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PHYSICS: ITS BIRTH IN GREEK IONIA

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If we are to imagine the birth of Greek natural science and philosophy in the Asiatic city of Miletus in the 6th century BCE, we need first to imagine one of the most dramatic changes in the physical appearance of the environment that the ancient Greeks, or any humans in history, have ever witnessed. Much of what we now call western Turkey, approximately the whole middle third, stretching inland from the modern coast for a minimum of thirty miles, had not yet been created. Miletus in the sixth century BCE was a famous harbour town still surrounded on three sides—west, north, and east—by seawater. But the dusty ruins of Miletus now stand near a small modern town of Balat, miles from the sea in any direction at all.

The Milesian thinkers who began discussing the unseen causes of the world were watching that world change almost every day. In about 1,000 BCE, their harbour began to silt up, as the winding ('meandering') River Maeander disgorged itself into the sea far to the north-west, and the heavy particles of rock and soil, 'alluvium', sank to the bottom of the estuary and stayed there. Every year that passed, the alluvium extended the shore towards Miletus. By the Christian era, Miletus itself was landlocked.

The process must have been about half completed when the first natural scientists were alive. They will have mourned the inexorable annexation of their beloved sea by the stones of the Asiatic continent. They had ships in their blood, and a foundational voyage in their history, since their own town had been settled by colonisers from the Peloponnese. Since, as Greeks, they were also insatiably curious—the third of the ten defining features I identified in my book *Introducing the Ancient Greeks* (2014)—it is little wonder that they enquired into the reason. Since they were watching fresh water and stones met salt-water and sand, producing new dry land every day, it is little wonder that they became the first people in recorded history to inquire into the origins of the world exclusively in terms of natural causes.

Earlier Greeks saw the universe as arising first from Chaos and then from the asexual and sexual reproduction of gods who resembled humans. Their creation myths were told in their equivalent of the Book of Genesis, Hesiod's *Theogony*. Every river, every tree and every mountain had its own numinous deity who inhabited it, and every sphere of human experience belonged to the portfolio of one of the Olympian gods or those of the Underworld. The only thing to do if the world changed in ways that were inconvenient, or in the face of a natural catastrophe, was to sacrifice to the relevant gods and attempt to propitiate them. If things went wrong it was because a human or community had offended, for example, Poseidon, the god of earthquakes, or Demeter, the goddess of arable farming. But religious and ritual expedients seemed useless in the face of the landlocking of the central part of the coast of Ionian Greece, Anatolia. Its inhabitants, who were called collectively the Ionians, were desperate. But they were also resourceful, open-minded and smart.

The first scientists of western Asia, these Ionians, proposed that the primary constituents of the universe when it arose were material substances. The first of them whose name we know was Thales. Thales was born in the 620s. He thought that the first cosmic principle or element—the one being pushed back by new land—was water. The argument he seems to have used to support this view was that inanimate things lose water and dry out. His student Anaximander then drew a map of all the physical world the Milesians knew; he suggested that the world they could perceive—both land and sea, which visibly limited each other—must be surrounded by something else that was

limitless and immeasurable—*apeiron*. The third Milesian thinker of the time, Anaximenes, watched land expand and sea shrink, and argued that *all* the constituents of the world man could see—fire, wind, cloud, water, earth, stones—are created out of air by processes of condensation or sublimation: the differences between them are to be explained in terms of their relative density. In Ephesus, another city not far from Miletus which also became steadily cut off from the sea, a fourth thinker named Heraclitus asserted the principle that the physical universe was constantly changing because of the action, rather, of a cosmic fire: *panta rhei*, he said, 'everything is in flux'.

The intellectual revolution which started in the Maeander estuary in the early 6th century migrated with men from that part of the Greek world first to its colonies in southern Italy, and in the fifth century, after the exponential rise of the Persian Empire, to classical Athens. Thales' intellectual descendants, in Ionia and then beyond, harnessed his spirit of non-religious enquiry to the investigation of the unseen structures and causes of change not only in land, sea and sky but also in human experience and human activities. The next generations developed rational medicine. They asked about the invisible inner workings of our bodies; they probed the relationship between the worlds we see in our mind's eye and those our senses tell us are physically present, how we make decisions about right and wrong, how we collect information, why people speak different languages and worship diverse gods, why we fight one another or come together in cities, and how the past became the present—how the world's empires came into existence. But it was that original move from mythical to matter-based explanation of the physical world which was essential to the entire intellectual revolution which ensued.

