# The Shape of the Earth

**Some proofs for the spherical shape of the Earth given in Astronomical and Geographical Text-books examined, and shown to be unsound.**

BY

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# THE SHAPE OF THE EARTH

"I have known, too, for a long time, that we have no arguments for the Copernican system, but I shall never dare to be the first to attack it. Don't rush into the wasp's nest. You will but bring on yourself the scorn of the thoughtless multitude. If once a famous astronomer arises against the present conception, I will communicate, too, my observations, but to come forth as the first against opinions, which the world has become fond of, I don't feel the courage."—*Alexander von Humboldt.*•

The standard text books upon Astronomy and Geography used in our schools and colleges, as well as the leading articles relating to these subjects in encyclopædias, have always given practically the same popular proofs for the spherical shape of the Earth. These so-called proofs have been deduced from such facts as, the circumnavigation of the Earth; 'the shadow' on the Moon during its eclipse; the mode of disappearance of a vessel, or other object, receding at sea; the declination of the North Star as observed by a person travelling southward, etc.; and have been so generally received as unquestionably reliable, that one is startled upon first observing that their soundness is being seriously questioned.

It is true, however, that the facts above mentioned do not furnish data from which valid proofs may be rationally deduced for the support of the fundamental tenets of the Copernican system of Astronomy; and that this is beginning to be recognised, is evidenced by the following statement, taken from the recent text book on *Mathematical Geography*, by Willis E. Johnson, Ph.B., Vice-President, and Professor of Geography and Social Sciences, of the Northern Normal and Industrial School, at Aberdeen, South Dakota. In the second chapter of his book, Professor Johnson pointedly opens his remarks upon "The Form

•August Tischner, *The Fixed Idea of Astronomical Theory*, Leipzig, 1885, p. 33.

of the Earth," with a statement discounting the so-called proof of circumnavigation. He says:—

"The statements commonly given as proofs of the spherical form of the earth would often apply as well to a cylinder or an egg-shaped or a disk-shaped body. "People have sailed around it," "The shadow of the earth as seen in the eclipse of the moon is always circular," etc., do not in themselves prove that the earth is a sphere. They might be true if the earth were a cylinder or had the shape of an egg. "But men have sailed around it in different directions." So might they a lemon shaped body. To make a complete proof, we must show that men have sailed around it in practically every direction and have found no appreciable difference in the distances in the different directions."[1]

How great a departure from views formerly held such a statement involves, may be well observed by a comparison of some of the statements upon this subject, made by other eminent authorities. The article on "The Earth," in the New Edition of Chamber's Encyclopædia, informs us, that—

"The most convincing proof to the popular mind is, however, that the Earth has been circumnavigated by vessels steering always in the same general direction."[2]

The Professor of Astronomy at Princeton University, Dr. Charles A. Young, whose revised work, *General Astronomy*, is said to be "without an equal in the English language," in that work says,

"It is not necessary to dwell upon the ordinary proofs of its globularity. We merely mention them. (1) It can be circumnavigated."[3]

The late Astronomer Royal of Great Britain, Sir George B. Airy, P.R.S., F.R.A.S., states—

"Again, people have sailed round the earth. This was done for the first time by Magellan and his successors in command: . . . The earth, therefore, roughly speaking, is something round, and there are limits to its extent."[4]

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[1] *Mathematical Geography*, New York, 1907, p. 24. See also R. A. Gregory, *The Planet Earth*, London, 1894, pp. 24-5.
[2] London, 1902, Vol. IV, p. 162.
[3] *General Astronomy*, Boston, 1904, p. 97.
[4] *Popular Astronomy*, London, 1868, p. 54.

While Sir J. Norman Lockyer, F.R.S., F.R.A.S., Professor of Astronomical Physics in the Royal College of Science, writes—

"Again the roundness of the Earth has been proved by navigators, who, sailing in one direction, either east or west (as nearly as the different bodies of land would permit), have returned to the place from which they set out."[1]

And Professor H. N. Robinson, A.M., Late Professor of Mathematics in the U.S. Navy, in his *Treatise on Astronomy*, says—

"Common intelligence must convince even the child, that the Earth must be a large ball, of a regular, or an irregular shape; for everyone knows the fact, that the Earth has been *many times* circumnavigated; which settles the question."[2]

Other authorities might be quoted, but the foregoing will suffice. In striking contrast to this testimony stands the statement of Professor Johnson; and the correctness of his views may be fully demonstrated.

