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What led to the intellectual transition from mythology to science in ancient Greece? The factors that are generally accepted as having created favorable conditions for such transition were geographic, economic, religious, and political. In this paper I add to the usual list of factors three new ones, the ancient Greek idiosyncrasy, the power of the Greek language, and the effect of making a habit of scientific thinking.

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By
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Abstract

What were the causes that led to the intellectual transition from mythology to science in ancient Greece? It is argued that while the generally accepted ones (those of geography, economics, religion, and political structure) might have been necessary, they were hardly sufficient. Thus a hypothesis is proposed: that these causes together with three others—(1) the intriguing ancient Greek idiosyncrasy, (2) the evolving ancient Greek language, and (3) the force of intellectual habits—all had an interwoven and critical role for the rise of Greek civilization and the birth of science. The factors of language and intellectual habits have not been sufficiently appreciated. Moreover, the factor of Greek idiosyncrasy is often overlooked, but I believe that any effort to understand the rise of a civilization is probably incomplete without also an attempt to understand the idiosyncrasy of the people who caused such rise.

Introduction

The most critical transition in the evolution of human thought was that from mythology to science—from the mythological and apparent worldview of deceptive senses to the rationalistic and intangible worldview of inventive intellect. Contributing to this transition was the rise of the Greek civilization. About 2,600 years ago the ancient Greeks had a magnificent intellectual awakening. Then, the age-old, popular but mythological worldview was questioned, rethought, and changed. Nature was no longer a chaos where the phenomena were random, unpredictable, incomprehensible, and attributed to mysterious supernatural forces through myths, superstition, and the chancy decisions of capricious, anthropomorphic gods. On the contrary, nature was a cosmos: a well-structured, organized, ordered, harmonious, self-contained, self-consistent, beautiful whole where the phenomena were *natural*, obeying intrinsic causal laws that could be discovered and understood by the practice of rational critique of nature and without invoking the supernatural. A profound transition in the way of thinking that was a consequence of their realization that nature *is* comprehensible, and of a simple question thereafter: what is the nature of nature? The prolific answers thenceforth ascribing purely naturalistic causes to all phenomena of nature gave birth to science. In an effort to understand what caused this birth, we begin by reviewing first the commonly accepted factors.

Geography, Economy, Religion, Politics

1. Geographic: Locally, a landscape of natural boundaries—mountains separating cities and the sea separating islands—helped in the formation of relatively isolated city-states (a thousand or so) and promoted intellectual diversity. Diverse ideas were ultimately shared and improved when people moved and interacted. Globally, the crossroads location of Greece exposed its people to ideas of other great civilizations from Europe, Asia, and Africa. Moreover, Greece's long coastline and many surrounding islands resulted in the establishment of coastal and island cities and made Greeks seafaring people. But their sea adventures aided them in demythologizing the phenomena of nature and stimulated them in conceiving rationalistic explanations.

2. Economic: Commoners became technologically inventive to better their lives. And even though technology is not science, rather the application of science, technology can lead to abstract theorization about how it can be improved and consequently the discovery of laws of nature upon which technology is based. On the other end of the economic spectrum, well-to-do people used their leisure to philosophize and theorize.

3. Religious: Contrary to theocracy and hierarchy, which impose dogmatic thinking, restrict inquiry, and impede progress, religious freedom in Greece allowed for contemplation of diverse views and created a potential for betterment.

4. Political: Social freedom and democracy prompted free debates on just about everything, resulting in the conception and exchange of new and improved ideas.

Because these factors have been contemplated extensively in the literature (Burnet; Gregory; Kirk et al.; Lloyd; Russell; Sagan; Schrödinger, *Nature*), my focus in this paper will be on the three influences that have not been sufficiently appreciated.

The first influence is the idiosyncrasy of the ancient Greeks: it was rational, passionate, and excessive. But it was the proper moderation between passion and logic that allowed them to become *creatively* excessive. The second influence is the Greek language. The superior communicative nature of ancient Greek helped in the conception and diffusion of knowledge in the most efficient way possible. While the first alphabet was Phoenician, the first true alphabet which contained vowels was the Greek. With this innovation Greek became the first easily read and written language of the world, and the facility of written Greek became significant in the evolution of ideas and the birth of science. The third influence is simply the force of intellectual habits. Using ideas from the theory of biological evolution, I will argue that the good habit of the Presocratics to practice science imposed an epistemological kind of natural selection by promoting intellectually favorable environments where learning science could continue to happen and new scientists could exist, thrive, and become abundant, contributing therefore to the constant development of the scientific outlook at the expense of the mythological one.

