# The Philosophic Origins of Science and the Evolution of the Two Cultures[1]

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> "A small but growing number of American philosophers have opened private practices as 'philosopher practitioners' offering a therapy based on the idea that solutions to many personal, moral, and ethical problems can be found not in psychotherapy or Prozac but deep within the 2,500-year-old body of philosophical discourse."

This quotation from the New York Times of March 8, 1998, may have been startling to some and amusing to others—the New Yorker used it as a preamble to a humorous article—but not to anyone, myself included, who has enjoyed the pleasure of delving into the history of philosophy and who appreciates its relevance to the scientific process. What a splendid opportunity, then, to explore the philosophic origins of science and its long and fruitful legacy.

The quest for knowledge is an old preoccupation with roots in prehistory, starting with Adam and Eve, who did not go about it scientifically—and you know what happened to them. Even so, ancient humans continued the quest to understand and study the nature around them: the trees and the animals, the bearing of children, the heavenly bodies; that is, the natural phenomena that today we refer to as the natural sciences.

Among the old civilizations, the Babylonians and Egyptians contributed considerably to these sciences, practiced primitive medicine and surgery, and collected facts about natural history and biology. It was, however, left to the Greeks to enlarge the scope of these collections and formulate from the facts a unified concept of nature and the laws that govern it.

The oldest Greek thinkers were natural philosophers, and it was much later that ethical issues and other problems found a place in Greek thought. Practically all philosophers were teachers; many had their own schools, had to teach several subjects (rhetoric, ethics, poetics, astronomy, physics, biology), and wrote treatises on these subjects, which were surely sometimes used as textbooks. A few of these philosophers were also poets and wrote their own books in verse; Empedocles, for example, wrote two treatises, "On Nature" and "Purifications," in dactylic hexameter. I shall mention only one of these early philosophers, Democritos (approximately 450 BC), for two reasons. The first is that he was the very antithesis of the usual image of a brooding philosopher; he was known by several nicknames, one being "the laughing philosopher" because he was good humored and jolly all the time (γελουσινός). In fact, one of his noteworthy treatises is entitled "On Cheerfulness." The other reason is that to most of us Democritos is known mainly as the father of the atomic theory, which is not quite the case. It was his teacher, Leukippos, who first conceived and formulated the atomic theory, which Democritos immediately espoused and refined. He wrote on almost every field known at the time: physics, psychology, logic, astronomy, the senses, the mind, music, poetics. Aristotle thought highly of Democritos and refers to his work frequently, particularly in his various biological writings.

Aristotle was certainly the greatest of this genre of philosophers and is justly considered one of the greatest thinkers of all time. He was born in 384 B.C. in Stageira, Macedonia, where his father was the physician to the royal court. At age 17, he was sent to Athens to study with Plato in the Academy, where later he also taught. He spent 3 years in Asia Minor in the court of his former student Hermeias, who gave him his niece in marriage. He was then appointed by King Philip of Macedon to be the tutor of his impetuous and brilliant teenaged son Alexander, and after 3 years, he moved back to Athens. Now

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a well-to-do man under the protection of Alexander, he founded his own school, the Lyceum (named after the nearby temple of Apollo Lycaeus). The Lyceum served as the prototype of a learned educational institution throughout the world. Here Aristotle taught while taking walks with his students and collaborators and wrote an incredible amount on various and different subjects, including logic, physics, ethics, art poetry, politics, economics, psychology, and biology. He retired to Chalkis, Euboea, where he died at age 62.

To the biologist, Aristotle's work on the "Generation of the Animals" is of special interest because it is the first systematic treatise on animal reproduction and embryology, taxonomy, and evolution. The "Generation of the Animals" is the culmination of Aristotle's zoological works that comprise 10 volumes and include "On the History of Animals," "On the Parts of Animals," and "On the Soul." I shall only touch upon those areas in which he made lasting contributions in the development of the biological sciences that have come down to us.