Who were these clever Greek Ionians of Anatolia, then? The word for 'Greek' in modern Arabic, Hebrew, Turkish and several Indian languages is not derived from 'Hellene' or 'Greek' but from the ancient term *Ionian*. The majority of Greeks living in direct contact with the non-Greeks who stretched into the Asiatic continent—it must have felt infinitely— were indeed Ionian. They intuitively looked eastward and felt themselves to a certain extent distinct from members of the other three Greek tribes, especially the Doric, which dominated some of the southerly Aegean islands and the southern Peloponnese. The Ionians believed that one of their tribal ancestors was Ion, himself a son of the god Apollo. In the *Iliad* Apollo, despite his indisputably Greek credentials, is associated with Troy, an advanced civilisation in Asia Minor. Apollo was from earliest times associated with prophecy, with the quest to understand the unseen and the unknowable, with music and the Muses, wisdom poetry, medical arts and healing. It is little wonder that his human descendants, the Ionians, invented rational philosophy, science, history-writing and medicine.

Science and philosophy as we understand them were both born in the Ionian Greek city of Miletus on the coast of Anatolia in the early 6th century BCE. During the century before, Miletus had formed an alliance, the Ionian League, with other Anatolian city-states. Under a controversial tyrant named Thrasyboulos, they had also fought a lengthy war with Lydia, and had succeeded in preserving their independence from that rich non-Greek land. The peaceful relationship that emerged from the war meant intense cross-fertilisation between the neighbouring barbarian and Ionian Greek cultures. The Milesians had also become the richest Greeks in the region and perhaps in the world. They had a powerful navy and built a maritime empire; they sent out more colonies than any other city-states, founding dozens of settlements, especially in the Black Sea, where they solved serious technological problems in transplanting the Greek way of life to colder climates. In the middle of the sixth century they came under the sway of the Persians when Cyrus conquered Croesus' Lydia. But for several decades Miletus, bordered by the old barbarian kingdoms of Asia, had been a formidable force in the culture of the Greek-speaking world.

The three great minds which invented physics belonged to men who were born into this milieu in the late seventh and early sixth centuries. This was the first time in recorded history when humans tried to explain the origins of the world about them exclusively in terms of natural causes. The concept of 'philosophy', which translates as 'love of wisdom', had not yet been given its distinctive name and *science* is a later, Latin concept. They were known as *physiologoi*, or men who discoursed about nature (*physis*). Each one of them also tried to put his various observations together in a way that constituted a coherent, unified model. They are often known as 'Presocratic' thinkers, a term I prefer to avoid because it implies they are only important in relation to the later thought of the Athenian Socrates.

And amongst these Ionians, what kind of man was the original *physiologos*, Thales? Herodotus tells us he was a Milesian citizen with Phoenician ancestry. Others said that he was fully Phoenician but living amongst Greeks in Miletus. These are fascinating traditions, because the seafaring Phoenicians of the Levant had reached an advanced

level of civilisation and technology long before the Greeks, giving to the world the phonetic alphabet, advances in naval technology and navigation. Even if the tradition is not strictly true, it reflects an ancient intuition that Greek science and philosophy owed much to other Ancient Near Eastern cultures. It is certainly not out of the question, either, that a Phoenician prior to Thales had suggested that the perceptible world was some kind of enormous sea-going vessel.

Thales' most famous achievement was said to be accurately predicting a solar eclipse, perhaps that we know took place on 28th May 585 BCE. During a battle between the Medes and the Lydians, daylight suddenly was replaced by night, just as Thales had predicted would happen that year. The combatants were so rattled that they made a truce. We still don't know how Thales had calculated the year in which the eclipse would occur. He may have had access to ancient records indicating the periodicities of eclipses as they had happened.

Thales is supposed to have had political acumen, recommending to all the Ionians that they form a federation ruled from a single master assembly in Teos. He put his empirical study of the seasons and agriculture to commercial use as well. He was criticized by people who said that the life of intellectual inquiry was useless. But he was able to use his scientific knowledge to predict one winter that next summer's crop of olives was going to be abundant. He had the foresight to rent all the olive presses in his area, acquiring a complete monopoly on them (the source, Aristotle, uses the word *monopolia* for the first time in world literature here). Thales then charged high fees for subletting them. He made a fortune, Aristotle tells us, 'so proving that it is easy for philosophers to be rich if they choose, but this is not what they care about'. Herodotus also says there was a story (1.75) that Thales had succeeded through hydro-engineering in diverting the river Halys so that the Lydian King could invade Cappadocia.

