THE BIRTH OF SCIENCE

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[Introduction]

Human evolution, and particularly the evolution of the human brain and mind is not something that is well understood scientifically. But it seems clear that at some point in the evolution of human consciousness, an inner world free from passive captivity in sensory impressions came to be -- a life of the mind, if you like. The task of this inner world was to impose order on the content of our senses; that is, there came a point in our evolutionary past when our minds began to demand that the universe make sense.

[History of Science]

Between 250,000 and 30,000 years ago a subspecies of Homo sapiens, commonly known as neanderthals, inhabited a territory from England across southern Europe into Asia. They built hut-like structures, hunted big game, and developed ceremonial rituals. The remains of this relatively short-lived group reflect a consciousness akin to our own. They clearly had a sense of the passage of time and physical mortality. Ceremonial burials show a concern with life after death. We find in the neanderthals the signs of a greater consciousness of the subtleties of the world and, in this greater consciousness, the roots of our own religious and scientific thinking. The subspecies to which all living humans belong, Homo sapiens sapiens, probably emerged somewhere around 100,000 years ago, and forms a cultural, and probably intellectual, continuum with the neanderthals.

We really don't know much concerning the specific world-views of early humans. We have only some burial sites, figurines, and cave paintings to provide tantalizing hints. These suggest that their thinking was of a type that would now be called magical or superstitious. It seems clear that these stone-age people sought to employ magical rituals to influence the external world, hoping to positively affect hunting, fertility, and other survival-related aspects of their lives. Though such thinking may seem primitive to us, it clearly reflects a mind attempting to bring order into the universe.

Many scholars believe that the magical, animistic approach to understanding the world led directly to the mythical approach. Repeated attempts at magic would probably give birth to ritual. Even when such a ritual outlived its original purpose or when its true meaning had become obscured over time, it might still remain a psychologically essential part of the culture. An appropriate myth could provide justification for its continuance. In any case, with the coming of civilization some 10,000 years ago, it is clear that the magical thinking of the earliest peoples had already evolved into mythology.

Myths, though differing in their local details, have some common threads running through them. Often powerful non-human, but anthropomorphic, figures create and control the world and its inhabitants. Myth is always related to creation; it tells how something came into existence (the universe, human beings), or how a pattern of behavior was established. This History is considered to be absolutely true and sacred.

Surely myth arose from our need to make sense of the world as a whole, and, particularly, of our place as human beings in it. We see in myth attempts to find cause and effect explanations for the experienced world. Early people wove basic sensory knowledge of the world into a pattern that seems reasonable. (The Mesopotamian creation myth used their knowledge of how silt deposits form land where fresh and salt water meet.) Thus, Although there are some obvious differences between the mytho-poetic approach and the scientific approach, we can also see connections. Myths are the first rungs on the ladder of discovery. Embedded within them are basic truths about both the universe and the human condition.

Science had its beginnings in ancient Greece. Although it is probably an exaggeration to think in terms of "the Greek miracle" or of "motherless

Athena," as is frequently done, it is clear that about 600 B.C. a new approach to understanding the universe emerged. Although the Greeks had their myths, they went beyond the myths to search for physical explanations. Unlike earlier cultures, they were not content to explain the universe in terms of the actions of the gods; the Greeks insisted on thinking in terms of natural processes. These protypical scientists made the remarkable assumption that an underlying rational unity and order existed within the flux and variety of the world. Nature was to be explained in terms of nature itself, not of something fundamentally beyond nature, and in impersonal terms rather than by means of personal gods and goddesses. Science was born here, not motherless, to be sure, but nonetheless a new and distinctly different way of looking at the world.

Map 1. The Greek World about 450 B.C.

Thales (624-547 B.C.) was born in the Greek city of Miletus across the Aegean Sea from the Greek mainland. The inhabitants of this region were known as Ionians (Greeks who fled the Dorian invasion). Its location on the coast of Asia Minor provided Thales with exposure to the cultures of both the Babylonians and the Egyptians, and in fact, he visited both countries. It was his knowledge of Babylonian astronomy that allowed him to make his famous prediction of the solar eclipse of May 28, 585 B.C.