Aristotle repeatedly pointed out that his predecessors' work and conclusions were often marred by insufficient observation. He himself, after a remarkable analysis of the reproduction of bees, states that he cannot arrive at certain conclusions because "the facts have not yet been sufficiently ascertained. And if at any future time they are ascertained, then credence must be given to the direct evidence rather than to the theories; and to the theories also, provided that the results which they show agree with what is observed." This, indeed, is the principle upon which his work is based. It is also the definition of the scientific method, which was later broadened in scope, especially by Bacon, and by and large constitutes the basis of the scientific method we practice today. Note the subtle yet critical point: Aristotle does not say "the results prove the theory," but "the results agree with the observations." Today, we take this reasoning for granted, that science proceeds and progresses not by proving hypotheses, but by disproving them. If the observations do not agree with a hypothesis, we shelve it; if it does agree with a high enough level of certainty and consistent repetition of the results, we accept it, but we can never prove it.

Up to the time of Aristotle, there had been no serious attempts at classification of animals. Thus, his classification was based almost entirely on his own observations. For animals not found in Greece, he referred to credible observations by others, e.g., Herodotos. In this area also, Aristotle made very important contributions by characterizing and differentiating among a number of systematic categories. In his own words, "Animals may be characterized according to their way of living, their actions, their habits, and their bodily parts." The most important criterion is certainly the parts of the animals, both external and internal: organs of movement, respiration, sense, blood circulation. By combining various qualities, he defined and characterized the groups. Aristotle's two major categories are blooded animals (he refers to red blood only) and bloodless animals.

Under blooded animals: humans, viviparous quadrupeds, oviparous quadrupeds, and footless animals (reptiles, amphibians), birds, and fishes.

Under bloodless animals: malacostraca (soft-shelled, crustacea); malakia (soft, without shell, cephalopods); entoma (insected animals, insects); and ostrakoderma (shell-skinned, testacea). These categories and nomenclature are still used today.

Aristotle also classified animals according to their mode of reproduction, but the most important part of his classification is the final two categories, the genus (γένος) and the species (εἶδος), the latter referring to the individual animal form: horse, dog, lion. This is a farsighted classification, and though it cannot be compared with the Linnaean with its manifold categories, it is certainly a pioneering achievement.

In his work on the reproduction of animals, Aristotle differentiates sexual and asexual reproduction. In sexual reproduction, male and female contribute equally, and in his thorough investigation of the development of animals from egg and embryo, Aristotle points out the phenomenon that we know today as "ontogeny recapitulates phylogeny." He disagreed sharply with the opinion of earlier philosophers that the seed is derived from all parts of the body and thus gives rise to similar individuals. On the contrary, he asserts that the seed goes to all parts of the body to form an individual, an explanation shown to be correct 2,000 years later. In addition, during embryonic development, there is a specific movement or substance in each part of the body which brings about its development as a specific part of the embryo. Today, we call such

substances organizers. Aristotle also recognized congenital malformations as imperfect developmental events in the embryo due to various causes, one being some irregularity in the seminal fluid. He correctly understood the functions of the placenta and the umbilical cord and was an ardent supporter of epigenesis. He made his observations in several animals, and it can be said that he introduced the comparative method to embryology.

Aristotle has been called the first evolutionist. His theory of evolution lies not only in the sphere of discovery, but also in his system of thought, embracing all phenomena of life. Here we find enunciated for the first time a truly complete theory of evolution, subject to natural laws and progressing from the lower to the higher forms of being. Although partly based on metaphysical speculation, the theory has proven fertile ground for future biologists.

Aristotle constantly compares nature and the products of nature with art and the products of art. Like nature, the artist or craftsman works to produce a finished product. Like the artist, nature uses instruments charged with specific modulations to bring these products to fulfillment. The most typical of these products of nature are, of course, living creatures. Nature aims always to produce a finality in the sense of a completely formed individual and that is the Final Cause in each case. "There is," Aristotle says, "more beauty and purpose found in the works of nature than in those of art." And who can disagree?