Idiosyncrasy

Was it geography that broadened the Greeks' intellectual horizons, or was it their curious adventurous *open* mind that let them to see the world (nature, their own culture and that of others too, as well as the very man himself) with a critical eye—freely question and analyze it for, like Socrates, they thought "the unexamined life is not worth living for"—and seek for more objective, coherent, universal, and timeless truths about nature (including man)? Was it tools (or free time) that sharpened their intellect, or their intellect that sharpened the tools and pursued leisure to philosophize? Was it the absence of theocracy (which imposes dogmatic and mythological thinking) that promoted free and rational thought among the Greeks, or was it their tendency for free and rational thought that opposed the formation of theocracy? Was it democracy that encouraged free public debates and open dialogues, or the Greeks' critical mind and love for freedom of speech and independent thinking that contributed in the invention of democracy? Was it the advanced Greek language that aided their thoughts (to be clearly conceived, expressed, and disseminated), or their thoughts (formed out of love for self-expression, rhetoric, dialectic, literature, and inquiry—for, *any* subject was to them open for contemplation, debate, and criticism—) that aided the language to advance? Could causes be mistaken as the effects? Although not absolutely, to some degree yes they could. If so, then in the rise of Greek civilization the idiosyncrasy of the Greeks cannot be overlooked. Well then, what kind was it?

Rational, Passionate, Excessive

In Plato's dramatic chariot allegory (from his dialogue *Phaedrus*), a charioteer, who represents the human soul, tries to drive a two-winged-horse chariot to the proper destination, that of truth. But the journey is not easy because the horses, who represent the complex twofold nature of the soul, have competing tendencies and pull forcefully towards their separate ways. One horse represents the tendency of the soul to conform to orderly reason, the other to surrender to defiant passion. Reason can tame passion, but passion can cloud reason. Reason alone may

lead the soul down a safe but dull path, passion alone down a risky but uncommon. Nonetheless, it is not the one or the other tendency that is the good or the bad for the soul. To the contrary, destination Truth (the discovery of something extraordinary) can be reached only by harnessing properly both horses' energy. For not only reason is natural and needed, but so is passion. The ancient Greek idiosyncrasy, like the charioteer, was a synthesis of the rational and the passionate nature. And each nature was excessive and at war with the other, like the mighty horses who pull vehemently against each other. But their delicate harmonization, whenever it was managed, is what steered the Greeks to creativity.

To eliminate the backward passions of magic and superstition and to liberate man from his dependence on irrational supernatural forces, the ancient Greeks rationalized nature and gave birth to science and intellectual freedom. To fight the corrupt passions of tyranny and autocracy they figured out the law and gave birth to democracy and political freedom. To face the blinding natural passions of human soul they contemplated morality, criticized themselves, each other (in fact, welcomed the latter), and the policies of their cities—and all in public—and gave birth to moral philosophy and philosophical freedom. It took a rational nature for them to philosophize, politicize, and do science; as well as to have, or actually try to have, the "know thyself" (to be conscious of their limitations and potentials) in order to take responsibility and control over their own understanding, actions and future (away from tyrannies, hierarchies, superstitions, dogmas, even their own passions). But also took a passionate nature to aspire and choose freely in spite of consequent suffering even death (as the heroes in their tragedies); to choose to die for freedom by battling internal oppressing tyrants and external despotic kings (as the heroes of their wars); and to despise powerful capricious gods and age-old mythical tradition and mysticism for the sake of religion based on philosophy and of knowledge based on rational inquiry (as the heroes of their everyday life). But none of these pursuits, neither religion nor philosophy nor science nor democracy nor freedom, were achieved through reason or passion alone. It was not just the one or the other that was the good but their combination. The Greeks were passionately rational, but also rationally passionate.

