



THE CLASSICAL ERA: SCIENCE BY DIVISION

The history of the species concept can be divided into a prebiological and a postbiological history, which is how the Received View has always treated it. But the two histories overlap substantially, and it is much better to consider instead the history of the species idea that applies to any objects of classification—the tradition of universal taxonomy and philosophical logic—and, independently, the particular history of the species idea that applies solely to biological organisms. Even though, for example, Linnaeus [Linne 1788–1793, vol. 3] famously applied the notion *species* to minerals as well as organisms, his biological usage included elements not included in the mineralogical case. We must separate universal and biological taxonomic notions of species.¹

So we will distinguish between two kinds of taxonomy. The *universal taxonomy* is largely the philosophical tradition from Plato to Locke (but which continues through to the considerations of sensory impressions, or *qualia*, by the logical positivist and phenomenological philosophical schools) and in which species are any distinguishable or naturally distinguished categories with an essence or definition. Then there is the *biological taxonomy* that develops from this tradition as biology itself develops from the broader field known as “natural history.”² These biological notions of species do not necessarily refer to reproductive communities, nor do they in the medical definitions of species of diseases of the period [Cain 1999b], but we do need to recognize that “species” develops a uniquely biological flavor around the seventeenth century.³

These two conceptions form what might be regarded as part of or an entire research program, in Lakatos's sense. The universal taxonomy program that began with Plato culminates in the attempt to develop a classification of not only all natural objects but all possible objects. It continues in some sense in the modern projects of metaphysics and modal logics. The biological taxonomy project that developed out of it resulted in a program to understand the units of biology, to which Darwin contributed, and to which genetics later added. We might see *species* as a marker for both projects. Seen in that way, we might reasonably ask what the core assumptions of these projects are. In the universal case, it is classification (and science) by division. In the biological instance, it is, as I will argue, the marriage of reproduction or generation, with form, which I call the "generative conception." This remains even today the basis of understanding *species*.

The general philosophical tradition of considering classification to be an indispensable aspect of science seems to end with Mill and Whewell (a point noted by Hull, personal communication), and although I have found later discussions on classification in Peirce and as late as 1873 in Jevons [1878], the revivification of taxonomy in philosophy of science in recent decades appears, with one exception [Woodger 1937], to be driven by biological systematics itself rather than through philosophy motivating biology. As a result, the philosophical foundations of taxonomy are critically incomplete, and systematists often rely on philosophers who disregard the matter almost entirely, like Popper [who only mentions it dismissively in Popper 1957b §27; Popper 1959: 65; as noted by Hull 1988c: 252].

TERMS AND TRADITIONS

The modern and medieval word *species* is a Latin translation of the classical Greek word *eidos*, sometimes translated as "idea" or "form." Other significant terms are also translations of Greek terms (see table): *genus* from *genos*, *differentia* from *diaphora*. Liddell and Scott [1888] tell us that *eidos* means "form," and is derived from the root word "to see," and *genos* means "kind" and is derived from the root word "to be born of." We still find these senses in the English words *specify*, *special*, *spectacle*, *generation*, *gene*, and *genesis*. *Diairesis* or "division" is an interesting term that will play a major role in our story. Another Greek term that is later adopted by the Latins is *synagoge* or, in Latin, *relatum*. *Relata* are those features by which things group together. *Essentia*, the Latin

SOME GREEK TERMS AND
THEIR TRANSLATIONS

Greek word, plural form	Classical meaning [Liddell and Scott 1888]	Latin translation	English translation
<i>Eidos, eidē</i>	That which is seen, form, shape, figure; a class, kind or sort.	<i>Species, forma</i>	Species, idea, kind, sort (Locke), form
<i>Genos, genē</i>	Race, stock, family. A generation.	<i>Genus</i> (pl. <i>genera</i>)	Genus, kind
<i>Diaphora</i>	Difference, distinction, variance, disagreement	<i>Differentia</i> (pl. <i>differentiae</i>)	Difference
<i>Diairesis</i> <i>Synagoge</i>	A dividing, division A bringing together; a conclusion	<i>Divisio</i> <i>Relatum</i> (pl. <i>relata</i>)	Division Relation, affinity

term used for “essence,” is a neologism for a phrase used by Aristotle, the “what-it-is-to-be.” The Latin term *substantia* is occasionally translated as “essence” in natural historical works, but this is a mistake that can mislead.

However, merely because words derive their etymology from older terms or translate words in other languages, it does not immediately follow that they are the same terms with the same intension or extension, or that one author is influenced by another. By *eidos* and *species*, for example, different authors have meant *forms, kinds, sorts, species* [in the logical sense of nonpredicables; Ross 1949: 57], *biological species, classes, individuals, and collections*, both arbitrary and artificial, or natural and objective. In particular, *species* has meant both varieties of ideas and sense impressions, *species intelligibilis* [Spruit 1994–1995], and also the material form of the elements of the sacraments in the Roman Catholic tradition. This must be borne in mind, or it will cause confusion when we consider the views of different authors. This is an instance of a more general problem, called “incommensurability” after Kuhn’s thesis that terms in scientific theories can have different referents in the shift from one theory to another; Sankey [1998] has called this particular problem “taxonomic incommensurability.” We should not make too much of this, but the terms used in classification shift in subtle and major ways that sometimes obscure the views each author is presenting. We are primarily

concerned with the tradition outside biology that *has* impacted on the biological notions and usage.

The English plural of *species* singular is *species*. The word *specie* refers to small coinage. However, in Latin there is a singular (*species*) and plural form (*speciei*), which is signified in one text [Porphyry 1975] by italicizing the ending thus: “*species*.” This is clumsy for the purposes of this book, so here I will follow the rule of the biological writers of the past century and refer to “the” species or italicize the entire word for the concept and leave the term unqualified for number except by context.

For the period from the Greeks to the beginnings of natural history in the sixteenth and seventeenth centuries, it may help to follow Locke’s suggestion (discussed later), to get a feel for the meanings and avoid anachronistic interpretations, by replacing *genos* and *genus* with “kind” in English, and *eidos* and *species* with “sort.” Thus, the informal usage of, say, Theophrastus in talking indifferently about *genē* and *eidē*, can be seen as the same sort of informal usage an English speaker might make by stylistically mixing “kind” and “sort” in a discussion to avoid repetition. It is imperative to remember that these were not technical terms of biology until the modern period, in particular after Linnaeus.

PLATO’S DIAIRESIS

As the Hellenic world began the process of expanding and consolidating, early Hellenic philosophers, known as the Milesians, had in the sixth century BCE begun to grapple with the problem of change—of generation and corruption—and what that meant for knowledge. This was essentially the core problem of Greek philosophy, for on it rested the entire conception of the possibility of the knowledge of Nature (*phusis*).

