

DEMOCRITUS: SCIENCE, THE ARTS, AND THE CARE OF THE SOUL

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DEMOCRITUS, ZOOLOGY AND THE PHYSICIANS

LORENZO PERILLI

1. *Preliminary remarks*

In 1645, the distinguished anatomist and surgeon Marcus Aurelius Severinus (1580–1656), an adopted Neapolitan on active service at the Hospital for Incurables, wrote a treatise on general anatomy that was to have its role in the history of medicine. Severinus was well known in Italy and abroad for his operating technique, and at various times he was arrested and convicted by the Inquisition. His treatise, published in Nürnberg, has the unusual title of *Zootomia Democritea—idest Anatomie Generalis Totius Animantium Opifici*. It opens with the transcription of one of the best known among the alleged letters of Democritus to Hippocrates concerning the research of modalities and causes for diseases, and it addresses also the usefulness of dissection, a method of exploration to which Severinus himself used to resort—for this very reason being brought to trial by the Inquisition.

As to the autoptic study of animals, the myth of the *primus omnium Democritus*, which found such a surprising hospitality in Severinus' work, largely predominated from antiquity and continued through the centuries (a history of which would surely be of interest in its details) and accounts for the key position of Democritus in every reconstruction of pre-Aristotelian zoology. This portrayal found easy access into later paradoxography, beginning with the imagined meeting of Hippocrates and Democritus at Abdera; its literary form was that of the pseudoepigraphic epistles included among the Hippocratic writings (*Epist.* 10–21 and 23, especially 17; see also Soranus, *Vita Hippocr.*, 6). The story is far from unimportant: it attests the creation of a symbolic figure while at the same time influencing it, a figure to whom the most improbable writings came to be attributed.¹ The same story of the fancied visit

¹ It is highlighted by Wolfgang Speyer, in his well known book on the 'literarische Fälschung' (1971), where he recalls Democritus' not incidental fame as a 'Zauberer' (p. 40).

of Hippocrates to his contemporary Democritus was used by Theodor Gomperz to open the chapter on atomism in his *Griechische Denker*, mirroring, he says, ‘bis zu einem gewissen Punkt einen realen Sachverhalt’ (I 261). According to this anecdote, Hippocrates had been called to heal Democritus’ insanity—Democritus who used to laugh at anything, even at other people’s misfortune. In the shade of the plane-trees, near the city walls, the philosopher was sitting *inter occisa corpora multarum animalium* (Severinus, p. 9), surrounded by the remains of animals he had dissected for scientific purpose. So, intent on his activity, Hippocrates would have found him.

Democritus’ real contribution to ‘zoology’ has still to be established. Zeller made short shrift of Democritus’ observations on animals, devoting to them just two lines of text and a schematic page of footnotes; he considered them (at least in the form in which they have survived) nothing more than isolated observations and hypotheses. Elsewhere, however, a marked reappraisal of Democritus’ studies concerning organic nature has led scholars to assign him a leading role as the sole forerunner of Aristotle.

As to the study of animals, Aristotle’s filter actually can distort the perspective, since it is with his research that zoology achieves the status of an autonomous science whose parameters cannot be superimposed on the preceding phase. Aristotle’s claim is correct, when in the first book of *De partibus animalium* he declares himself the founder of zoology (645a6): only with him can the discipline be envisaged as an autonomous one. As to the previous period, the warning (expressed among others by Pierre Pellegrin, 1986, 170) can be shared that any attempt to reconstruct a ‘zoology’ will run methodological as well as intrinsic risks. The term ‘zoology’ itself is inadequate when applied to the period before Aristotle—in what follows I will make use of it for the sake of brevity, but this does not imply the actual existence of such a discipline. Nevertheless, in this rather distinct phase, a significant amount of specific and even specialist knowledge had been set up concerning the animal world; due to the epistemological importance an individual meaning must be attached to each attempt at systematization and classification according to criteria corresponding to diverse and precise needs. The classification of animal species—or typologies, should the term ‘species’ appear untimely—was indeed a decisive element.

Long before Aristotle, the animal world had been the object of widespread interest. We have detailed studies concerning Homer, early lyric

poetry, Herodotus and many other sources, and we owe a number of observations to presocratic naturalists. A similar interest is witnessed in subsequent phases from the pre-Homeric (Minoic) age up to that of Speusippus, Mnesitheus and Diocles of Carystus. One can see the forming of knowledge strata which Aristotle himself will amply draw on. To this framework belongs Democritus, who receives from Aristotle his privileged position as an interlocutor, with several (not always positive) references.

The role of Democritus seems, nevertheless, to be anything but unambiguous, and I will try to give a more substantial character and, above all, historicity to his investigations, aiming at a reconstruction of the framework and of the network of connections in which his explorations are inscribed, although limited to a few fundamental elements. Despite the privilege he received from Aristotle, Democritus was not isolated, and to clarify his position requires at least verifying the content of the surviving materials, usually considered only summarily, as well as testing the reliability of sources dealing with his zoological studies—considering both the content and the authenticity of the works attributed to him by Thrasyllus' Catalogue as is found in Diogenes Laertius, whose titles have a strong aetiological slant (*Αἰτίαι περὶ...*).

2. *Democritus, traditional knowledge, and medical learning*

When evaluating the relationship of Democritus to this framework, the main role is played on the one hand by the treatises of the Hippocratic corpus and on the other hand by what we may call traditional knowledge. Indeed, considering the whole pre-Aristotelian period, and assuming Diocles of Carystus as a provisional arrival point, medicine can be identified as the main axis of zoologically-oriented research. Scholars have more than once assumed that Democritus' studies of animals directly influenced those writings of the Hippocratic corpus that show a zoological interest, primarily the second book of *De victu*—but this is to reverse the perspective. Actually, concerning zoological investigations, Democritus does not seem to make significant innovations. He seems rather to take up a position on topics which had been largely discussed and to act as a point of confluence of the two main, still-traceable routes: the 'functional zoology' of physicians, and the comparative attention to animals in order to draw analogical conclusions for man and the world.

We know, thanks to a series of investigations, that the Greeks from the most distant past (as seen as early as 1869 by E. Bruck) took advantage of knowledge which was to become increasingly detailed. This knowledge mirrors the more specific expertise of the *technitai*, on whose experience the information displayed by Aristotle will rest as well. Many examples could be adduced to show the interest in a knowledge which preexisted and continued to persist, compared to the development of zoology as a science, which was consolidated and structured during the fifth century.² Hence, one can set some points of departure, starting with the survey of names of animals in the authors at issue, a topic which can be of interest in itself—whether or not they have a motivated structure as is the case in Hecataeus and the comic poets, mainly towards the end of the fifth century (e.g., already Epicharmus, then Archippus, Philyllius, Aristophanes himself). Within philosophy, the main phases are well known, although essential links are probably lacking. The tradition attributes to Alcmaeon a not incidental resort to experiments and at least random dissections of animals, in order to explain anatomical and physiological issues. In Empedocles, according to Zeller and to later scholars, we see an attempt at taxonomic distinctions (B 20, 33, 76, see also 9, 117), which, however, will hardly have gone beyond common and already traditional knowledge, though Aristotle's references in his zoological works imply due consideration for Empedocles. Anaxagoras and Diogenes of Apollonia, too, can be counted among those who had an interest in zoology, and they too are explicitly mentioned by Aristotle—as was Democritus. A later philosophical outcome will be Anthistenes' *De natura animalium* and Speusip-

² The studies on this topic in its pre-Aristotelian phase start as far back as 1839 with W.Ph.Fr. Groshans and his (incomplete) *Prodromus faunae Homeri et Hesiodi*, and go on until Otto Körner's *Die homerische Tierwelt*, 1930 (and as early as 1917 in his *Das homerische Tiersystem und seine Bedeutung für die zoologische Systematik des Aristoteles*, with its hypothesis of an Homeric 'Tiersystem' then rightly rejected by scholars), passing through a series of works whose details can be found in the Bibliography. I would mention here, because they are devoted to specific fields of growing interest in the first decades of the 20th century, only the work of Norman Douglas, *Birds and Beasts of the Greek Anthology* (1928), and Hans Gossen's several interventions, published in various periodicals and in the *Realencyclopädie*, as well as the two glossaries by D'Arcy W. Thompson on birds and fishes respectively (1895, then 1936, the former, and 1947, the latter) and the *Antike Tierwelt* by Otto Keller (Leipzig 1909–1913). I include as well the first part of the noteworthy study of Adolf Palm (1933), entitled *Untersuchungen über die Geschichte der Zoologie bis auf Aristoteles: Die Entstehung des älteren Tiersystems und seine Nachwirkung bis zum Ende des 4. Jahrhunderts v. Chr.*, and, finally, the short but acute article by Georg Harig and Jutta Kollesch (1974). These are but a few of the most relevant examples. Most recently, see Zucker (2005).

pus' Ὀμοία. Speusippus offers series and classifications of animals (see fr. 125 ff. Isnardi) which no doubt recall those of his predecessors, while only partially corresponding to those of Aristotle. Starting from this observation (which has already been made by Long, then by Isnardi), I wonder if Speusippus' information could not go back rather to the so called alternative cataloguing of the medical tradition, which also occurs in culinary literature, as attested in the comic fragments of the end of the fifth century and the first half of the fourth, from Philyllius to Ephippus, Mnesimachus, Theopompus—and maybe already Cratinus, all of whom we know mostly through Athenaeus.

Before considering in some detail the position of Democritus, it is necessary to give a closer look at the other fundamental direction of studies of zoological interest in the fifth and fourth centuries, viz. that of medical tradition. A rather well known essay, published by the zoologist Rudolf Burckhardt in 1904, tried to reconstruct the development which would have led to Aristotle's systematization. Burckhardt located in the Hippocratic writings, particularly in chapters 46–49 of the second book of *De victu*, a systematic cataloguing of edible animals, in that 52 types of animals (about one-tenth of those recorded by Aristotle) were distinguished and classified, together with a description of their dietary characteristics and sometimes an attempt to adduce also the cause of such characteristics. Burckhardt saw in this classificatory scheme a proper 'koisches Tiersystem'. It was afterwards generally agreed to be a 'system', although its origin in the Coan milieu is not certain, and the alternatives suggested later, of an 'hippokratisches', or better 'voraristotelisches Tiersystem' (definitions proposed, respectively, by G. Harig-J. Kollesch and A. Palm), are to be preferred.

It will be of some use to remind the reader that the *De victu* can be dated to the last years of the fifth century, or perhaps to the first years of the fourth, i.e. nearly the same period as Democritus. The work consists of four books (three according to Galen, who combined the third and the fourth). The first presents an analysis of the nature of man, composed basically of fire and water (to which correspond the pairs hot-dry and cold-wet), and of the formation of embryos, while the third defines the appropriate regimen by means of the connection between nutrition and physical exercise, and investigates its disruptions and their potential pathological consequences. The fourth book deals with the role of dreams and has the alternative title *περὶ ἐνυπνίων*. In

this framework, the second book plays a special role. After two introductory chapters (37f.) on the effects of places and winds, it offers a series of ‘catalogues’ which remain unrivalled within the corpus as to extent and structure. These catalogues deal with the various elements of regimen—food, drink, and exercises—and with their respective characteristics and properties. It is clearly a technical insertion into the treatise, which has a more general, even philosophical character at times, the first book above all having been often associated with Heraclitean thought. Who the author is, and whether there was only one author, we do not know, and so it has been from antiquity, as Galen reports (see VI 473, XV 455); but little doubt remains that the second book has the character of a handbook and that its contents refer to earlier studies and classifications. It should not be ignored that Galen considered the second book of *De victu* as being worthy of Hippocrates—the only one which could reasonably be attributed to him (see *De alimentorum facultatibus* VI 473 K τὸ μὲν οὖν δεύτερον, ἐν ᾧ περὶ τῶν σιτίων διέορχεται, τάχ’ ἂν τις εὐλόγως Ἱπποκράτους ἄξιον ἠγήσασαιτο).