We consider Thales the first scientist because, as far as we can tell from the admittedly incomplete historical record, he was the first to approach the world from a scientific perspective. He wondered how the universe came to be and came up with an answer far different from that depicted in the creation of the gods myth of Hesiod's Theogony (8th century B.C.). It seemed to him that all things either came from moisture or were sustained by moisture. So he concluded that the universe grew from water. According to Thales the earth was a flat disc floating on a sea of water. The

unique element in the cosmology of Thales was the idea that the universe developed over time through natural processes from some undifferentiated state. The first recorded use of a physical model in explaining a natural phenomenon is Thales belief that earthquakes were caused by disturbances in the water that supported the earth.

As with any human being, Thales was of course constrained by the level of knowledge available at the time and by the cultural and intellectual context in which he found himself. It is clear that the earlier mythopoetic tradition exerted a strong influence on him. For example, from Aristotle we learn that included in Thales' metaphysical and cosmological doctrines was the idea that inanimate objects that move and are moved (magnets and iron, amber and wool) possess souls. It's hard to know what Thales meant by this exactly, but on the surface of it, it doesn't strike us as scientific.

There is an additional, more subtle, nonscientific element in Thales view. His two primary assumptions about the origin of the world were 1) that the present world order arose out of some preexistent state and thus had a beginning in time, and 2) that this world order occurred by a process of differentiation from a previous state. These beliefs are not suggested by an unbiased observation of nature itself, at least not as it was known to Thales. He must have come to this conclusion for deeper, perhaps subconscious, reasons. Similar psychological pre-dispositions have continued to play a role in science through to the present day.

Thales had a student named Anaximander (610-546 B.C.). He introduced the notion of a spherical universe, an idea that survived for more than 2000 years. He saw the earth as suspended in space (rather that floating on water). He also believed that living creatures arose from the moist elements when it had been partially evaporated by the sun. According to Anaximander, humans in the beginning resembled fish.

In the second half of the the fifth century, the materialism of the sixth century was adopted and extended by the atomist Leucippus of Miletus (fl. 440 B.C.E.) and Democrutus of Abdera (c. 470 – c. 400 B.C.). Democritus constructed a complex explanation of all phenomena in purely materialistic terms: The world was composed exclusively of uncaused and immutable material atoms. These invisibly minute and indivisible particles perpetually moved about in a boundless void and by their random collisions and varying combinations produced the phenomena of the visible world. In the words of Democritus, “nothing exists except atoms and the void; all else is mere opinion.”

It is interesting to note that a central concept in the thinking of Thales, Anaximander, and Democritus is that there is no real distinction between the terrestrial and celestial realms. Only later did Greek thinking regress to needing a fifth essence (the quintessence) for celestial objects.

The earlier and simpler phase of Greek thought terminates with the fifth century in a thinker of an entirely different type, Socrates (470-399 B.C.). With Socrates and his student Plato (427-347 B.C.), we have a unique synthesis of Greek science and Greek religion. The visible world contains within it a deeper meaning, in some sense both rational and mythic in character, which is reflected in the empirical order but which emanates from

an eternal dimension that is both source and goal of all existence. This is described in some detail in Tarnas, The Dual Legacy, pp 69-72.

With Aristotle (348-322 B.C.), the pendulum began to swing back toward the more down-to-earth perspective of the presocratics. Plato asserted the existence of archetypal Ideas or Forms as primary, while the visible objects of conventional reality are their direct derivatives. These Ideas, according to Plato, possess a quality of being, a degree of reality, that is superior to that of the concrete world. On the other hand, Aristotle assumed that true reality was the perceptible world of concrete objects, rather than the imperceptible world of Plato's eternal Ideas. Aristotle placed a new and fruitful stress on the value of observation and classification. He provided a language and logic, a foundation and structure, and, not least, a formidably authoritative figure without which the philosophy, theology, and science of the West could not have developed as they did. The Aristotelian system of physics, in a more or less modified form, was absorbed by the various philosophical schools of antiquity and played a very important part in the history of Christian thought. Its fundamental bases were:

Matter is continuous.