Anaximander argued that the world was composed of a single eternal substance, the *apeiron* (the unbounded), and that the world was only superficially changing. The Pythagoreans presumed that the foundation of the world was Number, and a table of contraries described by Aristotle in the *Metaphysics* 986a15 (limited-unlimited, one-many, odd-even, light-dark, good-bad, right-left, straight-curved, male-female, square-oblong, rest-motion) accounted for the world [Brumbaugh 1981: 36]. Later, Heraclitus famously asked if you could step into the same river twice, as the river changed from step to step (although he is often misunderstood to answer in the negative; rather, he thought there was

something eternal that preserved reference, noting that “Nature loves to hide”; fragment 10). And so on. Various philosophers attempted to divide the world into its constituent elements and the eternal forms of reality. This led to the idea of classification, through the uncovering of the eternal *logos*, a term or class or order.

Classification was at this time uncritically applied to all things, whether artificial or natural (a distinction the early Greeks would not have fully accepted anyway) and whether conceptual, semantic, or empirical. The problem of how to properly classify things, including living things, is first recorded to be dealt with in detail by Plato in the *Sophist* [219a–221a]. Plato, regarded by many later thinkers, particularly in the Renaissance, as *The Philosopher*, founded the philosophical school known as the Academy in Athens. He proposed a method of binary division of contraries until the object being classified was reached; this was known as the *diairesis* (division or, as some call it, dichotomy), in a similar fashion to the Pythagoreans.⁴ For example, he somewhat whimsically defined fly-fishing as a model for all such classification. He has the Stranger of the dialogue ask leading questions, such as whether the fisher has skill (*techné* = art) or not, defining art into two kinds: agriculture and tending of mortal creatures, on the one hand, and art of imitation, on the other. Later he introduces a fairly arbitrary distinction about acquisitive art, resulting in the following “final” definition of angling:

Stranger: Then now you and I have come to an understanding not only about the name of the angler’s art, but about the definition of the thing itself. One half of all art was acquisitive—half of the acquisitive art was conquest or taking by force, half of this was hunting, and half of hunting was hunting animals, half of this was hunting water animals—of this again, the under half was fishing, half of fishing was striking; a part of striking was fishing with a barb, and one half of this again, being the kind which strikes with a hook and draws the fish from below upwards, is the art which we have been seeking, and which from the nature of the operation is denoted angling or drawing up (*aspalientike, anaspasthai*). [Jowett’s translation]

As Oldroyd summarizes it [1986: 42], for Plato “angling is a coercive, acquisitive art, carried out in secret, in which live animals living in water are hunted during the day by blows that strike upwards from below!” (figure 1). In addition to division, Plato also classified by grouping (*synagoge*), so that he divided things and grouped them according to their differences and similarities [Pellegrin 1986]. Plato’s classification style

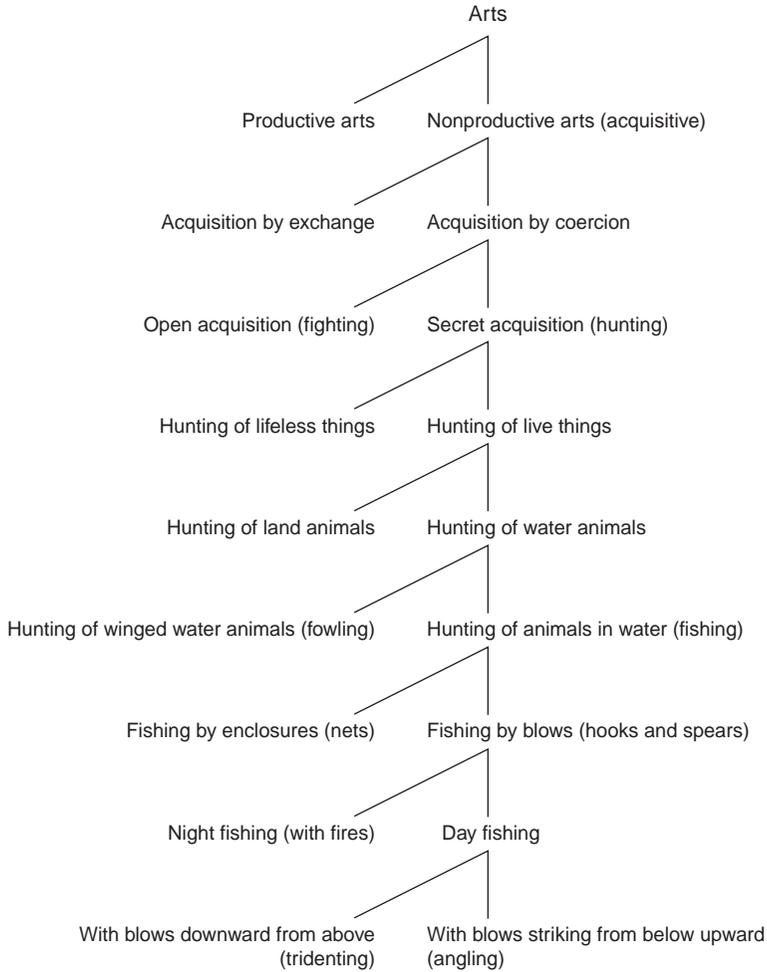


Figure 1 Plato’s classification of angling

here is clearly arbitrary. In order to force the division into dichotomies, he (through his “Stranger”) selects the “right” connections for the next differentia, but nothing is obvious about these steps, and it is clear that he knows ahead of time what he wants to deliver. In short, this is question begging, a party trick not unlike his “showing” that a slave boy “remembered” the proof of Pythagoras’s theorem in the *Meno* [82b–85b].

Plato does not distinguish between classification of natural things and artificial things. For him (or, rather, his protagonist Socrates), issues of justice and social order are on a par with, and in fact transcend,

issues of the natural world. Plato shows little deep interest in any aspect of the terrestrial world [Kitts 1987], although the heavens, being as close to the eternal as possible, are recommended as philosophical objects of study [*Timaetus* 27d–34b].

Clearly, there is considerable detail to Plato's views of Form or Idea (*eidos*) that must be passed over here, but this is a well-understood field of history of philosophy, and as it is entirely outside the scope of the present treatment, I am forced to avoid it.⁵ For Plato the *ideai* were metaphysical or ontological realities that were neither changeable nor in the transitory world and that were preconditions for knowledge. This is the commencement point for the later tradition of forms as the basis for classification we find in Aristotle—for instance, the famous “carve nature at its joints” passage in the *Phaedrus* 265d–266a:

Socrates: The second principle is that of division into species according to the natural formation, where the joint is, not breaking any part as a bad carver might. [Jowett's translation]⁶

Socrates then says he is a great lover of division and generalization, and follows anyone who can see the “One and the Many” in nature. Note, however, that Socrates includes human society in the term *nature* here.