The writer of the treatise (I refer only to the second book), while listing the 52 types of animals dealt with in chapters 46 and following, orders them first according to the more general classes (mammals, birds, fishes and other aquatic animals such as crustaceans and molluscs—the latter with the further development of the conchiferous), and then at times according to their habitat or nourishment, but primarily, and systematically, according to the δύναμις that they exert on those who feed on them, that is to say their dietary property—light or heavy, dry or moist, fat, astringent or laxative, slimming, useful for eyesight, or diuretic. This is a basic criterion for understanding that these investigations have no autonomous heuristic value, but rather receive their motivation from elsewhere. This is a fundamental point in tracing the development of these studies. Already Aristotle saw the line that divided the lore of the *technitai* (in his case fishermen, his main source of ‘oral’ information) from the knowledge of the scientist in the merely practical aim that prevents the former from adopting the larger, epistemological point of view. The scientist, on the other hand, investigates not in view of an incidental aim, but rather τοῦ γινῶναι χάριν (*GA* 756a33).³

³ See Vegetti (1980) 23, and also (1980b).

The author of *De victu* II is fully aware of the effort he is about to make. He describes with a dietary purpose not only animals, but also other things, primarily substances of vegetable origin, and he puts first a short methodological chapter (the 39th, which introduces the cataloguing of the various substances), in which he criticizes those forerunners who had tried to organize genres and categories from a more general point of view. Each substance, he argues instead, has a different δύναμις, and he finds that this very criterion of the specific δύναμις is the one to be adopted. To understand the dispute one must place it in the context of a medical debate that was long on-going, as also the *De aëribus aquis locis* asserts (as we shall see later on).

Be that as it may, the generally positive judgement concerning Burckhardt's work can still be shared, with the exception perhaps of his attempt to establish a too-direct connection with Aristotelian schemes. It is self-evident not only that the text of the Hippocratic treatise has the characteristics of the systematic classification Burckhardt saw in it (as did others after him), but also that it no doubt goes back to one or more earlier sources whose results it schematizes and perhaps rearranges.

Unlike the scanty information on the zoological interest of some pre-socratic philosophers and the merely hypothetical conclusions we can draw therefrom, the Hippocratic corpus presents us with a significant turning point that is not isolated. Though this is not the place to go into further detail, it must at least be pointed out that elements similar to those already mentioned can be found within the corpus itself, viz. in *De affectionibus* (περὶ παθῶν), and above all in *De affectionibus interioribus* (περὶ τῶν ἐνθῶς παθῶν), both earlier than *De victu*, where one finds a series of 19 fishes, all of them occurring in fixed groups (with only one exception in *Aff. int.* 49, where a fourth fish is added to the usual group of three). These treatises do not have the detailed structure of *De victu*, but still show significant similarities which become evident in the animals' being grouped according to common characteristics and in these groups being regularly repeated. Such coincidences cannot be taken to be random, and are scarcely the result of autonomous investigations by each author; rather, they refer to one or more systematizations that were established at that very time.

3. *The post-Hippocratic medical tradition*

It is no coincidence either that the Hippocratic systematization occurs again in the medical tradition that immediately followed, between Mnesitheus of Athens, who was especially interested in dietetics and in the first half of the fourth century wrote a treatise *De edibilibus*, in which a classification concerning food like the one of *De victu* could easily find a place, and Diocles of Carystus,⁴ who has been sometimes considered to be the link between the Hippocratic organization of the animal world and Aristotle.⁵ Already in the mid-fifth century the works of a certain Leophanes, mentioned for his view of generation and sex differentiation by Aristotle in the fourth book of *De generatione animalium* (765a21–25), and later in Pseudo-Plutarch's *Placita* (*Dox. Gr.* 420,7), demonstrate the ramifications of zoological, or perhaps more generally, biological knowledge.⁶ As G. Harig and J. Kollesch observed, the similarities between various authors, particularly the Hippocratic author of *De victu*, Mnesitheus, and Diocles, are not due to accident. Their comparison of the characteristics of edible animals (with a preference for marine fauna) shows common basic notions. In *De victu* the qualities listed are dry (ξηρός), moist (ὑγρός), light (κοῦφος, ἐλαφρός), heavy (βαρύς), rare (ἀραιός), dense (στερεός, βαθύς), and fat (πίων). The same or very similar terms occur in Diocles and Mnesitheus, and sometimes

⁴ Diocles is now generally considered to be a contemporary of Aristotle, as the ancients believed, perhaps even a bit earlier; a different proposal (340–260) had been made by Werner Jaeger. See Kudlien (1963) 456–461, von Staden (1989) 44ff., and (1992) 251–264, more recently Ph. van der Eijk, in his edition of the fragments of Diocles (II 31ff., etc.).

⁵ See Palm, 14f., 18.

⁶ Leophanes is an unknown author, one banished from all reference works I could consult, starting with the *Realencyclopädie*. Aristotle devotes four lines to his theory of the generation of males and females each from a different testicle, and the same is said, much more concisely, by Pseudo-Plutarch—a doctrine attested in the Hippocratic writings, for instance in *De superfetatione*, ch. 31, see *Epid.* IV 4,21, and one which witnesses the right-left polarity, so important for Greek thought, see Lloyd (1966) 50 and passim, and (1973), 167–186. It should be noticed that, although these doxographical lists do not allow any conclusion, in the *Placita* Leophanes occurs in a chapter entitled Πώς ἄρρενα γεννᾶται καὶ θήλεα, and his name follows those of Empedocles, Parmenides, Hipponax (?), Anaxagoras, and before Leucippus and Democritus (the doctrine of ἐπικράτεια), and again Hipponax. Leophanes' name is also found in two commentaries to the *Parva naturalia*, respectively Themistius (V 6,12) and Michael (32,3), but only as an example of solecism for the possible confusion Λεωφάνης / Λεωσθένης. Theophrastus, *causs. plant.* II 4,12, mentions him among τὴν μελάγγεων (the dark earth) ἐπαινοῦντες. Photius (*Bibl.* 114b8) lists him among the authors of philosophical books.

other items are added. Diocles and Mnesitheus know the same pre-Aristotelian ‘Tiersystem’ as the one attested to in the writings attributed to Hippocrates. The fragments from Diocles’ ‘Υγιεινὰ πρὸς Πλείσταρχον and Περὶ θεραπειῶν show the same taxonomic criterion: the δύναμις of the animals used as food and possibly for therapeutic purposes.

Here we have an essential point which allows us to argue that the classification of living beings, that is, the definition of categories and groups to which animals with common characteristics belong, was very likely not due to philosophical reflection, but to medical research. The latter had, indeed, neither a generic nor a scientific interest (improbable for that time), but it did have well-defined goals and needs which provided an adequate motivation for research and the application of ordering criteria. As previously suggested, there were two main lines along which the study of the animal world had been organized: dietetics, familiar as one of the main components in ancient therapeutics, and zootomy as an instrument for comparative study in order to draw conclusions about the human anatomy, knowledge about which, if not absent, was certainly very limited and rare, being systematically explored only in Hellenistic medicine. All these authors are indebted to a common source, not necessarily a single written source, but rather a ‘geistige Atmosphäre’,⁷ which also nourished the natural philosophers of the time—a widespread debate which penetrated different disciplines.

4. *Handbooks and the evidence of historians and comic poets*

Medical treatises as practical handbooks originated from the concurrence of the different *technai*. As such, these works acted as the point of confluence for a knowledge which had developed over the course of time and was in the hands of those same *technitai* who would be Aristotle’s main authorities, fishermen as well as butchers, farmers, hunters, veterinarians, apiarists, and cooks. They possessed an often remote empirical lore, usually beyond the grasp of the layman. It is from them that Aristotle systematically draws information.⁸ Such a direct source

⁷ See Harig and Kollesch (1974) 30.

⁸ See the very good outline of Preus (1975) 23ff., particularly 36ff.; Manquat (1932) 49–73; Vegetti (1971) 20f. On Aristotle see also Kullmann (1979), Kullmann–Föllinger (1997), on zoological enquiries Kullmann (1998).

surely was also known to his forerunners, including the physicians, and the competition between cooks and doctors in Greece, so amusingly portrayed by comic poets, is especially relevant if we consider that the zoological interest of physicians was focused on edible animals. One feature concerning the knowledge of animals, remarkably shared by Hippocratic doctors and Aristotle, is that aquatic animals outnumber terrestrials in their studies; this is easily explained, Greeks being so predominantly fishermen and sailors.

We must not underestimate, in this respect, the cookery handbooks (ὄψαρτυτική or μαγειρική τέχνη), which had a continuous development from the second half of the fifth century to the Imperial Age, a literary genre which became more and more specialized (there existed treatises exclusively devoted to fish dishes, or to baked goods, ἀρτοποιικά, as was the case of Iatrocles, according to Athenaeus). Cookery and dietary books written by physicians followed a parallel but autonomous route.⁹ Nor should the impact of these classifications of animals outside the scientific framework be ignored, as for instance in late fifth-century comedy, of which Philyllius fr. 13 K.-A. is a good example, with three consecutive verses devoted to a list of 17 aquatic animals. These are not listed at random, however, but carefully follow the classifications attested in the medical sources.¹⁰

⁹ Works of reference on ‘Kochbücher’ and ‘Kochkunst’ include those of Bilabel (1921) and Orth (1921). See also Klüger (1911), Bilabel (1927). More recently Dohm (1964), Berthiaume (1982), Degani (1990) and (1991), Wilkins, Harvey, Dobson (1995).

¹⁰ Philyllius, fr. 13 (ap. Athen., *Deipn.* III 86e): πουλυπόδειον, σηπιδάριον, κάραβον, ἀστακόν, ὄστρεον, / χήμας, λεπάδας, σωλήνας, μῦς, πίννας, κτένας ἐκ Μυτιλήνης / αἰρετ’ ἀνθρακίδα, τρίγλη, σαργός, κεστρεύς, πέρκη, κορακίνος. From fragment 10 (ὁ μάγειρος ἀδικήσας κτλ.) of the same comedy, entitled Πόλεις, we learn that the main character was, of course, a cook. Palm (1933, 19) thought it very plausible that the author had a book containing zoological materials before him; in any case, he closely follows the pre-Aristotelian ‘Tiersystem’, as can be seen from a comparison with the Hippocratic *De victu*, Diocles, Speusippus, Aristotle (see Palm, l.c.). Such lists are frequent in the comic poets, where often the same animals as in the *De victu* occur, see e.g. Mnesimachus fr. 4,31 (ap. Athen., *Deipn.* IX 403b–c): θύννου τεμάχη, / γλάνδος, γαλεοῦ, ῥίνης, γόγγρον, / φοξίνος ὄλος, κορακίνος ὄλος, / μεμβράς, σκόμβρος, / θυννίς, κωβίος, ἡλακατήνες, / κυνὸς οὐραῖον τῶν καρχαριῶν, / νάρκη, βάτραχος, πέρκη, σαῦρος, / τριχίας, φνκίς, βερίκος, τρίγλη, / κόκκυξ, τρυγῶν, σμύραινα, φάγρος, / μύλλος, λεβίας, σπάρος, αἰολίας, / θράττα, χελιδόν, καρίς, τευθίς, / ψήττα, δρακανίς, / πουλυπόδειον, σηπία, ὄρφως, / κάραβος, ἔσαρος, ἀφύαι, βελόναι, / κεστρεύς, σκορπίος, ἔγγελυς, ἄρκτος, / κρέα τ’ ἄλλα (τὸ πλῆθος ἀμύθητον) / χηνός, χοίρου, βοός, ἀρνός, οἰός, / κάπρου, αἰγός, ἀλεκτρονόος, νήττης, / κίττης, πέρικος, ἄλωπεκιόν. Similarly Ephippus fr. 12,1 ff. (ap. Athen., *Deipn.* VII 322d–e), clearly and directly related to Mnesitheus (as the italicized series shows): θύννου τεμάχη, γλάνδος, γαλεοῦ, / ῥίνης, γόγγρον, κεφάλου, πέρκης, / σαῦρος, φνκίς, βερίκος, τρίγλη, / κόκκυξ, φάγρος, μύλλος, λεβίας, / σπάρος, αἰολίας, θράττα, χελιδόν, /

A vehicle of this kind of knowledge in its wider (not merely technical) impact can easily be seen in the descriptions made, for example, by Herodotus, as well as by Hecataeus¹¹ one century earlier, of exotic (particularly Egyptian) animals, whose features and habits these authors specified. Hecataeus' prolonged stay in Egypt is attested with certainty, as are his writings concerning those regions with descriptions of flora and fauna, which were commonly used from Herodotus onwards. A 'descriptive zoology', which was to find an important follower, between the end of the fifth and the beginning of the fourth century, in Ctesias, known as an historian but also from an ancient Cnidian family of physicians. Ctesias is mentioned more than once by Aristotle (and later by Aelian, whose testimony is essential to us), who clearly bears the traces of such sources, which can be identified by means of a direct comparison—as the zoologist Maurice Manquat has done for Herodotus, showing an often direct and hardly questionable dependence.¹² It is not possible to track here the development of these research efforts in their entirety, but the ones described so far are the most evident and eloquent coordinates in which Democritus and the other naturalists are to be set.