Although Aristotle was not the last of the era in which the study of nature was in the province of philosophy, by the time of his death, there were already signs of specialization, that is, philosophers began to be concerned mainly with ethics and metaphysics, leaving the other subjects to those more informed about them. This trend continued through the Hellenistic and Roman times. Later, with the increase of knowledge and ease in its dissemination, the establishment of libraries, and invention of the printing press, the graduates of schools of higher education came to be recognized either as scientists, biological or physical, or as artists, poets, writers, painters, or musicians and received different credentials, in our time Bachelor of Arts or Bachelor of Science. In spite of the widening schism, the philosophic origin of the sciences and the arts is acknowledged and maintained today in the award of the highest academic degree, that of Doctor of Philosophy.

In his controversial Rede lecture presented in Cambridge in 1959, C.P. Snow (1905-1980), the British intellectual, first used the phrase "The Two Cultures" to describe the world of the sciences and the world of the arts, which had become culturally isolated. Sir Charles Percy Snow was himself a distinguished physicist, who during World War II made significant contributions to the British and Allied war effort and for his services was elevated to the peerage. He was also an excellent novelist. His magnum opus, "Strangers and Brothers," comprises eleven volumes written over 30 years, in which he recounts a saga of lives, events, and the passage of time, both for individuals and for English society as a whole. As Snow himself described his existence, "There have been plenty of days when I have spent the working hours with scientists and then gone off at night with some literary colleagues. I mean that literally. It was through living with these groups and much more, I think, through moving regularly from one to the other and back again that I got occupied with the problem of what, long before I put it on paper, I christened to myself as 'the two cultures.' For constantly I felt I was moving among two groups—comparable in intelligence, identical in race, not grossly different in social origin, earning about the same incomes, who have almost ceased to communicate at all, who in intellectual, moral and psychological climate had so little in common, that instead of going from Burlington House or South Kensington to Chelsea, one might have crossed an ocean."

Snow, of course, was addressing a situation prevalent in England and Europe in general in the late 1950s, but at that time, conditions on this side of the Atlantic may have been a little better. Nevertheless, the two cultures still exist and combine infrequently in rare and exceptional individuals.

Every era has had such exceptional individuals. The Renaissance produced a sprinkling of them, the towering and awesome figure of that era being Leonardo da Vinci (1452-1519), the Italian painter par excellence, and sculptor, but also architect, engineer, musician, inventor, anatomist, physiologist, geologist, botanist, and everything that you can imagine, and many things you cannot. Indeed, a thumbing through his voluminous diaries, originally

written in "looking-glass writing," will find him discussing, in addition to the subjects that I have already referred to, philosophy, geography, flight physics, mathematics, warfare, sailing, and scores of prophesies on scores of subjects. While in the long service of Ludovic Sforza in Milan, in addition to art, he performed various functions, including tutoring; designing churches, scientific instruments, and war machines; and organizing spectacular pageants. His biological writings constitute about 20% of his total output. They encompass discourses on anatomy, physiology, medicine, optics, and acoustics and are illustrated with exquisite drawings, which he did from his own observations and dissections. He dissected more than 30 bodies of men and women of all ages and made drawings and casts of anatomical structures, most of them at the hospital of Santa Maria Nuova in Florence and at the University of Pavia, where his friend Antonio della Torre held the chair of anatomy. It is impossible to discuss this work at length, but I would like to quote his ruminating on the nervous system: "The frog instantly dies when the spinal cord is pierced. Previous to this it lived without head, without heart, or any bowels or intestines or skin. And here, therefore, it would seem lies the foundation of movement and life."

