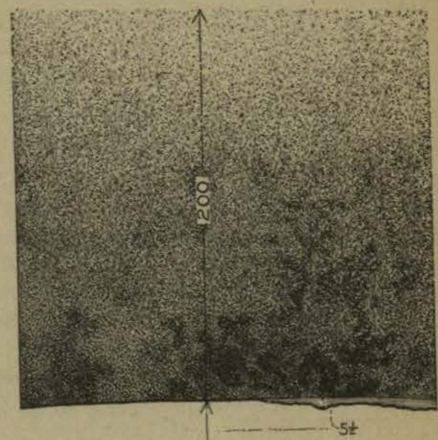

FIG. 16. — Relative depth of air and water on the earth. The figures refer to miles, five and one half miles being one of the greatest ocean depths.

8. The Atmosphere.[2] — There is some air at a height of 200 or 300 miles from the earth; but most of it is within a few miles of the surface. The air is a mixture of transparent gases, mainly oxygen and nitrogen, whose presence on every hand we hardly realize. Yet our every breath draws it in for the purpose of supplying life-giving oxygen. Though it cannot be seen, we feel its presence when the wind blows, or when moving rapidly through it.

There are many ways in which the air is of high importance. All plants and animals depend upon its gases for life. Its oxygen

[1] For latitude and longitude, see Appendix B; for maps, see Appendix I.
[2] See also Chapter XII.