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A History of the Ecological Sciences: Early Greek Origins

Editor's Note: Frank Egerton, a well-known science historian, has been working on a history of ecology for some time. He has agreed to provide the history to the ESA Bulletin, *in readable-sized units, as he finishes them. This installment is the first of several.* —A. M. Solomon

Introduction

Ecology is the most comprehensive and diverse of the sciences. Its scope is enormous, and it may be the most important science for managing the earth as an abode for humanity and for what is left of our natural environment. Yet ecology is also one of the youngest sciences, and its history is not well known. Histories of ecology already published attempt to describe the origins and development of some basic ecological concepts. That was a sensible way to begin, but it is time to move on to a more comprehensive history.

In doing so, we must recognize organizational realities. On the one hand, ecology is organized around certain concepts and perspectives. On the other hand, because it is such a diverse science, most ecologists think of themselves as belonging to a more narrow specialty, such as marine ecology, limnology, plant ecology, or animal ecology. They write textbooks for these specialties and teach courses in them. Many of these specialized fields arose before the umbrella science of ecology did, and members of some of these specialized sciences prefer to maintain their separate identities. Parasitologists and bacteriologists would perhaps find it presumptuous for anyone to place them under the ecology rubric. Nevertheless, the history of these subjects is still part of the history of ecology in a way that is not true of the history of physical sciences, however essential these latter are as foundations for ecology. Advances in physical sciences must still be noticed as they become relevant.

Observations and interpretations of ecological interactions extend back to the origins of science, but the term "oecologie" was not coined until 1866, and steps to organize the science were not taken until the 1890s. So where should we begin the history? If the ancient writings that now seem relevant had been forgotten and the science had been built only upon observations and interpretations made during the 1800s, it would be unnecessary to look back in history before 1800. However, the balance of nature concept was the earliest ecological notion, and it remained a fundamental ecological idea until recent times, even though reinterpreted in different ages. The problem was that ecological ideas got more or less lost within the framework of a broader science called natural history. Natural history included not only ecology but also botany, zoology, and geology. The other sciences (physics, chemistry, and astronomy were included in many of its components) were taken from natural history, but it has also drawn upon the already organized ecological sciences of biogeography, evolutionary biology, parasitology, bacteriology, virology, entomology, plant physiology, and so on. In this situation, it is appropriate to entitle this book *A History of Ecological Sciences* rather than *A History of Ecology*.

Science is a product of critical thinking, and some early Greek critical thinking included ideas that we consider ecological. The transition from mythopoeic to critical thinking was gradual; someone could have a mix of mythic and critical thoughts. Thales (c. 460–c. 547 BC) believed that all things come from water, which thought seems to have both mythic and critical aspects. Miletos was on the Aegean coast, beside the Menander River; water was the only substance known to the Greeks in solid, liquid, and gaseous forms. He also believed that all things have souls, which is a mythic idea. If Thales were a lonely voice, he would now seem quaint. But he initiated critical thinking, which means that Anaximander (c. 610–c. 545 BC) and others were interested in the cogency of his arguments (which mostly do not survive), and they were not intimidated by his wealth and prominence. Thales focused on substance as a way to explain change. If water can change into both ice and air (*pneuma*), then perhaps under some circumstances it changes into a tree (apply water to a planted seed) or a rock. Anaximander, a younger contemporary, disagreed. He thought water was only one of several pairs of "opposites." In contrast to Thales, he focused on process. He imagined that life came from the sea and that humans evolved from some species that matured more rapidly than we do.

Anaximenes (flourished c. 545 BC) pondered the ideas of his predecessors and concluded that water could not be the most basic thing in nature because one cannot get fire from water. He decided that *pneuma* is basic, because one can rarefy it by blowing on combustible material and coax a flame, but also *pneuma* condenses into rain, and water can condense (or expand) into ice, and so on. What we see in this small sample of the earliest natural philosophers is a progression in thought by "conjecture and refutation." The philosopher of science Karl Popper studied the ideas of early natural philosophers and concluded that this is the way science should progress. Popper said that scientists do not actually prove their conjectures, but that a conjecture can persist until refuted.