Russell has written of the Greeks, "Without the Bacchic element [passion, ecstasy, enthusiasm, frenzy, impulse, spontaneity, suffering, sorrow, joy, a divinely inspired madness, the liberation from the constraints, agonies, and pressures of the everyday, and the expression of one's true self, all feelings aroused at the Bacchic, the Dionysian Mysteries], life would be uninteresting; with it, it is dangerous. Prudence versus passion is a conflict that runs through history. It is not a conflict in which we ought to side wholly with either party" (p. 16). Plato (in his dialogue *Phaedrus*) believed something similar: "he who, having no touch of the Muses' [divine] madness [passion] in his soul, comes to the door and thinks that he will get into the temple [become a prophet] by the help of art [by reason alone, by mere knowledge of the art of prophecy]—he, I say, and his poetry [sane prophecy] are not admitted [for they lack a touch of a divinely inspired madness, passion]." Russell continues, "a large proportion of them [Greeks], were passionate, unhappy, at war with themselves, driven along one road by the intellect and along another by the passions ... . They had a maxim "nothing too much," but they were in fact excessive in everything—in pure thought, in poetry, in religion, and in sin. It was the combination of passion and intellect that made them great, while they were great. Neither alone would have transformed the world for all future time as they have transformed it" (p. 21). By the way, passion was one of the "evils" sealed in Pandora's box but Pandora's curiosity—*Greeks'* curiosity—freed it, for reason without passion is dull.

Their life's philosophy was everything in moderation, self-control. But it was inspired

because they were excessive and not of moderation for "noble self-restraint [reason] must have something [excessiveness, passion] to restrain" (Hamilton 224). One wants to make self-control his philosophy because one is excessive in his psychology. Hence such philosophy's goal was to warn them of the potential dangers of excessiveness, and their hope was to keep their excessive nature under control, self-control. The result, the proper moderation between passion and logic, allowed them to become *creatively* excessive, and in their search for a new worldview they invented democracy and discovered science and philosophy. Passion drove them away from the ordinary, but logic controlled their passion and allowed them to embrace the extraordinary. It is their zealous and continuous search for such moderation that shaped their adventurous path in history leading up to Western civilization and those nonwestern that aspire Greek ideals—great liberties such as the personal, the civic, the political, the religious, the scientific, and in general the intellectual. Incidentally, had we not have these great liberties (those of us lucky enough to have them), would we be willing to sacrifice ourselves in order to get them?

The ancient Greeks did. Nonetheless their critics say that the Greeks did not live up to their own ideals. Bruce Thornton responds that this, whenever it happened, "reflects only the banal truth that humans [*everywhere*] rarely live up to their own aspirations" (p. 4)—Greeks, in other words, were humans first. And this is a consequence of the fact that the war between reason and passion—the challenge to steer successfully the "chariot", our self, to the Good—is a universal human condition, a great truth that points towards yet another great truth of Greek origin—particularly a Stoic philosophy—that of our common humanity transcending our uniqueness in individuality: we are all rational beings with passions by nature, all other differences are superficial and/or accidental. Commonality, and in fact oneness, as a general law of nature (of which man too is part of), appears also in Greek natural philosophy as early as Thales—all things for him are made from the same stuff, water—and attains an astounding uniqueness in the worldview of Parmenides—for only what is, is, only the Being exists for him, one and unchangeable.

Stephen Bertman asked why were the Greeks the ones who invented science? "Because" he argued "the seminal principles of Greek civilization—humanism, rationalism, curiosity, individualism, the pursuit of excellence, and the love of freedom—were uniquely compatible with science's own essence" (Kindle Locations 52-53).

Language

What first interested me in investigating the language factor was a brief statement by Noble laureate Bertrand Russell: "The Greeks, borrowing from the Phoenicians, altered the alphabet to suit their language, and made the important innovation of adding vowels instead of having only consonants. There can be no doubt that the acquisition of this convenient method of writing greatly hastened the rise of Greek civilization" (p. 10). Although the Greek language is usually not regarded as a factor that created favorable conditions for the birth of science, I will argue that its influence was subtle but profound and thus cannot be overlooked.

I will lay the groundwork, in the next two subsections, by contemplating the general effectiveness of language in human survival and intellectual evolution.

The Sound of the Fittest

From the family tree of biological evolution the more anthropomorphic primates (the

hominids, species which are more human than ape) are a family of species whose first member is believed to have evolved some 7 million years ago (Tattersall). Its two most recent members, who are relevant to our consideration of the effect of language on both our physical survival as well as our intellectual evolution, are the evolutionary cousins homo Neanderthals and we, homo sapiens. Both species are thought to have evolved only about 200,000 years ago, with Neanderthals preceding. So at one time the two cousin species shared the earth and possibly interacted.

Neanderthals are our closest genetic relative. Physically, in some very general terms, the two species were not that different—a visit at the Museum of Natural History in New York City will convince anyone about this. Neanderthals were short and stocky with a more elongated skull, and homo sapiens were taller and thinner with our characteristic high dome skull. Furthermore, because the two cousin species share several brain similarities, it has been speculated that they were of comparable intelligence. This hypothesis, however, is the subject of current contention.

