CHAPTER 8

Elements, Processes, Substances, Stuff

As a further test and exemplification of the principles that I hold should apply to the cross-cultural comparative history of science, I may take sets of assumptions about what things are made of. We start from some indeterminate notion that most human beings throughout human history have entertained some ideas about that. We have noted that the anthropologist Philippe Descola (2013) identified physicality as one of the two topics (the other being what he called interiority) that enable broad comparisons to be made between the ontological regimes that are found in any human group. On that view we all have some more or less worked out, more or less inchoate, ideas about bodies, though very different notions have been held, as Descola pointed out, about such questions as whether humans have the same kinds of bodies, that is are made of the same stuff, as other animals or inanimate entities. While the naturalistic regime that he considers the default position of Western modernity holds that every physical object must be made of the same matter, that is certainly not true of other regimes. According to animism, for instance, it is not interiority that distinguishes humans from other creatures but physicality, the different bodies that we and they are made of.

Both ancient Greece and ancient China have exceptionally well-documented views on that general topic, indeed different ones within each ancient civilisation, and this will allow me to introduce some of the complexities it presents. I shall use my usual tactics of probing the issues by way of the similarities and divergences we find in the historical record. But first some comments are in order on the fundamental question of whether it is justified to talk of some one general topic that we are dealing with here. An immediate difficulty arises, in that it might be objected that this way of presenting the comparative data prejudices the inquiry from the outset. If we examine other cultures searching for their ideas about body, matter, elements and so on, will that not lead us implicitly or explicitly to judge them all against what we believe we have now learnt from modern physics

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and chemistry? Indeed positivist history of science, which is where the history of science began, did tend to set up a radical contrast between early, generally mistaken, views and sound, or at any rate better, contemporary solutions. But the consequence of a too easy assumption that all the problems have now been more or less definitively solved, or at least are on the way to being so, was that earlier views, like those of modern indigenous societies untouched by Western science, could be safely consigned to the dustbins of history, a matter of at most purely antiquarian interest.

But if we reject, as I do here, any such assumption that Western modernity has a secure vantage point from which everyone else can be judged – and found wanting – we can go back to the original complex sources for earlier and other views with a more open mind, to investigate not just different solutions to broadly the same problems, but also different construals of what the problems themselves were. Of course we must apprehend some commonality in the questions asked for comparison to get going in the first place and this will involve a certain suspension of judgement about what needs to be explained. There is, in any event, as I have insisted, no totally neutral way in which what we are investigating can be set out. But while the conceptual framework we bring to bear must be treated as provisional and revisable, that does not mean that no investigation is possible. Tentative though every inquiry must be, they can yield insights that allow us to reflect self-critically on the very assumptions that we initially took for granted. We shall see.

So to the Greeks first. Our understandings of the earliest speculations of the so-called Presocratic philosophers have been much influenced by a certain bias in our sources. These are mostly second-hand reports of their ideas rather than extensive extant texts setting out their theories in their own words, and even when we have the latter they have been selected by the sources that happen to have survived the vagaries of centuries of transmission. Aristotle provides us with much of our earliest evidence and although the idea that he systematically distorted the ideas of his predecessors in order to claim superiority for his own solutions to the problems has on occasion been much exaggerated (Cherniss 1935, contrast Guthrie 1957), he evidently did cast his descriptions and make his judgements in the light of his own philosophy. He does undeniably review their positions in the light of the contributions they make to his own 'mature' theories, notably on the all-important question of causes where he maintains in the *Metaphysics* that his own analysis of the types of explanations to be sought encompasses and supersedes all earlier efforts on the subject.

Thus his view is that several of the earliest philosophers were concerned with what he calls the material cause, what things are made of – the very topic that is our focus in this chapter. Thales in the sixth century BCE suggested water, he tells us at *Metaphysics* 983b18–27. But how exactly did Thales understand 'water'? We had better be careful since Aristotle himself expresses a certain hesitancy about the reasons that may have weighed with Thales when he made the proposal he did. Perhaps, Aristotle goes on, he got the notion from seeing that nourishment is moist, that vital heat is connected with moisture and that seeds are moist – in other words he saw water as essential for life. Aristotle even notes, though he does not himself endorse, a view that linked Thales' notion with the idea that the sea gods Ocean and Tethys are the parents of creation. Elsewhere (*On the Soul* 411a8) he reports that Thales held that 'all things are full of gods'. Yet there is nothing to suggest that Thales was simply promulgating some myth, traditional or otherwise, for his 'water' is not a mythical being, a person. On the other hand it was evidently not inert stuff. Moreover the key question for us is whether Thales saw it as what other things are made of in the first place, for his concern may rather have been with where they originate.