Leonardo's counterpart in the 20th century is undoubtedly Albert Schweitzer (1875-1965), the Alsatian physician, philosopher, musician, theologian, and great humanitarian. Those of our generation who recognize his name know him as the doctor who founded a hospital in Equatorial Africa. Actually, he came to medicine rather late, and by that time, he was an accomplished musician and organist and had written a monumental biography of J.S. Bach and an analysis of his work, to be followed later with his edition of Bach's organ music, all of which had made him the outstanding authority on Bach. He also attained the rank of professor of theology and director of the Strasbourg Seminary. But he was resolved to become a doctor in French Equatorial Africa, and at age 30 he began his medical studies, meanwhile continuing his other activities. In his mid-30s, he went to Lambarene in Gabon, where he established a primitive hospital, which eventually grew into an extensive medical facility, including a leprosarium. Except for a long period during World War I when he was a prisoner of war, he remained there most of the time to minister to the poor and the sick, with the help of a small, dedicated staff. He traveled frequently to the continent to raise money for the hospital, and once to the United States, in 1949, to address the Goethe Festival in Colorado. On these trips, he was honored in many countries for his work as a scientist, his artistry as an organist and musical scholar, and his contributions as a philosopher. In a three-volume series entitled Philosophy of Civilization, Schweitzer developed his own philosophy, which is summed up in the term Reverence for Life, a universal code of ethics that requires respect for the lives of all other beings. His theological writings include "The Quest of the Historical Jesus," in which he expresses a dissatisfaction with the way that the gospels treat the facts of the life of Jesus, and "The Mysticism of Paul the Apostle." He described his early years at Lambarene in "On the Edge of the Primeval Forest," and in the mid-30s, he wrote his autobiography, "Out of My Life and Thought." Schweitzer was awarded the Nobel Prize for Peace in 1952.

Norman Cousins, the late editor of the now sadly defunct Saturday Review, visited Schweitzer and, in a book about this visit, describes this scene of life in Lambarene, the customary singing of a hymn after dinner: "There was a piano in the dining room, old, dilapidated, unable to hold its tune because of the heat and the moisture. When I saw Dr. Schweitzer sit down at the piano and prop up the hymnbook, I winced. Here was one of history's greatest interpreters of Bach, a man who could fill any concert hall in the world. The best grand piano made would not be too good for him. But he was now about to play a dilapidated upright virtually beyond repair. And he went at it easily and with the dignity that never leaves him."

The Aristotles, the da Vincis, the Goethes, the Jeffersons, the Schweitzers are, indeed, rare individuals, true descendants of those early philosophers of the ancient world. Their works and their writings had, and continue to have, profound influence on life and civilization worldwide and are κτήμα ες αεί, possessions forever. We admire them, stand in awe of them, but they are in a sense remote to us, far beyond us. It is the work, the writings and contributions of individuals in whom the elements of the two cultures are combined in a more modest scale that are understandable and accessible to us, and they are the ones that influence us in our

occupations and interests and enrich our personal lives.

Some of these gifted people have attained a measure of fame, and we can read about them in any encyclopedia or good dictionary; most of them remain unknown, unless we come upon them and their work by accident or acquaintance. One of these, unknown even among biologists, is the British naturalist Langdon W. Smith, who did some excellent biological research and also wrote exquisite poetry. Smith was born in Scotland in 1877 and came to the United States when he was 14. Practically nothing is known about his education, except that in his early 20s he was engaged by the Museum of Natural History in New York to do research and was often invited by scientific societies to lecture. He also wrote articles on scientific subjects for newspapers. He wrote a particularly beautiful poem about evolution titled "A Tadpole and a Fish." A friend of his found this poem, which Smith had carelessly laid aside, and recognized it as something exceptional. He prevailed upon Smith to submit the poem to some of the best papers for an opinion. The first to examine the poem was the editor of the New York Herald, who gave Smith a check for $500, a considerable sum in those times, for the right to publish it.