With such general similarities, both species would have been expected to survive, but only homo sapiens managed. Unfortunately, between 25,000 to 30,000 years ago, Neanderthals became extinct. The theories for their extinction vary and are hotly debated. The cause might be just one or a combination of several, such as climate change or an isolated existence in clans, which might have resulted in limited exchange of ideas and thus a slower rate of intellectual progress than needed for surviving life's constantly changing challenges.

One theory of extinction relevant to our discussion on the importance of language in survival is Neanderthal-human competition (Diamond). Such competition might have, however, been destined to be unequal biologically. For through a mutation (a purely chance change in the genome, the hereditary substance) homo sapiens were accidentally gifted by nature with the anatomy of a more efficient larynx that could produce a richer variety of sounds, creating therefore the potential to develop a relatively more advanced language than that of Neanderthals. This must have aided in the general survival of homo sapiens. But some experts hypothesize that in a more specific way, this also might have been a contributing factor in our survival at the expense and general extinction of Neanderthals, by giving us a competitive advantage. It is probable that a better language enabled homo sapiens to communicate essential survival skills such as hunting and gathering, making and refining tools, finding shelter, making friends, living together in extended social groups, forming alliances, trading, and generally learning from each other.

Consequently, homo sapiens developed a better understanding of the world around them and achieved an intellectual edge over their cousins the Neanderthals in all aspects of their competition. But during the early competitive environment of predators, limited resources, and in general a nature where survival was of the fittest, such intellectual advantage achieved through language skills (regardless of how primitive initially) made a difference between life and death. Thus, this theory holds, homo sapiens secured their survival by overpowering and driving their own cousins to extinction.

Language is a useful skill, possibly the most powerful of humankind, not only in the struggle to survive, but also in our efforts to thrive and live fully. Language controls the flow of information and creates the potential for knowledge. But how rapidly does intellect evolve with the influence of language, especially an evolving language?

Biological vs. Intellectual Evolution

The effectiveness of language can be appreciated further by comparing the time required for the extremely slow biological evolution of the anthropomorphic family of species with that of the immeasurably faster intellectual evolution of the only species that managed it, homo sapiens, and trying to explain the reason for such huge time difference.

Specifically, on the one hand the biological evolution of this family describes a 7-million-year process (from its first member species, the Sahelanthropus, believed to have evolved about 7 million years ago, to its last and only extant member, homo sapiens, who evolved about 200,000 years ago), but on the other hand the incredible intellectual evolution of this entire anthropomorphic family is due exclusively to the achievements of just this last member species. And depending on what might be regarded as advanced knowledge, such evolution can be condensed to an unbelievably small time interval. It could be 30,000 years (since splendid art was painted on cave walls by Ice Age cave dwellers); or 10,000 years (since the end of the last glacial period, which roughly coincided with the transition from the lifestyle of hunter-gatherer to farmer and consequently the beginning of urbanization, or of civilization); or 5,000 years (since the beginning of written history when Sumerians in Mesopotamia invented the first type of writing in the world at 3100 BC); or 2,600 years (since the birth of science in ancient Greece); or 500 years (since the rebirth of science during the end of Renaissance); or 300 years (since the Industrial Revolution); or, even more impressively, a mere few decades (since the discovery of the computer)!

To emphasize the unprecedentedly rapid cultural and intellectual evolution of the last few decades, I recall a comment by Isaac Asimov concerning the conclusion of his *Chronology of the World:* that, while his initial intention was to write the entire history of the world, from the Big Bang to the date his book would be completed (a some 15-billion-year period for him), he was finally forced to conclude it with the events of 1945 instead of 1989, the book's completion date, falling short of his initial goal by a mere forty-four years. And the reason was, he explained, that the changes brought about by the evolving human culture between 1945 and 1989 were so many, rapid, and universal that to be effectively described would require their own book as extensive as the *Chronology of the World*!

I concur with Asimov's assessment and base my understanding on the evolving notion of language itself. For from the simple sounds and symbolic cave art of the distant past, to the rich languages, modern mathematical symbols, and sophisticated electronic communications of the present, language has evolved to diversified and creative new modes that allow for better conception, dissemination, and improvement of knowledge and consequently transforming our species intellectually faster than ever before.