Nelson and Platnick [1981: 67f.] quote a passage from Plato's *The Statesman* [262d] in which Plato presents an argument against incomplete groups that is similar in many ways to Aristotle's argument against privative groups given in the next section, but this point is not mediated to later writers on logic. As Hull [1967: 312] observes, Plato's direct influence on biology is late, not until the seventeenth century. Indirectly, though, is another matter, as I will argue later.

ARISTOTLE: DIVISION, AND THE GENUS AND THE SPECIES

If, as Whitehead said, Western thought is a series of footnotes to Plato, then biological thought is a series of footnotes to Plato's onetime pupil Aristotle, a fact also noted by Darwin shortly before his death, when, in a letter to William Ogle thanking him for a copy of his translation of Aristotle's *Parts of Animals* on February 22, 1882, he wrote, “From quotations which I had seen I had a high notion of Aristotle's merits, but I had not the most remote notion what a wonderful man he was. Linnaeus and Cuvier have been my two gods, though in very different ways, but they were mere school-boys to Aristotle. I never realized before reading

your book to what an enormous summation of labor we owe even our common knowledge.”⁷

Aristotle traveled widely throughout the Hellenistic world, tutoring the young Alexander before he became Great. He therefore lived at a time of increased travel and trade, as well as during the flowering of Greek thought and science. As such, he was able to access a great deal more information than had, for instance, the Presocratics. As Hull [1988c: 75–77] notes, we may quibble over whether Aristotle was a scientist, but that he behaved like one is not at issue. A large part of Aristotle’s poor reputation results from the rhetoric of the Renaissance humanists, who sought to downplay the worth of the leading contemporary source of Scholastic philosophy and theology.

Aristotle wrote several works of a biological nature, the most prominent for our purposes being *On the Parts of Animals*, *The History of Animals*, and *On the Generation of Animals*, which came in the later medieval period, after being translated into Latin, to be known as the *Liber Animalium*.

In his formal works, he employed the logical notions *genos* (genus), *eidos* (species), and *diaphora* (differentia) [Pellegrin 1986]. These were not special biological notions; in fact, they were part of his project of a wider classificatory logic, outlined in the *Metaphysics*, the *Categories*, and the *Posterior Analytics*. However, Aristotle was not an abstract philosopher, as he and his school undertook a number of dissections to establish the facts about many animals, although many of these texts seem not to have survived [Lennox 2001, chapter 5]. It does seem that Aristotle was not undertaking anything we would consider taxonomy, though, preferring a more teleological or finalist approach to classification of living things, and generally classifying when he did under habitat (land dwelling, water dwelling, and air dwelling) rather than morphology [ably reviewed in detail, with an attempt to reconcile the biological practice with the views expressed in the more technical works, by Charles 2002, chapters 8 and 9].

He was quick to point out a problem with the simple Platonic method of dichotomous classification, although he did not reject the idea of division as such [Pellegrin 1982, 1986]. Many of the categories used in a Platonic diairetic classification were what Aristotle called “privative” categories—defined in terms of what they were *not*, rather than what they were. He proposed instead a method of the decomposition of broader categories into parts on the basis of how the parts differed, but he did not require that each division had to be a dichotomy, as Plato and the Academicians had. There could be many parts in each category. In the

Posterior Analytics [96b15–24], he says, using the term *infimae species* for the most specific division of a topic:⁸

The authors of a hand-book on a subject that is a generic whole should divide the genus into its first *infimae species*—number e.g., into triad and dyad—and then endeavour to seize their definitions by the method we have described. . . . After that, having established what the category is to which the subaltern genus belongs—quantity or quality, for instance—he should examine the properties ‘peculiar’ to the species, working through the proximate common differentiae. He should proceed thus because the attributes of the genera compounded of the *infimae species* will be clearly given by the definitions of the species; since the basic element of them all [note: *sc.* genera and species] is the definition, i.e. the simple *infimae species*, and the attributes inhere essentially in the simple *infimae species*, in genera only in virtue of these. [McKeon 1941]

This method came to be known in the Middle Ages as *per genus et differentiam*⁹—“by the general type and the particular difference.” Something that was differentiable within a *genus* was known to the Western tradition as a *species*. In Scholastic philosophy, *species* represented a range of things we would now call propositions, sense impressions, and so forth, and this usage persisted through Leibniz to the philosophical discussions of Kant, Mill, and Russell. However, initially a species was merely something that could be differentiated out of a more general concept or term. In the *Topics* [101b16–25], Aristotle defines four “predicables” (that which is predicated of things): definition (*horos*), property (*idion*), genus, and accident (*symbebekos*). Species (*eidos*) is not, in Aristotle’s list, a predicable, because it is only true of individuals. This list came to prominence again briefly in the fourteenth-century debates on logic (discussed later).

He extends his discussion in the *Metaphysics* in book Z, chapter 12 [1037b–1038a], by asking what it is that makes *man* (the logical species) a unity instead of a “plurality” such as *animal* and *two-footed*. He argues that the differentiae of a genus can lead to its including species which are polar opposites in their specific differences, but, with respect to the genus itself, there is no differentiation. This makes sense only if each genus is divided further in terms other than the predicates that define the genus. Furthermore, he rejects Plato’s dichotomous approach, saying that “it makes in general no difference whether the specification is by many or few differentia, neither does it whether that specification is by a few or by just two.” Therefore, he asks whether the genus exists “over and above the specific forms constitutive of it” and answers that it doesn’t matter, because the definition is “the account derived just from the differentiae.” In the end, we reach the “form and the substance,” the last differentia,

unless we use accidental features, in which case we will find that we have an incorrect division as evidenced by the differentiae being “equinumerous with the cuts.” In short, a species is the form and the substance of the immediately preceding genus, when we reach the last differentia.

It is sometimes held that for Aristotle all classification was in terms of absolute definition and essence, and often this is true. But he did allow for an excess or deficiency of some organs or properties of organisms in the *Parts of Animals* [e.g., 646b20], and in the *Rhetoric*, one of the main topics or lines of argument was “the more and the less” [1358a21]. In the eighth book of the *Metaphysics* (Book Iota), he even says, “[I]t is important to understand the kind of differentiation, given that they are the principles of the beings of things. Some things, that is, are marked out by being more or, conversely, less F, by being dense, say, or rare and so forth, which are all instances of the surfeit/deficiency differentiation” [1042b, Lawson-Tancred translation;¹⁰ Aristotle 1998].

