be presided over by Dr. Harlow Shapley, director of the Harvard College Observatory, and the afternoon session by Dr. W. F. G. Swann, director of the Bartol Foundation of the Franklin Institute. In the evening there will be a lecture by Dr. Henry Norris Russell, professor of astronomy and director of the Princeton University Observatory, on "Stellar Energy and the Evolution of Atoms," at which Roland S. Morris, president of the society, will preside.

THE tenth annual meeting of the American Association of Physical Anthropologists will be held on April 4 and 5 at the Wistar Institute of Anatomy and Biology, Philadelphia.

THE Southeastern Section of the American Physical Society will hold its annual meeting at the University of Georgia, at Athens, on March 31 and April 1. A symposium on biophysics will be a feature of the program at which Dr. Detlev W. Bronk, director of the Eldridge Reeves Johnson Foundation for Medical Physics at the University of Pennsylvania, will be a guest speaker.

THE Midwestern Psychological Association will hold its annual meeting at the University of Nebraska on May 5 and 6, under the presidency of Dr. E. S. Conklin of Indiana University. The title of Dr. Conklin's presidential address will be "The Status of Academic Psychology." A special feature of the meeting will be the commemoration of the fiftieth anniversary of the founding of the psychological laboratory at the University of Nebraska, by Harry Kirke Wolfe.

THE 1938 expedition of the American School of Prehistoric Research was limited to certain parts of Anatolia and Bulgaria. Dr. Dorothy A. E. Garrod, of Cambridge University, the well-known authority on the prehistory of the Near East and leader of the expedition, was assisted by James H. Gaul and Bruce Howe, both former students of the school and at present enrolled in the Graduate School of Harvard University. In the cave of Batcho Kiro, near Drenovo, Bulgaria, they found a stratified paleolithic sequence (Mousterian and Aurignacian), surrounded by a deposit containing pottery and a recent fauna—the first sequence of this kind to have been reported from Bulgaria. With permission of the government and supervision by the National Museum in Sofia, the school will, in the near future, continue the excavations so auspiciously begun at Batcho Kiro.

THE Standards Association of Australia has established a Chemical Industry Committee, the functions of which are coordination and supervision of preparation of standards of chemical analysis and sampling therefor, and standards for materials and products the manufacture of which may be regarded as coming substantially under the heading "Chemical Industry." It will also act as an Advisory Committee to the Council of the Association on all matters relating to chemical industry. The committee consists of representatives of the Australian Chemical Institute, the Australasian Institute of Mining and Metallurgy, educational and government departments and other organizations with chemical interests. Dr. H. B. Taylor has been appointed chairman.

THE Rockefeller Foundation has offered to the University of Oxford £600 for the year 1939 to provide in the department of pharmacology scientific apparatus, laboratory supplies, technical assistance and a fund for current research expenses for investigation on hormones and on the central nervous system.

DISCUSSION

DESCARTES AND THE MODERN WORLD[1]

TO-DAY philosophers and scientists of the world do not hesitate to admit that in the mathematics lies the supreme creation of the human intellect. In every civilization of record the mathematician has occupied himself with the universe of number and of form, the creation of the mind. No external necessity and no practical need determined the developments of mathematical science. However, as developments were made applications were found, and thus, for example, the sciences of astronomy and physics were evolved, in truth, out of the mathematics.

For some thousands of years mathematical science could record a conquest of the material universe in the laws of number and of form largely only upon the assumption of a reasonable universe. Day follows upon day, season upon season, eclipse upon eclipse, in a determinable order; for many centuries the elementary arithmetic and the algebra with the pure geometry of the conics, the circle and straight line were sufficient for such physical measurements as the physicists and astronomers could achieve.

With Viète, Descartes and Fermat, and Leibniz and Newton a wholly new era of mathematics enters into the panorama of intellectual history. In this period the mathematical achievements of the ages are crystallized into systems that give control over the material universe far beyond simple explanation of known phenomena.

Permit an apparent digression, for a moment, to insist that the veritable proof of science lies not simply

[1] A paper presented in Paris, in July, 1937, at the Third International Congress of Philosophy and the Descartes Tercentenary; the author was one of the official delegates of the United States, appointed by President Roosevelt.

in the mathematical explanation of known phenomena nor even in the construction of machines. The incontestable proof of reason, the veritable demonstration of science lies in prophetic assertion concerning hitherto unobserved phenomena which lie beyond the control of the prophet scientist.