Classifications such as the one of *De victu* or the others hitherto considered, perhaps in a more simple but quite similar form can probably be traced further back, since the author of the Hippocratic *De morbo sacro* (which is plausibly dated around 430, see below) had already criticized their abuse or misuse by people characterized as 'magicians, purifiers, charlatans, quacks' (I 4 Jouanna = II Jones). And the *De victu* itself, as already noted, while proposing its own classification, opposes 'those who have undertaken to treat in general either of sweet, or fat, or salt

καρίς, τευθίς, ψήττα, δρακανίς, / πουλυπόδειον, σηπία, όρφός, / κωβίός, άφύαι, βελό-
ναι, κεστρεΐς. I wonder whether the two texts are interdependent or rather draw on the
same source, as the differences seem to indicate, a source such as a repertoire of the sort
which must have been popular already during the fifth century—an hypothesis, which
is close to the one proposed by Palm for Philyllius.

¹¹ The logographer from Miletus, not the later H. from Abdera, the latter perhaps a
follower of Democritean philosophy at the beginning of the Hellenistic age, who wrote
inter alia an important work called Αίγυπτιακά.

¹² See Manquat (1932) 37-47. He prints in parallel columns the (translated) texts of
Herodotus and of Aristotle's *Historia animalium* (where the historian is never mentioned);
a further source had been supposed in Hecataeus, see W. Jaeger (1923) 326 n., Palm
(1933) 6. It is relevant that among the large number of animals mentioned by Aristotle,
those from non-Greek regions (particularly Egypt) almost systematically agree with
those already described by Herodotus and other earlier sources (see Manquat, 100).

things, or about the power of any other such things' (II 39), positing instead different and more effective criteria: 'since therefore it is impossible to set forth these things in general, I will show what power each one has in particular' (ibid.).

Although sporadic or fragmentary, the evidence in favour of a systematization of pre-Aristotelian zoological knowledge is neither too scarce nor lacking in intrinsic coherence. The same classes and classification systems occur in different authors, who are sometimes quite removed from each other in interest and audience. This entails that such patterns were current—to some extent at least.

5. *A parallel: Egyptian science*

Hecataeus, Herodotus, and Ctesias show knowledge derived from other cultures, primarily Egyptian. Aristotle follows suit. That such an origin was not a fancy, and that the first Greek classifications of the animal world could date back to a much earlier time than the late fifth century, is corroborated by Egyptian evidence of primary interest. This evidence does not indicate the presence of epistemological reflections such as are to be found in Aristotle, but for this very reason it is important to us, since, as is the case with some treatises of the Hippocratic corpus, it consists mostly of 'handbooks' which reveal eminently practical aims and which have their place at the intersection between medicine and the study of nature: at this same intersection we can therefore locate the main field of origin for systematic zoological research.

From creation stories onward¹³ we can see that in Egypt animals are always listed following the classes to which they were said to belong according to their habitat. After a first division in big- and small-sized livestock, associated with earth, there were three basic categories: animals living in the air (i.e., birds and insects—two groups which, though sharing the same habitat, were regarded as distinct, as the existence of two different ideograms for their names shows); aquatic animals (i.e., fishes); and the group of ophidia and sauria, including lizards and worms, also having a terrestrial habitat. In these kinds of stories we can already see clues leading to the most ancient zoological classifications.

¹³ For western culture, the best known example is the story of the origin of life in the Garden of Eden.

Above all, the classificatory bent and expertise can be identified in works like the so-called veterinary papyrus from Kahun (ca 1850 BC), found together with other scientific (mathematical and medical) texts, in which we have a remarkable wealth of technical terms in the description of symptoms, and also the *onomastica* of Amenemope (ca 1100?) and that of the Ramesseum.¹⁴ These texts, which itemize animals according to classes, bear in their scarce remains detailed descriptions of the anatomical structure of cattle, clearly showing that this was the object of a specific study. Such materials have a marked descriptive-technical character and respond to the same taxonomic bent which is typical of the earliest phase of the study of animals in Greece.

Among the best preserved Egyptian texts of zoological interest is the extraordinary ophiological treatise on papyrus now at the Brooklyn Museum (no. 47.218.48 e 85), dating back probably to the fourth century BC and containing earlier materials.¹⁵ Divided into two sections organically related to each other, the former descriptive, the latter devoted to antidotes, it has a largely homogeneous structure, where each paragraph bears the name of the reptile and family, and a description of morphological characteristics, habits, and the appearance of the bite (sometimes very precisely described, including the number of pricks, the edema or necrosis of tissue, and the wound's width and depth). Also given are its association to a god, effects of the poison, prognosis, and suggestions concerning medical intervention. Clearly written by an author expert not only in snakes but also in medicine, the document was very likely a high-level one, and therefore no text for beginners, but a proper treatise of the sort preserved in temple libraries, in this case in particular, as Sauneron suggested, the library of the temple of Heliopolis (wherefrom it seems the whole lot of papyri originates).¹⁶

¹⁴ On the *Onomastica* see Gardiner (1947) and on a specific section of the *Onomasticon* of the Ramesseum concerning bovids, Dawson (1955). On veterinary treatises see also Kosack (1969). The lists of minerals found on *ostraca* or on the stele from the Egyptian town Sehel should also be mentioned, see Barguet (1953).

¹⁵ See the excellent edition, translation and study of Sauneron (1989), published long after his premature death in 1976.

¹⁶ An outline of the topic is given in the chapter by Betrò (2001). An interesting comparison of Greek and Eastern medicine, particularly medical praxis, has been made by Dietlinde Goltz, in her study of 1974. I dealt with this text, and with the relationship between Greek and Eastern medicine, also in Perilli (2005), with examples from the ophiological treatise, and Perilli (2006), where further bibliographical references can be found.

Here we have a rare example of an ancient zoological handbook, although the aim was not zoological, but medical (Sauneron 1989, 208). It has the purely practical angle typical of handbooks—aiming at the treatment of the consequences of snake bite—yet does not neglect to organize the subject-matter according to the most advanced scientific canons of the time. The efforts of the author to reach a high degree of precision are a sign of the noteworthy scientific attitude of Egyptian doctors and ‘scientists’: ‘les Egyptiens ont du moins franchi un pas considérable dans l’analyse des faits naturels; par leur classification des serpents, par la détermination de leur degré de nocivité; par l’observation des symptômes, et de leur evolution jour après jour’. Although ‘leurs connaissances scientifiques sont encore embryonnaires, et sur certaines points inexactes ... ils ont déjà mis au point et appliqué, dans la recherche des causes et celle des remèdes, *une méthode* qui, elle, garde une valeur éternelle’ (Sauneron 1989, 211, his italics). The relationship between ‘zoology’ and medicine in Egypt confirms that the origin of such treatises is to be looked for in a technical-scientific environment, one that precedes a more philosophical conceptualization as well as any link to the explanation of the structure of the universe, though the categories typical of the latter may have influenced, to some extent at least, the structure of the descriptions. The practical aim, however, and therefore the immediate possibility of a test or refutation of every statement prevents the preconceived application of foreign criteria.

As an expert in the field, Sauneron (1989, 209) remarked that the observations of the Egyptians had gone very far: ‘la nature qui les entourait était soigneusement répertoriée, en dictionnaires techniques, dont nous n’avons guère retrouvé jusqu’ici que des bribes, ou des citations éparées au hasard des traités scientifiques’. It is, however, beyond any doubt that ‘plantes et animaux étaient recensés, décrits, mesurés, et leurs mœurs, ou leurs propriétés étaient notés dans *des encyclopédies à l’usage des médecins*’ (my italics). This picture could also plausibly refer to Greece, where, although philosophical thought had a very different development, there can be little doubt that such inventories did exist with a similar aim—as Hippocr. *De victu* II 46ff. shows. Of these works in Egypt Sauneron says: ‘nous ne pouvons avoir encore qu’une idée très imparfaite; c’était, en somme, la préfiguration des livres des simples, ou des recueils de matière médicale des âges postérieurs’. What can be taken for granted is that the Egyptian doctor who wrote this treatise had a profound knowledge of snakes, while being fully aware

of scientific practice and criteria, as demonstrated by his distinguishing each situation and knowing, as the Hippocrateans did (for instance in the *Prognostic*), that it is necessary to recognise in advance which cases can be successfully treated and which cannot (see Sauneron 1989, 180f., 205f.).

This does not imply that Herodotus or others consulted this kind of treatise, but they certainly used knowledge which had solid roots and was formulated in an adequate way.

6. *Democritus: Thrasyllus and Aelian*

The surviving information concerning Democritus' zoological investigations is rather scanty. His privileged position, at least to our eyes, is due mainly to two elements: on the one hand Aelian's testimony which, though not always convincing, shows the level of detail in Democritus' investigations and, on the other hand, the catalogue of Democritus' writings compiled by Thrasyllus (who could perhaps draw on the materials of the Alexandrian library) preserved in Diogenes Laertius. It informs us of a treatise in three books of Αἰτίαι περὶ ζώων, which is listed among the works called ἀσύντακτα, that is to say *extra ordinem*. Its authenticity has been widely challenged and is still under discussion. The most radical position was perhaps that of Erwin Rohde, who following a 1870 study by Fr. Nietzsche categorically ruled out any chance of attributing the work to Democritus. He thought, with Nietzsche, that ἀσύντακτα meant writings which had been excluded from Thrasyllus' catalogue, and wrote, 'Und wir sollten Schriften, die sogar ein Thrasyll dem Demokrit nicht zutraute, für ächt halten?'.¹⁷ He imagined for these treatises an Alexandrian or even later hand, and elsewhere argued that the medical works mentioned in the catalogue were also the result of a Byzantine forgery.¹⁸ He finally cast doubts on the whole testimony of Aelian on Democritus' zoological observations, since these should have been presumably drawn from the same work (that this was Aelian's source, however, is nothing more than an hypothesis). Later scholars seem to have become persuaded of the contrary in that they believe that *extra ordinem* simply meant 'not better classified' within the imme-

¹⁷ Rohde (1901) I 214f.

¹⁸ See *RhM* 28 (1873) 266f.

diately preceding Φυσικά,¹⁹ or that if Democritus is not the author, the result is nonetheless Democritean.²⁰ But there is no decisive evidence either way.²¹ Judging from the surviving fragments and testimonies, my opinion is that if Democritus wrote such a treatise, as is at least plausible, it could have had a form similar to the *Problemata* attributed to Aristotle and his school.

