Cultural Contacts of Science*

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IN the study of man and his activities, three types of cultural development may be recognized; and they are all measured by different standards. In the Fine Arts the imaginative qualities of the mind appeal primarily to the emotions through stimulation of the æsthetic judgment; material culture is the province of mechanical arts; and science—the domain of reason—is systematic and formulated knowledge in all fields of human understanding—natural, moral, social and political. Natural science, or natural philosophy, is only one division of science as thus defined. The history of civilization is a history of intellectual development in which science has been the chief factor in changing habits of thought from superficial observation and speculative and anthropomorphic theories of causation to clear concepts, rational conclusions and progressive principles in the advancement of man and society.

In the most primitive times, man had to acquire knowledge of the world of Nature around him in order to survive. The effort to secure the food and shelter necessary for his existence demanded a never-ceasing exploitation of the resources of his environment for the progressive improvement of his material equipment—an equipment which he learned to turn against his fellow-man, no less than against the animal world upon which he preyed for food and clothing, or against which he must defend himself. But in this struggle, even more than on his personal prowess, his skill, and his knowledge of the habits of food-plant and animal, man relied upon his imagined understanding of, and his supposed power to control, the hidden causes of the nature and behaviour of the beings and objects of his world—in other words, his will to survive was rooted in magic. Though the magical beliefs of primitive man may seem to us vain and crude, let us not despise them; for in these blind gropings to probe causation in Nature, we may see the remote and humble beginnings of the urge to the understanding of the universe, which is science.

It is not, however, with man's progress in relation to material development with which we are now concerned, but with the contacts of science with what is known as 'polite' learning—literature, religion, and other expressions of the human spirit. The noblest aims of man are not represented by

great industrial advances, but by the search for the truths upon which they are based, and by the influence of this effort upon personal and social ethics. These intellectual or spiritual associations of science were more common in former times than now, when we are passing through, or perhaps, as it may be, just emerging from, a materialistic age in which they tend generally to be neglected.

The Fine Arts and literature are usually confined to the expression of what are understood to be the eternal verities of life; and, so long as this is so, though their form of expression may change, a supreme standard of excellence may be reached in any epoch. In the fourth and fifth centuries before the Christian era, the works produced by the artistic and literary genius of the Greeks are masterpieces which will command admiration for all time; and ancient Rome, India and China have each had a golden age of artistic and literary achievement. Similarly in western Europe, architecture, painting and poetry have reached the highest level of excellence at various epochs and then suffered a decline. Apart from the development of technical excellence, progress in any of these arts of expression can only be in the elaboration and enrichment of creative ideas; but the store of these is not thereby increased, and each age—each type of civilization—must work out its own ideals. Artists may aspire to emulate the paintings of Raphael or Leonardo da Vinci, but they cannot use the works themselves as a background upon which to add their own conceptions.

Science, however, differs from the Fine Arts in the fact that every discovery extends the boundaries of knowledge and may be the starting-point of further progress. It was upon the foundations laid by Kepler and Galileo that Newton was able to construct the universal law of gravitation; and it is by the succession of such discoveries that science advances, while the picture it presents is continually being enlarged and having new details added to it. The time may come when art and literature will be moved by such achievements of the human mind to make manifest their real meaning, and the imagination will be so quickened by the spirit of man reaching out to the stars that artistic and literary response to the beauty and mystery of Nature will be deeper than ever before.

Associations of science with literature in former times are chiefly connected with astronomy—the

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oldest of the sciences and the one most closely united with spiritual feeling. At the beginning of the history of civilization, the sun and moon were given divine attributes as well as used to mark the times of operations of life in days, months and years. Five thousand years ago, the Babylonians and Egyptians possessed a considerable store of knowledge of the skies. The constructions of the great temples and pyramids of Egypt, as described in preserved records, and shown in existing remains, are of particular astronomical interest, as well as for the study of mythology and religious belief. One of the most impressive structures of this kind, the remains of which still exist, is the great temple of Amon-Ra at Karnak, near Luxor, the length of which is about five hundred yards, with the open end pointing in the direction of the setting sun at the summer solstice. The rising of the star Sirius—the brightest in the heavens—just before the sun in July of each year heralds the annual inundation of the Nile and was used by early Egyptians to mark the beginning of a new year.