Let us look further into the matter. But to do this intelligently, our minds should be clear on two points involved in the discussion. First, we must be careful in our use of the term *round*. A circle is round, and a sphere is also popularly styled round. Now a circle may be described on any one of a number of kinds of surfaces, as, for example, on a cone, a cylinder, a sphere, or, on a flat surface. The knowledge, therefore, that a course, or path, on any surface is round, or circular, does not disclose the character of the surface upon which such a course is traced.—Secondly, we must have a clear understanding of the meaning of the terms *East* and *West*. Perhaps not one person in a hundred holds any really clear conception of what direction East or West is. The popular idea seems to be that derived from the weather vane finial, with its cardinal points indicated by the letters, N.S.E.W. Thus East and West are frequently thought to be direction, one way or the other, on a long straight line at right angles to direction North and South. Whereas, East and West are directions on circles concentric

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[1] *Elements of Astronomy*. New York, 1870, p. 83.
[2] *Treatise on Astronomy*, Cincinnati, 1855, p. 52.

with the northern centre, and as such, it will be noted, that *absolute* direction East and West changes with every change in the longitude of a geographical position. This point may be more clear from a simple experiment represented by Figure I. Let a pin be placed so as to secure a string in the centre of a table, and a pencil, or small stick, fastened to the string so as to be at right angles to it when held taut. The pin represents the northern magnetic centre, the string, direction North and South

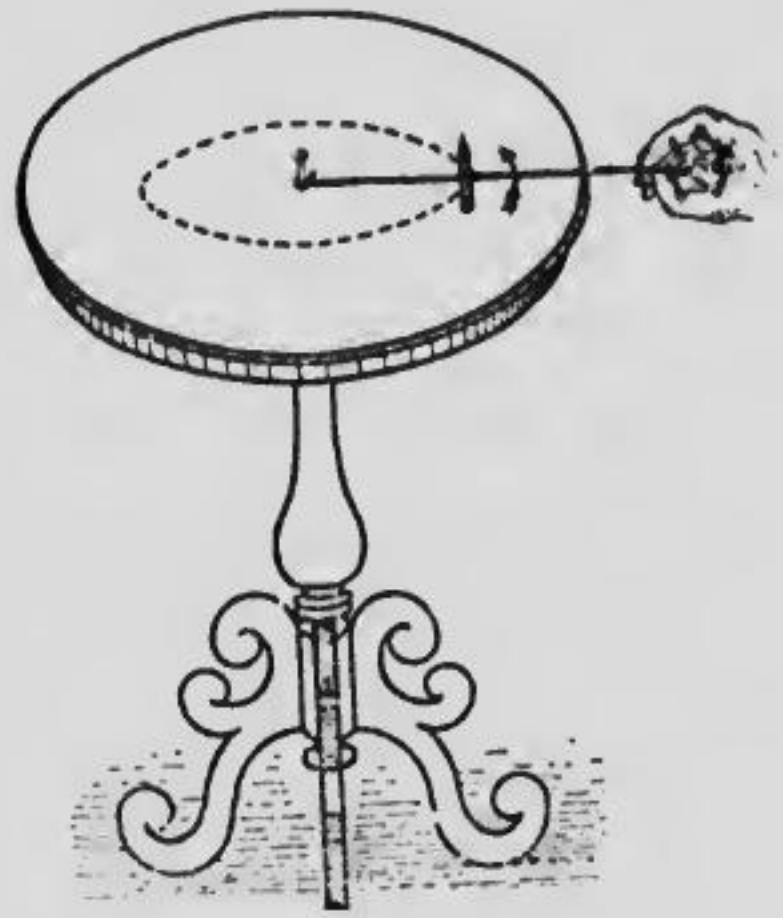

FIG. 1.

in the magnetic meridian, and the pencil, direction East and West. Now in walking with the string around the table, you will observe that your string is always North and South, and your direction of motion, while constantly changing, is, nevertheless, always East or West. On returning to your starting point, you will have completed a 'circumnavigation' of the table in an easterly, or westerly course.