Thales was probably an expert in cutting-edge mathematics, too. He may have been the first to express the theorem that the angles at the base of any isosceles triangle are equal. He is said to have measured the heights of pyramids by geometrical means involving shadows and measuring sticks and ratios. But it was for his physics that he is most famous. Where Hesiod saw the universe as arising first from Chaos and then from the asexual and sexual reproduction of anthropomorphic gods, Thales proposed that the substance from which the universe began, the cosmic first principle, was water. One argument he may have used to support this view is that dead things lose water and dry out. But Thales may well have argued that the world somehow rested on top of water, for he also seems to have said that earthquakes were 'rockings of the boat' (Seneca, *Natural Questions* 3.14).

Thales was believed to have written a treatise on navigation by use of the heavens, which we should associate with the tradition that he owed something to the master-mariners of Phoenicia. But it also raises the question of the relationship between the Milesians' ancestral cults and their talent for natural science. The cult of Apollo was central to Ionian life and Ionian colonial expansion. But over the last three decades our understanding of early Milesian cult has been transformed by the discovery outside the ancient city walls of an archaic temple of Aphrodite. Large numbers of 7th and 6th-century terracotta figurines of the goddess have been found, as well as graffiti which testify to the many dedications which Milesians made to her. Miletus exported its cults and calendars to its Black Sea colonies, in many of which Aphrodite was an important goddess, for example at Istria and Olbia, where she had the cult-title *Euploia* ('Fair-voyage). At Panticapaion in Crimea she was entitled *Naukratis*, or 'Ship-power', and at Cyzicus her epithet was *Pontikē*, 'Of the high seas'. At Miletus she was also worshipped as *Aphrogeneia* or 'Foam-born', in line with the old myth of her generation. But at both Phanagoria and Miletus she had an additional title, *Ourania*, or 'Celestial', a form in which the goddess was conceived as overseeing navigation by the stars. Thales may have found the leap from Olympian theology to his water-based cosmic theory much less massive than we do.

A follower of Thales named Anaximander, on the other hand, believed that the first principle was something else less tangible, and that it was completely without limit—*apeiron*. Scholars dispute whether Anaximander's 'Unlimited' was made of matter or immaterial. But he almost certainly regarded it as surrounding and 'steering' the world (the verb is *kubernan*, which means 'steer a ship'). It was also immortal and imperishable (Aristotle, *Physics* 203b). Anaximander's infinite substance was separate from the other elements and all worlds and surrounded them. The other certain great contribution of Anaximander was the drawing of a map of the world, presumably the regions perceptible to humans within The Unlimited.

The Milesians lived adjacent to Lydia, where, in the 7th century BCE, the first coins in human history were minted. This momentous technological advance may have been one impetus behind the innovative thinking of the Milesians, and especially behind Anaximander's abstract conception of The Unlimited. Coins made the ancient Greeks think. Their fable of the Phrygian king Midas, who starved to death because everything he touched turned into gold [Aristotle, *Politics* I.9], dates from this period and region, since Phrygia also bordered on Lydia. Or take the myth of Charon the ferryman. In Aristophanes' comedy *Frogs*, first performed in 405 BCE, the god Dionysus and his slave go on an escapade to the Underworld. They meet a corpse travelling down and plead with him to take their luggage on his bier. But he demands two drachmas, the equivalent of four days' pay for a labourer. The amount was also twelve times as much as the single coin which the Greeks placed in the mouths of the dead to pay the ferryman—the obol.

The corpse's bartering can't help him, since money could buy nothing in Hades. There was an ancient popular drinking-song which expressed this: 'Midas was blessed, but what man ever took with him to Hades more than a one-obol coin'? Aristophanes' dialogue on the road to the Underworld therefore asks whether money can get the better of death. Is there a form of value which can last beyond the grave? Can you take it with you when you die? Can it make you immortal? At Rome, the god credited with the invention of coinage should arguably have been Vulcan, god of metalworkers. But it wasn't. It was Janus, the two-faced god who inaugurates new years and looks backwards and forwards through temporal infinity.