It is not too important to know whether or not the information given by Aelian went back to the three books on animal aetiology. We must rather recall that Aelian (whose sources have been the object of the detailed analysis published by Max Wellmann, ‘Hermes’ 1891, 1892, 1895, 1896, 1916, who perhaps trusted too much in a direct straightforward filiation, and later by R. Keydell, *ibid.* 1937) almost certainly had no direct access to the original texts, but relied largely on intermediate sources. This was an increasingly accepted practice in post-Alexandrian and above all in the Imperial Age. Aelian’s sources were both all-important figures such as Aristophanes of Byzantium, and the lexicographer, *excerptor*, and encyclopaedist Pamphilus of Alexandria (2nd half of the first century AD), who with his monumental work—the impact of which is attested by the two subsequent epitomes made from it at short distance one from the other, only a few years after its completion—acted as landmark and source for many later authors including Galen. Mention should also be made of Juba II (1st cent. BC – 1AD), king of Mauretania by decree of August, who was also a source for Plinius and Plutarch as well as an advocate of the prop-

¹⁹ So e.g. J. Mansfeld in his collection (1987) 585. On the ἀσύντακτα see further the contributions by W. Leszl and A. Brancacci to this volume (pp. 17 and 181).

²⁰ So already Diels (1905) 316.

²¹ Rohde had a radical position about the possibility of distinguishing something genuine among the sentences attributed to Democritus. He thought that ‘alle Angaben über Demokrit’s Meinungen von Thieren und Pflanzen, welche bei Autoren nach Aristoteles und Theophrast erhalten sind, unterliegen dem Verdachte der Unächtheit’, and added a very long footnote, where he pointed among other things at the ‘so grosse Menge von Falsa’ which was traced back to Democritus, at the number of ethical Sentences ‘die dem Demokrit mit Sicherheit abzusprechen sind’, at the great amount of γνόμῃαι that ‘nicht nur unter Demokrit’s Namen vorkommen, sondern anderswo auch unter den Namen nicht nur des berufenen Demokrates, sondern auch des Chilo, Pythagoras, Solon, Heraclit u.s.w. bis zum Epictet herunter’, and so on; and he concluded after his long argumentation: ‘woher soll man, nach allen diesen Bedenklichkeiten, den Muth nehmen, einzelne bestimmte Sentenzen dem Demokrit zu belassen, andere ihm abzusprechen? Philologische Methode wird man in den Versuchen zu solcher Sonderung des Aechten und Unächten schwerlich bemerken können’ (p. 70f. = 215f.).

agation of Greek culture in Northern Africa and the author of many writings rich in historical, geographical, and ethnological information, and also in zoological descriptions of animals typical of those countries (e.g., elephants, lions, etc. in the *Περί Λυβίης*). Other sources include Leonidas of Byzantium (1 BC), author of a work on fishes and fishing presumably entitled *Περί ἀλιείας*, traces of which are also in Pamphilus, Plutarch and Athenaeus, and, finally, Sostratus (1 BC), whose renown as a zoologist was reputed to be second only to that of Aristotle (see Athen. VII 312e). Further, if we accept the reconstruction of Max Wellmann (Wellmann 1891), also Alexander of Myndos (1 AD)—sometimes identified with Alexander Polyhistor, and author of several works of zoological argument, among which was a remarkable *Περί ζώων*.

But Aelian did not use these authors. The information going back to them he took probably from Pamphilus, since Pamphilus had assembled in his encyclopaedic collection most of the technical knowledge then available, comfortably organizing it in *Sachgruppen* and then arranging the items within each group alphabetically (taking into consideration at least the first letter of each word). Aelian did not read Aristotle's original text either, instead he could use the epitome of the zoological works made by the above-mentioned Aristophanes.²² So I tend to dismiss the possibility that he would have read Democritus.

7. *Democritus and the other physiologi*

Let us go back to the question posed at the beginning: what was Democritus' contribution to the study of animals, and how original was it? What we can infer from Aristotle's testimony and from the surviving fragments, is that the Abderite *takes up a position* on current topics, and in doing so follows the same track as his colleagues the naturalists, adding his own suggestions. He is linked to rather than distinguished from them by Aristotle, and this is anything but accidental, as is apparent, for example, from a passage of the small treatise Bekker regarded as autonomous, the *De respiratione* (in the manuscripts, instead, it counts as the last part of the *περί νεότητος καὶ γήρωσ καὶ ζωῆς καὶ θανάτου καὶ ἀναπνοῆς*),²³ from which a rather homogeneous picture can be drawn

²² So A.F. Scholfield in the Loeb Aelian (1971) I XV.

²³ The interesting opening section of *De respiratione* has recently been investigated by Althoff (1999) 78–85.

(470b–471a = A 106 part.): ‘Democritus of Abdera then and some others among them who dealt with respiration did not make any distinction concerning other animals, but seem to speak as if they all breath. Anaxagoras and Diogenes instead explicitly say that all breath, and of fishes and bivalvs that they breath in a certain way, and Anaxagoras declares that fishes, when they send out water through the branchiae, breath in that they attract the air that is formed in the mouth, since there can be no void. According to Diogenes, instead, when they send out water through the branchiae, thanks to the void in their mouth they attract air from the water which surrounds their mouth, as if air were contained in water’. Soon after, an entire section is devoted to Democritus in chapter 4 (471b30–472b); the same will happen with Empedocles in chapter 7 (473a15ff. = Emp. B 100 DK). Elsewhere, Democritus is associated with Empedocles, as at *Gen. an.* II 8 (747a24 = A 149) with regard to the sterility of mules, or to Alcmaeon of Croton, as in Censorinus (5,2 = Alc. A 13 DK, together with Anaxagoras, against the hypothesis of seed originating from the marrow), and concerning the nourishment of embryos, Pap. Flor. 115, probably to be attributed to Galen,²⁴ where Democritus is coupled with the Crotonian. It is an instance of zoological lore in which Democritus is included, but not with a prominent role.

8. *The contents of the surviving fragments*

The contents of the Democritean fragments confirm this assessment. We must recall that, as in the case of seed or embryos, it is not always possible to distinguish clearly whether Democritus was talking about animals or humans, or both (τὰ ζῷα). Anyway, as far as we can reconstruct *embryology* and *reproduction* were his main topics, with detailed hypotheses concerning the origin of seed, the differentiation of sex, mating, the order of formation of the parts of the embryo, and the nourishment of the embryo.

We also have more or less isolated observations on spiders and the formation of webs; the lion, as the only animal being born with his eyes open; the owl, able to see even at birth; fish, their nourishment, respiration and habitat; dentition; why the cock crows before sunrise;

²⁴ The attribution has been proposed by Manetti (1985).

the origin of life on earth (worms); as well as the significant remarks about the division of animals into bloodless or provided with blood; and the existence of entrails in the former.

The most detailed discussion is preserved by Aelian, and concerns the origin and growth of horns in cervids and bovinds.

For the specific zoological contents of all these doctrines Democritus could rely on the investigations of the physicians as well as of the *physiologoi* in general, and to them he refers clearly enough. To judge from our scanty evidence he retrieves both broadly traditional elements, typical of Greek culture since the beginning, and features peculiar to the reflections of (natural) science, particularly those of medicine. It is not a matter of primacy nor of more or less direct relationship, rather one of reconstructing the background so as to reveal Democritus' role.

9. *Democritus and the classification of living beings*

Two important pieces of evidence highlight Democritus' knowledge of the taxonomic categories of the organic world current at the time, along a line which recalls the Hippocratic writings and their tendency towards classification. Aristotle writes (*Part. an.* 3, 665a30 = A 148): ... τῶν δ' ἀναίμων οὐδὲν ἔχει σπλάγγνον. Δημόκριτος δ' ἔοικεν οὐ καλῶς διαλαβεῖν περὶ αὐτῶν, εἴπερ ὠιήθη διὰ μικρότητα τῶν ἀναίμων ζώων ἄδηλα εἶναι ταῦτα ('... none of the bloodless animals has entrails. Democritus seems not to have judged rightly on this point, if he really thought that the entrails of bloodless animals could not be seen due to their smallness'). Hence the conclusion has often been drawn that Democritus had already classified living beings as ἔναυμα and ἄναυμα, with or without blood (approximately corresponding to vertebrates and invertebrates) and this is very likely, despite Zeller's objections. While there is no evidence that Democritus was the first to introduce the distinction, he probably knew it, since Aristotle gives no hint that it was a personal contribution, and rather seems to take it for granted. The further information given by Galen on this topic (*diff. puls.* I 25 K = B 126) would confirm an interest of Democritus in the invertebrates, 'those living beings which advance with a wave-like movement', ὅσα κυματοειδῶς ἀνὰ τὴν πορείαν πλάζεται (caterpillars).

The second piece of evidence comes from a corrupt text and concerns the subdivision of animal species and their numbers. Pseudo-

Plutarch (= Aet. V 20,1–2, *Dox. Gr.* 432) informs us that Plato and Aristotle had specified four γένη ζώων, *id est* χερσαία ἔνυδρα πτηνὰ οὐράνια, since according to them on the one hand καὶ γὰρ τὰ ἄστρα ζῶα, on the other hand the κόσμον is a ζῶον λογικὸν ἀθάνατον. But Democritus, and Epicurus after him, would have excluded the last category, that of the οὐράνια, from the classification. The text, however, has a lacuna at this point, and has only Δημόκριτος Ἐπίκουρος τὰ οὐράνια, which is integrated in Luria's edition with a possible οὐκ ἀποδέχονται ζῶα εἶναι.²⁵ This does not mean that Democritus had developed his own systematization; the same three classes also occur with regard to the Pythagoreans (at least according to Iambl. *vita Pythag.* 31 §207 = I 475,22 DK) and actually correspond to the most elementary categories for the organization of reality. But it demonstrates that Democritus took an active part in the debate, which presupposed a continuous interchange between 'scientific' and 'philosophical' thought.

10. *Embryology, reproduction, heredity.*
Democritus and the medical tradition

Setting aside the isolated and occasional scraps of information from which not much can be gained, and not taking into consideration the improbable (so they were already according to Aulus Gellius, *NA* X 12,6) *mirabilia* preserved by Pliny the Elder,²⁶ some of which is of zoological interest, two areas allow more tenable conclusions. The first is the body of testimonies and fragments concerning embryology and reproduction; the second is the long description of the growth of horns.

As to embryology, the debate had gone on throughout the whole presocratic period, finally converging toward medical writings. In its most technical terms, it goes back to at least Alcmaeon, and later will be found, with different positions, in Empedocles, Anaxagoras, Diogenes of Apollonia, and others, as Aristotle records (*Gen. an.* IV, 763b–764a). From the way in which Aristotle tackles the question, for instance with regard to sex differentiation during the embryo phase (see

²⁵ Diels, *Dox. Gr.* 432 in the apparatus suggested something like οὐκ ἐγκρίνει or μὴ λογικὰ εἶναι. A comparison for this kind of classification in Democritus is offered by Hermipp. *De astrol.* II 1,12ff. (B 5,2,12ff. DK).

²⁶ Some of them are in DK among the *spuria* to be attributed to Bolus of Mende; a list of the passages is given by Diels in B 300.8, and by Taylor (1996) 135f.

also 723a23 = Emp. B 65 DK), we learn not only how widespread the issue was, but also that the key doctrine was that of Empedocles, which ‘must have been typical of the Italic medical school as a whole’.²⁷ To him, Aristotle opposes Democritus, whose thought is also rejected.

The latter is of particular interest in that it shares the so-called ‘pangenetic’ theory (we owe the term to Charles Darwin, who first used it in 1868),²⁸ which asserts that the seed originates from the whole body, unlike Alcmaeon’s and (partly)²⁹ Hippon’s encephalo-myelogenic hypothesis, according to which the seed is generated by the brain and the marrow, which according to the ancients were a continuation of one another³⁰—and also unlike the hematogenous theory of Parmenides and Diogenes of Apollonia which later was deloped by Aristotle.

