

An earlier publication of Tartar's strengthens the case for making a sharp distinction between the roles of digital genetic information and analog pattern information in Stentor regeneration. Tartar found that partial realignment of the striped pattern and other regenerative changes could take place even if Stentor's nuclei were removed. In that case, genetic control of the regenerative process would necessarily be lacking. In Tartar's words:

We are particularly interested in any morphogenetic capacities or pattern activities which may be expressed even in the absence of the nucleus. From recent experiments it can be stated that enucleate *S. coeruleus* can (1) regenerate the holdfast, (2) form a new contractile vacuole, (3) heal the ectoplasm after cutting or grafting, and (4) align minced pattern patches in parallel and rejoin severed pigment stripes. Harmonization of disordered striping is, however, not as certain as in nucleate stentors and some patchiness of the stripe pattern may long remain. Enucleates can do much with their cortical pattern short of the major structurization of the oral primordium. (Tartar 1956: 91-2)

What this evidence points to is the need to recognize analog pattern control as supplementing, and in some cases replacing, digital genetic control of regeneration. But in general, pattern control of development (as opposed to regeneration) can at most supplement, not replace, genetic control. Another significant discovery of Tartar's was that enucleated Stentors died after about five days (Tartar 1956: 91). The conclusion we are led to therefore, is the one sketched at the beginning of the section, that the general, overall structure of an organism's development is established at the beginning of its life by its genes, and that the absence of digital genetic information results in death. But the detailed realization of this overall structure, especially in regenerative processes, requires a 4D template. Above and beyond genetic factors, an analog 4D pattern is needed.

CHAPTER 12

Essence, necessity, and explanation

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12.1 INTRODUCTORY REMARKS

It is perhaps still quite common among contemporary metaphysicians to think of essence along modal lines: an essential truth, on this conception, is just a modal truth of a certain kind (viz., one that is both necessary and *de re*, i.e., about a certain object); and an essential property is just a feature an object has necessarily, if it is to exist.¹ The essential truths, according to this approach, are thus a subset of the necessary truths; and the essential properties of objects are included among its necessary properties. Quine for example has such a modal conception of essence in mind, when he argues that the view he calls 'Aristotelian essentialism' is incoherent, because it requires quantification into intensional contexts (cf. Quine 1953).

But the view Quine calls 'Aristotelian essentialism' is for a variety of reasons not one Aristotle himself would have found congenial. One important respect, which will concern us here, in which Aristotle would have wanted to distance himself from what Quine calls 'Aristotelian essentialism' is that Aristotle does not subscribe to a modal conception of essence. For Aristotle, the essential truths are not even included among the necessary truths; and the essential features of an object are similarly not included among its necessary features. Rather, Aristotle conceives of the necessary truths as being distinct and derivative from the essential truths; and he conceives of the necessary features of objects, traditionally known as the 'propria' or 'necessary accidents', as being distinct and derivative from, the essential features of objects. Such a non-modal conception of essence also constitutes a central component of the neo-Aristotelian

¹ This chapter should be read as a sequel to Koslicki (In press), in which I raise many of the issues discussed here from the point of view of contemporary metaphysics, but do not go into the details of Aristotle's response to these questions as laid out in the *Posterior Analytics* and the biological treatises.

approach to metaphysics defended over the last several decades by Kit Fine (see for example Fine 1994, 1995a, 1995b, 1995c). Like Aristotle, Fine holds that we should not try to reduce essence to modality; rather, the modal status of necessary truths, in Fine's view, is grounded in, and hence derivative from, facts about essences.

As Fine points out, a non-modal approach to essence enjoys potential advantages over a modal approach, in that the former can make room for distinctions which are simply glossed over by the latter. For example, consider Socrates and the singleton set containing Socrates. Intuitively, it is not part of the nature of Socrates that he is the sole member of the singleton set containing Socrates, since presumably no feature concerning sets is relevant to a characterization of what it is to be Socrates. In contrast, it does seem plausible to think that it is part of the nature of Socrates' singleton set that it contains Socrates as its sole member. However, since necessarily each exists just in case the other does and Socrates is necessarily a member of the singleton set containing Socrates (if he exists), necessity coupled with existence alone does not suffice to capture the asymmetry in question. The modal approach to essence will thus generate the result that it is an essential feature of Socrates that he is the sole member of Socrates' singleton set, just as it is an essential feature of Socrates' singleton set that it has Socrates as its sole member. The same point applies when we express the ontological asymmetry in question using the vocabulary of ontological dependence: for while it seems plausible to think that Socrates' singleton set ontologically depends on Socrates as its sole member, it is not equally plausible to think that Socrates is also ontologically dependent on the singleton set of which he is the sole member. Given that the modal approach to essence lacks the resources to recognize an asymmetry in the relation between Socrates and Socrates' singleton set, a modal account of ontological dependence can be expected to suffer from a similar deficiency.

Both Aristotle and Fine, in their conception of the relation between essence and modality, rely on a distinction between what belongs to the essence of an object and what merely follows from the essence of an object. On both Fine's and Aristotle's conception, the essential truths characterize the essence of an object and state what features are essential to it, while the necessary truths characterize what merely follows from the essence of an object and state what features are necessary (but non-essential) to it. In order for this type of approach to essence and modality to be successful, we must be able to identify an appropriate consequence

relation which in fact generates the result that the necessary truths about objects *follow from* the essential truths. For example, if it is an essential feature of triangles that they have three angles and a merely necessary (but non-essential) feature of triangles that they have three sides, then we must be given some indication of how the second feature in some way derives from the first.

In Section 12.2 of this chapter, I discuss Fine's way of drawing the distinction between what is part of the essence of an object and what merely follows from the essence of an object. Fine's approach to essence and modality has the advantage over the traditional approach to *de re* modality that it is set up to reflect the sensitivity of essentialist truths towards their grounds, viz., the identity of those objects in virtue of which these claims are true. But Fine's approach, as far as I can see, does not settle all the questions we would like to have answered concerning the derivation of propositions stating necessary (but non-essential) features of objects (e.g., the triangle's being three-sided) from propositions stating their essential features (e.g., the triangle's being three-angled), since the relevant notion of consequence that is needed for this purpose cannot be merely that of logical entailment.