Coins represent *timeless* value. It's a value that can be divided into fractions of tiny denomination, but it can be accumulated limitlessly. Coins make it possible to imagine an amount of money too huge to be spent in a lifetime. This underlies its connection with physics and philosophy. Coins are different from portable chunks of bullion. The value they represent need not be the same as the value of the metal as a commodity. In extreme cases the coins may be entirely counterfeit. In many ancient cities, coins of small denominations were issued in bronze. Their face value bore little relation to their intrinsic worth. But the slippage between the two values—the nominal and the actual—began the minute the coin was struck. Karl Marx described this in the first volume of *Das Kapital*. The circulation of coins always reduces them to a semblance of the value they symbolise. 'Being gold,' *Goldsein*, turns into 'appearing to be gold', *Goldschein*.

Coins are concrete. You can touch them. They are made from matter. But they signify a quantity in the self-contained world of purely *abstract* symbolic value. All human labour and real-world objects can be measured by money and converted into it. This new, self-contained abstract world, existing exclusively in the mind, allowed the Greeks to reason and argue conceptually in terms of intangible ideas. Abstract notions of value, time, and existence were for the first time in intellectual history divorced from the real world of work, bodily needs, and the physical environment.

The value represented by coins can ceaselessly shift from the immaterial signification lent it by coins to the real use value represented in, say, bread. The experience of coinage may well also have prompted the idea that the universe was in a state of constant change. Anaximenes was the next Milesian 'material monist'—that is, thinker to claim that there was a single substance or element from which everything comes into being. But in Anaximenes' monism, the first principle was air. He seems to have thought that all things—fire, wind, cloud, water, earth, stones--are created out of air by processes of condensation or sublimation, and the differences between them are to be explained in terms of their relative density.

A later thinker, Aristotle's colleague Theophrastus, pointed out that this meant that Anaximenes must have posited a new and distinctive principle of permanent change within his air-based universe. But it was Heraclitus, a resident of Ephesus fifty miles to the south, whose name is inseparable from the idea of permanent fluctuation. Heraclitus famously said *panta rhei*, 'everything is in flux'. It is not possible to step twice into the same river, according to Heraclitus, because the water which constitutes it is constantly changing; nor can one come into contact twice with a mortal who remains in precisely the same state. Some scholars think Heraclitus is the first *physiologo*s or thinker who can seriously be called a philosopher, because, along with his fire-centred theory of the physical cosmic order, he searched for metaphysical and ethical principles. He was, at any rate, the earliest ancient Greek thinker to use the term *philosophos*, 'wisdom-loving'.

Heraclitus' theory of permanent change helped him to explain the confusing tension between sameness and otherness in the universe. Things which are opposites at one time can become unities at other times or in other circumstances: 'As the same things in us are living and dead, waking and sleeping, young and old. For these things having changed around are those, and those in turn having changed around are these'. Moreover, the concept of constant flux has implications for the attributes of things and for how different agents perceive those attributes: the sea contains water that is at the same time pure and polluted. For fish it is drinkable and promotes health, but for men it is undrinkable and causes harm. Heraclitus argued that all matter was transformed by being turned incessantly into fire and back again. But he compares this process with the ceaseless 'exchange' of gold into goods and vice versa. The universe was in flux. It could be measured, but only by the equivalent of cosmic money.

A later Christian Greek named Clement of Alexandria said that Heraclitus had drawn on 'the barbarian philosophy'. Perhaps he had been stimulated by the sanctity of fire in the religion of the Persians, Zoroastrianism. But he himself transformed all the ideas which contributed to his thought into beautiful Greek artistic prose—itself a new invention which had only been made possible by the advent of writing with the Phoenicians' phonetic alphabet as adapted by the Greeks. The fragments of Heraclitus which have come down to us are admittedly maddeningly obscure. The Greeks told a story in which Euripides gave a copy of Heraclitus' book to Socrates to read; when asked his opinion of the book, Socrates replied, 'The part I understand is excellent, and so too is, I dare say, the part I do not understand; but it needs a Delian diver to get to the bottom of it'. But Heraclitus, arcane or not, gave a great deal of thought to what was entailed in both science and 'philosophy'—self-conscious processes of enquiry into the nature of existence.