More precisely, with time and as a consequence of advances in mathematics, science, and technology, the notion of language has been broadened. Mathematics has added a versatile variation in symbolic and quantitative communication, science has enhanced our imagination and invented naturalistic and rational interpretations of nature, and technology, mainly after the invention of computers (especially their interconnection via the sociologically revolutionary Internet), has enriched communication through myriad modes, including ones that affect all people of this planet and potentially intelligent beings of other star systems. For, traveling at the speed of light, a radio signal transmitted from the Arecibo Observatory in Puerto Rico in 1974 has as its destination the globular cluster M13, a group of some 300,000 stars in the constellation of Hercules 25,000 light years away from us. The signal's coded information about us can be easily decoded if intercepted by an intelligent alien life form.

For millennia, the idea of language has included more than gestures and sounds. Knowledge

can be recorded many different ways and in places other than the human brain. Thus while we no longer need to remember everything, everything can still be remembered because the knowledge of the past is readily available and therefore accelerates the rate of progress. One can learn the accumulated knowledge of millennia by simply reading a book!

And all these because we were anatomically able to speak sounds, instinctively curious to develop them into coherent language, and intellectually successful in habitually passing on such great skill to our offspring. And such is the power of language: it is a skill for rapid and extraordinary intellectual bursts! Unquestionably language has been aiding in the advancement of science. But did it aid in its birth?

Ancient Greek Language and the Birth of Science

The evolution of the Greek language has been a huge topic for scholarly research. While I admit ignorance on such an immense linguistic field, I also know the generally accepted facts about Greek's extraordinary richness, such as a plentiful vocabulary, thorough and rigorous grammar, diverse phonology, and successful orthography, all of which contribute to the language's highly expressive and communicative nature. This distinct nature leads me to contemplate the connection of the language and the birth of science. But first some history.

Spoken since at least 2000 BC and written since at least 1400 BC (not yet with the Greek alphabet, which evolved a few centuries later), Greek is one of the world's oldest recorded living languages and the longest documented from the Indo-European family of languages where it belongs. Phoenicians invented their alphabet around 1050 BC. Modeled after that, the first true alphabet containing vowels was invented by the Greeks around 8th century BC. It was rapidly diffused throughout ancient Greece. With this innovation Greek became the first most easily read and written language of the world. This is so because alphabets are phonetic: each different sound of a language can be represented with a unique symbol and thereafter symbols can be combined to write and sound all the words of the language. Therefore, with an alphabet every language can be written and read relatively easily. In contrast, a pictographic writing system, in which a picture represents a word or phrase, is more complex. The success of the Greek alphabet is also indicated by the fact that after some 3,000 years, Greek is still written with the same letters that served as a basis for the Latin letters, and which, in turn, have been the basis of several modern languages. While Greek has been evolving, its overall identity has been basically preserved. Greek has remained relatively the same language until today, a rather rare but not accidental linguistic phenomenon. Parenthetically, part of the explanation for this might be that the Greeks value highly the written works of their ancestors that their references to them kept the essence of their language unchanged.

Because of its simplicity, the Greek alphabet assisted in making the good habit of literacy accessible to all in ancient Greece. By 5th century BC every male citizen was expected to know how to read and write. Such widespread literacy undoubtedly accelerated progress. In contrast, the complexity of some other cultures' writing systems, often combined with their theocratic (and hierarchical) political systems, made writing the nearly exclusive privilege of priests and professional scribes and not the populace, a situation arguably unfavorable for developing science. Greek literature begins with Homer's monumental epic poems the *Iliad* and the *Odyssey*, dated by consensus from around 8th century BC. However, their surviving present form is at latest from 6th century BC, the century when Greek philosophy science and mathematics began. From around 700 BC are Hesiod's poems *Works and Days* and *Theogony*. All four works

were significant in youth education.

These chronological facts indicate that Greek's relatively early growing richness was present by the time of the birth of science in early 6th century BC. This evidence, together with the fact that Homer was from Ionia (the Hellenic region of Asia Minor with the islands nearby), which was also the birthplace of the first scientists (the natural philosophers Thales, Anaximander, Anaximenes, Xenophanes, Heraclitus, and Pythagoras), proves that science was born at a place and time where language was already advanced enough to aid the evolving scientists in the clear articulation of their theories.

This is a significant conclusion, for it links directly the positive influence that the ancient Greek language had on the birth of science. Greek had equipped the early philosophers with the skills for conceiving and formulating their abstract thoughts, clearly expressing their minds, and efficiently converting their raw intelligence to systematic, rational, transferable, and debatable knowledge. Without such productively expressive language, their scientific theories would have remained unrefined, perhaps not even conceived in the first place.