Similarly, in the *History of Animals* [486a–486b], he discusses differences being more or less the same property in respect of the genus and, “in short, in the way of excess or defect,” “for the more and the less may be represented as excess and defect” [D’Arcy Thompson translation, Barnes 1984]. Species of birds and fish, for instance, may not properly instantiate their genus. The more and the less, however, refer to aspects of the *eidos* that can vary over a range and that can be important for the organism’s life [Lennox 2001: 178]. The range is precise and forms part of the differentia of that species.

In *The Parts of Animals*, Aristotle discusses why privative terms are not proper to classification [Book I, chapter 3, 642b–643a]. He says that you cannot properly further divide a privative term, and that precludes it from being a generic (that is, general) term. Worse, a privative classification can include the same group under contradictory terms. Classifications, according to Aristotle, must say something direct and clear. Dividing the world into things that are, and aren’t, describable by some predicate is at best only a partial classification, and the taxa that result are not good divisions of the broader genus. Some things that fall under a privative term must be species, but there is no genus out of which those species can be differentiated, and so the privative “genus” is illusory. Plato’s mistake was, he thought, to assume that classifications must be made in terms of polar opposites.¹¹ Aristotle was saying, as we would now describe it, that classification must always be cast in terms of proper sets and subsets. Partial inclusion is not legitimate in a good classification, in effect because it does not make proper sets.

It is traditionally held that Aristotle was inconsistent in the way he used *genos* and *eidōs* between the logical and the biological writings [e.g., Mandelbaum 1957], but recent work by Pellegrin, Balme, and Lennox has shown otherwise [Balme 1987a; Lennox 1987, 1993, 1994, 2001; Pellegrin 1986, 1987]. In part, the problem arises because the common view rests mainly on the postmedieval concepts that, we shall see, are derived out of the later neo-Platonic revision of Aristotelian logic. Aristotle is only inconsistent if understood to use the term *eidōs* as a technical term in the same way in the logical works as he does in the context of biology, and he doesn't.

Pellegrin says that Aristotle was not aiming to produce a biological taxonomy in *History of Animals*. Instead, he was producing general classifications, and animals happened to be one domain in which he applied that method. What Aristotle treats as genera and species do not answer directly to the modern, post-Linnaean, conceptions of species, although this has sometimes been the default interpretation. We have seen that for him a species is a group that is formed by differentiating a prior group formed by a generic concept. Genera have essential predicates (or definitions), and so do species. Infimae species happen to be indivisible, that's all. In this respect, biological species are no different to any other kind. Pellegrin says, "Aristotle thus conveys by the term *genos* the transmissible type that in our eyes characterises the species, and by *eidōs* the model that is actually transmitted in generation. It would be necessary for these two terms to converge and become superimposed for the modern concept of a species to be born. For Aristotle, the [biological] species did not yet exist" [1986: 110].

Pellegrin argues that Aristotle's disagreement with Plato is not that classification by division is wrong, but that one should not proceed by dichotomous division into groups that are defined by a differentia and its contrary. He notes [p. 48], "Although Aristotle condemns dichotomy as used in the Academy, and does so in all the relevant texts, he does not reject division." For Aristotle, he says, the (infimae) species is a group, and is merely the least divisible group, or, in other words, the least inclusive classification. However, in the later logical tradition from which Ray, Linnaeus, and others borrowed their systematic ranks, the smallest *group* category was the genus.¹² *Homo* was a species for them because all present men (women being included) were descendants of a single pair, Adam and Eve. Linnaeus's binomial nomenclature of the genus name and species epithet, as in *Homo sapiens*, was intended, like a personal name, to give the group (the surname, as it were) and a uniquely referring name

of that individual parental pair (and their descendants). This distinction must be borne in mind to prevent eisegesis.

Aristotle used the term *universal* to mean any term (predicate) that covered several things. In *On Interpretation* 17a–17b [Edghill translation, Barnes 1984; see also *Prior Analytics*, 24a], he says, “Some things are universal, others individual. By the term ‘universal’ I mean that which is of such a nature as to be predicated of many subjects, by ‘individual’ that which is not thus predicated. Thus ‘man’ is a universal, ‘Callias’ an individual.” A universal need not therefore be something that is literally universally true, but a general term that is predicated of many things. It is important to bear this in mind when discussing the “universals debate” and the question of the individuality of species. A universal is any term that covers two or more subjects.

Aristotle’s biological works and those of his student Theophrastus (discussed in the next section) also strongly influenced the later development of biology, and in particular early botany, but one particular doctrine was most influential: the doctrine of the souls of living things in *De Anima*. Soul (*psyche*) here means something like “motivating force”—plants have only a “nutritive soul” [413a21–35, 414a30], animals also have a “sensitive soul” capable of sensation [413b4–9, 414b3], and hence they must have an “appetitive soul,” as do all organisms capable of sensation, because they must have some desire [413b21–24, 414b1–15]. Some animals have in addition a “locomotory soul” [413b3, 414b17, 415a7] and one of those, Man, alone also has the power of rational thought, or a “rational soul” [415a7–12]. Soul is the source of movement and growth, and it is the final cause of those faculties [415b9–27], that for which things are generated. This forms the foundation for the later Great Chain of Being tradition, as we shall see, and it was the foundation for the initial classifications and explanations of Cesalpino and Bauhin [Sachs 1890].

Aristotle has thus developed what we might think of as “science by definition.” If one can define the proper attributes of a thing and what divides it from other universals, then one has understood and explained it. All those who attempt this method of science prior to the seventeenth century are in effect practicing Aristotle’s method. As a result, the terms *genos* (*genus*) and *eidōs* (*species*) come to have several senses based on the notion of differentiating out the special classes from the general. This has given some historians of biology, particularly those writing from a modern scientific perspective, considerable trouble.

Two issues arise. One is whether Aristotle thought that species were immutable, and the other is whether Aristotle was an essentialist with

respect to species. Lennox [1987, 2001] holds that Aristotle did not depend on species being eternal in the biological sense, that they were not fixed. They could come into being and pass away. But the *kinds* (*genē*) do not come into being and pass away [Lennox 2001: 154]. They are formed by virtue of having the differentia that distinguish them from their superordinate genus. To this extent, then, he is an essentialist and a fixist of kinds. But I do not think it is correct to saddle him with being a species (biological species) fixist. In a telling passage in *Generation of Animals* II.1 [731b24–732a1], he notes that while individuals cannot be eternal, as they are subject to generation and corruption, he admits that if anything can be eternal on earth, it is the *eidos* of men and animals. Note that he admits only the *possibility* rather than the necessity.