Two illustrations must suffice, since the power of the mathematical formulation to explain observed effects to suggest to the competent observer new and unobserved physical phenomena or the creation of new devices in the given field has been repeatedly demonstrated. With Adams and Leverrier you have the proof positive of the adequacy, for that day, of the Newtonian theories in the prophetical mathematical creation of the planet Neptune. The Newtonian laws justified the observed path of the moon, with the exception of certain perturbations. These variations, not consistent with the observed phenomena, could be explained by the postulation of the existence of another planet with an orbit that was derivable from the mathematical equations.

As a second illustration, D'Alembert, using the methods and notations furnished by Viète, Descartes, Newton and Leibniz and others, was able to set up the differential equations which explain the observed phenomena of wave motion. In the hands and mind of Maxwell this led to the electromagnetic theory of light and to Maxwell's prophecy concerning, in common language, "wireless electric waves." It is in the formulas of Maxwell that the radio is prophesied and one may say constructed. Hertz then found the coherer and thus actually detected the rays prophetically constructed by Maxwell; this was equally, as Hertz himself explicitly indicated, the achievement of Maxwell, an unhoped-for gift given by the mathematical formulation. The undeniable proofs of the correctness of Maxwell's equations are furnished finally by the senses in the phenomena whose existence is revealed as a by-product.

It is with some hesitation that I suggest to my philosophical colleagues that mayhap the answer to the ever-recurring question "What is reason?" lies most often in the demonstrations in the world of physical phenomena and must, in some measure, rest upon the material.

The modern mathematics of Viète, Descartes and Newton and the control over the physical universe was made possible by the logical geometry of the Greeks, the arithmetic, the algebra and the trigonometry of the Hindus and the Arabic genius for exposition and combination and extension of the Greek and Hindu material. Particularly the trigonometry to which the Arabs made many independent contributions was essential for the subsequent control over the physical universe.

To-day one can say, without hesitation, that in these developments that were transmitted to Europe by the Arabs the mathematical science of Egypt and Babylon contributed no mean and insignificant part.

The transmission to Europe of the science of the Orient and the near East was effected over several centuries by Latin and Hebrew translations. The universities were created to a large extent, as Sarton has indicated, to make possible the systematization of the tremendous mass of scientific material revealed to Europe in the translations.

Italy played a most important role in the development of algebraic techniques and notably in the algebraic solution of the cubic and bi-quadratic. In an attempt to systematize these solutions Viète created the literal symbolism, the initial and crucial step towards a new mathematics.

Without Viète there could be no Descartes and Fermat; without Viète, Descartes and Fermat, there could be no Newton and Leibniz.

Recall that the symbolism of Newton is a variation of Viète's literal symbolism employing the fluxion overhead dot; the Leibniz $\frac{dy}{dx}$ is another variation of the Viète literal symbolism. To the philosopher the paradoxes and the difficulties of the infinitesimal and the infinite cause a great deal of trouble; witness the papers of this congress. For philosopher and mathematician no solution is possible without some mathematical symbolism. For the application of mathematics to physical problems the infinitesimal calculus with some adequate notation is the only known road.

What is the part of Descartes in the progress of the mathematical control of the universe? In truth one can say that the analytical geometry is the application of the literal symbolism to geometry, the necessary first step towards the application of algebraic methods to physical phenomena.

Descartes' use of Viète's symbolism revealed that the literal symbolism (of x, y and r or v) was equally powerful in trigonometry. Upon this followed also, as Professor Elie Cartan, of Paris, has so well shown, the introduction into geometry of imaginary elements. The literal symbolism in the real plane made the $x + i.y$ symbolism of the complex plane an inevitable continuation. The interplay here between the algebra of real quantities, the algebra of complex numbers and the geometry and the trigonometry made possible mathematical developments of the greatest importance for the domination of the physical universe.