A poor language reduces not only the ability to express oneself but also the potential to learn from others, for if neither we nor others can think and communicate clearly, we can neither influence nor be influenced. And the poorer the speech and writing acquisition are, the more inadequate the cognitive process becomes.

It seems no accident, hence, that Greek language had been maturing roughly simultaneously with Greek thought in philosophy, science, and mathematics. For the sounds and symbols of a communicative language could create clearer thoughts, which could then refine further the language in a continuous interactive cycle of evolution of both. But mathematics is also a form of language, particularly the language of science. So while by language we usually mean the communication in terms of sounds and written words, mathematics has empowered such notion tremendously by utilizing numbers, equations, complex diagrams, and abstract concepts. Mathematics develops abstract thinking and quantifies science. In turn, science enhances technology, which in turn enhances both science and mathematics, in a mutually productive process. Now since mathematics adds a valuable extension to the definition of language, can we find yet another link between language (specifically the mathematical) and the birth of science?

During the rise of Greek civilization, science and mathematics were driving each other and evolving simultaneously. The first natural philosophers were both scientists and mathematicians. Russell has said, "The preeminence of the Greeks appears more clearly in mathematics and astronomy than in anything else" (p. 208). Mathematics was a skill which enabled them to conceptualize and rationalize their scientific theories more easily, but equally important, their unprecedented physical intuition concerning the workings of nature aided them in advancing mathematics, and thus language.

Thales (who flourished early 6th century BC) was also a geometer. After him, the Pythagoreans were superb mathematicians and the first to implement the mathematical analysis of nature, a practice of vital significance in modern theoretical physics. Physicist and Nobel laureate Erwin Schrödinger argues that what guided Democritus (the last of Presocratics) in conceiving his atomic theory of matter was his deep insight of mathematics (*Nature* 84). In fact, the most enduring discoveries from Greek science of antiquity were by natural philosophers who were also accomplished mathematicians.

The mathematical knowledge as a common characteristic among most of the Presocratics seems to indicate that science could not have been born by persons who did not know the language of mathematics. This is yet another conclusion which links directly the positive

influence of the ancient Greek language, which in its broader definition includes mathematics, with the birth of science. Without a doubt, the clear conception and coherent expression of complex ideas were made easier by the communicative nature of the prolific ancient Greek language. But could the scientific birth have survived and matured without good habits?

Habits

A combination of factors aided in the emergence of the first natural philosophers and in the transition from mythology to science. This unfolding new knowledge gradually advanced, spread, and grew popular, respectable, and practically valuable but also abstractly meaningful and satisfying. Among the Greeks generally, seeking knowledge became a way of life, a scientific habit that characterized the culture. And even though acquired properties such as knowledge and skills are not biologically inherited, habits (such as practicing science) and behaviors (such as a desire to advance the scientific outlook) associated with such properties are transmittable culturally through teaching and can still change the environment in complex and subtle ways. And in turn, through the process of natural selection from biological evolution, the environment can influence a species by controlling the direction of its evolution.

Specifically, the good habit of the first natural philosophers to practice science imposed an epistemological kind of natural selection by promoting scientifically favorable environments where learning could take place and new scientists could exist, thrive, and become abundant, contributing therefore to the constant development of the scientific outlook at the expense of the mythological one.

But since my goal is to explain the critical role that habits play in our intellectual evolution from the point of view of biological evolution, first I need to discuss further the notion of natural selection imposed by a habit.

Imposed Natural Selection

The process of biological evolution of the species begins with a mutation (a random alteration in the genome that can result in a new hereditary characteristic) and continues with the mechanism of natural selection (which says that inheritable characteristics that are also environmentally favorable become more common in successive generations; hence it describes the role of nature in the preservation or extinction of a species). Natural selection can proceed as a consequence of a variety of environmental influences such as chronic periods of coldness, hotness, dryness, wetness, the eruption of a super volcano, changes in atmospheric composition, an asteroid-earth collision, radiation from the sun, or a supernova explosion.