Observations of groups of stars seen just above the sun at dawn or at twilight were associated with seasons and other events on the earth in very early times. The groups were figures on a celestial dial, and the sun took a year to pass round the complete circle of the heavens upon which they were fixed. The division of the circuit into twelve parts, or signs, made up the Zodiac, as recognized and used for religious and seasonal observances by the Chaldeans, the Chinese, the Egyptians, Hindus, Persians, Greeks, Romans, and other peoples. The twelve signs or constellations of the Zodiac seem to be referred to in Joseph's second dream, and in Jacob's blessings of his children.

The sun as the source of all heat, light and life on the earth was the central object of religious belief of most early peoples. Whether it was worshipped as the god itself, or as his symbol, even by the priests, is doubtful; but for a short period in the history of Egypt, about thirteen hundred years before the Christian era, King Akhnaton, or Akh-en-Aten—signifying "The Blessed of the Disk"—the Sun-god was certainly worshipped as the one and only god, and the belief was, therefore, monotheistic. The finest expression in Egyptian literature is found in Akhnaton's "Hymn to the Sun-Disk". Similar hymns are found in the "Rig-veda", one of the four sacred books of the Hindu scriptures, where light is associated with moral and intellectual values, as well as with physical properties.

Astronomy was thus studied by early peoples not only for practical purposes but also for religious observances. The gods or natural forces which

determined the movements of celestial bodies were regarded as also ruling human nature. Astronomy and astrology were then combined in a single study. In the sixth century before the Christian era, Greek philosophers separated the conceptions of the influence of gods from the study of impersonal Nature, the laws of which were discoverable by the proper and methodical application of the human intellect. They first introduced the word φύσις, denoting *Nature*, to signify natural philosophy as apart from theology and mythology. The Hebrews also made a distinction between the worship of God and His works; but they saw all things as testimonies to the wisdom and power of the Almighty—as subjects of wonder and spiritual exaltation rather than as matters of intellectual inquiry.

There are many references to astronomical objects and phenomena in classical Greek literature from the sixth century B.C. onwards. The earliest Greek work on astronomy is that of Eudoxus, transmitted in verse by Aratus—third century B.C.—who mentions forty-four constellations. A commentary upon their works was written by Hipparchus, who was as great an astronomer as Aratus was a poet. Ptolemy (A.D. 100–178), who was the definitive authority on astronomy of the ancient world, enumerates forty-eight constellations; and these, with few changes, are still used by astronomers to mark the grouping of stars in the sky.

Aratus's astronomical poem was esteemed by both Christian and pagan philosophers. When the Apostle Paul spoke to men of Athens on Mars' Hill, he referred to Aratus when he remarked "as certain also of your poets have said: For we are also his offspring". The words used by St. Paul follow very closely passages in the text of the poem of Aratus. Cicero and other writers translated Aratus's poem into Latin; and several Roman poets, including Virgil, quoted largely from it. In his great didactic poem, the "Georgics", Virgil brings man into intimate contact with Nature by describing the relationship between agricultural operations and the constellations visible at different seasons. In the same period, Lucretius produced his great work "On the Nature of Things", which is more remarkable for its anticipation of modern views as to atoms and their relationship to space than for its description of scenes or actions in the celestial drama as viewed from the earth. His purpose was to present a theory or theories which would explain natural things and laws without assuming the existence of deities as legislators.