Democritus similarly also deals with the related issue of heredity, both of sex and of morphological features, a central topic on which documentary evidence is assembled and investigated in the rightly famous study of Erna Lesky, published in 1951. Democritus ultimately argued that seed, whose nature is made up of *pneuma* (see Act. V 4,3 = A 140), derives from all parts of the body, and that there exist a paternal and a maternal seed (Aristot. *Gen. an.* 764a6 = A 143), whose mixing generates the embryo. Sexual differentiation takes place in the embryo phase and is linked to the dominance of the father’s or the mother’s seed (see Alcm. A 14 DK) rather than to the different temperature, hot or cold (Empedocles), or to the left-right distinction (Anaxagoras, Leophanes). This is the *ἐπικράτεια* theory, entailing the dominance of one part of the seed on the other, a theory to be found already in Alcmaeon and to which Democritus gives a new content, according to which it no longer has to do with the general dominance of the contribution of one of the parents, but with the dominance of the specific part of seed coming from the reproductive system.³¹

²⁷ Lanza (1971) 971 n.

²⁸ The term has been used rather freely with regard to ancient theories, considering only its more general meaning. To give an idea of the exact meaning, I quote here the definition as can be read in the Merriam-Webster Dictionary, under the heading ‘pangenesis’: ‘a hypothetical mechanism of heredity in which the cells throw off pangens that circulate freely throughout the system, multiply by subdivision, and collect in the reproductive products or in buds so that the egg or bud contains pangens from all parts of the parent or parents’.

²⁹ On Hippo see, however, Lesky (1951) 1236.

³⁰ See Guthrie (1965) II 356n.

³¹ See Lesky (1951) 1297, Stückelberger (1984) 62.

The Democritean theory is very interesting, indicating a precise angle as well as a connection between Democritus' biological reflections and his more general atomistic view, in that it anticipates Aristotle by asserting that the umbilical cord, not the head or the heart, is the first to be formed in the embryo. The head and heart had been given this primacy due to the idea that the most important organs must also be the first to be formed in chronological order; the umbilical cord, according to Democritus, offers the foetus support for its growth, providing an 'anchorage' (Plut. *am. prol.* 495e = B 148, cf. Aristot. *Gen. an.* 745b25). After the cord, the external part would take shape, especially the head and abdomen due to the larger area of void in them—a typical atomistic and physicalist argument.

The embryo in the womb feeds by sucking, while the newborn infant has the instinct and the ability to suck its mother's breast (Act. V 16 = A 144). A detail links this hypothesis to research concerning mammals other than man since these, and ruminants in particular, have tiny fleshy outgrowths inside their abdomen (cotyledons) which are not found in humans, and from these the theory is likely to have started. This same hypothesis occurs in the sixth chapter of the Hippocratic *De carnibus*, a medical-cosmological treatise of particular interest, the only surviving case of a scientific-philosophical treatise from the end of the fifth century giving an idea of what 'presocratic' writings probably looked like, in which the embryo is explicitly said to suck in both nourishment and air through the mouth. This experience allows him, once born, to get nourishment from his mother. The idea was perhaps already one of Alcmaeon, if we can trust what Oribasius (III 56) records from Rufus (Alcm. A 17 DK). Further details on the Democritean vision about the causes of abortion (Aelian. *NA* XII 17 = A 152), multiple births and the sterility of mules, which, being an artificial product of man, have a malformed genital duct (Aelian. *NA* XII 16 = A 151) belong to the same field.

Democritus' pangenetic and embryological views and his related belief about hereditary characters are to be found also in other treatises of the Hippocratic corpus. On one hand we have *De aëribus* and *De morbo sacro*, whose epistemological importance is especially well known, and on the other hand the more technical so-called 'Cnidian' group, *De genitura*, *De natura pueri*, *De morbis IV* (usually considered as a whole, at least since Littré's edition of Hippocrates, and probably one and the same work; I. Lonie, who wrote a commentary on these works, thought that *De morbis IV* was a separate piece, but by the same author). It is in

these treatises that the topic is more closely examined.³² Democritus is not likely to have elaborated the theory, passing it on to the physicians, as has been argued;³³ this is not very plausible given also what has been said above about the ‘zoological’ investigations in the Hippocratic writ-

³² Cf. R. Joly (1966) e (1970); Lesky 1951, 76ff.; Stückelberger (1984) 57ff.; the commentary by I.M. Lonie was published in 1981, on our topic see 115ff. On embryology and heredity see also Balss (1936), as well as Geurts (1941), and De Ley (1970), (1971–1972), (1980), and, with regard to Aristotle, at least Kullmann (1979).

³³ Wellmann (1929) (we know that Wellmann, whose merits in the study of ancient medicine are common knowledge, was inclined to optimism as regards the possibility of tracing a theory back to its ultimate source, as can be seen both in his above-mentioned studies on Aelian’s sources and in his book on the *Hippokratesglossare*, as well as in some of the articles he wrote for the *Realencyclopädie*); Geurts (1941) 65; Lesky (1951) e.g., 1300 n. 3 et passim; Lopez-Ferez (1981). Lonie (1981) e.g. 116, et passim, follows Lesky and goes a little further, saying that even *De morbo sacro* and *De aëribus* could have been influenced by Democritus. Concerning pangenesis and heredity, he says, ‘in both treatises, the authors merely make use of a theory which they seem to regard as established, whereas it is the purpose of *Genit.* to establish it; it is therefore tempting to regard *Genit.* as the earlier work, on which *Morb. Sacr.* and *Aer.* depend. All three, however, might depend on a common source, possibly Democritus, since he alone among the presocratic philosophers is credited with the theory. Lesky suggests that the hypothesis was taken over from Democritus by the medical writers, who based it on their humoral theory, while in Democritus it was based on the body tissues. If so, it would be an interesting example of a specifically medical application of a more general theory’ (Lonie, 116). Lonie’s work is sound and detailed, but this hypothesis sounds chronologically difficult and is influenced by the common idea of an a-priori primacy of Presocratics over the medical doctors (i.e., of philosophy over medicine, insofar as it is possible to distinguish them clearly), so that an author (Democritus) of whose biological theories we only have scanty and indirect information, is proposed (‘since he alone among the presocratic philosophers is credited with the theory’) as the source of contemporary or later developments. I also believe it unlikely that a ‘specifically medical application’ could have come out ‘of a more general theory’, namely a philosophical one. If any *direct* relationship is to be assumed (and it cannot be taken for granted), it will have been rather the opposite, considering that, unlike the philosophers, the doctors had an immediate and crucial test—the life or death, health or illness, of the patient. Althoff (1999) 86 seems to accept, *en passant*, Lesky’s position, deeming it likely, however, that Aristotle in his discussion of the pangenetic theory directly followed the Hippocratic ‘Cnidian’ writings, as also Föllinger (1996) 144 n. 159 suggests, and Coles (1995) argued in detail concerning the notion of seed and its origin from the liquid nutriment in the body. A close examination of the association of Democritus with the ‘Cnidian’ treatises is in Salem (1996) 224–252, who starts from Wellmann’s position and ends up with the hypothesis—to me unlikely—of ‘innumerable debts’ of rational medicine to Democritus. Naturally enough, as in the case of Salem (cf. p. 229 and n. 6), there is a tendency to obliterate the fact that the most likely date for the ‘Cnidian’ treatises is not the one proposed by Wellmann (350BC), which indeed is fairly improbable given the archaic character of the style and the absence of any point of contact with theories later than the end of the fifth century, but rather the one which locates them not later than the end of the fifth century, and possibly a few years earlier (Joly himself, 1970, 23, revealingly enough states ‘on sera *forcé*

ings and in Democritus. I give up here any subjective arguments—though being convinced of them—according to which the hypothesis of a direct doctrinal influence exerted by philosophical notions on medicine concerning such very specific and technical topics would be in itself unlikely, considering also ‘Hippocrates’ attitude (e.g., in *De vetere medicina*).³⁴ A different conclusion could be admitted for more general views, for the major philosophical problems about the world and man (as, for instance, the theory of the four elements), which medical authors could have used in their writings whenever they needed a frame for the more specific discussion. Philosophy and medicine in antiquity have almost always been closely related to each other, although Hippocrates is credited by Celsus, in his *Prooemium* to the *De medicina*, with having ‘separated medicine from philosophy’. But I think we could apply also to earlier times what F. Kudlien (1970, 16) states about Hellenistic medicine and the idea of the physician as a philosopher,

d’admettre la datation traditionnellement reçue: la fin du Ve siècle’; Jouanna, 1992, 541, proposes the end of fifth to the beginning of the fourth century). Not much is added by the similarities to Democritus, which are to be seen in the Hippocratic *De carnibus* on the same topics, and these could even support the opposite conclusion, since that treatise too is most plausibly dated by the editors (both Deichgräber and Joly) towards the end of the fifth century. We should add, however, that in this case we have a piece which is half way between a presocratic treatise and a specialist medical work, following a line leading from Empedocles to Diogenes of Apollonia, an example of a *περὶ φύσεως* treatise concerning the formation of man (using the analogy of the cosmos) and his parts, and how organs of sense work. It would be easy to imagine this kind of work as the link between medical literature proper, aiming at handbooks or perhaps at an immediate applicative outcome, and a thinker like Democritus, who (presumably) had quite different goals.

³⁴ A similar position was held by Baldry (1932) 28 who, while investigating the undeniable kinship of the embryological ideas of physicians and the cosmological theories of philosophers, observed: ‘some aspects of early cosmogony can be properly understood only by comparison with embryological beliefs of the kind here expressed. ... [T]he only possible conclusion is that similar doctrines to those of *περὶ φύσιος παιδίου*, if perhaps in a simpler form, were already held in the time of the earliest philosophers, since it is scarcely conceivable that the medical writers should have founded their theories—theories tallying roughly with observation—on an analogy with the cosmogony of the century before last’. Democritus’ fragment 32 too (*Ξυνοουσίη ἀποπληξίη σμικρῆ, κτλ.*) may reveal a medical origin, if we are to credit Stobaeus III 6,28, who traces it back to Eryximachus, the physician (known almost exclusively through Plato): *Ἐρυξίμαχος τὴν συνοουσίαν μικρὰν ἐπιληψίαν ἔλεγεν καὶ χρόνῳ μόνῳ διαλλάττειν*. Gellius (*NA XIX 2*) attributes it to Hippocrates in person (*namque ipsius verba haec traduntur τὴν συνοουσίαν εἶναι μικρὰν ἐπιληψίαν*). Perhaps the pseudo-Galen of the *Definitiones* correctly attributes to Democritus only the second part of the fragment, as edited by DK (XIX 499 K: *ὁ μὲν Δ. λέγων ἄνθρωπος ἐξέσσεται ἐξ ἀνθρώπου παντός, cf. Gal. An animal sit quod est in utero XIX 176 K*). On this fragment see also Gemelli in this volume, p. 215ff.

namely that ‘the philosopher ... being himself interested in science and medicine ... could give ideas and mental stimuli to an interested physician’. At the beginning of ‘scientific’ medicine, one could resort to philosophy in search of a theoretical foundation, not of technical knowledge (cf. Kudlien, 5). There are two radically opposing parties: philosophers as a rule see an influence of Democritus on medical treatises concerning specific aspects, while historians of medicine usually tend to exclude it. I subscribe to the latter view.

Moreover, when investigations go beyond generalization (such as: ‘Democritus asserted a pangenetic theory; *ergo* anybody else sharing it, contemporary or successor, depends on him’) and become more detailed, the results are unambiguous, as is shown by Stückelberger’s broadly negative examination of the evidence assembled by Wellmann in view of the hypothesis that medical works depend on Democritus.³⁵ Among the many similarities, investigated one by one, only in a few, often unimportant, cases can a knowledge of Democritus’ doctrine be assumed on the part of the Hippocratic authors, while elsewhere, and for the most important theories, we can detect no more than conceptual or terminological analogies. More caution should also be suggested by the poverty of the evidence attributed to Democritus, sometimes only consisting in vague hints, so that no conclusion can be drawn.³⁶ As far as I can see this position tallies with Lonie’s conclusion

³⁵ Wellmann (1929); Stückelberger (1984), in the chapter entitled ‘Spuren Demokrits im Corpus Hippocraticum’ (pp. 49–87).

