partly on cicadas (the "man-on-the-street" calls them locusts), steam is visible (white), lightning follows zigzag paths with sharp bends, mammals of the order Cetacea (porpoises, dolphins, whales, etc.) are fishes, the tongue of a snake is its "stinger," moist air is heavier than dry air, etc., etc.

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MATHEMATICS AND THE TRUTH

IT is frequently said that the modern mathematician does not ask whether a certain result which he regards as established is true but that he is interested only in proving that it can be derived from the system of postulates which he has formulated. While it would be difficult to determine the amount of mathematical work which is now being done in such a philosophical frame of mind it would doubtless be safe to say that this amount is relatively very small. If one listens to papers presented at the meetings of mathematicians one can not fail to notice that there is a remarkable degree of confidence in the truth, and hence permanent character, of the new results which are being communicated. It is seldom that any reference is made to the system of postulates which are ultimately involved and it is quite likely that many of the most successful investigators would find it difficult to exhibit these postulates if they should be asked to do so.

As far as we know now the ancient Greeks were the first to realize the fact that mathematical reasoning must ultimately be based on postulates, and hence that the results with which mathematicians deal can be regarded as true only if these postulates are true. Recent discoveries have established the fact that the pre-Grecian mathematical developments were much more extensive than had been previously assumed, but these discoveries have not yet exhibited any system of postulates which antedates those of the Greeks. It is a very interesting fact in the history of scientific ideas that all known evidences support the view that before the ancient Greek civilization mathematical results were regarded as truths which were not ultimately dependent upon systems of postulates. The Greeks seem to have originated the philosophical frame of mind as regards mathematical results, and they fortunately also greatly extended these results so as to provide ample material for the activities of those who accept as true much that they themselves have not traced back to the ultimate postulates.

The popular orator who seeks to clinch a statement by saying that it is mathematically true conveys thereby a more useful view of mathematics than the critical student who observes that nothing can be really proved in mathematics since it is necessary to assume some things before you can reason about any question. Both those views are in order under appropriate circumstances, and they supplement each other. To exhibit the Greek view as regards the necessity of postulates in the development of mathematics we quote the following from Aristotle's Posterior Analytics:

> By first principles in each genus I mean those the truth of which it is not possible to prove. What is denoted by the first [terms] and those derived from them is assumed; but, as regards their existence, this must be assumed for the principles but proved for the rest. Thus what a unit is, what the straight [line] is, or what a triangle is [must be assumed].

What is perhaps of more importance in this connection is the fact that Aristotle not only knew that some of the postulates of mathematics can not be proved but he also saw that they do not necessarily appear self-evident to the beginner. This is shown in the following statement found in the work to which we referred in the preceding paragraph:

> Now anything that the teacher assumes though it is a matter of proof is a hypothesis if the thing assumed is believed by the learner, and it is, moreover, a hypothesis, not absolutely but relatively to the particular pupil; but, if the same thing is assumed when the learner either has no opinion on the subject or is of a contrary opinion, it is a postulate.

Hence it appears that at least some of the ancient Greeks looked at mathematics and the truth in about the same way as we do now. This is a very important fact in the history of the development of mathematical ideas, especially since during some of the intermediate centuries the postulates of mathematics seem to have been regarded as self-evident truths. The development of non-Euclidean geometry exerted a powerful influence towards making the function of the postulates in elementary geometry more widely known.

Some of the Greek writers called attention to what appeared to them as different properties of postulates and axioms, and many of the modern writers have followed them in this regard. On the other hand, there are those who see no essential differences between the concepts represented by these terms. The relation between mathematics and the truth is, however, not affected thereby. If at least one of the two terms axiom and postulate was used by the Greeks to represent a concept which was not regarded as self-evident they must have realized the philosophical difficulties involved in regarding mathematics as true in the sense that it is possible to establish a contradictory system based upon another set of postulates. O. Neugebauer recently directed attention to the fact that an important feature of pre-Grecian mathematics is that it excludes the concept of irrationality which plays such a fundamental rôle in the mathematics of

the ancient Greeks. From what precedes it results that another very important feature of pre-Grecian mathematics is that it does not involve the concept of postulates, which also plays a fundamental rôle in Greek mathematics and in the connections between mathematics and the truth.