In *History of Animals*, Book VIII, chapter 28 [605b22–607a7], Aristotle discusses what will produce variety in animal life—the main cause is locality, including climate. In Africa (“Libya”), “animals of diverse species meet, on account of the rainless climate, at watering-places, and there pair together; and such pairs will breed if they be nearly of the same size and have periods of gestation of the same length” [Barnes 1984]. Zirkle [1959: 640] says that Aristotle insisted that such hybrids were fertile, but it is unclear from the context exactly how different these diverse species were supposed to be. He goes on to say, “Elsewhere also offspring are born to heterogeneous pairs; thus in Cyrene the wolf and the bitch will couple and breed; and the Laconian hound is a cross between the fox and the dog.” He then reports that “they” say that the Indian dog is a bitch-tiger third-generation hybrid. If we allow that for Aristotle “species” here does not mean a strict biological species and that travelers’ tales are misleading him, he is not so obviously a mutabilist, either. Certainly he is restricting the amount of hybridization here.

As Lennox notes [2001, chapter 5], there is a great gap in practical biology between Aristotle and Theophrastus, and Albertus Magnus’s *De Animalibus* in the twelfth century. However, there continued to be philosophical treatments of the idea of division in living things throughout the remainder of the classical period.

THEOPHRASTUS AND NATURAL KINDS

Theophrastus (370–c. 285 BCE) in his botanical work *Enquiry into Plants* (*Peri phutōn historias*) [Theophrastus 1916] applies Aristotle’s notions of classification to the wealth of new specimens being returned to the Greek empire of Alexander from the new conquests. He is the first known

author to classify plants in an overall system and may thus be thought of as the first botanical systematist. His translator, Sir Arthur Hort (one of the translators of the first critical edition of the Greek New Testament), notes that Theophrastus's botanical work is guided by a "constant implied question . . . 'what is its *difference*?', 'What is its essential nature?', viz. 'What are the characteristic features in virtue of which a plant may be distinguished from other plants, and which make up its own 'nature' or essential character?'" [p. xviii]. In short, Theophrastus is applying Aristotle's notion of classifying into *differentia*.

He may not have studied all the plants himself. Some descriptions, such as of the cotton plant, banyan tree, cinnamon bush, and so forth, are taken from reports by Alexander's followers who were trained observers. Still, what is most significant about Theophrastus in this context is that his method of classification was an attempt to discover the underlying essence of the kinds of plants based on evidence. His differentiations are almost entirely based on anatomical features of the organisms, although he also allows the habitat (locality) to be employed—for instance between water dwellers and land dwellers. He says, "Now it appears that by a 'part' [*meros*] seeing that it is something which belongs to the plant's characteristic nature, we mean something which is permanent either absolutely or when it has appeared (like those parts of animals which remain for a time undeveloped) permanent" [I.1.ii].

But this is unsatisfactory, because some crucial diagnostic characters, like flowers, inflorescences, leaves, fruit, and so forth, and the shape of the shoot itself, are all temporary or seasonal. He concludes that the characteristics, or "parts," should be chosen from those that are most directly concerned with reproduction [I.2.2]. After setting out the parts he will use (branch, twig, root), he says, "Now, since our study becomes more illuminating if we distinguish different kinds (*eidē*), it is well to follow this plan where it is possible. The first and most important classes, those which comprise all or nearly all plants, are tree, shrub, under-shrub, herb" [I.3.1], Elsewhere, in VI.1.2, he says "Now let us speak of the wild kinds. Of these there are several classes (*eidē*) which we must distinguish (*di-airain*) by the characteristics of each sub-division as well as by those of each class (*genos*) taken as a whole (*tois holois eidesi*)." In the case of the dwarf palm (II.6.10), he distinguishes it as a different *genos* from the ordinary palm.

The translator, Hort, notes in a footnote that Theophrastus "uses *eidōs* and *genos* almost indiscriminately. Here *tōn holōn genōn* means the same as *tois holois eidesi*; and below *genōn* and *eidōn* both refer to

the smaller divisions called *merē* above.” Theophrastus is attempting, in a nonsystematic and perhaps less careful manner, to apply Aristotle’s philosophy of classification to botany, but he uses these terms in a more vernacular sense of “form” and “race” or “stock.” In any case, his theory of classification, if it can be called that, is morphological and seeks in this the “nature” of the plants. *Species* as such has no special meaning for him here. To back up this interpretation, note that in his *Metaphysics* [Theophrastus 1929], he offers the same view as Aristotle: “Knowledge . . . does not exist without some difference (*diaphoras*). For if things are other than one another, there is difference; and within universals (*katholou*), the things that fall under the universals being more than one, these too must differ, whether the universals are genera or species.” In particular, he asserts that this is how science is done: “in general it is the task of science (*epistēmēs*) to grasp what is the same in several things, whether it is asserted of them in common and universally or in some special way with regard to each, e.g., of numbers and lines, of plants and animals; complete science is that which includes both these kinds.”

Zirkle [1959: 639] says that Theophrastus spent the entirety of Book II showing how species could change from one to another. Given the informal way in which Theophrastus talks about species, we might consider this doubtful. In fact, what he talks about there is generation (including spontaneous generation), “but growth from seed or root would seem most natural” [II.1.1; see also Book I of *De causis plantarum*, 1.2–3, 5.1–2, but he notes that this is sometimes from “unnoticed seeds” in 5.3 and 5.4], and especially vegetative propagation. Zirkle appears to be referring to the “degeneration” of some cultivars into wild forms [e.g., II.2.5]. The oak sometimes “deteriorates from seed” [II.2.6, cf. *De causis plantarum*, 1.9.1], for example, so that the child is unlike the parent. Sometimes wild trees like pomegranates, figs, and olives can spontaneously change into a domestic form and vice versa [II.3.1], and so on. It is a very long stretch to call these changes of species. In modern terms, these would either be due to genetic expression of latent varieties, or somatic mutation and development.

One case that is ambiguous is the change from one-seeded wheat and rice-wheat in the third generation when they are bruised (in seed form?) before they are sown [II.3.4], but then he says that “[t]hese changes appear to be due to change of soil and cultivation” and seasonal variation. He does say, as Zirkle noted, that “the water-snake changes into a viper, if the marshes dry up,” but it is unclear he thinks this is a species change

in our sense. Instead, “when a change of the required character occurs in the climatic conditions, a spontaneous change in the way of growth ensues” [II.4.4]. This is hardly a claim of mutability of species. The remainder of the book consists of a discussion of transplanting, grafting, watering, and planting. He does note that fruit trees are male and female [II.6.6]. Another case is the widely held view that gall wasps come from the seed of the wild fig [II.8.1–2], which causes their fruit to drop, and he also follows Aristotle on the spontaneous generation of animals when the earth is warmed and “qualitatively altered” by the sun [*De causis plantarum* I.5.5]. These are all that I can find that match Zirkle’s claim. It will pay to be skeptical of the oft-repeated claim that species were *always* held to be changeable before the seventeenth century.