The fundamental importance of trigonometry in the progress of mathematical science has not been sufficiently recognized by historians of mathematics. To apply the mathematics to physical phenomena it was absolutely essential to have mathematical expressions

for recurrence. The Hindus, by a stroke of genius, dropped the Greek trigonometry of chords and introduced the half-chord or sine function. With the shadow function of the Hindus, further developed by the Arabs and Europeans, one has a trigonometry adaptable to simple mathematical formulations, as Viète demonstrated in so masterly a fashion. This trigonometry leads back again to algebraic formulations employing the complex numbers; it is sufficient here to mention the names of Demoivre and Euler and Gauss. Progress in early mathematical science hinged upon this constant interplay between algebra and geometry. This was the path, also, that made possible the application to physical phenomena. It is for that reason that one can say that Viète, Descartes and Fermat, Newton and Leibniz created the modern world in which recurrent phenomena, not only the wave motion of the mathematician, but also "quantity production" made possible in industry by such phenomena, play so important a role.

In conclusion I must recur to a point of view mentioned by Professor Elie Cartan, *i.e.*, that there are those who deny to Descartes the invention of the analytic geometry. The opinion of Coolidge,[2] that the Greeks invented analytic geometry, is characterized, possibly by a slip of the pen, as "une des opinions les moins déraisonables."[3] I prefer to phrase it as "les plus déraisonables." This assertion by Coolidge is an absolute denial of progress in science. This is, it seems to me, of a piece with that madness that would characterize all science as Greek or as Aryan. If you say that the Greeks had the analytic geometry, what becomes of all that majestic work done by the Hindus, systematized and transmitted by the Arabs, and worked over again by generations of Europeans, culminating in Viète, Descartes and Newton. Science is progressive; mathematical science is the indisputable achievement of the human intellect of all the ages past and of all peoples, including Moslems and Jews and Christians and followers of other gods.

The modern world of electricity, of the aeroplane, of quantity production and of the wireless was made possible by the mathematical formulas of the literal algebra, the analytical geometry, the trigonometry and the calculus with their derivative sciences. The new mathematics made it possible not only to explain the observed phenomena but to create a new material world quite different from the old world. In the process of transition many have forgotten and some would even deny the mathematical creation. The progressive character of this creation has made it easy to forget the creator.

In mathematics one can not leap from the Greeks to Newton and Leibniz. There is only one intellectual highway to the modern mathematics and that leads, as I have indicated above, through the intellectual accomplishments of the Hindus and Arabs, by the way of the Jewish and Christian translators of the Arabic and the Greek, through Europe of the middle ages and the renaissance to those majestic men of science, Viète, Descartes and Newton. Their work crystallized the mathematical achievements of all past ages; no nation can claim them; in any age of reason these men belong to humanity.[4]

LOUIS C. KARPINSKI

[2] See J. L. Coolidge, *Osiris*, I, pp. 231–250, 1936.

[3] Elie Cartan, *Actualités scientifiques et industrielles*, 535: 146–153, 1937.

AUTHORITY CITATIONS IN NOMENCLATURE

THE discussion of authority citations raised by Donald Culross Peattie and continued by others seems, thus far, to have been confined to workers in modern biology. The problem is even more acute in the fields of paleontology and paleobotany where species are often necessarily established on form rather than on phylogenetic bases, as well as on fragmentary remains. Later evidence may require one or more subsequent changes to be made in the classification of a species, in which case a full citation of authorities becomes impossible.

A case in point is that of the Carboniferous fossil fern originally called *Staphylopteris sagittatus* Lesquereux, described and figured in the Report of the Geological Survey of Illinois, Volume IV, 1870. Ten years later Lesquereux himself had cause to refer this species to a new genus, and the change was published in the Report of the Second Geological Survey of Pennsylvania, Vol. 1, 1880. To be actually complete, the name and authority would have to be cited as *Sorocladus* (*Staphylopteris*) *sagittatus* (Lesquereux) Lesquereux. A further study of the species was next made in 1902 by Sellards, working in Kansas, who found that the species should be referred to the genus *Crossotheca* Zeiller. This change was published in the *American Journal of Science*, Vol. IV, 1902. Obviously, a complete citation of authorities after the name would be awkward. Consequently, the name is usually cited by paleobotanists merely as *Crossotheca sagittata* Lesquereux, credit being given to the original author without reference to the several authors of the generic changes. Examples of this nature are numerous, and it can be seen at once that a change in authority with every change in classification would lead to disassociation of a given species from its original description. This would lead to endless confusion, especially among younger workers in the field who have not had

[4] See also: B. de Kerékjártó, *Actualités scientifiques industrielles*, 535: 166–173; Casimir Wize, the same, pp. 144–146; M. Abel Rey, the same, 531: 27–32.