However, the intellectual ferment that Popper found at work among some early natural philosophers did not prevail among all. Soon after the Milesian philosophers began their debates, Pythagoras (c. 560–480 BC) began teaching a natural philosophy that focused on quantities and patterns rather than on substance and process. He believed that there are numerical harmonies in nature, and that mathematics is the key to finding them. When chemists assert that water is made of two parts hydrogen and one part oxygen, they are vindicating the faith of Pythagoras and his followers. Chemical formulas are whole-number ratios, and these philosophers believed that all of nature could be expressed in such ratios. When chemists speak in terms of whole-number ratios, they are talking about elements; but when the Pythagoreans did, they had only numbers in mind. That was reasonable in astronomy and music—sciences that particularly interested them. Astronomical bodies could be thought of as mathematical points, and musical harmony does not seem tangible. However, neither in mathematics nor in real-world measurements do quantities always appear as whole numbers. There is a story told about the Pythagoreans that may not be true, but it seems to capture their bias. Someone measured the diagonal of a square having sides of one and discovered what ever since have been called "irrational numbers." The story is that they all agreed to keep secret this discovery, but someone told the outside world and was then expelled from their commune.

The idea of scientific proof undoubtedly comes from Pythagoras' idea of mathematical proof. According to tradition, Pythagoras developed the proof of the geometrical theorem that, in a right triangle, the two sides squared is equal to the hypotenuse squared. In some sense, Pythagoreans may also have "proven" that musical harmony is achieved when harp strings are in whole-number ratios of length, but in other aspects of science, they depended on faith, not proof.

Pythagoras began teaching on his native island of Samos, but later took his followers to Crotona, on Italy's southern coast. They recruited a local scholar, Alcmaeon (born c. 535 BC), who applied the Pythagorean notion of harmony in nature to medical thought. Alcmaeon had the idea that there are body "forces" (hot and cold, sweet and bitter, and so on) that are in a proper "balance" with each other when one is healthy, and that illness occurs when these forces fall out of balance. After 500 BC, Greek physicians began to synthesize this idea, known later as the balance of "humours," with Egyptian empirical surgery and medicine, to create classical Greek medicine. Greek medicine then became part rational—the balance of humours—and part empirical. The way in which the rational ideas and empirical medicine came together is illustrated by physicians' concern that people live in healthy environments, eat healthy diets, and get an adequate amount of exercise. Physicians learned that living near marshes caused fevers (malaria) in summer, and that people get colds mainly in the winter.

There are more than 50 brief medical works written around 350–250 BC from a rational and/or empirical perspective. These writings are known as the *Hippocratic Corpus*, because they were later attributed to Hippocrates (460–c. 370 BC), a respected physician who might have written one or more of them. *Airs, Waters, and Places* had an ecological goal of correlating diseases in a community with changing weather conditions (paragraphs 1–11). The author also attempted to identify environmental factors that determine racial characteristics (paragraphs 12–20). Greek physicians used the stars to keep track of the seasons, but they did not consider the stars as environmental influences. Although they knew three kinds of parasitic worms found in human intestines, this knowledge did not lead to a theory of germs and contagion, and without such a theory, an environment vs. health research program could achieve little. Furthermore, there was no institutional support for medical research of this kind. Nevertheless, the *Hippocratic Corpus* represents a significant advance over the writings of early natural philosophers, because the latter only reasoned from commonplace evidence. They did not, therefore, bother to describe evidence in any detail (as far as we know). In medicine, however, physicians needed more details than commonplace knowledge, and thus the *Corpus* as a whole (but not individual treatises) meets a loose definition of science: it provides observational evidence, interprets the evidence, and draws conclusions based on the evidence.

Natural philosophy influenced not only Greek medicine, but also Greek history. Herodotos (died c. 425 BC) is called the father of history because, like Homer's *Iliad,* his *History* gives both a Greek and a foreign perspective. For Herodotos, the foreign perspective included especially Persian recollections of the Greco–Persian Wars. Herodotos was not a natural philosopher, and his *History* is a mixture of old and new thinking. He was a traveler, visiting Egypt, Phoenician ports, and other places in the eastern Mediterranean, Black, and Aegean Seas. His interest in plants was substantial, though mostly practical, and included reports on pollination of date palms and the fig trees. His reports on animals included the natural history of wild species and some accounts are ecologically significant. His discussions of geography are also sometimes ecologically relevant.