Now the Earth might actually be circumnavigated in easterly, or westerly directions, at all latitudes, if no spaces of land, or ice, intervened on the courses; and by such circumnavigation

the Earth might be proved to be a globe, by simply demonstrating, that the lengths of the circular courses, obtained at all latitudes, were respectively equal to what they should be on a globe the size the Earth is said to be. Such data of sailings, at all latitudes, has never been obtained. However, this is not the manner in which the facts of circumnavigation are used for a proof. Instead it is argued, that if 'men could sail around the earth in practically every direction, and find no appreciable difference in the distances in the different directions,' then such sailings would demonstrate that the shape of the Earth is globular.


FIG. 2.

We do know that men have at least sailed around the Earth in easterly, or westerly, directions. What is the significance of this? Does it mean that men have *circumnavigated* a globe? By no means. They have simply *sailed around* the Earth *in a circle*. This was done, in the above illustration, with the table; and it was accomplished on a flat floor. But let us proceed to review all the possibilities of circumnavigation. First, let us take a case in which the Earth is circumnavigated in an easterly, or westerly, direction, that is, at right angles to the meri-

dians, and with the North,[1] as a centre; and, to select a course whose length may serve as a standard to which the distances of other courses may be referred, we will assume our course to be on the Equator. In Figure 2, N. represents the magnetic north —the locality towards which the magnetic needle tends to point, A, B, C, D and E, represent mariner's compasses, placed at various stations on the Earth's surface. Each compass needle, automatically, takes up a position in the magnetic meridian, and points towards the magnetic north. East and West are, of course, at right angles to the long axis of the needle. Thus, while East and West, *relatively*, are always in direction at right angles to North and South, yet, as pointed out above, East and West *absolutely* are different geo-


FIG. 3.

graphic directions at places having different longitudes on the surface of the Earth. If now we start from A, with a compass, and move eastward, keeping at the same latitude, and pass through the Stations, B, C, D and E, we eventually return to the starting place A; as Professor Johnson pointed out, such circumnavigation could also be performed on "a cylinder," "an egg-shaped body," or a "disk-shaped body."

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[1] For the purposes of our illustrations the north magnetic centre may be conceived to be coincident with the north geographic centre. Confusion arising from the use and repetition of phrases distinguishing these centres will thus be avoided.

Again, let us suppose circumnavigation of the Earth in other courses, equal to the equatorial distance, and in directions compounded of East and West with North and South. Such courses, obviously, would be eccentric to the northern centre. Referring to Figure 3, and assuming the non-intervention of land, or ice, spaces, let us start our journey from P, on, say, a north-easterly course, constantly changing direction, and passing through the Stations Q, R, S and T. We again return to P. In this case, also, we have circumnavigated the Earth, but after all, we have only travelled in a circle, and made such a circumnavigation as