All matter is somehow made up of the four elements, Earth, Air, Fire, and Water, which in their turn contain the four "qualities," hotness, coldness, dryness, and moisture, in binary combination.

The earth is a sphere. It is fixed as the centre of the universe, which is itself spherical.

The stars and planets move with uniform velocity in concentric circles, or in circles within circles, round the earth. They are not composed to the four terrestrial elements but of a fifth element, the quintessence or aether.

Circular movement is the most perfect conceivable and represents the changeless, eternal, and perfect order of the Heavens as contrasted with the mutable, mortal, and imperfect order that prevails on this our earth.

The universe is finite.

This system lasted unshaken for 2000 years, roughly from 350 B.C. to A.D. 1600.

Islam & Science

Astronomy in the Greek tradition was carried on in Islam, however. In just a century the followers of Muhammad (about 570 – 632) conquered all the Middle East to India, as well as North Africa and most of Spain. After their victories they became tolerant of diverse ideas and attitudes, and conditions for intellectual life improved in their domains. Starting around 750 and for the next 250 years, the caliphs of Baghdad became patrons of science and the city a center of learning. By the eleventh century the library of the caliph of Cairo contained roughly 150,000 volumes; by contrast, a Western monastery considered itself fortunate to have 150.

An important factor in the development of Islamic science was the old Greek writings that the Arabs found in the lands they conquered. Within just a few decades after 750 the major Greek scientific works were translated into Arabic; by the end of the tenth century essentially all the known Greek manuscripts had been translated. The atmosphere of tolerance was such that this work was done by Christians, Jews, and pagans, as well as by Islamic scholars.

The religious requirements of Islam were a powerful impetus to the study of astronomy. For example, Islam adopted (and generally still uses) a strictly lunar calendar, which, however, begins not at the time of the new Moon, but at the first sighting of the crescent Moon just after sunset. Calculating when this occurs requires fairly complex geometry. Since the lunar year is about 354 days long, the months of the Islamic year cycle through the seasons in about 33 years. Mosques had to be oriented toward Mecca, and Muslims were to pray facing in that direction. Furthermore, time-keeping was required to properly set the five times for daily prayer.

In attacking such problems, Islamic scholars developed mathematics, especially trigonometry and spherical geometry, far surpassing the Greeks. They learned of the sine trigonometric function from India, and invented the other five. They also derived some of the relations among these trigonometric functions, such as the law of sines. With these developments, it was far easier to solve the geometric problems of astronomy. The Arabs also used a system of numbers, including the concept of zero, which they had acquired from India, which in turn they transmitted to the West, and which we use today. These Arabic numerals, as they are called, are far easier to calculate with than are Roman numerals. Arab texts describing these new mathematical developments as well as various summaries and commentaries on the Almagest eventually found their way in Latin translation to the West, where they became standard works for centuries.

Islamic astronomers refined many of the basic astronomical constants, for example, the length of the year and the eccentricity and inclination of the Sun’s (really the earth’s) orbit, data that were later used in the West. Although they worked within the Ptolemaic tradition, they questioned some of the constructs of Ptolemy. The equant (the point around which the angular motion was uniform), for example, was felt not to conform to the requirement of uniform circular motion. Even epicycles were questioned, and attempts were made to construct a system that did not require them.

From our point of view, however, the Muslims' most important contribution was that they preserved much of the Greek learning, and then, beginning around the year 1000, became the means by which it was retransmitted to the West. Cities near the boundaries between Islamic and Christian domains, such as Toledo in Spain, became centers of a "translation industry" (from Arabic to Latin) and Arabic words such as zenith, nadir, alchemy, algebra, and algorithm entered our language, along with star names such as Algol, Aldebaran, Alcor, Vega, Deneb, and Betelgeuse.