Herodotos spent about 4 months in Egypt, which fascinated him. Egyptian experience with rivers was virtually limited to the Nile, which they viewed as a gift from the gods. Their concern for it was religious, not scientific. The Greeks, however, were familiar with a number of rivers, and the Nile was the only one they knew that flooded in summer instead of spring. Other Greeks had speculated about the cause, and Herodotos attempted to find the most plausible natural explanation. He found the evidence for north-blowing winds as the cause of the flooding to be very weak, although his own speculation—a change in the pathway of the sun from summer to winter—was no better (II, 24-25). The Nile crocodile was conspicuous and dangerous, and therefore of great interest. It was the largest creature known to him that began as a small egg. (An elephant is fairly large at birth, and mammalian eggs were unknown.) He reported that when crocodiles come ashore, they open their mouths and allow sandpipers (Egyptian Spur-winged Plovers, *Hoplopterus armatus*) to eat leeches from inside, without ever harming the birds in appreciation for this service (II, 68). Such a relationship (if true) is what ecologists now call mutualism, and this was the earliest report for what we now call the balance of nature concept.

Perhaps Herodotos never got to Arabia, but he came close enough to collect Arabian evidence for his balance of nature concept (III, 108-109):

The wisdom of divine Providence. . . has made all creatures prolific that are timid and fit to eat, that they be not diminished from off the earth by being eaten up, whereas but few young are born to creatures cruel and baneful. The hare is so prolific, for that it is the prey of every beast and bird and man; alone of all creatures it conceives in pregnancy; some of the unborn young are hairy, some still naked, some are still forming in the womb while others are just conceived. But whereas this is so with the hare, the lioness, a very strong and bold beast, bears offspring but once in her life, and then but one cub; for the uterus comes out with the cub in the act of birth. This is the reason of it: when the cub first begins to stir in the mother, its claws, much sharper than those of any other creature, tear the uterus, and as it grows, much more does it scratch and tear, so that when the hour of birth is near seldom is any of the uterus left whole.

It is so too with vipers and the winged serpents of Arabia: were they born in the natural manner of serpents no life were possible for men; but as it is, when they pair, and the male is in the very act of generation, the female seizes him by the neck, nor lets go her grip till she has bitten the neck through. Thus the male dies; but the female is punished for his death; the young avenge their father, and gnaw at their mother while they are yet within her; nor are they dropped from her till they have eaten their way through her womb. Other snakes, that do no harm to men, lay eggs and hatch out a vast number of young. The Arabian winged serpents do indeed seem to be many; but it is because (whereas there are vipers in every land) these are all in Arabia and are nowhere else found. (Godley translation)

Although there is superfetation in hares, most of this account is incorrect; the winged serpents cannot be identified. If Herodotos had applied quantitative reasoning to his account of lions, he would have found that the situation he describes would lead to rapid extinction. Nevertheless, the differential reproductive capabilities of predators and prey became a permanent part of balance of nature concepts.

Herodotus was a free spirit, but most Greeks felt strongly bound to their city state. The Greco-Persian Wars were at a time when the Greek states had united and achieved a glorious victory. Fifty years later, however, these states polarized into opposing alliances and fought the destructive Peloponnesian War. Thucydides (c. 460–c. 400 BC) was a general for Athens who arrived at a besieged city too late to save it from the Spartans, and for that he was exiled. While living in exile, he collected information from participants on both sides of the conflict and wrote his *History of the Peloponnesian War*, which is more critical and sophisticated than Herodotos' *History*. One famous episode that he described was the plague of Athens. Although Greece endured malaria and other diseases, it never had an epidemic until the Spartans invaded Attica in 430 BC. Pericles' strategy was to let the Spartans ravage the countryside while he kept the people safely within the walls of Athens. However, with so many people crowded together, an epidemic erupted. Thucydides' account of it is so detailed that some historians speculate that he may have gained insights from reading contemporary medical writings, even though none of these dealt with epidemics. If one wonders why physicians did not also leave accounts of it, he provides a clue: the ones who were there to treat the sick also died from the epidemic. He said that it spread from Ethiopia or Egypt, it was contagious to both people and animals, and he gave detailed descriptions of its symptoms from early appearance to death, with few survivors. (There has been much discussion by historians of medicine on what the disease was, but with no consensus.) In 429 it killed Pericles, which was a major blow to the Athenian cause.

