

Remote Learning Module for 25 March 2020

Lecture Notes for Fernando Espinoza's *The Nature of Science*, Chapter 2

Yesterday, in Chapter 1, we discussed the importance of scientific literacy in the modern world. Today we will turn our attention to the ancient origins of scientific inquiry itself. Curiously enough, one of the first questions that launched the beginnings of Western science was about the very possibility of there being an origin to things—what we may call the “riddle of origin.” Doubtless we are familiar with this riddle in the humble expression: Which came first, the chicken or the egg?

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(0) Before Philosophy. Science and philosophy were once indistinguishable from one another; the distinction between them only emerged when thinkers in ancient Greece began to separate questions of *natural philosophy* (what we nowadays call natural science), on the one hand, from questions of *moral philosophy* (what we now call ethics, politics, and social science), on the other hand. The first of these natural philosophers did not even have the word, “philosophy” available to describe their endeavors; rather they called themselves *physikoi* (pronounced: foo-see-koi). These *physikoi*, or natural philosophers, developed their thinking along the coast of the modern Turkish subcontinent, then known in the Greek-speaking world as Ionia. The first of these lived in the port city of Miletus, and therefore known today as the Milesians.

Why are we turning our attention to the Milesians as we begin our chapter on the science as the business of accomplishing tasks? Because, as we noted last time, we accomplish tasks by way of inventing tools, and besides the hand-tools and machine-tools our ancestors fashioned to accomplish the tasks of engineering (technology), there were mind-tools; and conducting the business of fashioning and utilizing mind-tools (theoretical models, for example) was the occupation of the first philosopher-scientists.

But the thoughts of these first thinkers did *not* emerge from nowhere. Before the first questions, there had to be concepts, ideas, which could be hammered into the form of general questions about the nature of things. For the ancient Greeks, there were four of these essential concepts that would find their way into the very first philosophical problem: the riddle of origins. These concepts emerged as a result of a transformation in Greek grammar. Yes, that’s right: grammar. Greek, as we’ll see, has an easy way of turning verbs, adjectives, and adverbs into nouns: placing the definite article (*tó* in Greek), *the*, in front of a verb, adjective, or adverb. For example, in English, we can turn the adjective “beautiful,” into a noun representing an abstract thing, “the beautiful,” or as we are more likely to say, “Beauty.”

When the Milesians appeared on the scene in the Sixth Century BCE, they already had the following four abstract nouns ready to hand.

-- **κοσμος** (cosmos): from *cosmein*: to organize, especially to marshal troops (as opposed to chaos, and latent in our words, cosmic and cosmetics).

-- **φυσις** (physis): from *phusein*: to grow; in Latin, *natura* (as opposed to *techne*, or the artificial).

-- **αρχη** (archē): this term was systematically ambiguous in ancient Greek, an ambiguity was mirrored in the Latin translation, *principe*, but that is resolved in English by a trick of spelling; it means alternately: *principle* or *principal*. An *archē*, in other words can mean a rule or a ruler; it can also mean “first” or “origin” (we find it in our words *democracy* and *archeology*).

- **λογος** (logos): from *legein*: to speak to say; this term has a multitude of meanings in ancient Greek: a single word, many words, a story, an argument, reasoning, giving an account.

From these four concepts the Milesians fashioned the very first philosophical problem: to provide a *logos* (an account) of the *archē* (principles) that regulate the *cosmos* (order) of *physis* (nature). In this problems we can see not only the beginnings of natural philosophy, but the everyday work of modern science today.

In particular, the Milesians wanted to understand the *archē* of both **change** (Greek: *kinesis*) and **multiplicity** (or the relation between the singular and plural forms of nouns; what the Greeks called the One and the Many, or *monas* and *hoi poli* respectively).

(1) Anaximander and the Riddle of Origin. Anaximander was born in Miletus in 610 BCE. The Homeric poem, the *Illiad*, dates from about two hundred years earlier, while Plato would not compose this famous *Dialogues* for another two hundred years after Anaximander.

(a) The riddle (which we can frame on analogy to the question, Which came first, the chicken or the egg?) actually begins with one of Anaximander’s predecessors, Thales, who is typically regarded as the very first *physikoi*, or natural philosopher. Thales had said that there is one *archē* responsible for both change and multiplicity: the principle of fluidity (or, generically, water).

(b) Anaximander rejected this account, this *logos*, on the grounds that since water is one of the four most basic material elements, earth, air, fire, and water, and since one element cannot produce another, there must be a more basic substance that underlies the four elements of experience. You can see in Anaximander’s reasoning here the more familiar reduction to which we appeal nowadays when we say that every material thing in the universe is some combination of the elements of the periodic table, and that the elements are themselves formed by unique combinations of the units of charge, positive, negative, and neutral, or protons, electrons, and neutrons. Anaximander was not an atomist, however; the Greek world would have to wait for Democritus to fashion that notion. Instead, Anaximander hypothesized that the origin of all things must itself be so general as to be without any specific qualities like fluidity or solidity whatsoever. He called this *tó aperion* in Greek, or that which has no boundary, no perimeter; usually translated into English as “the boundless” or “the infinite.”

(c) To Anaximander this notion (that the *archē* of all things is The Boundless) further implied that the Universe must have an *infinite past*, a doctrine later embedded in the Latin phrase, *ex nihilo nihil facit* (or, from nothing, nothing comes, which you expand into saying that if there was ever nothing at all, there still would be nothing at all).

(3) Anaximander was well aware that he was facing a paradox (two incompatible beliefs that appear equally warranted), because at the same time that it seems necessary for the universe to be eternal (that is, *not* to have a beginning), it also seems necessary for the universe to have a very definite beginning, since an infinite past seems impossible because from an infinite past to the moment we call, *now*, there would have to have been an endless wait; but here we are, and therefore there must have been a *first moment*. We'll return to the logic of paradoxes soon, but for now, let's examine how Anaximander attempted to resolve the paradox of the chicken and the egg for the entire universe.

(a) His reasoning is simple enough: let's ask of each existing thing: Does it have an origin? He answers: No, that is, there must be at least one infinite thing (a thing without any beginning at all). Otherwise, every scientific explanation of the order of things (the *cosmos* of nature) would find itself confronting an infinite regress of causes, which would be tantamount to saying that there is no ultimate cause, and therefore no complete science, at all. You can see in this reasoning the appeal of the now reigning model of the known universe in our time: the Big Bang.

(b) In fact, Anaximander's idea anticipates modern cosmogony rather well, insofar as he went on to ask: If there is an infinite thing, The Boundless" (*tó aperion*), how does it generate the world of bounded (finite) things? His answer was that this must have happened by a separation of the *homogeneous* into the *heterogeneous*; and this is exactly what we find in today's cosmogony: first there is the utter singularity of the Big Bang itself; then 10^{-32} seconds later, the universe begins expanding; 10^{-6} later, there are protons; 100 seconds later there are helium and lithium; 100 million years later there are stars; 500 million years later there are the first galaxies ,, and 9 billion years later, our solar system.

(c) For living things, Darwin later demonstrated empirically what Anaximander hypothesized conceptually: since eggs need to be hatched and chicks need to be raised, some non-chicken must have laid the first egg: The Egg Came First.

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Next class, we'll continue our tour of *the first mind tools*, with a bit more about the logic of paradox and the ways we have fashioned for resolving them. Then we'll carry on discussing the remaining material in Chapter 2, about the Origins of Accomplishing Tasks. Be well everyone, and remember: social distancing saves lives, which is presumably why we are not in JUB 202 presently.