The richness, diversity, and power of the Greek writings made a deep impression on Western scholars, and soon they were attempting to accommodate them to the Christian tradition. Thomas Aquinas (1225 – 1274) was a key figure in this effort (called Scholasticism), and he showed how much of Aristotle's thought could be integrated into Christianity. This amalgam became the foundation for natural science in the West.

RELATED QUOTES:

1. It is through wonder that men begin to philosophize. Aristotle

2. The world of primitive peoples was a dynamic, animated, living reality in which natural phenomena are considered to be manifestations or embodiments of a kind of spiritual power. An I-thou attitude toward the world as opposed to an I-it attitude. Schlagel p. 49

3. Primitive humans seek to influence the threatening demons and spirits and demigods by imitating or propitiating them. This repeated attempt at magic gives birth to ritual, to which myth is closely related. Freund p. 23

4. Frazer shares Lang's belief that myth began as a form of primitive science, but goes beyond that -- some myths are belated rather than initial explanations, not of natural objects or processes, but of long honored magical rites. Freund p. 30

5. The kind of logic in mythical thought is as rigorous as that of modern science. The difference lies, not in the quality of the intellectual process, but in the nature of the things to which it is applied. C. Levi-Strauss, Schlagel p. 37

6. Myths are not the work of imagination, but the result of interpreted observation. In them a great store of ancient and direct experience is laid up. They are fossil history: actual happenings which lie far beyond the reach of history proper. Hans Bellamy, Freund p. 25

7. Even myths, therefore, are not just imaginative stories of the origin of the world created out of the visions and legends of shamans, seer-poets, or prophets. Instead, they represent a feat of intellectual abstraction in which certain prominent empirical occurrences are rendered stable and intelligible by being fitted into the only available theoretical frameworks of the time -- a story as to "how things came to pass." Schlagel p. 64

8. The striking originality of Thales consists in discarding the personifications of natural phenomena, in rejecting the anthropomorphic explanations as found in the Theogony, and in abstracting from the content of experience a natural observable element as the basic constituent or principle of things. Schlagel p. 69

9. Egyptian and Mesopotamian technical knowledge contained no hint of an attempt to explain all the phenomena of the universe on the basis of an intelligible system of natural law. Technical achievement in itself is not proof of the power of conscious abstraction. Farrington p. 5

10. Today, still, it may seem strange to many that Anaximander's thought, starting from a wrong idea, such as the rotation of the sky, and leading to a wrong conclusion, such as the central position of the earth, should be considered justified and important because of the reasoning that joins the two. de Santillana p. 36

11. In much of his account Anaximander has to preserve the language and images of his predecessors in order to make himself understood. But we see that he is using all these images and is not controlled by them. de Santillana p. 38

12. What made the Ionian way physical is that the cause of things is no longer imagined in a dramatic or mythical way, but as some kind of primordial -- and stable -- substance. de Santillana p. 22

13. The Greek thinker who advanced the opinion stood behind the opinion himself. He claimed objective validity for his statements; but they were his own personal contribution to knowledge and he was prepared to defend them as such. Earlier world-views were based on sacred books; an orthodoxy to be maintained by authority. Farrington p. 18

14. The great originality of the Iliad is that the events of which the story consists are represented as springing out of the character of the actors. Man the author of his own destiny not a puppet in the hands of fate. Nothing could be more opposed to the fatalism of Chaldean astrology. The Iliad provided Ionian science with the background of secularism which was prerequisite. Farmington p. 17

15. If the modern thinker discards the notion that he knows nature as it is, and realizes that he knows it only relative to his intellectual or symbolic framework, then he is in a position to recognize that his thinking is similar to that of the primitive. Levi-Strauss, Schlagel p. 37

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