Smith became ill and returned to England, where he died some months later of tuberculosis. The poem, which was later published under the title "Evolution" in 1909 and was included in anthologies published by the Haldeman-Julius company of Girard, Kansas, in 1922 and 1924, makes a felicitous conclusion to this essay: like the essay, but in a grand context, it takes us back to our roots:

## A Tadpole and a Fish

Langdon Smith

I

When you were a tadpole and I was a fish,
In the Paleozoic time,
And side by side in the ebbing tide
We sprawled through the ooze and slime,
Or skittered with many a caudal flip
Through the depths of the Cambrian fen,
My heart was rife with the joy of life
For I loved you even then.

II

Mindless we lived and mindless we loved,
And mindless at last we died;
And deep in a rift of the Caradoc drift
We slumbered side by side.
The world turned on in the lathe of time,
The hot land heaved amain,
Till we caught our breath from the womb of death,
And crept into light again.

III

We were Amphibians, scaled and tailed
And drab as a dead man's hand;
We coiled at ease 'neath the dripping trees,
Or trailed through the mud and the sand,
Croaking and blind with our three-clawed feet
Writing a language dumb,
With never a spark in the empty dark
To hint at a life to come.

IV

Yet happy we lived, and happy we loved,
And happy we died once more;
Our forms were rolled in the clinging mold
Of a Neocomian shore.
The eons came, and the eons fled,
And the sleep that wrapped us fast
Was riven away in a newer day,
And the night of death was past.

V

Then light and swift through the jungle trees
We swung in our airy flights,
Or breathed in the balms of the fronded palms,
In the hush of the moonless nights.
And oh! What beautiful years were these,
When our hearts clung each to each;
When life was filled, and our senses thrilled
In the first faint dawn of speech.

VI

Thus life by life, and love by love,
We passed through the cycles strange,
And breath by breath, and death by death,
We followed the chain of change.
Till there came a time in the law of life
When over the nursing sod
The shadows broke, and the soul awoke
In a strange, dim dream of God.

VII

I was thewed like an Auroch bull,
And tusked like the great Cave Bear;
And you, my sweet, from head to feet,
Were gowned in your glorious hair.
Deep in the gloom of a fireless cave,
When the night fell o'er the plain,
And the moon hung red o'er the river bed,
We mumbled the bones of the slain.

VIII

I flaked a flint to a cutting edge,
And shaped it with brutish craft;
I broke a shank from a woodland dank,
And fitted it, head and haft.
Then I hid me close to the ready tarn,
Where the Mammoth came to drink;—
Through brawn and bone I drave the stone,
And slew him upon the brink.

IX

Loud I howled through the moonlight wastes,
Loud answered our kith and kin;
From west and east to the crimson feast
The clan came trooping in.
O'er joint and gristle and padded hoof,
We fought and clawed and tore,
And cheek by jowl, with many a growl,
We talked the marvel o'er.

X

I carved that fight on a reindeer bone,
With rude and hairy hand,
I pictured his fall on the cavern wall
That men might understand.
For we lived by blood, and the right of might,
Ere human laws were drawn,
And the Age of Sin did not begin
Till our brutal tusks were gone.

XI

And that was a million years ago,
In a time that no man knows;
Yet here tonight in the mellow light,
We sit in Delmonico's;
Your eyes are as deep as the Devon springs,
Your hair is as dark as jet,
Your years are few, your life is new,
Your soul untried; and yet—

XII

Our trail is on the Kimmeridge clay,
And the scarp of the Purbeck flags,
We have left our bones in the Bagshot stones,
And deep in the Coraline crags;
Our love is old, our lives are old,
And death shall come amain;
Should it come today, what man may say
We shall not live again?

XIII

God wrought our souls from the Tremadoc beds
And furnished them wings to fly;
He sowed our spawn in the world's dim dawn,
And I know that it shall not die,
Though cities have sprung above the graves
Where the crook-boned men made war,
And the ox-wain creaks, o'er the buried caves
Where the mummied mammoths are.

XIV

Then as we linger at luncheon here,
O'er many a dainty dish,
Let us drink anew to the time when you
Were a Tadpole and I was a Fish.

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