EPICUREANISM AND THE GENERATIVE CONCEPTION

The Aristotelian and Platonic traditions were not the only ones in the classical period that dealt with species. The atomists, and in particular the Epicurean tradition, also had an account of why forms are as they are. Epicurus’s (341–270 BCE) own writings are largely lost, in particular his *On Nature*. However, we have a full account of the Epicurean doctrines in the work *On the Nature of Things* by Lucretius, a first-century BCE Roman disciple of Epicurus. Lucretius tied specific natures of things to the ways in which they came to be:

If things could be created out of nothing, any kind of things could be produced from any source. In the first place, men could spring from the sea, squamous fish from the ground, and birds could be hatched from the sky; cattle and other farm animals, and every kind of wild beast, would bear young of unpredictable species, and would make their home in cultivated and barren parts without discrimination. Moreover, the same fruits would not invariably grow on the same trees, but would change: any tree could bear any fruit. Seeing that there would be no elements with the capacity to generate each kind of thing, how could creatures constantly have a fixed mother? But, as it is, because all are formed from fixed seeds, each is born and issues out into the shores of light only from a source where the right ultimate particles exist. And this explains why all things cannot be produced from all things: any given thing possesses a distinct creative capacity. [Lucretius 1969: 38, Book I, 155–191]

It is commonly understood that Lucretius gives a more or less faithful exposition in Latin of Epicurus’s ideas expressed in Greek some two centuries earlier, in the period following Aristotle of the fourth century BCE [Sedley 2007]. This being so, we can suppose that something

resembling the biospecies concept existed by the fourth century BCE. The Epicurean view of species (which is not restricted to biological species—like Aristotle’s, it applies to elemental forms of all things but is here illustrated in terms of living things) relies on the potential nature of the composite parts of things. It is, if you will, a kind of *generative conception of species*. He goes on to say that things grow at the right season and are able to live because only then are the right “ultimate particles” (i.e., atoms) available to promote growth. Otherwise, everything could happen, such as children and trees maturing in an instant: “But it is evident that none of these things happens, since in every case growth is a gradual process, as one would expect, from a fixed seed, and, as things grow, they preserve their specific character; so you may be sure that each thing increases its bulk and derives its sustenance from its own special substance” [Lucretius 1969: 38].

We shall see this generative notion of species being struck on repeatedly in the history of the concept both before and after the term *species* attains a technical sense in biology (for example in both Cusa before it and Buffon after). It is of interest that Epicurus’s teachings appear to deny Aristotle’s acceptance of spontaneous generation [Lennox 2001, chapter 10], given the role spontaneous generation plays in the later history of living species.

Lucretius further expounds the nature of species in the generalized sense of classification of all things in terms of the natures of the atoms that comprise those things, in Book I [pp. 584–598]. Again he appeals to the natures *in potentia* of the constituents as determining the limits of a species.

Furthermore, since in the case of each species, a fixed limit of growth and the tenure of life has been established, and since the powers of each have been defined by solemn decree in accordance with the ordinances of nature, and since, so far from any species being susceptible of variation, each is so constant that from generation to generation all the variegated birds display on their bodies the distinctive markings of their kind, it is evident that their bodies must consist of unchanging substance. For, if the primary elements of things [i.e., atoms] could be overpowered and changed by any means, it would be impossible to determine what can arise and what cannot, and again by law each thing has its scope restricted and its deeply implanted boundary-stone; and it would be equally impossible for the generations within each species to conform so consistently to the nature, habits, mode of life, and movements of their parents. [Lucretius 1969: 49]

[E]very species that you see breathing the breath of life has been protected and preserved from the beginning of its existence either by cunning or by courage or by speed. [Lucretius 1969: 191]

Intriguingly, and famously, Lucretius [V, pp. 837–877] and the Epicureans have an “evolutionary myth” of the origins of living species, and in it they suppose that these generative natures were not fixed in the initial period of life. The mixtures of the elemental particles were random, and so all kinds of organisms and monsters were born. Eventually, only those that could propagate remained in existence, and the others died out. It is sometimes held that Lucretius and the Epicureans therefore held a natural selection view of adaptation [the classical locus being Osborn 1894], but in fact they suppose that the species are as they originally were formed by chance and are thereafter kept to the limits of their generative potential. This is not selection as Darwin and Wallace proposed it—there is no variation except in the different but unchanging natures of the characters of the particles that by chance form the species themselves, not within the species.

The Epicureans therefore differed from Aristotle, who held that species were forms that are imposed on the substance of things, instead holding that species are forms generated by the natures of their substances. For Aristotle, material substance is malleable. For Epicureans, it is deterministic of the nature of the things it comprises. Of course, Aristotle, too, held that the four elements he proposed in the *Physics* contribute through the “material cause” to the nature of the objects, but he also allowed for formal, efficient, and final causes. Epicurus and his disciples seem not to allow for any determination of natures other than by the material atoms.

This explains a comment made in Boëthius’s *Second Commentary* on Porphyry’s *Introduction (Isagoge)* to Aristotle’s *Categories* some four centuries later, which is crucial to the transmission of the species problem to the medieval universals debate, and thence to the modern era:

It is clear . . . that this happened to him [Epicurus], and to others, because they thought, through inexperience in logical argument, that everything they comprehended in reasoning occurred also in things themselves. This is surely a great error; for in reasoning it is not as in numbers. For in numbers whatever has come out in computing the digits correctly, must without doubt also eventuate in the things themselves, so that if by calculation there should happen to be a hundred, there must also be a hundred things subject to that number. But this does not hold equally in argumentation; nor, in fact, is everything which the evolution of words may have discovered held fixed in nature too. [*Second Commentary on Porphyry’s Isagoge*, Book I, section 2 (McKeon 1929: 73)]

Boëthius is complaining that the Epicureans and the “others” (other atomists, that is) have presumed that because they have been able to construct a coherent account, that what is said must be true of the things being spoken of. Aristotelians, and the neo-Platonists who followed, held that the physics of Aristotle was based on observable features of the world, while Epicurus’s atoms are mere speculations, and hence so are the things that depend on them for their natures, such as species. This is somewhat ironic, given the clearly theoretical nature of the quintessence in Aristotle’s cosmology, and even more so given the merely logical role that *genus* and *species* play in Aristotle’s categorical logic. Aristotelian essence is, in effect, exactly the kind of reification to which Boëthius, who is defending Aristotle, objects. Although Aristotle’s essence concept was not then considered to be an inappropriately abstracted notion [what Whitehead 1938 later called the “Fallacy of Misplaced Concreteness”] when Boëthius wrote, the issue had been raised by Porphyry himself as to whether species exist merely as abstract mental objects (discussed later). The Epicureans were not well regarded during the period of Christian domination [Clark, Foster, and York 2007]. The tradition was held to be an impious and immoral philosophy, by Christian as well as by Jewish thinkers of the post-classical era. The direct influence of Epicurean generative conceptions is thus likely to be sparse before the Enlightenment.