In Section 12.3, I turn to Aristotle's account of the distinction between what belongs to the essence proper of a thing and what merely follows from the essence proper of a thing. The relevant consequence relation which characterizes this contrast, according to Aristotle, is that supplied by his technical concept of *demonstration* (*apodeixis*), as developed in the *Posterior Analytics* (henceforth abbreviated *APo*). Demonstration encompasses more than deductive entailment, in that the *explanatory* order of priority represented in a successful demonstration must mirror precisely the *causal* order of priority present in the phenomena in question. In particular, as essences are the causal bedrock of Aristotle's metaphysics, so definitions, the linguistic counterparts of essences, are the explanatory bedrock of Aristotle's theory of demonstration. Aristotle's central idea, to trace the explanatory power of definitions to the causal power of essences, has the potential to open the door to a philosophically satisfying response to the question of how the necessary features of an object are related to its essential features.

12.2 FINE'S NON-MODAL CONCEPTION OF ESSENCE

Fine (1994) urges us to resist the modern assimilation of essence to modality:

My point, rather, is that the notion of essence which is of central importance to the metaphysics of identity is not to be understood in modal terms or even to be regarded as extensionally equivalent to a modal notion. The one notion is, if I am right, a highly refined version of the other; it is like a sieve which performs a similar function but with a much finer mesh. (Fine 1994: 3)

In Fine's view, a modal account of essence succeeds in providing a necessary criterion, but fails to provide a sufficient criterion, for essentialist claims. Thus, if an object has a certain property essentially, then it follows that the object has the property necessarily (or that it has the property necessarily, if it exists). But the converse, so Fine argues, does not always hold: it does not in general follow that if an object has a certain property necessarily, then it also has the property essentially. The relation between Socrates and Socrates' singleton set provides an illustration of this contrast. For while it is necessary that Socrates is the sole member of Socrates' singleton set, it is not plausible, in Fine's view, to think that it is also an essential property of Socrates to be the sole member of Socrates' singleton set, even though it is plausible to think that it is an essential property of Socrates' singleton set that it has Socrates as its sole member.

The example involving Socrates and Socrates' singleton set serves to bring out one of the main shortcomings Fine sees with the modal account of essence: while *de re* modal truths, as they are traditionally construed, are insensitive towards the ground or source of their truth, essentialist truths, for Fine, precisely do manifest such a sensitivity towards their ground, viz., the identity of the object or objects in virtue of which the claim in question is true. To represent this sensitivity, Fine utilizes an indexed modal operator, ' \Box_x ', to be read as 'it is true in virtue of the identity of x that ...', which denotes an unanalysed relation between an object, x , and a proposition. Essentialist claims of the form, ' $\Box_x A$ ', in this framework, are thus explicitly relativized to their source, viz., in this case, the object, x , in whose identity the truth of the proposition that A is said to be grounded. Essences themselves, for Fine, can be identified for the purposes at hand with collections of propositions that are true in virtue of the identity of an object or objects. Such a collection of propositions which is true in virtue of x 's identity can simultaneously be thought of as a real definition of x . (Real definitions contrast with nominal definitions and concern objects themselves, rather than the linguistic expressions we use to refer to objects or the concepts we use to conceive of them.)

Using this apparatus, we can now represent the asymmetry in the relation between Socrates and Socrates' singleton set as follows:

- (1) a. \Box (Socrates is the sole member of Socrates' singleton set)
 b. \Box_{Socrates} (Socrates is the sole member of Socrates' singleton set)
 c. $\Box_{\text{Socrates' singleton set}}$ (Socrates is the sole member of Socrates' singleton set)

In Fine's view, all three statements make distinct claims: the *de re* modal claim in (1.a) is true, as far as it goes, but manages to state only a necessary condition that would be required to hold in order for either (1.b) or (1.c) to be true. The true essentialist claim in (1.c) correctly represents Socrates' singleton set as being the object in whose identity the truth of the proposition in question is grounded. (1.b), on the other hand, misrepresents the ground for the truth of the proposition in question as being Socrates' identity, rather than the identity of Socrates' singleton set. The traditional modal account of essences cannot distinguish these three claims: as long as we take essentialist claims simply to be *de re* modal statements, as traditionally construed, we will remain blind, in Fine's view, to such distinctions with respect to ground as those illustrated in (1.b) and (1.c). But we are required to draw precisely such distinctions, if we want to be able to recognize such ontological asymmetries as that illustrated by the relation between Socrates and Socrates' singleton set.

Given the sensitivity of essentialist claims to the object or objects in whose identity their truth is grounded, we can thus expect, on Fine's conception, that each object, or type of object, will generate its own sphere of essential truths, namely those that are true in virtue of the identity of just the objects in question. The essentialist claims that are true in virtue of the identity of certain objects include, in Fine's view, those that belong to the essence, narrowly construed, of the objects in question, or what Fine calls 'constitutive essence'. But they also include the logical consequences of these claims: these latter propositions belong to the essence of an object, more widely construed, or what Fine calls 'consequential essence'. Thus, if the proposition that Socrates' singleton set has Socrates as its sole member belongs to the constitutive essence of Socrates' singleton set, then the proposition that Socrates' singleton set has *some* member or other belongs to the consequential essence of Socrates' singleton set, since the latter logically follows from the former.²

² I am here relying primarily on Fine 1995a: 276–80, for the way in which the constitutive/consequential distinction for essences is to be drawn; but similar thoughts (though presented in a more

But this puts us before an immediate difficulty. For the logical truths are logically entailed by any proposition whatsoever. By the method just outlined, they therefore make it into the consequential essence of any object whatsoever. For example, following this reasoning, the proposition that 2 is self-identical will be included in the consequential essence of Socrates' singleton set (just as it will be included in the consequential essence of every other object). At the same time, however, the essential truths are also supposed to be those claims which are true in virtue of the identity of some object or objects: we would therefore expect these truths to be immediately relevant to a characterization of the nature of, or what it is to be, these very objects in virtue of whose identity they are true. But it is not plausible to think for example that the truth of the proposition that 2 is self-identical is grounded in the identity of Socrates' singleton set or that we would appeal to this proposition in a characterization of what it is to be Socrates' singleton set. Since the logical truths are just those which remain true under any re-interpretation of the non-logical vocabulary, we cannot expect these truths to be grounded in the identity of any particular objects at all; rather, the logical truths are true regardless of which particular object is under consideration. If these truths are grounded in the identity of anything at all, the only plausible candidate would be the logical operations, not the objects to which these logical operations are applied.