The subsequent equally problematic history of other early Greek speculation shows how important it is not to jump to conclusions here. Later sources put it that Thales' successor Anaximander considered the principle to be what he called the Boundless, while according to Aristotle again (*Metaphysics* 984a5) the third major figure based at Miletus, Anaximenes, chose air. Here too we have to question whether what those thinkers were after was some idea of the matter of which everything is made. It is not just that the proposals they put forward may seem so counter-intuitive to us. What is it for anyone to be committed to the idea that everything is *made of* 'the Boundless'? The expression 'that out of which' in Greek (*ex hou*) is ambiguous – as indeed Aristotle himself points out – for while it can ask for an answer in terms of matter, it can also pose the question of origins. The latter interpretation of the early philosophers' problematic has in its favour that it represents them engaging in an issue that would have been familiar to their audiences, in that it had already been discussed in earlier poetry. The most notable example of this is Hesiod's *Theogony*, that gives an account of the beginnings of the cosmos though it does so not in terms of such physical items as water, but mainly in those of the generations of divine living beings, many of whom (though not all) have very distinct wills and personalities. There is still an important contrast between the early Presocratic philosophers and Hesiod, in that for Hesiod the current

dispensation of things is guaranteed by individual gods. But on the account I would consider more likely the initial Presocratic programme would be more correctly represented as one to do with cosmogony, rather than with cosmology.

If we take it that the earliest Presocratic interest was in origins we can make sense of something like a progression in the answers proposed, as one would-be expert attempts to outdo another. We are familiar with that competitiveness in other contexts, though to be sure that does not guarantee that this line of interpretation is correct in this instance. Thus Anaximander's Boundless, as a more indeterminate entity, might be construed as a way of avoiding an objection to Thales' view, namely that if water is the origin, it is hard to explain how fire, for instance, came to be. Again Anaximenes' proposal of air goes further than Anaximander in one important respect in that our sources suggest it was accompanied by a speculation concerning how changes begin to occur, namely by processes called rarefaction and condensation. The original air rarefies to become fire, and condenses to become water and then solids such as earth. 'Condensation' thus serves to capture something of the transformations from gaseous, to liquid, to solid states, though it would be grossly anachronistic to represent that as Anaximenes' own original understanding for he would have been talking not of states but of bodies.

As noted, this sequence of Presocratic theories would tally with a picture with which we are very familiar in later Greek thought, namely of thinkers engaged precisely in competitive dialectical exchanges in a bid to outdo one another in their claims, not just that there is a correct account to be had on even the most abstruse questions but also that they in particular are Masters of that Truth (Detienne 1996). Nevertheless, when all is said and done we have to admit that we ourselves are ultimately reduced to guesswork as to why these speculative theories were proposed and how they were vindicated if indeed they were. Nor is it at all clear how far they may have actually convinced contemporary ancient Greek audiences most of whom, we may imagine, were not much concerned with such flights of fancy.

We are on somewhat firmer ground about the views of later Greek thinkers for whom we have more reliable evidence. The first philosopher who produced what we can be fairly confident is an answer to the question of what we call the primary physical elements of things, the basic substances of which everything else is composed, is Empedocles in the fifth century BCE. He dubbed fire, air, water and earth the 'roots' of all things. They are the building blocks of which everything else is composed: the

'roots' combine in different proportions to produce compounds under the influence of two forces he named Love and Strife.[1]

Versions of some such theory of fire, air, water and earth as elemental were taken up by many subsequent Greek thinkers. They included Plato, in the *Timaeus*, though he considered those four simple bodies not to be primary, but themselves to be constructed out of elemental geometrical shapes, four of the regular solids analysed in terms of two types of primary triangles. Plato thereby took over and adapted an idea from the chief rival physical theory, that of atomism which had been proposed by Leucippus and Democritus in the late fifth century BCE. But the first crucial difference, in Plato's hands, is that the primary shapes are not indefinitely many (as in Democritus) but limited to those four regular solids. The second is that the whole story of creation, in the *Timaeus*, is under the auspices of the influence of a benevolent and beneficent creator figure, the Demiurge, who ensures that, so far as matter and necessity permit, the cosmos created is the very best possible (Sedley 2007).