³⁶ I find, for example, that Jouanna’s skepticism should be shared, when he (Jouanna 1992, 386f.) remarks how scholars, after having ascertained a parallelism between doctors and philosophers on embryological topics, usually tried to establish debts owed by doctors to philosophers, resorting to all available names: Empedocles, Anaxagoras, Diogenes of Apollonia, the Pythagoreans, and, above all, Democritus, of whose most peculiar atomistic doctrine, however, no trace can be found in the treatises at issue, nor have we any information concerning Democritus as the first to have elaborated any of these theories: ‘Il semble donc que les érudits cèdent, encore plus que les anciens Grecs, au mirage du premier inventeur. ... Notre connaissance de l’embryologie [and not only embryology] des Présocratiques est très indirecte et très parcellaire ... sans compter que l’essor des recherches sur l’embryon chez les philosophes présocratiques peut aussi bien s’expliquer par une influence de la pensée médicale. Il y a eu, très vraisemblablement, des influences réciproques qu’il n’est plus possible de démêler’. I would, as already stated, be even more radical in assuming a one-way relationship—for those cases in which the hypothesis of a relationship is allowed—from doctors *towards* Democritus. This applies at least to the more specific theories, while concerning the complexity of the philosophical and scientific debate in the fifth century, one must be rather cautious, as argued by Temkin 1955. The difficulties in this regard are also clear to Lonie (cf. his chapter ‘Relation of the treatise to the pre-Socratic philosophers’, 62–70), who is,

(1981, 65), shared by Althoff (1999, 87), that Aristotle's 'doxographic' reconstruction concerning pangenesis seems to be directed not against a single forerunner, but against a widespread opinion: 'the impression left by the passage in Aristotle is that he is arguing not against a particular opponent but against a well-known view which had been frequently canvassed and supported by various arguments in more or less public debate' (Lonie, l.c.).

As regards 'Hippocrates', the first difficulty is chronological. Although there can be no certainty, the *De aëribus* has been dated around 430BC,³⁷ and the *De morbo sacro* not far away, probably only a few years later, when Democritus' doctrine is not likely to have been so mature and widespread as to be used *tout court* in medical literature. A second difficulty lies in the summary way in which both *De aëribus* and *De morbo sacro* mention the doctrine: *Aër.* XIV 4 Jouanna (= XIV Jones) ὁ γὰρ γόνος πανταχόθεν ἔρχεται τοῦ σώματος, ἀπό τε τῶν ὑγιερῶν ὑγιηρὸς ἀπὸ τε τῶν νοσηρῶν νοσηρὸς, *MSac.* II 2 Jouanna (= V Jones) ὡς ὁ γόνος ἔρχεται πάντοθεν τοῦ σώματος, ἀπό τε τῶν ὑγιερῶν ὑγιηρὸς καὶ ἀπὸ τῶν νοσηρῶν νοσηρὸς. Both times the statement, which in itself would seem elementary, closes and grounds detailed arguments concerning the heredity of acquired somatic traits, or pathologies. The brief and, I would say, scholastic formulation of the doctrine suggests that it was common among doctors around 430BC. It is taken for granted, and used to confirm other, more specific, assertions as the explanatory γὰρ of the first text shows, and the technical character of the context makes an origin in Democritus (*pace* Diller) unlikely. The same can be said for other hypotheses, such as that substituting Anaxagoras for

however, convinced that 'the influence of Democritus seems ... to pervade the whole treatise', but specifies that 'it is more because of this generally mechanistic approach than of any particular feature' (70), and also remarks that other contributions are to be taken into account. So far, Lonie's position is well-grounded and could be easily shared, although I still have some reservations (also concerning the spread and knowledge of Democritus' doctrine in the last decades of the fifth century). The difficulties and at times errors hidden in the attempts to establish these kinds of comparisons and influences, among which are some of those made by Lesky and other later scholars, have already been dealt with. I mention here only J. Jouanna's contribution to the Hippocratic Colloquium of 1992 and A. Thivel's to that of 1996, the latter clearly restating, after recalling Jouanna's (1992) investigation, that 'die pangenetische Theorie ist durchaus kein Werk der Atomisten; denn sie war lange vor ihnen vorhanden, und die Atomisten sind nur Vertreter derselben, neben anderen' (66).

³⁷ Heinimann (1945) 170ff. ('Anhang'); Jouanna, ed. CUF; so already Wilamowitz and Nestle; Vegetti (1976, 191) proposes the interval 430–410.

Democritus.³⁸ One may further note, though only marginally,³⁹ that *De aëribus* bears no trace or echo of peculiarly Democritean doctrines, primarily atomism, and that the Democritean materialistic bent seems to be far removed from the attention paid to religion and the sacred by the Hippocratean author, whom Diller was inclined to locate in the Democritean circle.⁴⁰ The sheer sharing of an aetiological perspective cannot lead to such a strong relation as proposed by Diller.

The ‘more rich and differentiated’⁴¹ image offered by the so-called Cnidian treatises (I stick to this controversial name, for the sake of convenience) is to be chronologically located at the end of the century. It shares with Democritus’ doctrine both the theory of pangenesis and the notion of sex-differentiation as due to two seeds, male and female, and to the dominance of the one over the other, as well as the idea that fertilization takes place when the two seeds meet. Also, the belief of *pneuma* as the cause of growth (particularly of the embryo) is similar to Democritus’, but this theory is to be found elsewhere in medical writings too. In spite of all similarities, however, there is a fundamental difference: while the atomistic pangenetic explanation revolved around the notion of the atom and its characteristics (to the extent that Lesky proposed a comparison with Darwin’s gemmules),⁴² that is to say that it moved on a physical, or physicist, basis, the medical treatises have a purely physiological and nosological angle, relating the hypothesis of pangenesis to the humoral doctrine typical of the whole Hippocratic corpus—despite all the variations occurring in the different treatises before its codification in the *De natura hominis*, and going through the whole history of ancient medicine up to Galen and, through him, to the following centuries. Humours (the specific object of *De morbis IV* since its very beginning, see also *genit.* I 1, III 1) as a whole form the basic ὕψόν of the body, and thus originate seed, diseases, and their heredity, since they are transmitted from one generation to the following without changing their characteristics.⁴³

³⁸ Cf. e.g. Vegetti (1976) 218.

³⁹ With Pohlenz (1938) 27.

⁴⁰ Diller (1934) 64f.

⁴¹ Lesky (1951) 1301.

⁴² In the theory of pangenesis, gemmules are minute, self-multiplying particles considered to be transmitted from somatic to germ cells and to mediate in a new individual the production of cells like those in which they originated.

⁴³ It is not possible to investigate here the connections between *De aëribus* and *De morbo sacro* on the one hand, and those of *De genitura*, *De natura pueri*, and *De morbis IV* on the other. See, for example, Lesky (1951) 1304f. n. 2. It should be noted that con-

Democritus' original contribution is to be found elsewhere. As Lesky points out (p. 1295), until then matter in general, and the human body in particular, had been assigned multiple qualities (hard or soft, thin or thick, etc.); atomism adds the qualities of form and dimension, which become decisive for living organisms as well as for any other thing (the ἄτομοι ἰδέαι of Plut. *adv. Col.* VIII, 1110F = A 57). The introduction of the concept of atom gives also to biology the notion of a minimum morphological unit, to which one could resort, for example, to explain the much discussed question of heredity.

Not only does the idea of the four humours introduce a substantial change compared to Democritus, but also the related notion (on which see *nat. puer.* XVII 1) of the heredity of tissues—generally classified as ὑγρὸν and above all πυκνὸν and ἀραιὸν, terms important for the atomists too, but not for them only—according to the principle of the *simile cum simili*, that is, each tissue having its own characteristics passing on to the embryo through the seed. Most interesting perhaps is that the Hippocratean who wrote these treatises explicitly states the empirical, if not experimental, method he used to get his results. He says he has observed an early, deliberately induced abortion (*nat. puer.* XIII) and the hatching of twenty eggs at an interval of one day, one from the other (ib. XXIX). He is fully aware of the methodical significance of what he says, since at the end of the first case he states its role in order to validate his assertions: it is a ἰστόριον παντὶ τῷ ἐμῷ λόγῳ, ὅτι ἐστὶν ἀληθής (XIII 4), a proper *proof*, which in order to be expressed requires a specific term, ἰστόριον, as rare in Greek as it is peculiar to 'Hippocrates'.⁴⁴ This again marks the distance from Democritus,

cerning the origin of seed Coles (1995) 50 remarks that Aristotle was himself extensively influenced by the 'Cnidian' treatises; he also accepts Lonie's position that these treatises show the influence of Democritus. It is again on the basis (to me uncertain, see above nn. 33 and 36) of the assumed Democritean influence that Lonie (71) proposes as a *terminus post quem* the date of 420BC for these works, which date is the most likely.

⁴⁴ It should not escape notice, however, that although this sort of experimental test has for a long time been rightly admired, it is adopted by the author to confirm a clearly erroneous idea of the formation of embryos, in which the a-priori element plays an important role. I confine myself to R. Joly's remarks in the introductory *Notice* to his edition, 28–33; more generally, about the scientific method of the author, strongly lessened compared to a sometimes exaggerated enthusiasm, see Joly (1966) 70–119 (with some bibliographic references: also R. Burckhardt, mentioned above with regard to the pre-Aristotelian *Tiersystem*, counted among the admirers of the no doubt surprising experiment of the eggs). But, although it is true that the data of the Hippocratean are incorrect and that apriorism still plays an important role in the treatises at issue, and although it is above all undoubtedly incorrect to search for

compared to which Aristotle himself takes advantage when he observes (in the previously mentioned *Part. an.* 665a30ff.) that the σπλάγχνα, although very small, can nevertheless be seen by anyone observing an aborted embryo, and he criticizes Democritus for having said that the smallness prevented direct observation. It is a remarkable issue since, even though we know that Democritus also used to resort to ‘experiments’ (such as the unsuccessful one on removing salt from sea water),⁴⁵ he seems to share with the author of the Hippocratic work *De victu* also the tendency towards a purely rational development of available data.⁴⁶

Democritus is not at the origin of the doctrines at issue. He rather follows not only the results of medicine, but also the ancient traditions and popular wisdom and beliefs, when he says that, well, seed comes from the whole body, but specifies, καὶ τῶν κυριωτάτων μερῶν, οἷον ὀστέων σαρκῶν καὶ ἰνῶν (*Aet.* V 3,6 = A 141), namely, in particular from the most important parts: bones, flesh, and sinews. That is to say—as Odysseus learns from his mother in Homer’s *Nekyia*, in *Odyssey* XI—exactly the three parts of which mortals are deprived in Hades, being pure εἶδωλα, οὐ γὰρ ἔτι σάρκας τε καὶ ὀστέα ἴνες ἔχουσι (λ 219). These are the vital parts, wherefrom, according to the Greeks, the principle of life derives, the seed, whose role in Greek culture and religion is of paramount importance from the earliest time and which is related to numerous rituals.⁴⁷ The conceptual distance from Democritus is further

forerunners of modern science in antiquity, nonetheless, Joly’s criticism appears to be somewhat ungenerous, since the epistemological awareness of these writings, with all its limits, is unquestionable. The claiming of epistemological merits and primacies is due to modern interpreters, not to the ancient author.

⁴⁵ Aristotle speaks of the experiment and recommends it (*Hist. an.* VIII 2, 590a18, sim. *Meteor.* II 3, 358b35). Aelian traces it back to Democritus, see IX 64. Cf. Diels (1904) 312f.; Preus (1975) 22f., 268. A useful annotated survey of 32 ‘experiments’ of the Hippocratic corpus, compared with other authors, is found in Senn (1929).