To address the quandary just raised, Fine proposes a procedure he calls 'generalizing out', which in effect allows us to remove the logical truths from the consequential essence of any object. The 'generalizing out' procedure takes advantage of the special feature of logical truths just noted, viz., that they remain true under all re-interpretations of the non-logical vocabulary. The central idea underlying this procedure is this: if an object enters as a constituent into a proposition belonging to the consequential essence of another object only through logical closure, then such an object can be 'generalized away'. For example, the proposition that the number 2 is self-identical belongs to the consequential essence of Socrates' singleton set; but so does, for every object whatsoever, the proposition that that object is self-identical. In this way, the number 2 can be 'generalized out' of the proposition that the number 2 is self-identical, which belongs to the consequential essence of Socrates' singleton set.³

condensed fashion) are also found in Fine 1995b: Sections 3–4. See also Koslicki (In press, Section 4), for further discussion of Fine's constitutive/consequential distinction for essences.

³ The following is a more precise characterization of the notion of 'generalizing out' (cf. Fine 1995a: 277–8). Consider a proposition $P(y)$, which has an object, y , as a constituent. For example, $P(y)$ might be the proposition that Socrates is identical to Socrates for $y = \text{Socrates}$. Fine's first step is

The 'generalizing out' procedure is certainly helpful with respect to the quandary just posed, since it allows us to carve out an intermediate *restricted* consequential essence for every object, namely that collection of propositions which includes all the logical consequences of those propositions that belong to the object's constitutive essence, minus the logical truths. The restricted consequential essence of Socrates' singleton set for example includes the proposition that Socrates' singleton set contains some member or other, but not the logical truth that 2 is self-identical, since the latter is blocked from the restricted consequential essence of Socrates' singleton set by means of the 'generalizing out' procedure. And this is just as it should be, since the proposition that Socrates' singleton set has some member or other does pertain to the nature of Socrates' singleton set, albeit only indirectly (by being logically entailed by a proposition that directly pertains to the nature of Socrates' singleton set), while the proposition that 2 is self-identical does not even pertain indirectly to the nature of Socrates' singleton set.

We thus arrive at two types of claims which, on Fine's account, can be regarded as properly essentialist claims pertaining to the nature of some object or objects. The first category consists of those propositions which directly pertain to the nature of an object; these propositions make up an object's constitutive essence. The second category consists of those propositions which pertain to the nature of an object only indirectly, namely by being logically entailed by propositions of the first kind, minus the logical truths; these propositions make up an object's restricted consequential essence. The logical truths can be discounted, since they only make it into an object's unrestricted consequential essence by default, so to speak, i.e., by being logically entailed by any proposition whatsoever.

In addition to these two types of propositions (i.e., the properly constitutive essential truths and the restrictedly consequential essential truths that are logically derived from them), an important further category of propositions must also be accommodated in some fashion. This third category consists of propositions which Aristotle would characterize as

to define the notion of a 'generalization' for propositions, rather than objects (i.e., constituents of propositions): the generalization of a proposition, $P(y)$, is the proposition that $P(v)$ holds for all objects, v . Thus, the generalization of the proposition that Socrates is identical to Socrates is the proposition for all objects, v , that v is identical to v . (To obtain the generalization, $P(v)$, of a proposition, $P(y)$, all occurrences of the constituent, y , must be replaced by occurrences of v .) Given the notion of a generalization, defined for propositions, we can now make sense of the idea that an *object* can be 'generalized out' of a collection, C , of propositions in the following way: an object, y , can be generalized out of a collection, C , of propositions if C contains the generalization of a proposition $P(y)$, whenever it contains the proposition $P(y)$ itself.

necessary (but non-essential) truths, i.e., propositions stating the necessary (but non-essential) features of objects, viz., their so-called 'necessary accidents' or 'propria'. Propositions that belong to this third category resemble those of the second category above, in that they pertain to the nature of an object only indirectly, namely by following from propositions that directly pertain to the nature of an object. But the notion of 'following from' cannot be analysed as 'is a direct logical consequence of the constitutively essential truths'. For, unlike the propositions that are included in an object's restricted consequential essence, these necessary (but non-essential) truths do not logically follow solely from propositions that belong to an object's constitutive essence. To account for this third category of propositions, a notion of 'following from' that goes beyond logical consequence, as it is conceived of in the relation between an object's constitutive essence and its restricted consequential essence, is needed.

To illustrate, for Aristotle, it is part of the essence proper of planets that they are heavenly bodies that are near; but it is not part of the essence proper of planets, in his view, that they do not twinkle. The latter proposition states merely a necessary (but non-essential) feature of planets which follows from, but is not itself part of, the essence proper of planets. But the proposition that planets do not twinkle, stated in (2.b), does not logically follow from the proposition that planets are heavenly bodies that are near, stated in (2.a), at least not without the help of additional premises:

- (2) a. Planets are heavenly bodies which are near.
 b. Planets are heavenly bodies which do not twinkle.

The inference from (2.a) to (2.b) becomes logically valid if we supply (2.c) for example as an auxiliary premise:

- (2) c. Heavenly bodies which are near do not twinkle.

But the appeal to (2.c) in deriving a necessary truth about planets from an essential truth about planets is problematic for several reasons. First, (2.c) is a statement about heavenly bodies in general, not about planets in particular. Secondly, if (2.b) states a derived necessary (but non-essential) feature of planets, then presumably, by the same reasoning, (2.c) ought to be regarded as stating a derived necessary (but non-essential) feature of heavenly bodies in general as well. These two considerations suggest that propositions stating necessary (but non-essential) features of planets cannot be logically derived from propositions stating essential features of planets alone.

Moreover, as Aristotle notices as well in the *Posterior Analytics*, once we allow ourselves to appeal to auxiliary premises, we face a further difficulty. For the inference from the explanatorily less basic necessary truth in (2.b) to the explanatorily more basic essentialist claim in (2.a) can also be made logically valid with the addition of an auxiliary premise, such as (2.d):

- (2) d. Heavenly bodies which do not twinkle are near.