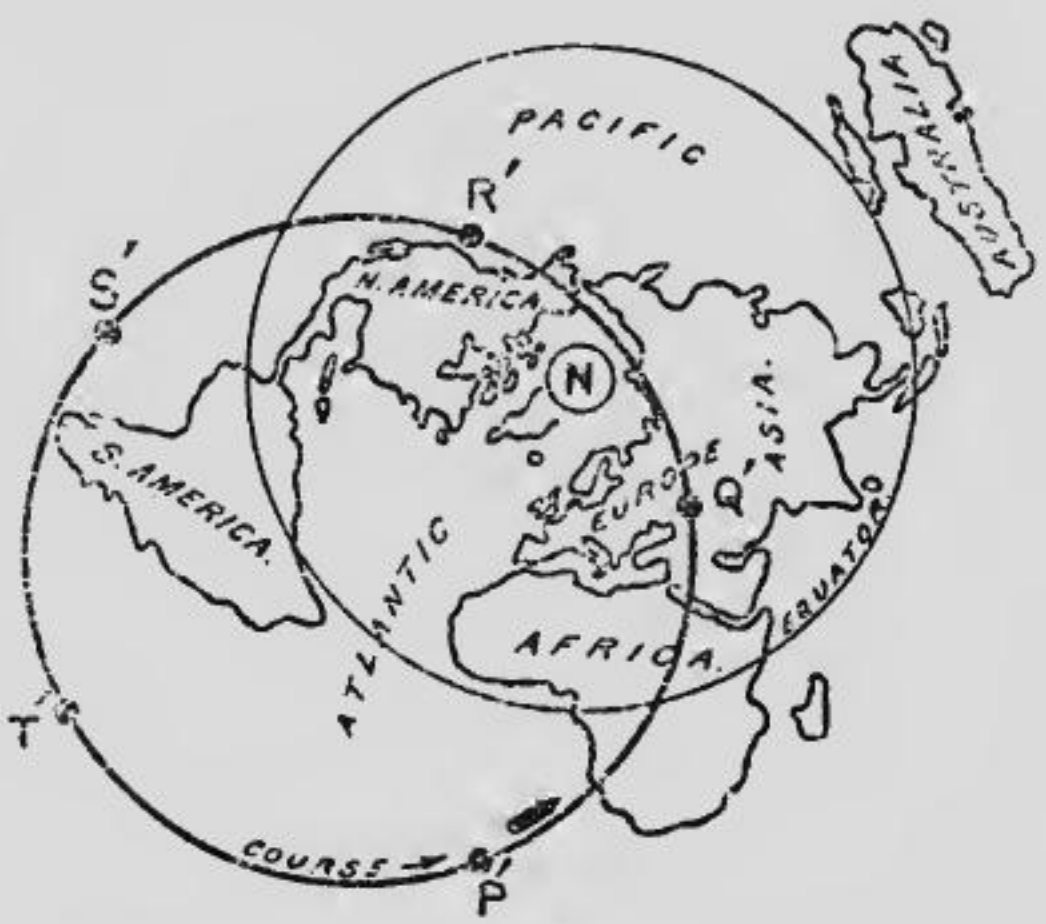


FIG. 4.

Professor Johnson says, might also take place on "a lemon-shaped body." It is, at least, clear, as may be seen from Figure 4, that such circumnavigation could take place on a flat surface, providing its area is sufficiently great to admit the sailing upon it of various circular courses, equal in length to the equatorial distance, (on the globe), and eccentric to the northern centre.

The only course now left for us to take is a circumnavigation due North and South. If this could be accomplished, and a course equal in distance to the equatorial circumference, or even approximately so, could be traced from North to South, and back to the North, then, indeed, would the Earth have been circumnavigated in every direction; and this of itself would be sufficient *to prove* it a globe. It is only necessary to state that, owing to the impassable ice barriers in the regions of the, so-called, North and South Poles, such a course has never been sailed.

Since, then, circumnavigation as thus far performed on the Earth's surface, is a feat that might be performed, so far as course is concerned, with equal facility, on other bodies not having a spherical shape; and performed, indeed, even on a flat surface, it must be clear that circumnavigation is no proof, whatever, that the Earth has a spherical shape,—the dogmatic statement of hundreds of astronomical, and geographical, authorities to the contrary, notwithstanding.

## "The Shadow" on the Moon.

In the quotation from Professor Johnson's work, above given, he points out that the statement, "The shadow of the Earth as seen in the eclipse of the moon is always circular," does not, of itself, convey proof that the Earth is a sphere. He does not, however, fully expose the fallacious nature of this proof, and yet, no 'proof' offered for the Earth's spherical figure, upon examination in the light of logic and fact, vanishes as quickly as does this shadow proof.

That this proof is among the most prominent given for the Earth's globular shape may be seen, without multiplying instances, from the statement of the eminent authority, the Professor of Astronomy at Princeton University, Dr. Charles A. Young. Says Professor Young,—

"It is not necessary to dwell on the ordinary familiar proofs of the earth's globularity. One, first quoted by Galileo as absolutely conclusive,

is that the outline of the earth's shadow seen upon the moon during a lunar eclipse is such as only a sphere could cast."[8]

Now, some unwarranted assumptions are involved in this proof; and some peculiar features, associated with the phenomenon of a lunar eclipse, and unfavourable to the shadow proof, are not emphasised as they ought to be.

FIRST.—The usual explanation given for an eclipse of the Moon, viz., that the eclipse is produced by the shadow of the Earth on the Moon, is itself a pure assumption, and has never been proved.

SECOND.—It is assumed that the Moon is only a reflector of the Sun's rays; an assumption out of harmony with certain observed lunar phenomena, and, as yet, incapable of proof.

THIRD.—It is not made clear that many other objects besides a sphere, such as a disc, a cylinder, or an oval shaped body, might cast a circular shadow.