⁴⁶ An instance of it is in *vict.* II 47, where birds are said to be more dry, ξηρότερα, compared to quadrupeds, because the absence of a bladder entails the absence of urine and spittle. Their stomach is warm, and to remain so it uses the body’s moisture, so that, as the author repeats, they neither urinate nor spit. He adds: ἐν οἴῳ δὲ μὴ ἔνι τοιαύτη ὑγρασίῃ, ξηρὰ εἶναι ἀνάγκη. This conclusive and more general ‘necessity’, according to which an animal lacking in such moisture must fall within the ξηρὰ category, is removed from any empirical perspective, and not really justified apart from its being logically consistent with the argument. Although, as has been observed in note 44, the three ‘Cnidian’ treatises also make use of unparalleled elements, the effort of finding test criteria is, in that author, manifestly greater.

⁴⁷ Cf. Onians (1951), passim, see Index, s.vv.

emphasized in the *De genitura*, which stresses instead, in the same idea of pangensis, the brain and marrow as the dominant parts.

Democritus performs an unusual association of common knowledge and scientific knowledge, as we shall see again in the other topic on which we have sufficient details: horns.

11. *The growth of horns*

Democritus' way of tackling the issue of the origin and growth of horns in cervids and bovids confirms his perspective and his position in the development of Greek scientific thought, as well as his relationship to medical treatises, by which he seems to be strongly influenced. Aelian (XII 18–20 = A 153–155), by devoting three chapters to it, furnishes a wealth of details on a topic which may seem to be, but is not at all, unimportant.

Democritus' work in this area reveals remarkable attention to the processes of animal anatomy and physiology, explaining how the veins running throughout the animal's body become increasingly thicker as they get closer to the head and especially at its top. The veins are porous, as is the thin and membranaceous bone containing the brain (the mention of the latter is not accidental). The head gets nourishment and reproductive power from the veins, while the strength of the nourishment (ἡ ἰσχυρὸς τῆς τροφῆς) approaches it by means of them. Hence, from the outcrop of wet matter, horns begin to grow, being supplied by the humour (ἰκμάς), which forces outwards what precedes it. The wet matter (ὑγρόν), once out of the body, hardens (σκληρόν), thanks to the air which renders it compact and horny. The outer part hardens with the cold, the inner one remains soft because of heat. In chapter 19 Democritus is said to have maintained (rightly, according to Darwin, *Descent of man*, II 17, ap. Onians 1951, 239 = 288 ital. ed.) that castrated oxen have differently-shaped horns which are long, thin and hooked, as opposed to having the normal shape, which is large at the base and also straight and shorter. Finally (chapter 20), the absence of horns in some oxen is explained by the lack of 'alveolation' of the frontal bone, and by the characteristics of the whole cranium, impervious and therefore unfit to receive the humours reaching it and to let them pass through. Aelian concludes, 'in short, the afflux of these (humours) is the cause of horns' growth, and the veins conveying this afflux are very many and big, and they secrete as much humour as they can contain'.

This long discussion has a twofold meaning. First, it shows that the conclusions are not based on empirical control, but on an inductive-deductive process (since it would have been easy to ascertain that horns, and particularly those of cervids, are indeed purely bony formations, coated by an epidermal integument, whereas bovids' horns, though being themselves made of bone, are coated by a corneous case which could better justify an explanation like the one given by Democritus). Secondly, it has been overlooked (to my knowledge) that Democritus' explanation of the growth of horns basically depends on the investigations of his contemporaries the doctors, as stated, e.g., in the *De morbo sacro* itself, whose importance we have already seen.

Let us declare beforehand that a Democritean influence on the Hippocratic treatises concerning this topic is unlikely, since the latter are much more detailed and systematic and are clearly and professionally based on direct observation. Democritus seems to pick up and reuse arguments of this kind (not necessarily the one of *De morbo sacro*, although the similarity is striking); he sums up their content, merely reporting the main points—even though in such comparisons it is necessary to remark more than ever that, as regards language, Aelian's testimony probably is not very faithful to the original.

A few examples are in order. When the author of *De morbo sacro* wants to argue against what he considers the error of traditional belief, specifically that they assign to the so-called 'sacred disease' a divine origin, he asserts that the cause of epilepsy, as of all other major diseases, lies in the brain; in so doing, he illustrates the brain's anatomy, starting from his own observations of animals and transferring the results to humans on the usual analogical basis, as had already happened in Alcmaeon for his investigations on the brains of animals (see A 5–11), especially goats (if we must refer to the brain A 7 = Aristot. *Hist. an.* I 11, 492a13). The veins' route (see the texts in footnote 48), described with a wealth of details in the Hippocratic treatise, is in Democritus summed up with the cursory attitude of someone not very interested in technicalities, who confines himself to the beginning clause (*MSac.* καὶ φλέβες δ' ἐς αὐτὸν τείνουσιν ἕξ ἅπαντος τοῦ σώματος, cf. Democr. τὰς φλέβας δὲ αὐτῶν τὰς διὰ τοῦ σώματος πεφυκίας παντός). Such veins are πολλαὶ καὶ λεπταί (numerous and thin) according to the Hippocratic, ἀραισιότατας (very thin, porous) according to Democritus. In both authors they go towards the brain, τὸν ἐγκέφαλον (the mention of which in Democritus is all the more significant since it is not immediately relevant to the argument), which is divided by a thin membrane (μῆνιγξ λεπτή) for the

Hippocratic, whereas for Democritus it is surrounded by a membranaecous, light, porous bone (δοτέον ... λεπτότατον εἶναι καὶ ὑμενώδες καὶ ἀραιόν)—an observation recalling the more general anatomic notions of doctors, cf. *Loc. hom.* Π 5 τῆς μήνιγγος ... τῆς περὶ τὸν ἐγκέφαλον περιτεταμένης, see further I 18, as well as *Vuln. cap.* Π 4 ξυμπάσης τῆς κεφαλῆς τὸ δοτέον λεπτότατόν ἐστιν ..., καὶ ὁ ἐγκέφαλος κατὰ τοῦτο τῆς κεφαλῆς πλείστος ὕπεστιν, Π 17 ὑπὸ λεπτοτάτῳ γὰρ δοτέῳ ἐστὶ ταῦτη ὁ ἐγκέφαλος. According to Democritus, the veins going towards the top of the head become thicker (παχυτάτας), as, again, the author of the Hippocratic *De morbo sacro* had already said: τὸ μὲν παχύτατον καὶ μέγιστον καὶ κοιλότατον ἐς τὸν ἐγκέφαλον τελευτᾷ.⁴⁸ The concept of ὕγρον, too,

⁴⁸ I give the texts in full (the Democritean one only as far as it is of interest here). Hippocr. *De morbo sacro* III 2–5, Jouanna (= ch. VI Jones): ὁ ἐγκέφαλος ἐστὶ τοῦ ἀνθρώπου διπλός ὡσπερ καὶ τοῖσιν ἄλλοις ζώοις ἅπασιν τὸ δὲ μέσον αὐτοῦ διείργει μῆνιγξ λεπτή· διότι οὐκ αἰεὶ κατὰ τὸ αὐτὸ τῆς κεφαλῆς ἀλγεῖ... Καὶ φλέβες δ' ἐς αὐτὸν τείνουσιν ἐξ ἅπαντος τοῦ σώματος πολλὰ καὶ λεπταί, δύο δὲ παχεῖαι, ἡ μὲν ἀπὸ τοῦ ἥπατος, ἡ δὲ ἀπὸ τοῦ σπληνός. Καὶ ἡ μὲν ἀπὸ τοῦ ἥπατος ὧδ' ἔχει· τὸ μὲν τι τῆς φλεβός κάτω τείνει διὰ τῶν ἐπὶ δεξιᾷ παρ' αὐτὸν τὸν νεφρὸν καὶ τὴν ψόην ἐς τὸ ἐντὸς τοῦ μηροῦ καὶ καθήκει ἐς τὸν πόδα καὶ καλεῖται κοίλη φλέψ· ἡ ἑτέρα ἄνω τείνει διὰ τῶν φρενῶν καὶ τοῦ πλεῦμονος τῶν δεξιῶν, ἀπέσχιται δὲ καὶ ἐς τὴν καρδίην καὶ ἐς τὸν βραχίονα τὸν δεξιόν, καὶ τὸ λοιπὸν ἄνω φέρει διὰ τῆς κληῖδος ἐς τὰ δεξιὰ τοῦ ἀγένης ἐς αὐτὸ τὸ δέρμα ὥστε κατάδηλος εἶναι, παρ' αὐτὸ δὲ τὸ οὖς κρύπτεται καὶ ἐνταῦθα σχίζεται· καὶ τὸ μὲν παχύτατον καὶ μέγιστον καὶ κοιλότατον ἐς τὸν ἐγκέφαλον τελευτᾷ, τὸ δὲ ἐς τὸ οὖς τὸ δεξιόν, τὸ δὲ ἐς τὸν ὀφθαλμὸν τὸν δεξιόν, τὸ δ' ἐς τὸν μυκτήρα. Ἄλλο μὲν τοῦ ἥπατος οὕτως ἔχει τὰ τῶν φλεβῶν διατέταται δὲ καὶ ἀπὸ τοῦ σπληνός φλέψ ἐς τὰ ἀριστερὰ καὶ κάτω καὶ ἄνω, ὡσπερ καὶ ἡ ἀπὸ τοῦ ἥπατος, λεπτοτέρα δὲ καὶ ἀσθενεστέρα. ('The brain of man, like that of all animals, is double, being parted down its centre by a thin membrane. For this reason pain is not always felt in the same part of the head ... Veins lead up to it from all the body, many of which are thin, while two are stout, one coming from the liver, the other from the spleen. The vein from the liver is as follows. One part of it stretches downwards on the right side, close by the kidney and the loin, to the inner part of the thigh, reaching down to the foot; it is called the hollow vein. The other part of it stretches upwards through the diaphragm and lung to the right. It branches away to the heart and the right arm. The rest leads upwards through the collar-bone to the right of the neck, to the very skin, so as to be visible. Right by the ear it hides itself, and here it branches, the thickest, largest and most capacious part ending in the brain, another in the right ear, another in the right eye, and the last in the nostril. Such is the character of the veins from the liver. From the spleen too extends a vein downwards and upwards to the left; it is similar to the one from the liver, but thinner and weaker'. Transl. Jones, with changes). Democr. A 153 (= Aelian. *NA* XII 18): αἰτίαν δὲ ὁ αὐτὸς λέγει τοῖς ἐλάφοις τῆς τῶν κεράτων ἀναφύσεως ἐκείνην εἶναι. ἡ γαστήρ αὐτοῖς ὡς ἐστὶ θερμοτάτη ὁμολογεῖ, καὶ τὰς φλέβας δὲ αὐτῶν τὰς διὰ τοῦ σώματος πεφυκνίας παντὸς ἀραιοτάτας λέγει καὶ τὸ δοτέον τὸ κατευληφὸς τὸν ἐγκέφαλον λεπτότατον εἶναι καὶ ὑμενώδες καὶ ἀραιόν, φλέβας τε ἐντεῦθεν καὶ ἐς ἄκραν τὴν κεφαλὴν ὑπανίσχειν παχυτάτας. τὴν γοῦν τροφήν καὶ ταύτης γε τὸ γονιμώτατον ὄκιστα ἀναδίδοσθαι καὶ ἡ μὲν πιμελή αὐτοῖς ἔξωθεν, φησί, περιχεῖται, ἡ δὲ ἰσχύς τῆς τροφῆς ἐς τὴν κεφαλὴν διὰ τῶν φλεβῶν ἀναθόρνται. ἔνθεν οὖν τὰ κέρατα ἐκφύεσθαι διὰ πολλῆς ἐπαρόδομας τῆς ἰκμάδος... ('And the same writer says that the

is typical of this Hippocratic treatise and of other texts of the corpus, such as the one of heat inside the belly, but in this case the kinship is too generic to draw any conclusion.

Unlike Democritus' sometimes fanciful description, the author of *De morbo sacro*, like his colleague of the aforesaid *De natura pueri*, unambiguously declares that the source of his information lies in direct investigations, thus earning a remarkable esteem: XI 4 ἦν διακόψας ὄρᾳς τὴν κεφαλὴν, εὐθῆσαις κτλ. (the reference is to goats). The heuristic value lies in opening the animal's head and making personal observations.