But we would be moving in the wrong explanatory direction if we were to try to derive the essence proper of planets from their merely necessary (but non-essential) features. Thus, the relevant entailment relation that is needed for the purpose of deriving the necessary truths from the essential truths also cannot be that of logical consequence supplemented by an appeal to auxiliary premises, since the relation in question will then lack the requisite asymmetry.⁴

It thus seems that a full account of the modal status of propositions stating necessary (but non-essential) features of objects, such as (2.b), requires additional apparatus beyond the notion of logical consequence, as it is employed in Fine's constitutive/consequential distinction for essences. A proposition can be derived from the propositions that belong to the properly constitutive essence of an object if it is a direct logical consequence of these propositions. But propositions stating necessary (but non-essential) features of objects may not follow logically from the properly constitutive essential truths alone; and yet, these propositions should be asymmetrically derivable in some fashion from propositions stating essential features. What, then, is the appropriate sense of 'following from' that can be used to account for the modal status of propositions of this third category? As far as I can see, this question is, as it stands, left open by Fine's account of essence and modality.

12.3 THE CAUSAL ROLE OF ESSENCES IN ARISTOTLE'S PHILOSOPHY OF SCIENCE

As it turns out, Aristotle thought quite hard about many of the questions just raised in connection with Fine's account of essence and modality. As

⁴ The dialectical situation here is reminiscent of Sylvain Bromberger's famous 'Hagpole' objection to Hempel's Deductive-Nomological model of scientific explanation. For just as the length of the Hagpole's shadow can be logically deduced from the length of the Hagpole with the help of auxiliary premises, so the length of the Hagpole can also be logically deduced from the length of the Hagpole's shadow with the help of auxiliary premises. But it would be odd to explain the Hagpole's length by appeal to the length of its shadow. As we will observe below, Aristotle anticipated the

I hope to show in what follows, Aristotle's responses to these questions are philosophically extremely interesting and pertinent to current debates in contemporary metaphysics.

12.3.1 *Deduction, demonstration, and definition*

Like Fine, Aristotle also recognizes the need for a distinction between what belongs to the essence proper of an object and what merely follows from the essence proper of an object.⁵ But, unlike Fine, Aristotle's derived notion, as observed earlier, also extends to necessary truths which do not follow by logic alone directly from the propositions that belong to the essence proper of a thing.⁶ For Aristotle, the notion of 'following from' that is at issue in the distinction between the properly essential truths and the derived necessary truths is that given by his technical concept of '*demonstration*' (*apodeixis*), as developed in the *Posterior Analytics*. In Aristotle's view, the proposition that planets do not twinkle *follows from* a proposition that states the essence proper of planets, in the sense that it can be *demonstrated* from such a proposition (viz., the proposition that planets are heavenly bodies which are near), together with an auxiliary premise (viz., the proposition that heavenly bodies which are near do not twinkle). We are thus to regard the proposition that planets are heavenly bodies which do not twinkle as a derived proposition, or *theorem*, of

modern reaction to Bromberger's case and proposed to supplement logical entailment with causal priority, in order to arrive at an appropriately asymmetric conception of scientific explanation.

⁵ According to Fine, essences (for the purposes at hand) can be identified with collections of propositions that are true in virtue of the identity of some object or objects. Aristotle, as I read him, would not be happy with this characterization of essences as collections of propositions. For Aristotle, the essence of a kind of thing includes at least its form. (Whether the essence of a kind of thing also includes additional components besides the form, e.g., the matter, is a controversial question which I will leave open for present purposes.) For example, the essence of a living being encompasses at least its soul, i.e., the form of the living being. But, given Aristotle's conception of the soul as associated with certain kinds of powers or capacities [*dynamis*] (e.g., the capacity for growth and nourishment, locomotion, perception, and thought), it would be strange to think of the soul of a living being as a collection of propositions. It is perhaps more natural to think of *definitions*, which Aristotle takes to be linguistic entities [*logoi*] of some sort (viz., formulae or statements of the essence), as collections of propositions (or perhaps as only a single proposition, if there is only a single canonical way of stating the essence of a kind of thing). I will now switch to a less propositional conception of essences, according to which definitions *state*, but are not to be identified with, essences.

⁶ A further difference between Fine's and Aristotle's account, which will become more salient below, is that Aristotle thinks of essences (at least in contexts that are relevant to our present concerns) as being associated with *kinds* of phenomena (e.g., the kind of thing, thunder), rather than with *individuals* belonging to these kinds (e.g., individual occurrences of thunder). Fine, on the other hand, seems quite happy to conceive of essences as individual essences, rather than (or perhaps in addition to) kind-essences.

astronomy, since it appears as the conclusion of a demonstrative argument which belongs to the theory of astronomy. The premises of such a demonstrative argument can either be themselves first principles, or *axioms*, or they can be theorems which follow from (theorems which follow from ...) first principles or axioms. The first principles in question may include (i) axioms that are special to astronomy; (ii) axioms that are common to all rigorous disciplines (e.g., the axioms of logic); or (iii) axioms that are imported into astronomy from related special disciplines (e.g., physics, optics, or applied mathematics).

A demonstrative argument, in Aristotle's view, must be at least deductively valid; that is, a demonstration is at least a deduction. But not all deductively valid arguments also amount to demonstrations.⁷ The question of which conditions must be fulfilled by an argument in order for it to be deductively valid belongs to the subject-matter of logic; but the question of what additional criteria must be met by a deductively valid argument in order for it to constitute a demonstration is a question that is of relevance to science and the philosophy of science.⁸ For the acquisition of demonstrative knowledge (*epistēmē*) (i.e., knowledge that is obtained by way of, or at least can be presented in the form of, demonstrative arguments) is the aim of science, as Aristotle conceives of it.

As Aristotle specifies in *APo* A.2, a subject, S, demonstratively knows (*epistasthai*) a proposition, p, if and only if (i) p cannot be otherwise, i.e., p is *necessary*; and (ii) S grasps *why* p is the case, i.e., S is in possession of an *explanation* for p's being the case.⁹ The elucidation of what Aristotle takes to be involved in condition (ii), being in possession of an explanation for why p is the case, will take up the remainder of this chapter. The first

⁷ The question of how tightly connected Aristotle's philosophy of science, as laid out in the *Posterior Analytics*, is to his syllogistic logic, as developed in the *Prior Analytics*, is a complicated one, which has received considerable attention in the literature. I shall loosely follow the reading advocated in Barnes (1981), according to which Aristotle's theory of demonstration is couched in terms of his syllogistic logic, only because Aristotle had come to think that deductive entailment is best characterized in syllogistic terms. But, wherever possible, I will in what follows abstract away from the peculiarities and limitations of Aristotle's syllogistic logic, in my characterization of his philosophy of science.