The exotic figure of Pythagoras came from the Ionian island of Samos. He was held by some in antiquity to have studied with Zoroaster 'at Babylon' himself; others said his teacher was a priestess of Apollo at Delphi called Themistoclea or Aristoclea; the Pythagorean school is often represented as being more open than most ancient intellectual communities to women. But Pythagoras's true contribution is difficult to assess. He left Samos, perhaps out of distaste for the tyranny of Polycrates, and settled in Croton in south Italy. His doctrines were more mystical than those of the Milesians, and the community he ran was an esoteric sect which may have practised vegetarianism and other austerities. He may have believed in metempsychosis and reincarnation. He made advances in the relationship between music and mathematics, and the idea of harmony seems to have been important in his cosmic theories as well. He is of course best known for the theorem which goes under his name, that in a right-angled triangle, the area of the square of the side opposite the right angle is the same as the sum of the areas of the two squares made from the other side of the triangle. But in this case, there is no doubt that this Greek thinker was drawing on 'barbarian lore', for the Babylonians had cracked the fundamental relationship of the 'Pythagorean' triples as early as 1800 BCE.

The Pythagoreans in turn influenced Empedocles, a Sicilian Greek whose main contribution was his cosmogonic theory of the four classical elements, Earth, Air Fire and Water. To these he added the idea of forces he called Love and Strife, which mix and separate the elements, respectively. The four elements, however, are simple, eternal, and unalterable; all change is brought about by these two principles of movement.

Empedocles believed that there was an early time when the four pure elements and the two forces co-existed at rest, in the form of a sphere, which is the embodiment or representative of God. Eventually strife became more powerful and dissolved the bond that held the elementary substances together in this divine sphere, producing the world of separate phenomena we see around us—earth and sea, Sun, Moon, Air, plants, animals, and humans. These were originally random and misshapen, but eventually more perfect forms emerged and became individuated by sex through a prolonged process of spontaneous aggregation. These were better adapted to the environment—a foreshadowing of Darwin's Natural Selection.

The other important group of Greek thinkers in the west were known as the Eleatics because they lived in Elea in south Italy (it is still called Velia), a town which had been founded by exiles from the Ionian city of Phocaea—the mother-city of Massilia/Marseille—fleeing the Persians in the 530s. The fragments of the Eleatic Parmenides' poem *Way of Truth* are some of the most obscure and contested in the history of thought. Yet they also show Parmenides' extraordinary importance as the founder of the Study of Being (Ontology) and of the ultimate reality as a distinct topic for intellectual discussion.

Parmenides was born in about 510 and was able to build on his Ionian predecessors' ideas. It seems somehow appropriate that the much-travelled, motile Phocaeans, eastern Ionians who had yet settled further west than any other Greeks, should claim that existence, far from being plural and in flux, was in fact *unitary*. Like all the Eleatic school, Parmenides was a monist, in that he believed that existence was single as well as unchanging, and thus truly knowable. Things cannot come into being from nothing and cannot pass away. There is no change or plurality, which means that motion is illusory. Existence has no past and no future. It just *is*. This apparently bald statement is usually acknowledged as having brought western *philosophy* in the technical sense into being, because it propounds a general and totalising thesis built on some of the central conceptual planks of rational thought—truth, continuity—and uses argumentative methods such as the pointing out of contradiction.

Parmenides' argument that motion is illusory was enthusiastically defended by a younger Eleatic, named Zeno, in a series of colourful 'paradoxes'. The term paradox means a demonstration that absurd consequences can follow from seemingly reasonable assumptions. The most famous is known as 'Achilles and the tortoise'. Most people, who think motion exists, will assume that, because Achilles can run faster than the tortoise, he will overtake it if he chases it. But Zeno said that *every time* Achilles is just about to catch up with the tortoise, the tortoise will have a chance to progress forward very slightly. If taken to infinity, this means that Achilles can never actually get to the place the tortoise is in before the tortoise leaves it.

A second notorious paradox of Zeno argued that a flying arrow is not in motion, even though most people believe it is, because at any single instant it is in a specific place, and therefore still. These and Zeno's other paradoxes are harder to disprove than it might appear. They were therefore much discussed in antiquity. They are often the first philosophical bones which undergraduates are given to chew on even today.