Democritus, as I was saying, seems to pick up data coming from the most up-to-date investigations in order to obtain reliable means to explain various and more general phenomena. The topic of horns, seemingly a minor one, is indeed recurrent from the very outset of Greek culture (as it was already in Egypt). The symbolic value of horns is very high; they are assigned honours particular to them, even sometimes being coated with gold (Hom. γ 437f., 384, K 294). In Minoan-Mycenaean times they were already regarded as sacred⁴⁹ and placed on altars, which could even be entirely made of horns, as was the case at Delos (see Onians 1951, 238 = 287 ital. ed.). The sacred meaning can be explained by considering that horns represented (and here Democritus should be recalled) an outcrop of the head's vital substance: seed, which embodies force, and derived according to some theories from the ἐγκέφαλος. What is born from the head is an emergence of what is inside; the etymological connection of κέρας and *cerebrum*, cf. germ. *Hirn*, angl. *horn*, etc. will have been far from incidental. For all this, Democritus, with the help of medicine, attempts an anatomical and physiological explanation.

reason why deer grow horns is as follows. He agrees that their stomach is extremely hot, and that *the veins throughout their entire body are extremely fine*, while the bone containing *the brain is extremely thin, like a membrane, and loose in texture*, and *the veins that rise from it to the crown of the head are extremely thick*. The food at all events, or at any rate the most productive part of it, is distributed through the body at great speed: the fatty portion of it, he says, envelops their body on the outside, while the solid portion *mounts through the veins to the brain*. And this is how horns, being moistened with plentiful juices, come to sprout ...'. Transl. Scholfield). Another obvious parallel to Democritus' account on horns is offered by ch. 19–20 of *De natura pueri*, where the growth of nails and hair is described, recalling Empedocles' account of nails and, before Democritus, perhaps paralleled in Anaxagoras and Diogenes of Apollonia.

⁴⁹ See A. Evans, *JHS* 21, 1901, 107, 135ff.; M. Nilsson, *The Minoan-Mycen. Religion*, 154; Onians (1951) 237 = 286 ital. ed.

12. *Democritus' contribution to zoology, on balance*

We can now attempt a provisional balance, as well as an answer to the question concerning Democritus' contribution to zoology at its early stage. Aristotle was right: his interest in Democritus does not concern individual theories about animals, though these are mentioned, but the different theoretical colouring of his investigations. Aristotle, in the first book of *De partibus* (*Part. an.* 642a24 = A 36, cf. 640b30), observes that Democritus' real contribution must be sought in his remarkable interpretative effort of natural phenomena, of *physis*, since he was the first to realize the importance of defining the essence of things, of going beyond a purely phenomenological survey of data. Aristotle's text is explicit: αἴτιον δὲ τοῦ μὴ ἐλθεῖν τοὺς προγενεστέρους ἐπὶ τὸν τρόπον τοῦτον ὅτι τὸ τί ἦν εἶναι καὶ τὸ ὁρίσασθαι τὴν οὐσίαν οὐκ ἦν, ἀλλ' ἦψατο μὲν Δημόκριτος πρῶτος, ὡς οὐκ ἀναγκαίου δὲ τῆ φυσικῆ θεωρίας, ἀλλ' ἐκφερόμενος ὑπ' αὐτοῦ τοῦ πράγματος ('The reason for which our forerunners did not reach this kind of explanation is that they did not know the essence, that is, could not define the substance. Democritus was the first to touch upon it, not because it was necessary to natural science, but being driven by things themselves').⁵⁰

Aristotle links this wider perspective of Democritus' research to the latter's atomistic view. The section on Democritus in the fourth chapter of *De respiratione* clearly states that the issue of animal respiration is handled by Democritus in line with his idea of body and soul as atomic compounds; inhalation of air, by means of which elementary particles are introduced into the body from outside, is needed to redress the exhalation of soul atoms from the body (471b30ff.). In the same way, i.e. in connection with his atomistic outlook Democritus regarded seed and its distribution within man's genital apparatus in such a way that the dominance of one kind of 'seminal atom' ('Samenatome' according to Althoff),⁵¹ ὁποτέρου ἂν κρατήσῃ τὸ σπέρμα τὸ ἀπὸ τοῦ μορίου ἐλθόν (*Gen. an.* 764a6 = A 143), would determine the sex of the baby; thus the atomistic view is opposed to Empedocles', also quoted by Aristotle, in that the heat of the uterus is decisive.⁵² Significant in this respect is a passage from Philoponus' commentary on Aristotle's *De anima* (Philopon. in *Aristot. De an.* XV 67.30: the passage commented on is *De an.*

⁵⁰ On this Aristotelian passage, see also Jaulin in this volume, p. 263.

⁵¹ Althoff (1999) 90.

⁵² On these Aristotelian passages see Althoff (1999) 78ff., 90ff.

A 2, 404a1 πανσπερμίαν στοιχεῖα λέγει τῆς ὅλης φύσεως, scil. Leuc. and Democr.): πανσπερμίαν φησὶ τὸ πλῆθος τῶν σχημάτων· ὥσπερ γὰρ ἐν τῇ πανσπερμίᾳ ἐστὶν ἐν τῷ σωρῷ καὶ σῖτος καὶ κριθή καὶ τὰ ἄλλα σπέρματα, οὕτω καὶ ἐν τοῖς ἀτόμοις πανσπερμίαν εἶναι τῶν σχημάτων. ταύτης δὲ τῆς δόξης φησὶν εἶναι καὶ Λευκίππον· ἑταῖρος γὰρ ἦν Δημοκρίτου ('he [scil. Democritus] calls *panspermia* the figures as a whole. As indeed in the *panspermia* of a pile of corn there are wheat and barley and other seeds, so also among the atoms there is a *panspermia* of figures. He says that this is also Leucippus' opinion, for he was a fellow of Democritus').

As we have seen, with the fruitful extension to biology of concepts related to his atomistic view of matter, starting with the concept of atom, Democritus could establish a minimum morphological unit which was essential to his physicism. To this he added an aetiological angle, as Aelian remarks (VI 60 = A 150a), who reproaches Democritus and his colleagues for having looked for causes without any suitable basis (this was inconsistent with Aristotle's critique of the atomists—that they had given up any deserved causal investigation—but he was speaking more generally and not with regard to individual events). But such an angle⁵³ must be looked for not only the way Aelian does, in the explanation of individual phenomena, nor is it very evident indeed in the few Democritean remains of zoological interest. An 'aetiology', in this sense, is also found in the writings attributed to Hippocrates, or, perhaps in a simpler form, in Herodotus or Hecataeus (cf. *FGrH* I F 302a) or Ctesias (cf. *FGrH* 688 F 46a). Though with regard to Democritus it is proper to speak of various levels of αἰτιολογία,⁵⁴ and to abandon a reductionist logic tracing everything back to atoms and void, nonetheless, in the case of zoology this perspective should be appraised as a more general framework, as an overall method of interpreting reality, according to the criterion οὐδὲν μάτην, ἀλλὰ πάντα ἐκ λόγου τε καὶ ὑπ'ἀνάγκης.

In Democritus, a more developed methodical awareness is added to an already established observational heritage, which is seen from a definite angle, viz. the atomistic one. The novelty of his contribution lies in the attempt to locate the zoological level within his broader view, so as to make an organic unity out of his investigations. Already established notions, traditional knowledge, new discoveries or hypotheses—

⁵³ Recently investigated by Morel (1996), see also (2000).

⁵⁴ Morel (1996) 28f.

in themselves rarely decisive—acquire a new meaning in that they are adapted to the atomistic theory. A visible sign of this is in the persistence of a peculiar linguistic use, even in scarce or not always linguistically reliable sources. For example, the occurrence of such terms as ἐκθλίβειν (A 153, Aelian) referring to horns; the whole description of this phenomenon in terms of an outcropping of substances thanks to the fine and porous (ἀραιόν) character of the bony base; the συμμένειν, usually typical of atoms, referring to the embryo in A 152 (Aelian), as well as hot/cold alternation (referring to atoms in A 49, Galen, as θεομαίνεσθαι—ψύχεσθαι), or ἀντίτυπος, which is said of atoms in A 66 (Ps.-Plutarch), and of the bovid's cervical bone in A 155 (Aelian). We must proceed with due caution, as all the evidence is indirect and the terms also occur in other authors. Their combined presence in Democritus suggests, in any case, a not insignificant arrangement.

The direct association of the concept of the atom with that of seed, and the use of embryological analogies to explain cosmological phenomena, give precise hints concerning the reception of Democritus' doctrine in antiquity. The most revealing example is perhaps to be found in the first book of Lucretius' *De rerum natura*. It can be said that Lucretius, following Epicurus and atomism, recognizes no other meaning of the terms and concepts of biology than that of a more adequate description and understanding of the origin and 'physiological' processes of the universe. His work opens, right from the first lines after the proemial Hymn to Venus, with a precise parallel between the elementary cosmic particles and the seeds of animal and human generation, which is described by means of terms and phenomena typical of biology, concepts like the one of *genitalia corpora* and *semina rerum* (I 58f.), or the *genitali / concilio* of lines 182f., and the evocative sequence *creet, auctet alatque* of I 56. Lucretius wants to demonstrate not only that nothing is generated from nothing, but also that things can only be produced by particular seeds. The reference to the technical terms of biology is never abandoned, and occurs also in Cicero (*nat. deor.* II 81,14), where the *semen* is described as something such *ut id, quamquam sit perexiguum, tamen, si inciderit in concipientem comprehendentemque naturam nantumque sit materiam qua ali augerique possit, ita fingat et efficiat in suo quidque genere, partim ut tantum modo per stirpes alantur suas, partim ut moveri etiam et sentire et appetere possint et ex sese similia sui gignere*.⁵⁵ This kind of argument is trans-

⁵⁵ Cf. Schrijvers (1978).

ferred by Lucretius to elementary particles in general, after his having identified them with the seed.

Lloyd remarked (1966, 245 ff.) that Anaxagoras' theory of σπέρματα acted as an important precedent in the deliberate reliance on a biological model in order to develop a general physical theory, and that a concept such as that of πανσπερμία had not only a technical value to express the pangenetic view, but also the purpose of describing the mixture of elementary particles: 'In spite of the problems of interpretation which Anaxagoras' theory presents, the doctrine of seeds seems to be an important instance of the deliberate application and adaptation of a biological model to a general physical theory. Like Anaxagoras, and conceivably under his direct influence, the Atomists seem to have used an image of seeds, or rather of a 'seed-mixture', in connection with the primary substance, the atoms themselves' (p. 247). Not incidentally, in Epicurus the word σπέρμα occurs as a technical, atomistic term in three cases, with no hint of its biological implications. Lucretius' entire first book attests to the analogy between biological phenomena and cosmology: this evidently was the most remarkable contribution of atomism according to the ancients.

I regard as quite to the point, as well as in accordance with Democritus' case, what has been observed about the relationship between natural science and natural philosophy (or 'physiology') in the times before Aristotle:⁵⁶ 'Wir wissen, daß in voraristotelischer Zeit die Naturwissenschaft im allgemeinen biologische, genauer gesagt, zoologische Beobachtungen *nur dann zur Kenntnis nahm, wenn sie für naturphilosophische Theorie von Belang waren. Zoologische Beobachtungen als solche wurden nur in der die empirischen Bedürfnisse berücksichtigenden Literatur ausgewertet* [i.e., technical and, especially, medical literature], während sie für die in dieser Zeit betriebene Naturwissenschaft von sekundärer Bedeutung blieben' (italics are mine). Democritus is not a zoologist, nor do his observations in themselves, as far as we can judge, offer a very original contribution. In this field, his role appears to be philosophical rather than scientific; he contributes to it with a positive drive, more than with a specialist's technical engagement.

⁵⁶ Harig and Kollesch (1974) 28.

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