Plato's particular geometrical analysis of fire, air, water and earth had few, if any, followers. But Aristotle's adaptation of Empedocles' theory had an enormous influence on later European speculations all the way down to the seventeenth century. His view was that each of those simple bodies is constituted by a pair of the primary opposites, hot and cold, and dry and wet (where moist or fluid is sometimes a better translation of *hugron* than 'wet', though its contrary, 'dry', *xēron*, as applied to fire for instance can certainly not be equated with our 'solid'). Thus earth is dry and cold, water wet and cold, air wet and warm, fire dry and warm. Aristotle rejected any type of geometrical atomism primarily on the grounds that it is a simple category mistake to reduce qualitative differences (as in hot and cold as he represents them) to quantitative differentiae. Thereafter some version of four-element theory was dominant not only among those who considered themselves 'natural philosophers' (*phusikoi*) but further afield, particularly among medical writers concerned with giving an account of what human bodies are made of,[2] and what constitutes health (a topic to which I shall return in the next chapter).

[1] Yet Empedocles' roots are anything but just 'stuff': they are divine (as also are the forces he calls Love and Strife) as is clear from his use of the names of traditional gods for them, as for example 'Hephaestus' for fire in Fragment 96.

[2] The Hippocratic treatises dating, mostly, from the fifth and early fourth century BCE contain a wide variety of theories concerning the fundamental substances that constitute the human body, some using various combinations of earth, water, air and fire and so on, others ideas concerning the primary opposites, such as hot and cold, wet and dry, and yet others developing one or other version of a theory of humours. But it is characteristic of Greek debates that there were radical disagreements

Our familiarity with the fortunes of theories based on earth, water, air and fire may lull us into underestimating first just how controversial they were among the ancient Greeks themselves. I have mentioned their chief rival, atomism. But fundamental doubts about the viability of the theory of four primary elements were raised already by Aristotle's associate and successor Theophrastus. In his treatise *On Fire* he raised questions about the status of that as a simple body and one of the elements. Unlike the other elements fire needs fuel to sustain itself, and unlike them it is always in a process of becoming,[3] whereas the other three are – more or less – stable substances. Yet those difficulties did not lead Theophrastus to propose an alternative general theory, nor did any of the many later writers who adopted some version of it propose substantial modifications. Whatever the possible objections to Aristotle's view here, it seems that for many these were outweighed by its simplicity and economy and the amount of prima facie support for it that could be adduced.[4] The choice that confronted Greek theorists who wanted to resolve the question of what things are made of remained broadly one between some version of the four-element theory and some mode of atomism. But there the disagreement over whether matter is infinitely divisible, or whether there must be ultimate indivisible units, was not one that could be settled by reference to observational data.

Then a further mistake that we ourselves must guard against is to suppose that what we are dealing with is always just a question about what things are made of, their material causes as Aristotle would say. In fact

not just on the right answers to the questions of these constituents, but also on how one should go about investigating the problem. The treatise *On Ancient Medicine* in particular attacks those who base their ideas on what the author calls 'hypotheses' – that is, postulates – such as hot, cold, wet, dry which (he says) nowhere exist as separate substances in the body. Chapter 1 of that work puts it: 'if one were to speak and declare the nature of these things, it would not be clear either to the speaker himself or to his audience whether what was said was true or not, since there is no criterion to which one should refer to obtain clear knowledge'. We have here a prime example of an ancient Greek author endeavouring to win an argument on a first-order question by recourse to a second-order criterion.