But natural selection can also be imposed by the habits of a species; after all, species are part of nature and their actions affect it. In this case, if some members of a species already have or develop an inheritable trait (a mutation) that is favorable to a kind of environment created by a habit, either their own or another species', then they will be naturally selected. This means that these members will begin growing up more easily, prospering, adapting, preferentially reproducing, and becoming more abundant in such environment that is friendly to their rare trait. Assuming the habit persists, in time the species will gradually evolve to the point that most of its members possess the genetic trait favorable to the environment created by the habit. Following are two specific examples:

1. Microbes: While on the one hand a moderate use of antibiotics can be beneficial to our

survival by killing myriad common harmful microbes, on the other hand a habit of thoughtless overuse of antibiotics can promote the evolution of rare but more harmful microbes that are resistant to the antibiotics we use. Natural selection, in this case imposed by the habit of overuse of antibiotics, can make common population characteristics rare (common microbes killed in myriads) and rare ones common (mutant microbes resistant to our antibiotics).

In the microbes example, the habits of one species, humans, can impose natural selection onto another species, microbes. The example below shows that the habits of a species can impose natural selection onto itself.

2. Birds: With the desirable genetic trait of wings, birds avoided many predators only when they began habitually using their wings for flying and building their nests high up in trees. Such habit imposed natural selection by creating an environment that selected and promoted even further the evolution of birds that could fly the best. With time these skilled high fliers became more abundant, while birds that could not fly proficiently became rarer.

The mythological worldview was once popular and the scientific rare, but since the birth of science their status has been gradually reversing, a fact that is contributing to the overall intellectual evolution of the human species. This observation brings me to a hypothesis, to be introduced in detail in the subsection below, that the good habit of doing science imposes an epistemological kind of natural selection that gradually selects people with scientific and, in general, intellectual tendencies. Such a habit not only secured the safe birth of science during the critical early stages 2,600 years ago but also has since then been contributing to the overall evolution of the scientific outlook at the expense of the mythological.

Erwin Schrödinger in his *What is Life? & Mind and Matter* gives a detailed analysis of (a) how behavior in general influences natural selection and thus the process of biological evolution and (b) how our invaluable characteristic of intelligence allows us to conceive and implement incalculable choices and so both our behavior and consequently our evolution depend on us, at least to a certain degree. Thus, he argues, our evolution does not depend solely on chance mutations. This is an encouraging but also challenging prospect. Based on these two points, he speculates on the potential of intellectual degeneration in our species. Below I will focus on an analysis exploring the opposite: how practicing science habitually has imposed an epistemological natural selection and has been influencing positively the evolution of the human intellect. (This is not to say, of course, that it could not influence it negatively).

Habits Influence Evolution

Since habits can impose natural selection and cause biological evolution, they can also cause intellectual evolution, for our organ of intelligence, the human brain, is just one of many body organs known in biology to have been evolving. So good human habits can cause a biological evolution of the brain and consequently create the potential for intellectual evolution. Just as birds that could fly the best were selected in the environment where flying became a bird habit, it is not unreasonable to suppose that the developing good habits of the Presocratics to understand nature scientifically instead of mythically imposed natural selection by creating favorable environments for new scientists to flourish, multiply, and evolve. In short, the good habit of doing science set up an epistemological environment where the scientific man, in general the intellectual man, is favored and thus naturally selected.

The Presocratic era was the first habit-forming period for science. Specifically, several good habits of Presocratics—people who were keenly observant, curious, skeptical, investigative,

unconventional, open-minded, free-spirited, innovative, rational, passionate, critical, eager to speak and write and debate, truly scientific, and generally epistemological (interested in knowledge of diverse fields)—have been inherited by succeeding generations, from their place to another, from the few to the many, from then to now, from ancient Greece to the rest of the world, and seem to have been imposing an epistemological kind of natural selection by promoting scientifically favorable environments.

These good habits have therefore contributed systematically to the formation of an ever-improving scientific worldview at the expense of the mythological one, and consequently advancing our overall intellectual evolution. For truly epistemological individuals have found such environments intellectually appealing, rewarding, welcoming, and increasingly more adaptive, so much so that today's humans have evolved to become intellectually superior to our ancestors, in fact to any other species known. Hence the kind of environment set up by the good habit of learning (or flying in the bird example) favors, through imposed natural selection, the increase of those interested in learning (or flying).