FOURTH.—An eclipse of the Moon is not, after all, a phenomenon as clear cut in its detail, and capable of ready association with the Earth, as many suppose, and it becomes necessary to appeal largely to the imagination. Some of the general characteristics of this phenomenon may be well understood from the statement of the noted Copernican astronomer and writer, the late Mr. Richard A. Proctor. He says—

"Another proof of the globular figure of the earth has been derived from the shape of the earth's shadow as seen during a lunar eclipse. This proof is not perhaps very striking, because the curvature of the earth's shadow as seen on the moon is by no means so well marked as many suppose. The shadow has not a well-defined edge, the circle it belongs to is much larger than the moon, and finally the moon's surface is marked with so many variations of brilliancy as to confuse the border of the umbra."[9]

But, if it be granted that no peculiarities, such as are mentioned by Mr. Proctor, affect the proof, even then, however,

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[8] *Manual of Astronomy*, Boston, 1904, p. 106.
[9] *Knowledge*, Vol. VI, p. 275.

nothing could excuse the illogical manner in which assumption is incorporated in it. *The circular form* of "the shadow" seen during a lunar eclipse, is, by itself considered, of no importance, whatever, as a proof of the Earth's globularity; because, if it can be shown that it is the Earth that casts the shadow, then, its globularity is a foregone conclusion; and for this reason: before the Earth, (viz. land and seas), can be conceived to cast a shadow at all, it must be independently proved, that land and seas together constitute a body, self-contained, and isolated, in space. Such a body, possessed of the motions in space which are attributed to the Earth, must, of necessity, be globular. This fact is recognised by Copernicus and his followers, and the globular form of the Earth is, therefore, assumed by Copernicans as the very basic doctrine of their system. In the statement, then, that the darkening of the Moon's face during an eclipse is caused by a shadow cast upon it by the Earth, it is implicitly assumed, that the Earth is so situated, in space, that it is in a position to cast a shadow, and, as pointed out, such an assumption involves the *pre-assumption* that the Earth is a globe.

Let the elements vital to the shadow proof derived from the phenomenon of a lunar eclipse first be demonstrated. Let the Moon be proved a reflector, let the position of the Earth in space be established, and let it be proved that it is the Earth that casts the 'shadow.' If this is first done, we need not be required, as at present, to lay aside all rules of logic, and give credence to a proof, so-called, every essential proposition of which is an assumption.

No *fact* of *practical* astronomy can ever suffer from any test applied to it. As we have said above, the spherical shape of the Earth is the very basic feature of the Copernican System of Astronomy, and, as such, this shape should be established by the most unquestionable proofs. Now two of the most important proofs given for the Earth's spherical form have been seen to be unsound. If our enquiry were extended further, it might be found, that amongst all the proofs given in the text books, and taught to our youth, as the veriest facts, none could be shown

to be an absolute and valid proof of this most important feature of modern theoretical Astronomy, viz., the globular shape of the Earth.

Is it too much to ask, that all these so-called proofs should be submitted to the critical examination of the day, and, that our teachers and text-books should be more guarded in what they put forth as Knowledge and Truth? In the absence of absolute proof for the spherical shape of the Earth, *the hypothetical character of this fundamental feature of the Copernican System, and, indeed, the hypothetical character of the whole Copernican System of Astronomy*, cannot be too strongly emphasised. That this is not an unreasonable demand upon the teaching of the present day, is, we believe, supported by the general statement of the Preface addressed *To the Reader*, in Copernicus' own book. The reader is there forewarned against accepting the new Copernican hypothesis as *truth;* and the Preface concludes with this remarkable pronouncement,—

"Neither let anyone, so far as hypotheses are concerned, expect anything certain from astronomy, since that science can afford nothing of the kind; lest, in case he should adopt for truth things feigned for another purpose, he should leave this study more foolish than he came."[10]

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[10] "Neque quisquam, quod ad hypotheses attinet, quicquam certi ab astronomia expectet, cum ipsa nihil tale præstare queat, no, si in alium usum conficta pro veris arripiat, stultior ab hac disciplina discedat quam accesserit."

N. Copernicus, *De Revolutionibus Orbium Cœlestium*, Libri VI (Editio Princeps), Nuremberg, 1543, Preface, *De Hypothesibus hujus Operis*. The authorship of this Preface is now generally attributed to Andreas Osiander to whom was entrusted the publication of *De Revolutionibus*.