CLASSICS OF SCIENCE:

The Earth and the Ancients

Astronomy—Philosophy

An object which, viewed through our frame of conventions, may seem to be behaving in a very special and remarkable way may, viewed according to another set of conventions, be doing nothing to excite particular comment.—EDDINGTON.

Here are two "frames of conventions" provided by the Greeks, showing the scientific and philosophical fetters from which Copernicus had to escape.

THE WORKS OF ARISTOTLE translated into English: DE CAELO, by J. L. Stocks, M. A., D. S. O. Oxford, 1922.

Let us first decide the question whether the earth moves or is at rest. For, as we said, there are some who made it one of the stars, and others who, setting it at the centre, suppose it to be 'rolled' and in motion about the pole as axis. That both views are untenable will be clear if we take as our starting point the fact that the earth's motion, whether the earth be at the centre or away from it, must needs be a constrained motion. It cannot be the movement of the earth itself. If it were, any portion of it would have this movement; but in fact every part moves in a straight line to the centre. Being, then, constrained and unnatural, the movement could not be eternal. But the order of the universe is eternal. Again, everything that moves with the circular movement, except the first sphere, is observed to be passed, and to move with more than one motion. The earth, then, also, whether it move about the centre or as stationary at it, must necessarily move with two motions. But if this were so, there would have to be passings and turnings of the fixed stars. Yet no such thing is observed. The same stars always rise and set in the same parts of the earth.

Further, the natural movement of the earth, part and whole alike, is to the centre of the whole—whence the fact that it is now actually situated at the centre—but it might be questioned, since both centres are the same, which centre it is that portions of earth and other heavy things move to. Is this their goal because it is the centre of the earth or because it is the centre of the whole? The goal, surely, must be the centre of the whole. For fire and other light things move to the extremity of the area which contains the centre. It happens, however, that the centre of the earth and of the whole is the same. Thus they do move to the centre of the earth, but accidentally, in virtue of the fact that the earth's centre lies at the centre of the whole. That the centre of the earth is the goal of their movement is indicated by the fact that heavy bodies moving towards the earth do not move parallel but so as to make equal angles, and thus to a single centre, that of the earth. It is clear, then, that the earth must be at the centre and immovable, not only for the reasons already given, but also because heavy bodies forcibly thrown quite straight upward return to the point from which they started, even if they are thrown to an infinite distance. From these considerations then it is clear that the earth does not move and does not lie elsewhere than at the centre.

From what we have said the explanation of the earth's immobility is also apparent. If it is the nature of earth, as observation shows, to move from any point to the centre, as of fire contrariwise to move from the centre to the extremity, it is impossible that any portion of earth should move away from the centre except by constraint. For a single thing has a single movement, and a simple thing a simple: contrary movements cannot belong to the same thing, and movement away from the centre is the contrary of movement to it. If then no portion of earth can move away from the centre, obviously still less can the earth as a whole so move. For it is the nature of the whole to move to the point to which the part naturally moves. Since, then, it would require a force greater than itself to move it, it must needs stay at the center. This view is further supported by the contributions of mathematicians to astronomy, since the observations made as the shapes change by which the order of the stars is determined, are fully accounted for on the hypothesis that the earth lies at the centre. Of the position of the earth and of the manner of its rest (*Turn to next page*)

(Reproduced from a painting by Howard Russell Butler, N. A., by courtesy of the American Museum of Natural History)

EARTH FROM THE MOON. A modern artist's conception of our planet from a detached viewpoint, which would have been quite impossible to even the wisest of the Greeks

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or movement, our discussion may here end.

Its shape must necessarily be spherical. For every portion of earth has weight until it reaches the centre, and the jostling of parts greater and smaller would bring about not a waved surface, but rather compression and convergence of part and part until the centre is reached. The process should be conceived by supposing the earth to come into being in the way that some of the natural philosophers describe. Only they attribute the downward movement to constraint, and it is better to keep to the truth and say that the reason of this motion is that a thing which possesses weight is naturally endowed with a centripetal movement. When the mixture, then, was merely potential, the things that were separated off moved similarly from every side towards the centre. Whether the parts which came together at the centre were distributed at the extremities evenly, or in some other way, makes no difference. If, on the one hand, there were a similar movement from each quarter of the extremity to the single centre, it is obvious that the resulting mass would be similar on every side. For if an equal amount is added on every side the extremity of the mass will be everywhere equidistant from its centre, i. e., the figure will be spherical. But neither will it in any way affect the argument if there is not a similar accession of concurrent fragments from every side. For the greater quantity, finding a lesser in front of it, must necessarily drive it on, both having an impulse whose goal is the centre, and the greater weight driving the lesser forward till this goal is reached. . . .