⁸ The term, 'science' (like its Latin relative, 'scientia'), is here used to apply to any rigorous discipline which aims at the acquisition of the kind of knowledge to which Aristotle applies his technical term, 'epistēmē', as it is characterized in the *Posterior Analytics*. Any such rigorous discipline, in Aristotle's view, must be capable of being presented as an axiomatized theory, which consists of first principles or axioms together with the theorems which can be demonstrated on the basis of these first principles. Geometry, for example, is a paradigmatic example of such a rigorous discipline.

⁹ Quite possibly, Aristotle also requires, in order for a subject, S, to have demonstrative knowledge of a proposition, p, not only (i) that p cannot be otherwise, but also that (i') S grasps that p cannot be otherwise.

condition, that demonstrative knowledge concerns only necessary propositions, might at first sight seem puzzling to the contemporary reader; but we should keep in mind that, for Aristotle, science is concerned only with lawful (i.e., necessary) connections among kinds of phenomena, i.e., universals, rather than with the accidental features of individual instances of these kinds. Thus, for Aristotle, questions such as the following would count as properly scientific: 'what is thunder?', 'why does thunder occur?', 'why is thunder loud?', or 'why does thunder accompany lightning?'¹⁰ Individual instances of a kind of phenomenon, in Aristotle's view, can only be perceived through sense-perception; but they are not the proper subject-matter for scientific demonstration and definition.¹¹

One of Aristotle's central goals in the *Posterior Analytics* is to spell out in detail what distinguishes demonstrative arguments from those that are merely deductively valid; the latter he takes himself to have already characterized in his treatise on syllogistic logic, the *Prior Analytics*. Consider for example the following two arguments:

- (2) c. Heavenly bodies which are near do not twinkle.¹²
 - a. Planets are heavenly bodies which are near.
 - b. Therefore, planets are heavenly bodies which do not twinkle.

¹⁰ Both the question, 'what is thunder?', and the question, 'why does thunder occur?', for Aristotle, are answered simultaneously, once it has been discovered what the essence of thunder is, i.e., what it is to be thunder. Aristotle thinks that the first question, 'what is thunder?', asks for a definition (i.e., a statement of the essence) and is answered, in this case, as follows: 'thunder is a kind of noise in the clouds caused by the extinction of fire'. This (alleged) definition of thunder also immediately delivers an answer to the second question, 'why does thunder occur?': 'because fire is extinguished in the clouds'.

¹¹ Moreover, since demonstration is a species of deduction, any proposition which is suitable to occur in a demonstration must also at least be suitable to occur in a deduction. But such propositions, for Aristotle, are of the form, AxB , where A and B are terms (i.e., with A being the predicate-term and B being the subject-term) denoting *universals* (i.e., species and genera) and x corresponds to one of the four syllogistic relations that can obtain between terms (' A belongs to all B ', ' A belongs to no B ', ' A belongs to some B ', or ' A does not belong to some B '). Neither Aristotle's theory of deduction nor his theory of demonstration makes room for singular propositions (e.g., that Socrates is wise).

¹² It is an interesting question what the status is, in Fine's or Aristotle's system, of auxiliary general premises such as (2.c), that heavenly bodies which are near do not twinkle. Can this proposition itself be derived from essential truths of some kind? Consider the more general proposition that what is near does not twinkle. Neither the phrase, 'what is near', nor the phrase, 'what does not twinkle', picks out a genuine natural kind which (in Aristotle's eyes at least) could be expected to be associated with an essence. If we want to maintain that in general all necessary propositions can be derived in some way from facts about essences, as both Fine and Aristotle seem to want to do, our best bet in this case might be to look for a ground for the necessity of the proposition in question in the essence of the phenomenon of light and its interaction with distance. The proposition that heavenly bodies which are near do not twinkle would then present us with a particular instance of a more general proposition concerning the interaction between light and distance. If this route towards grounding the necessity of the proposition in question in essential

- (2) d. Heavenly bodies which do not twinkle are near.
 - b. Planets are heavenly bodies which do not twinkle.
 - a. Therefore, planets are heavenly bodies which are near.

Aristotle would characterize both arguments as deductively valid; but only one of them, viz., the first, succeeds in meeting the additional criteria imposed on deductively valid arguments which are also demonstrative.¹³ If we abstract away, for a moment, from the syllogistic form of these arguments, both can be summarized in the form of 'because'-statements as follows: the first argument in effect states that planets do not twinkle because they are near, while the second argument in effect states that planets are near because they do not twinkle. What follows the connective, 'because', in these statements is what Aristotle would call the 'middle term', i.e., the term which is common to both premises and therefore serves to connect the remaining two terms which occur in the premises and the conclusion.¹⁴ In a proper demonstrative argument, the middle term must be *explanatory* of the conclusion, in a very specific sense: the middle term must state what properly belongs to the *definition* of the kind of phenomenon in question (viz., in this case, planets).

Successful definitions and explanations, for Aristotle, are the linguistic correlates of essences and causes.¹⁵ A definition (*horos* or *horismos*),

truths of some kind proves to be feasible, we would also need to allow (not surprisingly) that the derivation of theorems of astronomy may rely on the importation of axioms and/or theorems from other related disciplines, such as physics and optics. In any case, as our excursion into Aristotle's biology below will indicate, one cannot hope to succeed in grounding the necessary truths about one particular kind of phenomenon (e.g., camels) solely in facts about the essences of that kind of phenomenon; rather, the derivations in question only go through if we are permitted to appeal to facts about the essences of related phenomena as well.

¹³ Cf. Aristotle's distinction in *APo* A.13 between arguments which merely state a fact or what is the case (*to hoti*), as in the second argument, and arguments which also *explain why* a given fact is the case (*to dihoti*), as in the first argument. The solution to the puzzle raised there, as to how exactly this distinction is to be drawn, is not completed until *APo* B.16, when much more machinery connecting definitions to demonstrations has been put in place.

