

board drawing). The two taken together prove that the earth is spherical.

3. An eclipse of the moon is produced by the earth coming between the sun and the moon, and casting its shadow upon the latter. The teacher should illustrate with a drawing. Hundreds of eclipses have been observed, in which the earth has been in many different positions. This shadow is observed to be always circular. As the sphere is the only body which casts a circular shadow in every position, this is an absolute proof that the earth is round. That pupils may clearly understand this proof, it may be necessary to have shadows produced from objects of various shapes in different positions.

4. The horizon, wherever observed on the surface of the ocean or on level ground, is circular. This alone is not a proof of the earth's roundness, as the distance which the eye can see is equal in all directions, and therefore circular; but in clear weather an object on the surface of level ground, or of the water, can be seen just as far with the naked eye as with a powerful telescope. As light moves in straight lines, this shows that the surface "rises up" or curves between distant points.

5. When a ship is coming into port, we see first the topmasts, then the sails, and finally the hull. If the earth were flat, we would see the upper and lower parts at the same instant. As the top part is seen first, the earth must be curved; and since the appearance is the same, no matter from which direction the ship is approaching, we infer that the earth is evenly curved or spherical.

6. A plumb line points to the centre of the earth. If two plumb-lines are dropped from high towers, a sufficient distance apart, and the distances are measured between the tops, the centres, and the bases of the lines, it will be seen that the lines are not perfectly parallel, but are nearest together at their bases and farthest apart at the top. The opposite walls of a building, if built perpendicular, are farther apart at the top than at the bottom. This proves that the plumb-lines point to a common centre, which could be true only of a circular body. Illustrate with a drawing or by sticking two splints into an apple, each pointing toward the centre of the apple.

7. Civil engineers, in constructing canals, must make allowance for the curvature of the earth. The bottom must not be made a straight line, for if it were it would soon come to the surface. The following is the rule for the curvature of the earth:

Square the distance in miles and take two-thirds of this for the curvature in feet.

Thus, at a distance of one mile the curvature is 8 inches; for two miles, 32 inches; for three miles, 6 feet, and so on.

- (a) What is the curvature for 5 miles?
- (b) What is the curvature for 6 miles?
- (c) What is the curvature for 8 miles?
- (d) What is the curvature for 10 miles?

In Holland, where water covers a portion of the level surface, teachers sometimes illustrate to their pupils the shape of the earth by setting up three stakes in a line, at a distance apart, each the same height above the water. Then by sighting from the first to the third, the middle stake is observed to be higher than the others.

8. By examination with a telescope all the other planets

are seen to be globular. The planets belong to our system. We can reasonably conclude that the conditions which would make any of them round would make all of them so. Hence we may fairly infer that the earth is round.

3. The Earth an Oblate Spheroid.

The following proofs that the earth is an oblate spheroid are not easily comprehended by pupils of immature minds; hence it is not advisable to spend much time with this topic unless pupils are pretty well advanced.

1. If the earth was ever a liquid mass, the tangential force generated by its rotation would make it bulge out in the equatorial regions. Geology proves that it was once in a liquid condition. Other planets seen through the telescope appear to be oblate spheroids, and reasoning from analogy we may conclude that ours is not an exception to the rule.

2. A degree is 1/360th of a circumference, a *measure of curvature and not of length*. As measures of curvature degrees are always equal, but if the circumference is large the length of the degree as a line is longer than in the smaller circumference. A degree of latitude as a line is longer in the polar than in the equatorial regions. Dr. Lardner gives the length of a degree near the Arctic Circle as 4,000 feet longer than one near the equator. If a degree is longer, it must be a part of a longer circumference; hence the earth is not a perfect sphere, but "flattened" at the poles.

3. It is an established fact in physics that the mutual attraction of two bodies becomes greater as they approach each other, so long as they are wholly external the one to the other. A body weighs more the further it is carried toward the poles. This fact shows that it is coming to the earth's centre. This difference of weight is partly due to the tangential force generated by the earth's rotation, which is greatest at the equator.

4. Size of the Earth.

Diameter—Polar, 7899.1 miles; Equatorial, 7925.6 miles.
Circumference—Polar, 24902 miles; Equatorial, 24860 miles.

5. Motions of the Earth.

There are two: 1. Rotation on Axis; 2. Revolution around Sun. What are the direction, time and effect of these two motions?

Have pupils know what is meant by the ecliptic, and inclination of the earth's axis. Show how much the axis is inclined and how it always points in the same direction. Show why the tropics and polar circles are located where they are, and what marks the boundaries of the zones. Name the zones and give their width.

6. Directions of Earth's Rotation.

The earth turns from west to east. This makes what two heavenly bodies appear to move from east to west?

Every morning this movement of the earth brings pupils and teacher into the sunlight, and makes this light come from the east. What would happen if the earth should forget for a week to rotate?

On account of the earth's rotation, in this way it happens, that, when the London boy goes home from school at five o'clock for his supper, the Boston boy is going home for his dinner at 12 m., and the San Francisco boy is going to