If the earth was generated, then, it must have been formed in this way, and so clearly its generation was spherical; and if it is ungenerated and has remained so always, its character must be that which the initial generation, if it had occurred, would have given it. But the spherical shape, necessitated by this argument, follows also from the fact that the motions of heavy bodies always make equal angles, and are not parallel. This would be the natural form of movement towards what is naturally spherical. Either then the earth is spherical or it is at least naturally spherical. And it is right to call anything that which nature intends it to be, and which belongs to it, rather than that which it is by constraint and contrary to nature. The evidence of the senses further corroborates this. How else would eclipses of the moon show segments shaped as we see them? As it is, the shapes which the moon itself each month shows are of every kind—straight, gibbous, and concave—but in eclipses the outline is always curved; and, since it is the interposition of the earth that makes the eclipse, the form of this line will be caused by the form of the earth's surface, which is therefore spherical. Again, our observations of the stars make it evident, not only that the earth is circular, but also that it is a circle of no great size. For quite a small change of position to south or north causes a manifest alteration of the horizon. There is much change, I mean, in the stars which are overhead, and the stars seen are different, as one moves northward or southward. Indeed there are some stars seen in Egypt and in the neighborhood of Cyprus which are not seen in the northerly regions; and stars, which in the north are never beyond the range of observation, in those regions rise and set. All of which goes to show not only that the earth is circular in shape, but also that it is a sphere of no great size; for otherwise the effect of so slight a change of place would not be so quickly apparent. Hence one should not be too sure of the incredibility of those who conceive that there is continuity between the parts about the pillars of Hercules and the parts about India, and that in this way the ocean is one. As further evidence in favour of this they quote the case of elephants, a species occurring in each of these extreme regions, suggesting that the common characteristic of these extremes is explained by their continuity. Also, those mathematicians who try to calculate the size of the earth's circumference arrive at the figure 400,000 stades. This indicates not only that the earth's mass is spherical in shape, but also that as compared with the stars it is not of great size.

THE REPUBLIC OF PLATO, by Ernest Barker. London, 1906.

And now that you agree with me, Socrates, I proceed in my commendation of astronomy, which you formerly reproved as superficial. For it is evident, I conceive, to every one, that this discipline compels the soul to look to that which is above, and from the things here conducts it thither. It is probable, said I, that it is evident to every one but to me. For to me it does not appear so. How then do you think of it? replied he. In the way it is now pursued by those who introduce it into philosophy, it entirely makes the soul to look downwards. How do you say? replied he. You seem to me, said I, to have formed with yourself no ignoble opinion of the discipline respecting things above, what it is: for you seem to think, that if any one contemplates the various bodies in the firmament, and, by earnestly looking up, apprehends every thing, you think that he has intelligence of these things; and does not merely see them with his eyes; and perhaps you judge right, and I foolishly. For I, on the other hand, am not able to conceive, that any other discipline can make the soul look upwards, but that which respects being, and the invisible; and if a man undertakes to learn any thing of sensible objects, whether he looks upwards with mouth gaping, or downwards with mouth shut, never shall I say that he learns; for I aver he has no science of these things, nor shall I say that his soul looks upwards, but downwards, even though he should float as he learns, lying on his back, either at land or at sea. I am punished, said he; for you have justly reproved me. But which was the proper way, said you, of learning astronomy different from the methods adopted at present, if they mean to learn it with advantage for the purposes we speak of? In this manner, said I, that those varied beauties in the heavens, as they are embroidered in a visible subject, be deemed the most beautiful and the most accurate of the kind, but far inferior to real beings: to those orbits in which real velocity, and real slowness, in true number, and in all true figures, are carried with respect to one another, and carry all things that are within them. Which things truly are to be comprehended by reason and the mind, but not by sight; or do you think they can? By no means, replied he. Is not then, said I, that artistic beauty in the heavens to be made use of as a paradigm for learning those real things, in the same manner as if one should meet with geometrical figures, drawn remarkably well and elaborately by Dædalus, or some other artist or painter? For a man who was skilled (*Turn to next page*)

Prosperity Due to Indian

Archaeology

The Indian laid the foundation of the economic greatness of the United States, Dr. Clark Wissler, professor of anthropology, Yale University, told the Conference on Midwestern Archaeology in St. Louis.

"It is not that we took merely the Indian's land," he said. "We acquired tobacco, maize, potatoes, peanuts, tomatoes, and some forty additional food plants. The yearly value of these products produced in the United States alone, when stated in dollars, is incomprehensibly large. We would have discovered tobacco in time, maybe, but it took the Indians centuries to develop the art and the plant. Maize, the economic backbone of agriculture in the Mississippi Valley, would have remained undiscovered for a long time at least.