During the period from the ninth to the fourteenth century, when the study of natural knowledge was cultivated by the Arabs with con-

spicuous success, astronomy was given particular attention and Arabic works upon it, translated into Latin, were afterwards widely read. Omar Khayyam, who lived in the latter half of the eleventh century, was an astronomer as well as a poet, though there are few astronomical references in his "Rubaiyat". He lived in the golden age of Arabic science; and the next great poetic genius was Dante, who made detailed and accurate use of the scientific knowledge of the times. Dante derived his knowledge of celestial objects and movements from a celebrated Arabic astronomer, Alfraganus, who flourished at the beginning of the ninth century and wrote a number of works on the sundial, the astrolabe and other astronomical subjects. Chaucer was another astronomer-poet who was indebted to Arabian science for much of the astronomical knowledge revealed in his works. He was the first great master of English verse, and his poems contain many references to celestial subjects, chiefly from the point of view of their relationships to human life and events.

Three centuries after Dante, Milton, in "Paradise Lost", described many astronomical objects and phenomena. Milton met Galileo, and in well-known lines refers to the astronomer's observations of the moon and the Milky Way. He knew the Copernican system of the universe, which was established by Galileo's observations, and described the differences between it and the Ptolemaic system which was then generally accepted, but he left the question unanswered as to which system should be accepted as true. Even Francis Bacon persistently rejected the Copernican theory, though there were eminent men, astronomers and others, anterior to, or contemporary with him, who adopted and taught it. The theory had been before the world for nearly eighty years before Bacon's "Novum Organum" was published, and he gave great attention to the methods by which astronomy ought to be studied; yet he refused to accept the theory and constructed an elaborate celestial system of his own. Even after the discovery of the satellites of Jupiter by Galileo in 1609, seventeen years before his death, Bacon opposed the Copernican view that the earth moved in an annual orbit around the sun. It is unfortunate that a philosopher with such a wide range of knowledge, whose object was to show others how science could be advanced, did not appreciate the simplicity of the Copernican theory as an explanation of celestial movements. In this respect, however, his attitude was that of many of his contemporaries, including those not influenced by theological prejudices, as well as Catholics and Protestants.

The adoption of the Copernican theory meant

that the foundations of belief in the earth and man as centres of the universe were destroyed. Later, when Newton had shown that the law of gravitation was sufficient to account not only for the movements of the planets but also for the paths of comets, it was no longer reasonable to believe that these were sent as signs or warnings to the human race. The intellectual expansion thus brought about, together with the sense of justice which resulted from the existence and permanence of law in Nature, profoundly influenced human thought and resulted in social changes which had the greatest civilizing effects.

A similar revolutionary adjustment of thought had to be faced when, three centuries after Copernicus, man was placed in a new relationship to the rest of living creatures and shown to have a sub-human ancestry. The principle of evolution gives new hope to life and the promise of a golden age in the future instead of the past, if man follows his highest ideals; for, as T. H. Huxley pointed out, evolution embodies the idea of progressive social and ethical standards, as well as development of physical structure. Any nation or people which separates itself from the rest of the world in the name of race or religion, and cultivates ideals of conquest by force in order to assert its claims, is reverting to the law of the jungle and retarding the higher evolution of mankind.

The view that the sole function of science is the discovery and study of natural facts and principles without regard to the social implications of the knowledge gained, can no longer be maintained. It is being widely recognized that science cannot be divorced from ethics, or rightly absolve itself from the human responsibilities in the application of its discoveries to destructive purposes in war or economic disturbances in times of peace. Men of science can no longer stand aside from the social and political questions involved in the structure which has been built up from the materials provided by them, and which their discoveries may be used to destroy. It is their duty to assist in the establishment of a rational harmonious social order out of the welter of human conflict into which the world has been thrown through the prostitution of the rich gifts with which they have endowed the human race. Science has made the world one through the facilities of transport and communication now available; and it recognizes no political or racial boundaries in the fields of knowledge. By the wise use of this knowledge, the earth could indeed become a celestial dwelling-place instead of a world of dust and ashes which prevailing conditions seem to be making its destiny.