¹⁴ According to Aristotle's logic, both arguments exemplify the first figure syllogism known as *Barbara* and are hence of the following form: AaB , BaC ; therefore, AaC . (' A holds of all B '; ' B holds of all C '; therefore, ' A holds of all C '). In the first argument, A stands for 'not twinkling', B for 'being near', and C for 'planets'; in the second argument, A stands for 'being near', B for 'not twinkling', and C for 'planets'. The syllogistic relation, a , which holds between the terms, A , B , and C , indicates that the propositions in question express universal affirmative judgements. The corresponding 'because'-statement thus has the schematic form: ' A belongs to all C because of B '.

¹⁵ By 'explanation', I mean here something that could serve as an answer to what Aristotle would regard as a properly scientific question (e.g., such questions as 'what is thunder?', 'why does thunder occur?', 'why is thunder loud?', or 'why does thunder accompany lightning?'). An explanation, understood in this way, could be stated either by means of a 'because'-statement or by means of an argument, as illustrated above. In what follows, when I use the term, 'explanation' (or grammatical correlates), I have in mind only *causal* explanation; but I understand 'cause'

according to Aristotle, is a formula or statement (*logos*) of the essence (*to ti ên einai*), i.e., of what it is to be a certain kind of thing.¹⁶ And since *essences*, for Aristotle, themselves *cause* the other necessary (but non-essential) features of a thing, so *definitions*, as the linguistic correlates of essences, *explain*, together with other axioms, the propositions describing these necessary (but non-essential) features. On Aristotle's way of thinking, then, the explanatory power inherent in definitions, in their role as the linguistic correlates of essences, is a direct reflection of the causal power of essences. This idea really constitutes the crucial step in Aristotle's attempt in the *Posterior Analytics* to supplement the notion of demonstration with scientifically useful content beyond what is already provided by the purely logical consequence relation of deduction.¹⁷

Given their role as the linguistic correlates of essences, Aristotle takes definitions to figure among the first principles or axioms of a demonstrative science. As first principles or axioms, definitions are thus explanatorily basic, in the sense that no further demonstrative proof of them can be given. Like any other axiom, definitions cannot be demonstrated from other explanatorily more basic premises, since no other premises are explanatorily more basic than the axioms of a theory. Thus, once we have

here in the Aristotelian, rather than the contemporary Humean, way. Thus, a causal explanation, according to the conception I will adopt, could in principle consist in citing any of the four Aristotelian causes (formal, final, material, or efficient cause), while a causal explanation understood in the contemporary Humean way, typically consists in citing only what Aristotle would consider to be an efficient cause, i.e., the source of a particular motion or change. The Greek does not disambiguate between 'cause' and 'explanation', since the same terms (*aitia* and *aitton*) can be translated in both ways.

¹⁶ For the sake of simplicity, I speak here as though Aristotle recognizes only a single kind of definition; this is in fact not so, as is attested for example by *APo* B.10, where Aristotle distinguishes between at least three or four different ways in which the term, 'definition', is employed (depending on how one reads the chapter). Among other things, Aristotle seems to recognize *nominal* definitions ('an account of what a name signifies') in addition to more or less partial or complete *real* definitions, viz., statements of the essence. A term like 'centaur' might for example have a nominal definition (viz., 'the term 'centaur' signifies a mythical creature with the head, trunk, and arms of a human being and the body and legs of a horse'), even though no real definition in this case is possible, since the kind allegedly denoted by the term does not exist. My current use of the term, 'definition', is intended to correspond to what is typically accessible to a scientist only at the *end* of a successful investigation into the nature of a particular phenomenon. At the start of a scientific investigation, the inquirer may have only a very partial and indeterminate grasp of the phenomenon he is investigating; he might know for example only that thunder is some kind of noise in the clouds, but not yet know specifically what kind of noise in the clouds it is and what causes it. At the conclusion of his investigation (if indeed the investigation was successful), the scientist will have discovered the essence of thunder. It is the linguistic correlate of this mature scientific understanding of the essence underlying a natural phenomenon (i.e., a complete real definition) that I am here calling 'definition'.

¹⁷ For a similar emphasis on the causal role of essences, as reflected in the explanatory role of definitions, see also Charles (2002: especially Part II); Charles (2010b); and Lennox (2010).

explained for example why planets do not twinkle by citing their nearness, no further demonstrative proof of the premise that planets are heavenly bodies that are near is possible, in Aristotle's view, since we have at that point reached the definition of planets. To ask why planets are heavenly bodies that are near (assuming that this proposition in fact gives at least a partial correct statement of the essence of planets) would be a silly question, in Aristotle's mind: for to be a heavenly body that is near, after all, is just what it is to be a planet.¹⁸

These results also help us to see more clearly what has gone wrong in the case of the second argument above, as compared to the first argument. In the second argument, 'not twinkling' is invoked as a middle term allegedly to explain why being near belongs to all planets. In the first argument, on the other hand, 'being near' is used as a middle term to explain why not twinkling belongs to all planets. But the attempt to explain why planets are near on the basis of their not twinkling at best captures an *evidential* order of priority, not a *causal* order of priority. We might have learned that planets are near on the basis of observing that they do not twinkle; but it would be strange to suggest that the nearness of planets is actually caused by the fact that they do not twinkle.