Athens finally surrendered in 404. Recriminations followed, but peace returned. Plato (427–348/47 BC) founded the Academy in Athens around 385 BC. He used the dialectical method of his teacher, Socrates, to organize his *Dialogues*, the most widely read work in the history of philosophy. Plato was strongly influenced also by Pythagorean mathematics, and the conviction that numerical patterns provide a key to understanding nature. Although a few mathematicians and astronomers were associated with the Academy, it more closely resembled a sectarian college than a modern university. When one left the Academy, one was prepared to be a member of the ruling class, which meant that one could answer any questions raised by the lower class. In *Republic*, Plato developed an elaborate metaphor of the cave (VII, 514–517), the purpose of which was to discredit sensory observations. If one understands that collecting data is pointless, then one can gain an understanding of the world and society in the only reliable ways left open, mathematics and dialectics. This is where myth comes in; one discusses the possibilities and then develops a scientific myth that is as close to an understanding of nature as one can get. Popper claims (p. 38) that, "historically speaking all—or nearly all—scientific theories originate from myths, and that a myth may contain important anticipations of a scientific theory." Let us test Plato's myths against this claim. He tells us two different creation myths in different dialogues. They need not be seen as contradictory, however, since the one told in *Protagoras* can be seen as providing details about one aspect of the myth told in *Timaeus*. Timaeus, the scholar for whom the dialogue was named, asserts (30b-c) that "this Cosmos has verily come into existence as a Living Creature endowed with soul and reason owing to the providence of God." He then asks a rhetorical question: "In the semblance of which of the living Creatures did the Constructor of the Cosmos construct it?" To us, this is a loaded question (since we do not believe that it is in the likeness of any animal), but at the Academy, it seemed plausible. A sampling of Timaeus's reasoning can help us to understand the thinking involved: "We shall not deign to accept any of those [answers] which belong by nature to the category of 'parts'; for nothing that resembles the imperfect would ever become fair." Therefore, God "constructed it as a Living Creature, one and visible, containing within itself all the living creatures which are by nature akin to itself," (30d, Bury translation).

This mythic answer may sound irrational today, but it became the source of two related concepts: the superorganismic balance-of-nature concept and the microcosm–macrocosm concept. The first concept asserts that living beings are actually organs of a super "being" which is nature, and the second asserts that the parts of the human body correspond to different parts of the universe. This, of course, was metaphysics, not science.

Protagoras of Abdera was a sophist who presumably did not take myths seriously; Plato nevertheless has him tell a creation myth in the dialogue named for him: the god Epimetheos designed all the species of animals (320d-321b): "he attached strength without speed to some, while the weaker he equipped with speed; and some he armed, while devising for others, along with an unarmed condition, some different faculty for preservation." (Lamb translation) The main point of the myth was that when Epimetheos finished, he had forgotten to leave any physical advantages for humans, and his brother, Prometheos, had to step in and give intelligence to humans. We notice that Epimetheos' creations are mythic generalizations of Herodotos's balance of nature concept, which he described using particular species as examples. Both Herodotos and Plato contributed to what we might call providential ecology: God created permanent species with traits that mesh in such a way that no species ever becomes extinct.

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The Ins and Outs of the ESA Annual Meeting: Eight Things You May Not Have Known

For nearly 5 years, I have been a consultant working with the Ecological Society of America, planning, organizing and running the Society's meetings. With an undergraduate degree in ecological science, and 25 years of fund-raising and meeting-planning experience, I have the requisite background for the job. But nothing could really prepare me for the overwhelming decency of ESA members and the downright Byzantine complexity of an Annual Meeting which, every summer, attracts between 2,600 and 3,100 attendees, costs the Society over $450,000, and generates 2,200 to 2,500 scientific abstracts. After 85 years of ESA Annual Meetings, there is a wealth of history to honor, while at the same time striving to understand the needs of a new generation of members living in a cyber-age. It's a great job! As ESA's point person, I have heard a fair share of complaining and I have also gotten plenty of pats on the back. The Society's Annual Meeting, however, is a real team effort, a working partnership between volunteers and headquarters and Ithaca-based staff, local convention and visitors bureaus, sales representatives, vendors, and sometimes even local elected officials. It generally all takes place behind the scenes. All the activity is focused on making certain that the Society's Annual Meeting represents the best we can provide, and that attendees have a productive, professionally enriching, and personally satisfying meeting experience.

The questions for this article were inspired by conversations with members, and by the Annual Meeting evaluations I have reviewed.

1) How do ESA meeting locations get selected?

In order to guarantee that ESA has sufficient meeting room space, favorable hotel rates, and dormitory housing, any group as large as ours has to start between 7 and 10 years before the meeting actually takes place. This has not always been the case, but as the ESA meeting has grown in size from 1,100 people less than 10 years ago to more than double that number today, the Society has had to get more proactive.

The process starts by looking at the location of previous meetings and reviewing places we haven't been, or places where we have been that were popular with attendees. We look for geographic balance between east and west, north and south, and we keep tabs on locations constructing or opening up state-of-the art