THE HERMETIC TRADITION: SPECIES COME FROM LIKE

Even less immediately influential were the Hermetic writers, although they became significant in the Renaissance. Around 100 CE, a text was written under the pseudonym of Hermes Trismegistus, today known as *Asclepius* I [Scott 1924]. This tradition in part is the direct descendant of Plato and the Academy, with a strong veneer of mysticism and *gnosis*. In this text, nature is the matter that nourishes the forms (*species*) that are imposed on it by God [3c], and in the manner of Plato’s souls in *The Republic*, different kinds (*species*) are realized according to the source. The god-kind produces gods, the demon-kind produces demons, and the man-kind produces men [4]. Unlike Plato, however, the author allows that individuals might partake in many kinds, “though all individuals exactly resemble the type of their kind, yet individuals of each kind intermingle [*miscentur*] with all other kinds.” A later scribe has interposed the comment that organic bodies receive their kinds by the fiat of the gods, and individual things receive form by the ministration of daemons.

In *Asclepius* II (c. 150–270 CE), matter is considered “ungenerated” [15] but to have a “generative power” and to be creative, reiterated also in Book II (c. 270 CE). The Hermetic tradition is likely influenced strongly by the Stoics. The subsequent influence of the Hermetics was strong in the alchemical and mystery religions, and through them to the gnostic traditions of European thought. It is therefore a minor source for the later Great Chain of Being.

THE CLASSICAL TRADITION OF NATURAL HISTORY

The classical period of biology divides mainly into two” the Peripatetic period deriving from Aristotle and Theophrastus, and the practical or encyclopedic period instituted by Pliny the Elder and Dioscorides, in which botanical and zoological information was assembled for practical use. The latter tradition developed into the herbalists of the Middle Ages, in which medical information was the goal and rationale [Stannard 1968; reprinted in Stannard, Kay, and Stannard 1999]. A later third tradition was the so-called etymological tradition that began with the *Physiologus* (c. 200) and ended with Isidore of Spain’s *Etymologiae*.

Pliny the Elder (23–79 CE), who famously perished while observing from a boat the eruption of Vesuvius that buried Pompeii, wrote an encyclopedic account of all animals, birds, trees and so on known to Roman science, called the *Historia naturalis* (*Natural History*). It was the standard reference work for some 1,500 years, influencing the later bestiary tradition [Pliny the Elder 1906, 1940–63] and being the foundation for almost all medieval botanical works. In it, he refers to kinds of organisms almost always as “genera”; for instance, he speaks of two “kinds” (*genera*) of camel, the Bactrian and the Arabian [II.xxx],¹³ or of kinds of lions [VIII.xx], or six kinds of eagles [X.iii]. There is no emphasis placed on reproduction in Pliny, and most of the descriptions are morphological and behavioral. Likewise, the herbalist tradition that began with Dioscorides’ *De materi medica* (first century CE) assumes that there are kinds and sorts, but makes no clear distinction between them. Even so, modern classifications can be fairly clearly mapped onto the species mentioned [Dioscorides 1959: 663–679]. Pliny based much of his material on Theophrastus and Dioscorides [Nordenskiöld 1929: 191].

THE NEO-PLATONISTS: SPECIES AS A PREDICABLE

Aristotelian categories strongly influenced the neo-Platonists, who in turn influenced the medieval scholastics from whom Linnaeus drew his ranking categories. A clear example is the fourth- or fifth-century writer

Martianus (or Felix) Capella. In Martianus's scheme, which is representative of the tradition, genus is the higher grouping and species are the members of the genus. What is a genus with respect to one predicate can be a species with respect to another. Martianus, who was by tradition a farmer in fifth-century CE Africa but more probably a wealthy landowner, did not explicitly deal with the classification of living things and effectively repeated the abstract position of Aristotle's chapter 13 of the *Categories*. His text, whimsically entitled *The Marriage of Philology and Mercury*, was used as a major textbook of the medieval educational program that came to be known as the Quadrivium and the Trivium, for over a thousand years, surely a record for a purpose-written instructional textbook (excluding, perhaps, Euclid). Martianus wrote of a genus being a collection of forms under one name, and species are "man, horse, lion." He wrote that "we also call species forms," which have a "name and definition." "The term and definition of genus are thus determined."¹⁴

The interesting thing about this is that there is no necessity that a living species should not be further decomposable (see the later discussion regarding Whately's *Logic* of the nineteenth century), somewhat at odds with the standard conception of the Aristotelian metaphysical logic. In the neo-Platonic interpretation of Aristotle, mediated to medieval Christianity by Martianus and Porphyry in the *Isagoge*, via Boëthius in the *Commentaries*, a species was a member of a broader group—a genus—that was formed by a predicate. There was no necessity for any object to be a member of a single genus, and a species might be, with respect to some other predicate, a genus in its own right. In short, species were predicate-relative individuals. However, they were individuals in neither the nominalist sense—name-bearing particulars—nor the Strawsonian sense [Strawson 1964, chapter 8]—historically and geographically delimited objects. They were whatever was differentiable out of the genus. This gave rise to Porphyry's dichotomous notion of classification, although the terminology and many of the concepts were derived from Aristotle's *Posterior Analytics*. Porphyry of Tyre, a student of Plotinus (c. 232 or 234–c. 305 CE) syncretized Plato's dichotomous method with Aristotle's logical division of predicables. Aristotle's conception of the *infimae species* was primarily a matter of logical analysis. Porphyry combined this and Plato's method of classification in the *Sophist* to produce what became known as *Porphyry's comb* or *tree* (*Arbor Porphyriana*) in the later Middle Ages, which is topologically the same as a cladogram (see figure 2). But a major distinction between a phylogenetic tree and Porphyry's comb is that the former is derived from history, while the latter is derived from diagnosis [Nelson and Platnick 1981].