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THE DEVONO-MISSISSIPPIAN BOUNDARY IN THE SOUTHEASTERN UNITED STATES

STUDIES made in Tennessee and Virginia under a grant from the Rockefeller Fund for Research in Pure Science of the University of North Carolina have led to the following observations and conclusions.

The Chattanooga shale in the type area at Chattanooga, Tennessee, is entirely Mississippian in age. From Chattanooga it can be traced through northeastern Tennessee into southwestern Virginia where it gradually fingers out, finally disappearing near Holston, Virginia. Throughout most of this region it maintains its typical threefold division into upper Big Stone Gap black shale, middle Olinger gray shale and lower Cumberland Gap black shale members. In Virginia, in the Clinch Mountain area, the gray Olinger shale rapidly becomes black also and merges with the overlying Big Stone Gap and the *upper* part of the underlying Cumberland Gap members to form a single black shale series. At the same time the *lower* part of the Cumberland Gap shale, which has here become a black to gray-black shaly sandstone, splits into a series of wedges which intertongue with sandy shales and shaly sandstones carrying an upper Devonian (Chemung) fauna. It thus follows that the lower part of the Cumberland Gap member is Devonian in age while the upper part is Mississippian, as proved in 1927.[1] The Devono-Mississippian boundary lies, therefore, *within* the Cumberland Gap black shale member and can be represented by only a slight stratigraphic break, if indeed by any at all. Its unimportance is further emphasized by the following facts. 1. At the southern end of Clinch Mountain black shale deposition extends without interruption across the boundary, the Chemung and Chattanooga beds uniting in one continuous black shale series. 2. The overlap of the upper Devonian beds towards the southwest continues, without sign of a regression of the sea, across the boundary and on through lower Chattanoogan times. 3. Conglomerates just below the Chattanooga in the upper Chemung, which by some geologists have been regarded as marking the boundary, are all purely local and intraformational in character.

Towards the west and southwest the Devonian portion of the black shale rapidly wedges out and the Chattanooga becomes, as in the type area, entirely Mississippian in age, and probably so continues across the Mississippi River into the southwestern United States.

In view of the Mississippian age of the Chattanooga shale at Chattanooga, Tennessee, the term "Chattanooga" should be restricted to the Mississippian portion of the shale, if it becomes feasible to separate it from the underlying Chemung black shales. A distinct formational name should then be applied to the latter.

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[1] "Chattanooga Age of the Big Stone Gap Shale," *Amer. Jour. Sci.*, 14, 1927: 485–499. *Cf.* also: "Age and Stratigraphy of the Chattanooga Shale in Northeastern Tennessee and Virginia," *Amer. Jour. Sci.*, 17, 1929: 431–448.

PORTO RICAN AND DOMINICAN STRATIGRAPHY

THE following stratigraphic sequence of Porto Rican sedimentaries is a revision suggested in the light of advancing knowledge.

Pleistocene to Recent: Dune sands, Alluvials, Playas, San Juan formation. *Lower Miocene:* Ponce chalk beds, Quebradillas limestone, Aguadilla limestone. *Upper Oligocene:* Lares and San Sebastian beds, Guanica limestone, Lower Ponce beds, Juana Diaz shales. *Upper Eocene:* Rio Descalabrados and La Muda deposits. *Middle Eocene:* Rio Jueyes beds. *Upper Cretaceous* (*Maestrichtian*): San Germán deposits, Enseñada shale, Fajardo and Cape San Juan limestones. *Lower Cretaceous:* (?) Limestone south of Cidra. Doubtful, but possibly equivalent to the Fredericksburg.

Regarding Dominican Republic sedimentaries, I now refer my Gato beds to marine Pliocene, and my Caimito beds to Upper Miocene.

In 1917, I made my Cercado and Gurabo formations the types of Lower and Middle Antillean Miocene, respectively. Lately Dr. Woodring has placed the division between Lower and Middle Miocene below the Cercado, running it up into Middle Miocene. But the association of *Ostrea cahobasensis* and *Orthaulax aguadillensis* in the May Pen limestone, Jamaica, draws the Las Cahobas and equivalent Cercado relationship downward. Furthermore, the Bulla which grades into the Cercado is probably, as Dr. Vaughan thought, largely contemporaneous with the Baitoa. Therefore it seems to me a truer time relation that the Cercado should remain as type of the Lower Miocene of the Antilles.

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