[3] 'Everything that burns is always as it were in a process of coming-to-be, like movement (*kinēsis*). And so it perishes in a way as it comes to be, and as soon as what is combustible is lacking, it too itself perishes along with it' (*On Fire* ch. 3, Coutant 1971: 5.8ff.). Such a view owed much to the far more radical cosmology of Heraclitus, for whom the cosmos itself is 'an ever-living fire' 'kindling in measures and being extinguished in measures' (Fr. 30). Much later, in the Hellenistic period, Stoicism was to revive the idea of the cosmos as fire, providing a further example of a doctrine that can be considered closer to Chinese process-oriented theories than most other Greek accounts.

[4] It was recognised that there are many different varieties of 'stones' and 'minerals' – the subject of a treatise by Theophrastus, *On Stones*. But these were mostly thought of as 'earth', sometimes with an admixture of another element, thereby forming what were called 'homoiomerous', that is homogeneous, substances. Metals, being liquifiable, were considered to be mainly 'water' and so on.

much more was generally at stake, for the answer to that question usually formed one part of a more comprehensive account of the world.[5] In the wake of Aristotle especially continuum theorists tended to be teleologists, insisting that not just material but also final causes have to be taken into account (cf. Furley 1987, 1989). Thus it was not enough to say what a particular part of the human body was made of: its function had also to be explained for a full account to be given. The heart is not just flesh in a certain configuration: it serves, some said, as a source for the blood in the body, or as others claimed, as the central cognitive organ. Yet again it was Theophrastus especially who puzzled over the scope of such explanations, questioning just how far it is appropriate to search for and find final causes at work in nature (Theophrastus *Metaphysics* 10a22ff., Lloyd 1987: 148–50).

Against the teleologists, however, the atomists maintained that final causes, purposes, should be excluded. Physical interactions alone provided the sole valid explanatory framework. So the dispute was not just about the account to be given of stuff, but whether we should view the cosmos as a whole as under providential control. 'Physics' in the ancient sense of the study of nature, and 'cosmology', were thought to carry implications for ethics, for the place of humans in the scheme of things (if there is indeed such a scheme), for our ideas about the good life and human happiness indeed. The view of both the teleologists and their opponents was that you had to understand natural phenomena (as they called them) if you were not to live in fear and ignorance. But there were plenty of sceptics who disputed the assumption that such causal explanations can be secured. They agreed that the goal was to achieve peace of mind, but for them the way to do that was to suspend judgement where such speculations were concerned.

All this Greek material is reasonably well known and the stuff of standard histories of the development of Greek speculations about the physical world. But to investigate just what is or is not distinctive about Greek preoccupations here, it is instructive to compare and contrast how ancient Chinese thinkers described the world they lived in, its development, the place of humans and how we should behave, where the first point to insist on is that the Chinese did not all adopt precisely the same position on such questions any more than the ancient Greeks we have considered did.

[5] As already noted, for many Greek theorists the primary elements are divine, as also were the so-called heavenly bodies.

Chinese cosmogonical accounts, as we might call them, often started from an assumption of an original undifferentiated state, that began to be transformed once yin and yang started to become differentiated – not that that was represented as the work of some transcendent and providential Demiurgic force.[6] But undifferentiated *qi* 氣 (a term whose meaning spans both breath and energy) came to be modified, producing the cycles of creation and destruction which were associated with the so-called five phases (*wu xing* 五 行). These were fire, earth, metal, water and wood, linked in that order in the mutual production cycle, and in the order water, fire, metal, wood, earth in the mutual conquest cycle, as is exemplified in the second-century BCE text *Huainanzi*.[7] Given first that each forms a cycle which starts again once it has been completed, and secondly that production and conquest themselves balance one another, the ultimate victory of one item over the others is out of the question. But not only was there no classical Chinese teleological cosmology: no more was there the resolutely anti-teleological stance associated with atomism in ancient Greece. The idea that the fundamental physical constituents of things are indivisible atoms was not so much rejected as counter-intuitive as not even contemplated.[8]