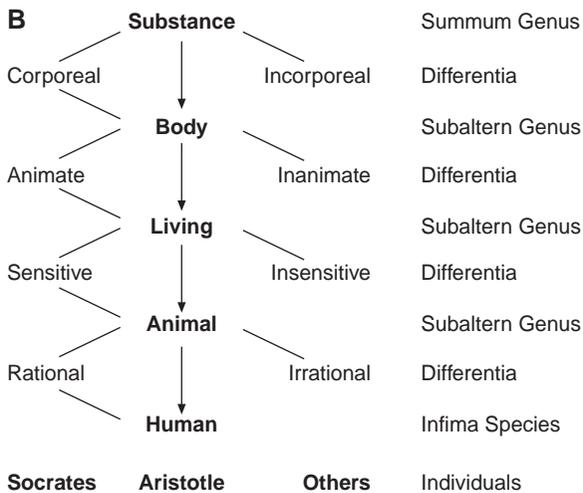
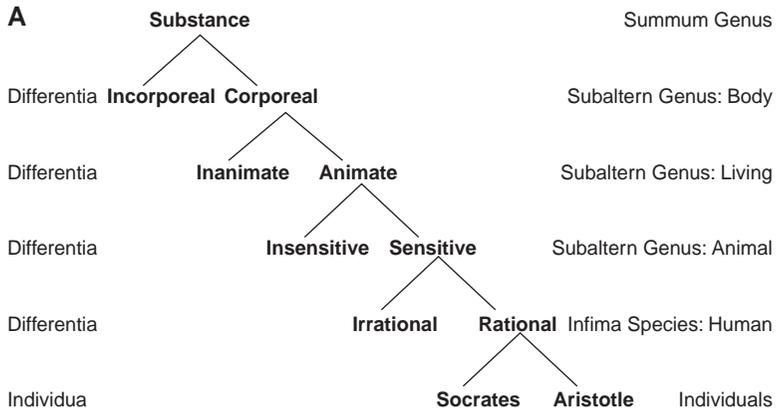
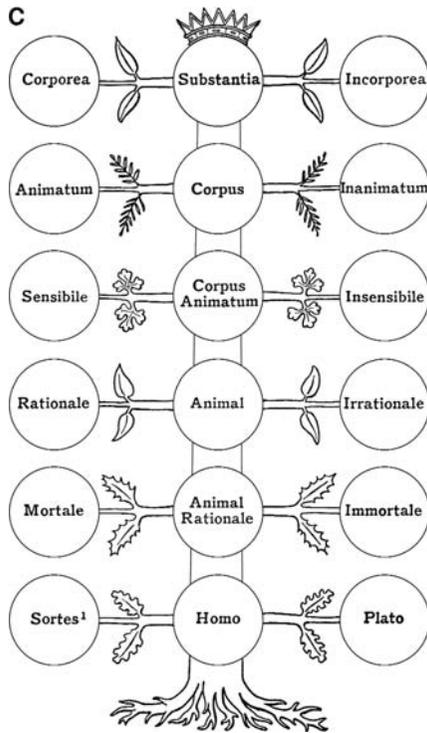


Figure 2 Porphyry’s tree. The top version (A) has been adapted from Oldroyd [1983: 29] to make the logical isomorphism with a cladogram clearer; the traditional form of Porphyry’s tree is more like the one Oldroyd presents (B), a late example of which [from Baldwin 1901, 2: 714], is shown at the right (C), where “Socrates” has, ironically, been corrupted as “Sortes.” See also the discussion by Barnes [Porphyry and Barnes 2003: 109*f.*], who locates the earliest such tree in the Middle Ages, not in Porphyry’s own text. The terms used are those of the late medieval scholastic tradition.



Porphyry treated species slightly differently to Aristotle. In place of the four predicables of Aristotle, Porphyry had five: genus, difference, species, property, and accident [cf. Barnes's commentary §0 in Porphyry and Barnes 2003: 26–32; also see Joseph 1916, chapter 4], replacing *definition* with *species*.¹⁵

Boëthius reported that Porphyry had raised the issue of whether species and genera exist only in the mind, some 1,400 years before Locke addressed the same issue (discussed later), and indeed well before the nominalists of the fourteenth century:

As for genera and species, [Porphyry] says, I shall decline for the present to say (1) whether they subsist or are posited in bare [acts of] understanding only, (2) whether, if they subsist, they are corporeal or incorporeal, and (3) whether [they are] separated from sensibles or posited in sensibles and agree with them. For that is a most noble matter, and requires a longer investigation.¹⁶

This began what we now know as the “Universals” debate and led, fairly directly, to the position that came to be known as nominalism. Why did Porphyry even raise this question? It seems to come out of

nowhere. Aristotle had no doubt that the *eidos* was real—it was the form of the thing that existed as a material object. Plato had no such doubt, either—to him *only* Ideas were real.¹⁷ I suspect that Porphyry was responding to the debates over atomism that bridge the period of Aristotle and the Epicureans, and his day, around five hundred years' duration. Plotinus had addressed the arguments of the Gnostics in his *Enneads*, which Porphyry edited. It is possible that the topic had indeed been raised by the Roman Epicureans, who discussed the nature of sensation extensively, and that the Aristotelians in the person of Porphyry are attempting to defend the essentialist account against the atomistic substantist one.¹⁸

AUGUSTINE: THE MUTABLE IN GOD'S DESIGN

Augustine's *Civitas Dei* (*The City of God*) was finished in about 426 and espouses a Christianized neo-Platonism of sorts, which is not surprising, as Augustine was in the Roman part of Africa from which neo-Platonism sprang. Although not directly interested in matters of natural history, he did assert in Book VIII, chapter 6, that

all forms of mutable things, whereby they are what they are (of what nature soever they be) have their origin from none but Him that is true and unchangeable. Consequently, neither the body of this universe, the figures, qualities, motions, and elements, nor the bodies in them from heaven to earth, either vegetative as trees, or sensitive also as beasts, or reasonable also as men, nor those that need no nutriment but subsist by themselves as the angels, can have being but from Him who has only simple being.
[Augustine 1962]

Forms (species) are thus maintained by the direct action of God, rather than any internal or innate quality. Augustine's focus is, as the title suggests, on heaven, and bodies of organisms are of interest only so far as they are relevant to resurrection. This lack of interest in the natural world extends until the late Middle Ages, as we shall see. This chapter was influential on Peter Lombard (c. 1100–1160 or 1164 CE) in the much-discussed *Four Books of Sentences* [Book I, Discussion III, chapter 1; McKeon 1929: 190f.] where the same points are made.

One text of Augustine's that has been interpreted to mean he held to an "evolutionary" view is in his commentary on the meaning of Genesis:

Where, then, were they [*plants, when they were created*]? Were they in the earth in the "reasons" or causes from which they would spring, as all

things already exist in their seeds before they evolve [develop—JSW] in one form or another and grow into their proper kinds in the course of time? . . . it appears [from Scripture—JSW] . . . that the seeds sprang from the crops and trees, and that the crops and trees themselves came forth not from seeds but from the earth. [*De Genesi Ad Litteram (The Literal Meaning of Genesis)*, c. 390 CE, Book V, chapter 4 (Augustine 1982: 151f.)]

However, this is best understood that God created secondary powers that spontaneously generate plants at the right time. This passage does not license an interpretation of Augustine as propounding either fixism or mutablism.