A Good Genetic Trait and a Good Habit

So, having an environmentally desirable genetic trait (for example, a larynx, a complex brain, legs, wings) from which a good habit can develop (language, learning, walking, flying) is only one required element in the struggle for survival. Using the trait systematically and habitually is the second required element. For only then can the trait influence the environment via imposed natural selection so that the members who have it can be naturally selected even further and consequently increase their chances for survival and betterment by becoming environmentally fitter. In the evolution of birds, for example, those that did not take up the good habit of flying, despite their anatomic ability to do so, generally have less chance to survive attacks by predators. On the other hand, the expert fliers that use their wings proficiently flourish. Varieties that are not environmentally favorable (such as birds who despite having wings are not using them) can become rare and perhaps extinct. But even if they do manage, not following good habits makes their existence much more vulnerable.

Extending the logic of the bird example into the realm of humans and their intellectual habits, we see that a greater chance to flourish belongs to those who use their brains intelligently and try to develop good learning habits, such as attending school, in order to keep up with new challenges and opportunities of a changing environment. In this bird-human analogy there is, however, an important difference in favor of humans. We have a far greater level of intelligence. We have a choice of how to behave, and since behavior influences evolution, through our choices we too contribute significantly to our own evolution. Specifically, through chance mutations we were endowed by nature with the raw intelligence of an anatomically complex brain, but what also plays a critical role in its development is our conscious choice of using it productively. Again, I assert that practicing science habitually has imposed an epistemological kind of natural selection, changed the intellectual environment, and allowed us to realize our potential to live up to our name and become truly sapiens: wise. Starting around the 6th century BC, science, philosophy, and mathematics were gradually becoming a way of life in ancient Greece, increasingly systematic and habitual, not just for a few individuals in a few places but for whole populations in many cities, especially in the education of the young, creating therefore a better chance for this way of life to be passed on to next generations and to people in new places. Since then, because learning science has gradually become a significant skill in life, the

numbers of those with the mythological worldview have been decreasing while those with the scientific have been multiplying. This development is comparable to the declining numbers of the rarer birds who cannot fly proficiently and the growing numbers of the numerous expert high fliers who flourish in an environment where flying became an important skill for survival.

Practicing Science Habitually

The notion of a habit was very crucial in the development of Greek civilization. For there is absolutely no reason to believe that, before or after the Greeks and independently of them, others in the world would not have conceived a scientific idea about nature or a mathematical demonstration of some theorem. In fact, the proof of my opinion is that all kinds of people from all over the world do, or can learn to do, science and mathematics. Nonetheless if something profound like practicing science—that is, seeking exclusively *naturalistic* (scientific, rationalistic not supernatural) explanations for *all* the phenomena of nature, including the origin and evolution of man and of life in general—had not happened completely, systematically, freely, enthusiastically, and most importantly, truly *consciously* (not accidentally or merely instinctively) and *habitually* (not occasionally), as in the case of the Presocratics, such good skill would not have evolved into a cultural tradition, would not have spread, and almost certainly would have quickly vanished without significant effect on society. But evolutions occur when a phenomenon leaves a mark on the environment. A significant reason for the rise of Greek civilization was that philosophy, science, mathematics, and the love of free thinking—and consequently democracy, which aided in the preservation and continuation of the good habit of practicing science—all evolved into a good habit that has been influencing the world ever since.

Hence, it must be acknowledged that in addition to a variety of a more commonly understood factors, an important element in the intellectual transition from mythology to science in ancient Greece was that the Greeks pursued their new ideas in a systematic, persistent, and habitual manner. And in their explanations of how nature works, the Presocratics applied exclusively the scientific outlook for all phenomena of nature. For them every phenomenon had a natural cause; thus supernatural interventions were ruled out. This is the reason we speak of a scientific birth in Greece around the 6th century BC. Had they explained some phenomena naturalistically but others supernaturally, this birth of science would not have occurred. From the Greeks the scientific outlook spread and today is a way of life and a culture, a human culture.

Conclusion

Geography, economy, religion, politics, language, and the practice of good habits, all appear to have an interwoven and critical role in the creation of favorable conditions for the rise of Greek civilization and the birth of science. However, it is likely that even these do not tell the whole story. For example, I believe that to understand the rise of a civilization we must also attempt to understand the idiosyncrasy of the people who caused such rise. With this in mind, the ancient Greeks were passionate, rational, excessive, original, critical, political, religious, philosophical, scientific, brilliant. They debated freely, zealously, and with no fear, any theory to the end despite its implications. They took chances, made mistakes, but rose victorious just as many. And one of those rises was the birth of science. Their scientific theories, although the very first, were extraordinary! What were they and how do they measure up with our sophisticated mind-bending modern science after two and a half millennia of scientific progress? The answer

will be surprising. But this is a subject for another time.

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