Given the presence of fire, earth and water in the five phases it was almost inevitable that Western observers, starting with the Jesuits in the sixteenth century, treated those phases as the equivalent of Aristotelian elements (Gernet 1985). Indeed they deplored the inclusion of metal and wood, which they thought (following Aristotle) should be treated as homogeneous compounds, and they criticised the Chinese for failing to treat air as the fourth primary element. Yet this was entirely to miss the point, which is that the five phases are not primarily names for substances, but rather for processes (as my translation 'phases' for *xing* 行

[6] One such account appears in the *Huainanzi* ch. 3: 1a, a text compiled under the auspices of Liu An, King of Huainan, around 135 BCE: see Major 1993, Major et al. 2010. The lack of teleological cosmogonies should not be taken as an excuse to underestimate let alone to deny an interest in cosmogonical questions as a whole in ancient China, as Goldin (2008) has argued particularly forcefully.

[7] *Huainanzi* ch. 3: 28b sets out the mutual production order, and *Huainanzi* ch. 4: 11a the mutual conquest one. As with some Greek ideas, there is a prima facie plausibility in at least some of the relations presupposed. Thus in the mutual conquest cycle water can be seen to put out fire, and fire melts metal. However, as Sivin has documented (Lloyd and Sivin 2002: 253ff.) the doctrine of five phases only took its final form after developments that spanned several centuries.

[8] We have to add that we depend, as usual, on our extant sources. But they show no signs of an interest in the debate that pitted atomism against continuum theory in ancient Greece. Indian cosmologies, by contrast, do include ones based on atomism. The question of whether this was an independent development or one influenced by Greek ideas continues to be disputed, Zimmer 1952, Mohanty 1991, Bronkhorst 1999.

implies).[9] Ancient Chinese texts are explicit on that point, saying, for example, that 'water' is 'soaking downwards', 'fire' 'flaming upwards'.[10] So where in ancient Greece the view that generally came to dominate thanks to the Aristotelian synthesis focussed on more or less stable substances, consisting of elements that come together to form various compounds, in ancient China more attention was paid to the dynamic processes that things undergo, the transformations to which they are constantly subject. The Jesuits might have drawn on their knowledge of Greek and Roman cosmology to compare Heraclitus or the Stoics: but convinced that the Aristotelian view was generally correct, or at least the best available, they continued to be dismissive of the Chinese ideas they encountered.

But as in Greece, so also in China, more was, in any case, at stake than just an account of stuff. If we wish to flourish we have to recognise that the key to success is to mirror, in our own lives, the orderly and harmonious interactions that we see played out on a cosmic scale. The secret is often represented as depending on knowing your place and acting accordingly. The father should be fatherly, the son filial, and kings and ministers should act properly as the kings and ministers they should be. We shall have more to say about this when we come to discuss health and well-being and their opposites in the next chapter.

It is time now to take stock of what we can learn from this brief exercise in comparative history. Modern physics and chemistry, some may think, provide us with the correct answers to these questions with which thinkers in ancient societies struggled so pitifully. Yet first we have insisted that modern physics and chemistry are far from having resolved all the problems in a definitive fashion. Even in the case of chemistry, where we might assume that the analysis of 'water' as H_2O is utterly secure, we should not treat its victory over rival formulae as a foregone conclusion. As Hasok Chang (2012) showed, the alternative, HO (with a different analysis of the hydrogen component), not only initially had much going for it, but (he has argued) even may have points in its favour still today. Meanwhile modern

[9] Even though in his pioneering work on Chinese science Needham (1954–) was well aware of the primary texts that describe the cycles of the phases, he persisted in writing of the *xing* as 'elements', no doubt assuming that that would make more sense to his readers.

[10] Thus in the *Hong Fan* chapter, dated to between the mid fourth and early third century BCE, in the *Shang Shu* (Book of Documents, Karlgren 1950: 28 and 30) we read: 'Water means soaking downwards. Fire means flaming upwards. Wood means bending and straightening. Metal means conforming and changing. Earth means accepting seed and giving crops.' In each case the explanation concentrates on how the process acts rather than on what the substance is or how it is constituted.

philosophy of physics wrestles with appreciably more demanding issues, the nature and properties of quarks or of dark matter, not to mention the satisfactory reconciliation of relativity and quantum mechanics. And if fundamental particle physics tells us one story about the ultimate constitution of ordinary tables and chairs, how that story is to be squared with our ordinary experience of those objects as we sit down to dinner is still the subject of some dispute.