It was the first of the Eleatic thinkers, Xenophanes, who moved the focus of science and philosophy towards theology, anthropology and political thought. Born about 570 BCE in Colophon, one of the original cities of the Ionian League, itself founded by Athenians, he had moved westward, like Pythagoras. He probably worked for much of his life in Ionian colonies in Sicily and South Italy. He is a foundational figure in many respects. He was the first philosopher to use ridicule and parody as formal devices for critiquing other thinkers' positions. He was also the first ancient Greek author who clearly espouses a *relativist* position. That is, he denied that any proposition could be absolutely true, since whether it was regarded as true or false depended on the subjective outlook of the individual assessing it. Xenophanes is so sure of the difficulties involved in acquiring true knowledge that he has been called the first Sceptic. He seems to have been the first to argue systematically that there is a real and important difference between belief and knowledge. He proposed that aiming for certain knowledge in the case of matters which were not evident was hazardous—indeed, even if humans do accidentally hit on the truth about such matters, they have no way of knowing for certain that it is true. He does not, however, deny that it is worth *trying* to make progress in terms of knowledge by persistent enquiry (fragment 18).

Xenophanes used poetry to criticise the very poems which constituted the repository of Greek wisdom, those of Homer and Hesiod. He targeted the stories which these poets related about the gods doing things which men regard as disgraceful—adultery, theft, and deceit. With Xenophanes we can see a clear advance to a different, more remote and more disinterested single deity, having little in common with the spiteful, self-indulgent, childish, glamorous Olympians. He has also learned, from thinking about different ethnic groups' diverse approaches to religion, that men tend to make god in *exactly* their own image: 'The Ethiopians make their gods black and blunt-nosed; the Thracians say theirs have blue eyes and red hair.' We see Xenophanes' wit and use of the absurd to make profound intellectual points in his reference to the animal kingdom: if cattle and horses and lions could create images of gods, they would portray them in the form of cattle and horses and lions respectively.

It is not that Xenophanes did not have a god, or rather God. His supreme God was to be identified with the entire universe, which was a single unchanging, motionless entity. This God is not in human form, nor does he have a mind in any way like a human's. He does not speak to us directly and does not make appearances in human circles. This leads to one of Xenophanes' most radical inferences—radical since many subsequent Greeks who doubted the existence of the Olympians nevertheless participated in all the rituals of their cities. Xenophanes despised a particular ritual in which houses were decorated with pine branches because they were supposed to have a numinous power. He despised prophets and miracle-workers. He did not believe that divination worked. This scientism and religious scepticism was closely bound up with his understanding of the physical properties of the

universe. Some spectacular events that occurred in nature, popularly believed to be signs from the gods were, he said, no such thing. The rainbow, which the Greeks knew as the goddess Iris, was just a cloud with colourful streaks. When sailors saw purple lights flashing from the top of their masts (St Elmo's fire, caused by freak electrical charges, often after thunderstorms), it was not, in fact, the Dioscuri pledging their protection. It was small clouds which generated light as they moved. God did not communicate with man.

As a man from Colophon, Xenophanes had seen the Lydian kingdom in action at first-hand, and he certainly thought its invention of coinage was important enough to discuss. The city had been subdued by Gyges himself in the mid-7th century. But it maintained friendly relations with the later Lydian King Alyattes between 613 and 560 BCE. There was a tradition that Alyattes had brought the Colophonians to heel by disbanding their cavalry. Xenophanes criticised his compatriots for not only adopting but flaunting in public the more extreme aspects of the Lydians' plush lifestyle (widely attested in other sources), especially their sumptuous purple robes, perfumes and ostentatious hairstyles. He called these affectations 'useless' in the sense that they did not in any way help the civic community. This rejection of the 'delicate' or 'refined' way of life imitated from the eastern barbarians, which was in fact popular amongst many members of most Ionian cities as well as the Colophonians, was connected with Xenophanes' famous objection to the extravagant prizes bestowed in their home towns on athletes who had won victories at the Olympic games. He cited their cash rewards and free meals and rights to front seats at the contests. His objection is that the benefit they confer on communities is ephemeral; it does not improve the city's government or prosperity. Since athletics were largely the prerogative of the wealthy and aristocratic, there is almost certainly a proto-democratic political undertone to this critique.