"It was native Indian trade that enriched Europe and made the rapid development of our country possible. The Indian was a consumer of goods, eager to buy and to pay extravagantly in furs and other products. In truth, it may be said that the American Indian put the white man on the map."

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in geometry, on seeing these, would truly think the workmanship most excellent, yet would esteem it ridiculous to consider these things seriously, as if from thence he were to learn the truth, as to what were in equal, in duplicate, or in any other proportion. Surely it would be ridiculous, replied he. And do not you then think, that he who is truly an astronomer will be affected in the same manner, when he looks up to the orbits of the planets? And that he will reckon that the heavens and all in them are indeed established by the artifices of the heavens, in the most beautiful manner possible for such works to be established; but would not he deem him absurd, who should imagine that this proportion of night, with day, and of both these to a month, and of a month to a year, and of other stars to such like things, and towards one another, existed always in the same manner, and in no way suffered any change, though they have a body, and are visible; and search by every method to apprehend the truth of these things? So it appears to me, replied he, whilst I am hearing you. Let us then make use of problems, said I, in the study of astronomy, as in geometry. And let us dismiss the heavenly bodies, if we intend truly to apprehend astronomy, and render profitable instead of unprofitable that part of the soul which is naturally wise.

Aristotle (384-322 B. C.) was born at Stagira, but became a pupil of Plato in Athens at 17. He remained with the older philosopher for the remaining 20 years of his life, teaching and developing a new experimental method of thought. Plato considered Aristotle his most brilliant student in spite of the difference in their method of thought. Upon Plato's death Aristotle left Athens. Three years' residence at the court of Hermias, tyrant of Atarneus, whose niece he married, ended with his patron's death. Eight years with Philip of Macedon as tutor to his son Alexander, afterward called the Great, terminated upon Philip's death. Aristotle then returned to Athens where he kept his famous school in the Lyceum and wrote his many books. The twelve years of Alexander's glory, when Aristotle was between the ages of 48 and 60, comprised the life of the Lyceum. Alexander's death made Athens unsafe for his old tutor, and the last two years of Aristotle's life were spent practically in exile in Chalcis.

Plato (427-347 B. C.) was in his youth a devoted friend of Socrates, whom he made one of the characters in his dialogues. Socrates was condemned to drink hemlock in 399, when Plato was 28 years old. During his later life, Plato taught the youth of Athens in the grove called Academus, and there in 367 Aristotle became one of his pupils. Case sums up the difference between the two thinkers: "Philosophically, Platonism is a philosophy of universal forms, Aristotelianism a philosophy of individual substances: practically, Plato makes us think first of the supernatural and the kingdom of heaven, Aristotle of the natural and the whole world."

Earth is the third planet from the sun, around which it revolves at a mean distance, "as every schoolboy knows" of 93 million miles. From its neighboring planets on either side, the features of its surface would probably be indistinguishable during a large part of the time on account of its atmosphere and frequent clouds. Under the best visibility, the works of man would be quite invisible to dwellers upon both Mars and Venus. Venus-ians, if their own atmosphere did not interfere, would get the best view of our planet, for the Earth and its Moon would appear to them as a great double planet, the most conspicuous object in the night sky. To the Martians, Earth would show phases as Venus and Mercury do to us, and the time of their occurrence would prevent their ever getting a good view of the whole surface of the Earth.

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Nature Ramblings

By Frank Thone

Marsh Marigold

Usually a little later in starting than its cousins, the buttercups, the marsh marigold makes up for lost time when it does come by bursting into a veritable bombshell of yellow light. All over the plashy edges of ponds, and marking ankle-wetting meadows with cushiony tufts of gold and glossy green, this is one of the most attractive of all our ornaments of wet places. It is, by the same token, one of the most aggravating of flowers if you want to pluck it, for it always grows just beyond arm's-length reach from the nearest solid ground, and you have to pay for a nosegay with a pair of wet feet.

In a world grown somewhat anxious about conserving wild flowers, it is a relief to find one that can take care of itself in this manner, and one, moreover, that can be gathered by the handful or even cropped by splashing cows, without apparent danger of depleting the visible supply. For the marsh marigold is a lusty and rank grower, and seems to be able to replace lost branches and leaves as nonchalantly as so much marsh grass.

If you have had the curiosity to gather some flowers of this plant, you will have a chance to read for yourself a lesson in that outdoor physiology of plants which the learned call ecology. You will see that each stem is hollow, or sometimes pierced lengthwise with several hollows. This is a common device among plants that grow with their heads in air and their roots in water or thoroughly soggy soil. Roots must have air to breathe, just as leaves do, and if the water excludes it, the next best thing is to bring it down through natural air-pipes which the plant can grow for itself.

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Whether tea is known as black or green depends on the method of preparing the leaves.