12.3.2 Aristotle's explanatory method in biology

It is one thing to posit, in the abstract, that the explanatory order of priority represented in a successful demonstration must directly mirror the causal order of priority present among the phenomena in question, but quite another to apply and test this model of scientific theorizing as a practising scientist. If, as theorists about science, we are to assign to definitions the heavy explanatory lifting they are required to do in Aristotle's

¹⁸ Since definitions, like all first principles, cannot be demonstrated, they also cannot be *known* demonstratively [*epistasthai*]. Aristotle uses a distinct term [*nous*] for the epistemic state corresponding to one's grasp of first principles. The term, '*nous*', in this context, can be (and has been) translated into English in a variety of different ways, e.g., as intuition, understanding, or comprehension. In his very difficult and condensed discussion of *nous* in the very last chapter of the *Posterior Analytics* (*APo* B.19), Aristotle states that we reach the epistemic state of *nous* (i.e., the grasp of the first principles) through a process of *induction* [*epagōgē*]. For Aristotle, induction begins with the perception of particulars and somehow leads through a series of steps involving memory, learning, and experience, to the ability to 'give an account', which itself amounts to or leads to the grasp of first principles. But how exactly this cognitive achievement comes about is not spelled out in any detail. Aristotle devotes considerable attention to perception (*De Anima*), deductive reasoning (*Prior Analytics*), demonstrative reasoning (*Posterior Analytics*), and dialectical reasoning (*Topics*); but, as far as we know, he never wrote a separate treatise on inductive reasoning and the grasp of first principles.

theory of demonstration, a practising scientist would need to find that essences (the non-linguistic counterparts of definitions) actually do the requisite amount of heavy causal lifting to justify the placement of definitions among the explanatorily basic axioms of a theory. Does the natural world Aristotle encounters in fact conform to the model of scientific theorizing he sets out in the *Posterior Analytics*?¹⁹ In particular, given Aristotle's background assumptions about the natural world, is his central thesis, that all necessary (but non-essential) features of a kind of thing can be causally traced back to facts about essences and hence explained by appeal to definitions, tenable from the point of view of a practising scientist?²⁰

12.3.2.1 Case-study: the multiple stomachs of camels

These questions are best addressed by turning to Aristotle's biological treatises.²¹ In particular, I will focus my remarks in what follows on a single example from *Parts of Animals* (henceforth abbreviated '*PA*'): Aristotle's

¹⁹ There are many interesting and worthwhile questions that arise concerning the relation between Aristotle's theorizing about science, in the *Posterior Analytics*, and his behaviour as a practising scientist, as illustrated for example in the biological works. One interesting debate that has ensued among scholars for example concerns the question of how (if at all) the blatant absence of explicitly syllogistic reasoning in the biological treatises is compatible with Aristotle's theory of demonstration, as developed in the *Posterior Analytics*. (For discussion, see for example Balme 1987a, 1987b; Barnes 1975 and Barnes 2002: 'Introduction'; Bolton 1987; Charles 1990, 2002; Gothelf 1987; Lennox 1987, 1990; *et al.*) Given my present concerns, we can bypass this question and view the information conveyed by a syllogistic argument, as illustrated above, as tantamount to what is conveyed by the corresponding 'because'-statement. My interest currently is only with the specific question of whether, in the face of scientific evidence, Aristotle can maintain his central thesis that essences play the causal role required to justify the explanatory role assigned to definitions in his theory of demonstration.

²⁰ Among Aristotle's background assumptions, which shall become important in what follows, are these: (i) Species are eternal. (ii) Concrete particular substances are compounds of matter and form. (iii) The natural world is best understood along teleological lines. (iv) The natural world exhibits the following compositional hierarchy: concrete particular substances are composed of non-uniform parts (e.g., feathers, beaks, eyes, etc.); non-uniform parts are composed of uniform parts (e.g., blood, marrow, bone, etc.); uniform parts are composed of the four elements (*viz.*, earth, air, fire, and water). (v) The composition and organization of the bodies of living organisms is constrained, on the material side, by the fact that only a limited amount of each element is available for each type of living organism. (vi) Hard materials (e.g., those composing horns, teeth, bones, nails, hair, and the like) contain a high proportion of earth.

²¹ For those who are not familiar with the life and work of Aristotle, it is worth emphasizing Aristotle's excellent credentials not only as a theorist of science, but also as a practising scientist, especially in the field of biology. After his twenty-year-long stint as a student and associate at Plato's Academy, Aristotle left Athens at the age of thirty-seven, after Plato's death in 347 BC, and is thought to have spent the next ten years or so of his life, among other things, conducting extensive biological research along the coast of Asia Minor. The wealth of detailed observations Aristotle amassed during this period of his life is truly impressive and takes up approximately one quarter of his surviving texts (cf., *History of Animals*, *Parts of Animals*, *Movement of Animals*, *Progression of Animals*, and *Generation of Animals*).

treatment of the question, 'why do camels have multiple stomachs?'²² This specific case, while quite complex, allows us to illustrate the variety of explanatory factors on which Aristotle draws in the biological works; it also brings out some of the potential challenges Aristotle's approach to scientific explanation faces, when put to the test against the vast array of observed correlations that need to be explained by a successful theory of biology.

In *PA* III.14, Aristotle discusses the question of why some animals have one stomach, while others have multiple stomachs.²³ He notes that the number of stomachs an animal has seems to be correlated with several of its other features, e.g., with whether the animal is viviparous (*i.e.*, gives birth to live young), sanguineous (*i.e.*, blooded), or ambidentate (*i.e.*, has front teeth in both of its jaws); with whether the animal is polydactylous (*i.e.*, has many digits), has solid hoofs, or is cloven-hoofed; with whether the animal has horns; and with whether the animal eats very thorny and woody food. All animals that are viviparous and sanguineous, Aristotle notes, have only a single stomach, whether they are polydactylous (e.g., human beings, dogs, and lions), solid-hoofed (e.g., horses, mules, and donkeys), or cloven-hoofed (e.g., pigs), as long as they are ambidentate. Horned animals tend to be non-ambidentate and have multiple stomachs (e.g., sheep, cows, and goats). As Aristotle remarks in his discussion of horns (*PA* III.2), animals that have horns, typically for the purposes of defending themselves, tend to be non-ambidentate, since (in his view) the earthy material that is needed for the construction of horns is then no longer available for the construction of front teeth in both jaws. To make up for the lack of front teeth in both jaws, horned animals tend to have multiple stomachs, to help them digest the food they eat properly.

Camels are an interesting case for Aristotle: for even though they lack horns, camels are nevertheless similar to horned animals in that they are non-ambidentate and have multiple stomachs. As Aristotle notes in *PA* III.2, very large animals (like the camel) do not need horns in order to defend themselves. But given the surplus earthy material that is freed up by their lack of horns, one might expect camels to have front teeth in

²² I am here drawing on Gothelf (1987), who considers Aristotle's discussion of the multiple stomachs of camels in *PA* III.14 in detail.