As we have seen, an impetus behind Xenophanes' religious scepticism and intellectual relativism was his observation that different ethnic groups create gods with different appearances. Thracians have gods with red hair and blue eyes, and Ethiopian gods have blunt noses. There was from the outset an intimate connection between the ancient Greeks' encounters with other peoples, and their creation of a comparative methodology for thinking about their ways of life—comparative anthropology. It is not surprising, therefore, that Xenophanes was often discussed in antiquity in the same breath as Hecataeus, the man who pioneered the detailed study of the lifestyles of different peoples. Hecataeus was born in Miletus in about 560 BCE; he was thus a little younger than Xenophanes. He is said to have admired the work of Anaximander and to have made a considerable improvement to the map associated with that famous natural scientist. He extended Anaximander's map by adding the lands which comprised the Persian Empire by the end of the 6th century, especially Egypt. He also included new detail about the areas around the Black Sea (Scythia) and the western Mediterranean which the process of colonisation had made available to Greek thinkers. Part of his achievement was cartographic, but he did not fall into the precise category of either 'historian' or 'geographer': what seems to have absorbed him was the study of the individual character of different ethnic groups, or ethnology. To understand a people, say the Libyans, it was of course necessary to know something about their past and their physical environment as well as their customs, and so both historical and geographical material contributed to his great work, *Journey round the Earth*. This seems to have taken the form of a *Periplous*, or account of different places and their inhabitants in the order in which a ship would pass them as it sailed along the coastline.

By the early fifth century, therefore, the Greeks of Anatolia and Italy had essentially formulated the basic principles which made it possible for empirical science to develop: the universe was made of matter, changes in it took place because of the interaction of the elements that constituted it, empirical observation made it possible to predict what would inevitably happen. These principles also made it possible to ask the three great questions which underpin ancient and much modern philosophy—what is the nature of existence (Ontology/Metaphysics)? How do we know things for certain (Epistemology)? How should we live (Ethics/Political Theory)? The Ionians had called into question the idea of the Olympian gods and traditional religion; they had invented natural science and comparative anthropology.

A fascinating combination of circumstances made 6th-century Ionian culture produce men who articulated these questions head-on, without waiting for a god to tell them the answers: their sense of affiliation with the cerebral god Apollo; their communication amongst themselves along the coast of Ionia, which built an intellectual milieu partly defined against the great monolithic kingdoms of the east; their confidence and intellectual furniture as mariners; their eastern-facing outlook; their intensive contact and cultural exchange with other peoples, especially

the Phoenicians, Lydians and Persians; and their response to the invention of abstract value in the form of minted coins.

In Athens in the 5th century, a new generation of thinkers from eastern and northern Greece gathered to push forwards the intellectual discoveries and concepts of the earlier Ionians. Anaxagoras of the Ionian city of Clazomenae wrote a treatise which began with a description of the primeval conditions which used to exist before our universe was articulated; at that point, he says, 'All things were mixed together'. His account of the Creation was summarised as saying, 'Then Mind came and things.' This creative force, which Anaxagoras calls 'Mind', started the development from a simpler state of Order. The rest of the work attempted to explain the varied material phenomena of the universe as it exists for us.

And no account of early Greek physics would be complete without the two first atomists. They were men from Clazomenae and its colony Abdera, where Phoenician influence was also important: Leucippus and Democritus. They proposed that matter is not made up of a continuous flow or stream, but an enormous number of atoms separated by empty space through which the atoms move. Atoms are solid, homogeneous, indivisible, and unchangeable. All apparent changes in matter result from changes in the groupings of atoms. There are different kinds of atoms that differ in size and shape. And the properties of matter reflect the properties of the atoms the matter contains.

We shall be returning to Abdera in the next lecture, on ancient medicine. For Democritus was fascinated by the work of doctors and surgeons; and another crucial contributory factor in the Ionian intellectual revolution was the development of medicine. Medical professionals still take the oath attributed to the ancient Greek doctor Hippocrates, which is preserved along with a group of the seventy or so treatises which have been transmitted under his name. Some of these were certainly written as early as the mid-fifth century BCE, including *On the Diseases of Women.* Hippocrates himself was probably a native of the island of Cos, whose works crystallised a longstanding tradition of medical practice and enquiry. He may have belonged to a formal guild or group of medical experts on Cos, but closely associated with others on the mainland at Cnidus, which also boasted a distinguished school of medicine. His brilliance needs to be understood as a consummation of many decades, even centuries, of medical practice and accumulated lore. In the next lecture in this series, we will be switching the primary focus from the constitution of the physical world to Hippocrates' empirical, medical study of the workings of the human body.

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