But it is also important to see that the ancient theories too that we have passed under review differ not just in the solutions they offer but also, more subtly, in the scope of the problems they address. If we state that problem in the most general terms, as concerned with what things are made of, then there are commonalities that link ancient and modern speculations – and that allow a comparison between them to get off the ground. But as soon as we factor in what else is at stake, we can see how mistaken it would be to attempt to treat all these ideas on a par, let alone to settle on one view as straightforwardly correct, the others more or less disastrously flawed. What we can learn from ancient history here is something of the variety of the ways in which the problems themselves were construed, sometimes in terms of elements and compounds, sometimes in those of interacting processes. What on each occasion may look initially like a set of suggestions just about physical change turns out to be just one component in a complex world view in which it is not just an understanding of physical structures that is at issue, but also how we as humans should conduct ourselves. Of course nowadays strong links between natural science and ideas of human well-being have, as we said, generally (though not entirely) been severed. But if we wish to understand and appreciate our predecessors it is as well to recognise in what ways they saw them to be connected and to ponder the implications of doing so.

We may certainly agree with Descola when he drew attention to some of the importantly different ways in which what we call body, physicality, stuff, have been conceived and perceived in different cultures at different periods. But whereas his focus in this context was almost exclusively on the continuities or discontinuities between humans and other living beings, we have considered instances in which further differences turn out to be significant. Both ancient Greece and China figure as analogistic regimes in Descola's taxonomy and indeed both ancient civilisations make extensive use of analogies in their cosmological and physical accounts (Lloyd 2015). That is the chief mechanism by which links are established between the so-called macrocosm (the world as a whole) and the two microcosms – of human

bodies, and states, that is political or social arrangements (Sivin 1995b, Lloyd and Sivin 2002).[11]

But the crucial additional factor that emerges from our examination of ideas about the constituents of physical objects is the tension between viewing these as more or less stable substances on the one hand, and as processes in constant transformation into one another on the other. 'Physicality', on this account, may for some be not so much a matter of static stuff as of dynamic change, and in this context, whichever option is adopted will apply *both* to humans *and* to other living creatures. Yet that commonality – where humans and other animals are made of the same stuff – was a feature that Descola associated not with 'analogism' so much as with 'naturalism' where it is indeed our modern understanding that provides him with his paradigmatic example of that latter regime.

We shall return, in Chapter 10, to review the question of how well 'interiority' in turn stands up to scrutiny when used as the second basic criterion of differentiation between ontologies. But for now the chief lessons we may take away from our examination of physicality are first that this should not be treated as the sole purview of a discipline of 'physics' stripped of any implications for conceptions of values. Rather, our survey shows how notions about stuff may be deeply implicated with conceptions of the cosmic dispensation and of the place of humans within it. But then secondly we find that the very idea of stuff is not cross-culturally stable and not just in the ways identified by Descola, but across the board. Beyond the issue of the possible similarities and differences between humans and other animals on this score, the answers to the question of what things are made of have sometimes been cashed out in terms of substancehood but sometimes in terms of process, and that in turn may be thought to introduce a further complication if we have the ambition to draw up an exhaustive taxonomy of ontological regimes using 'physicality' as one of the key criteria.

[11] Thus as has often been pointed out, in China correlations (and not always the same ones) were proposed between the five phases on the one hand, and on the other, many other items including seasons, cardinal points, tastes, smells, musical notes, star-palaces, colours, instruments, classes of living creatures, domestic animals, parts of the body, sacrifices, rulers and ministries (Needham 1956: 253ff., Henderson 1984, Schwartz 1985: ch. 9, Graham 1986, 1989, Bodde 1991, Hall and Ames 1995: 123ff., Lloyd 1996a: 112ff.). Yet as I argued in 1996a: ch. 5 it is a mistake to represent the Chinese as obsessed with correlative thinking to the exclusion of an interest in causes, since there is ample evidence also for the latter. Once again the temptation to picture the relationship between China and the Greeks as one of polar opposition is to be resisted.