²³ That animals must have stomachs at all, in Aristotle's view, follows from facts about essences in the following way. Like all ancient Greek philosophers, Aristotle takes it to be obvious that all living organisms, including plants, have a soul. The most basic capacity all living beings possess simply by virtue of being alive, *i.e.*, simply by virtue of having a soul at all, is the capacity for growth and nourishment. Having this capacity requires that an organism have some method of ingesting food and extracting the nutrients found therein for its own use. Unlike plants, animals have internal organs for digesting the food they take in (*viz.*, their stomachs) and internal organs for removing the residue that remains after the food is digested (*viz.*, their intestines).

both of their jaws, regardless of what their stomachs are like. So the question Aristotle wishes to answer concerning camels is this: why, given that camels lack horns, are they nevertheless non-ambidentate and have multiple stomachs? The answer he gives is as follows:

The explanation of this is that it is more [necessary] for the camel to have multiple stomachs than to have front teeth. Its stomach, then, is constructed like that of non-ambidentates, and its teeth match its stomach – for the teeth in question would be of no service. Its food, moreover, being of a thorny character, and its tongue necessarily being made of a fleshy substance, nature uses the earthy matter which is saved from the teeth to give hardness to the palate. The camel ruminates like the horned animals, because its multiple stomachs resemble theirs. . . . For since the mouth, owing to its lack of teeth, only imperfectly performs its office as regards the food, the stomachs receive the food one from the other in succession, the first taking the unreduced substances, the second the same when somewhat reduced, the third when the reduction is complete, and the fourth when the whole has become a smooth pulp. (*PA* III.14, 674a34–674b13)²⁴

Aristotle thus reasons that, because their diet is so thorny and woody, camels benefit more from having multiple stomachs, in order for them to be able to digest the food they eat properly, than they would benefit from having front teeth in both jaws. But given the camel's need for multiple stomachs, it is now no longer necessary for the camel to have front teeth in both of its jaws, since its multiple stomachs already take care of the task of dealing with the camel's thorny and woody diet better than a second row of front teeth could. The surplus earthy material which is now freed up, due to the camel's lack of the second row of front teeth, could of course go into the construction of horns. But since the camel does not need horns (due to its size), it would be better served by having the surplus earthy material used to make the roof of its mouth very durable, so that it can withstand the thorny and woody food it ingests without injury.

12.3.2.2 *Telos, matter, and habitat*

Aristotle's discussion above presents us with a number of lawful generalizations concerning camels, such as the following:

- (3) a. Camels lack horns.
- b. Camels have multiple stomachs.
- c. Camels are non-ambidentate.

²⁴ Translation by W. Ogle (see Barnes 1984). I have substituted 'necessary' for 'essential' in the first line of the cited passage, since the Greek has 'ἀνοχ/κατότροπον' and the distinction is of course important for present purposes.

- d. Camels have hard and durable palates.
- e. Camels eat very thorny and woody food.

In his explanation of why camels have the particular necessary (but non-essential) features they do, Aristotle finds himself appealing to a variety of explanatory factors originating roughly from the following three sources: (i) *Telos*: considerations concerning the proper functioning of an organism and the characteristic activities in which it engages; (ii) *Matter*: considerations concerning the types of materials that compose an entity; and (iii) *Habitat*: considerations concerning the environment in which an animal naturally resides. To illustrate:

- (4) a. Living organisms are capable of growth and nourishment.
- b. Animals are capable of digesting food internally.
- c. Stomachs are internal organs capable of digesting food.
- d. Camels are very large animals residing in desertous regions.
- e. Deserts are geographical regions that are extremely hot and dry.
- f. Earthy material is hard and durable.

Teleological considerations (e.g., (4.a)–(4.c)) for example dictate that camels, like all animals, must be able to ingest and internally digest food in some fashion, in order to manifest their capacity for growth and nourishment. Environmental considerations (e.g., (4.d)–(4.e)) dictate that, given their natural habitat, camels must be able to ingest and digest very thorny and woody food, since (so Aristotle presumably reasons) this is the only kind of food that is readily available to them in the desertous regions in which they naturally reside. Given these factors, together with other assumptions Aristotle makes, material considerations (e.g., (4.f)) dictate that the bodies of camels and the parts of their bodies exhibit certain physiological features, e.g., hard and durable palates made of predominantly earthy material.

If Aristotle's explanatory strategy in this particular case is to follow the outlines of his general approach to scientific explanation, his account of why camels have the necessary (but non-essential) features they do must indicate how these features can be traced back causally to facts about essences. But there is of course no reason to expect that the necessary (but non-essential) features of camels can be causally explained *solely* by reference to facts about the essence of camels: as illustrated above, facts about the essences of various other types of entities (e.g., animals and living organisms in general, stomachs, desertous regions or earthy material) also turn out to be relevant to a causal explanation of why camels have

the particular necessary (but non-essential) features they do. For example, the fact that the palates of camels are hard and durable is at least in part causally explained by reference to the fact that the palates of camels are made of earthy material. But the fact that things made of predominantly earthy material are hard and durable, for Aristotle, is itself directly traceable to facts about the essence of earth. Thus, causal explanations of why camels have the particular necessary (but non-essential) features they do (viz., hard and durable palates) may also terminate in facts about the essences of other types of entities which are in some way implicated in the activities, physiology, or habitat of camels.

12.4 CONCLUSION

Given a broadly non-modal conception of essence, the question arises of how propositions stating necessary (but non-essential) features of objects can be derived from propositions stating essential features. In the foregoing remarks, I singled out two crucial ways in which Aristotle's construal of the relevant notion of 'following from', viz., demonstration, supplements that of deductive consequence. First, for Aristotle, the relevant notion of entailment that is found in a proper scientific explanation inherits its asymmetry from the actual causal order of priority that obtains among the phenomena being characterized. Secondly, we learn from examining Aristotle's biology that a successful scientific explanation of the necessary (but non-essential) features of one type of phenomenon (e.g., camels) may require an appeal to facts about the essences of various other related types of phenomena (e.g., earth, stomachs, deserts, and the like). Both of these considerations strike me as important from the point of view of contemporary metaphysicians who are sympathetic to Fine's project of grounding modality in essence.

CHAPTER 13

No potency without actuality: the case of graph theory

David S. Oderberg

13.1 INTRODUCTION

Dispositional essentialism is the thesis that at least some characteristics or properties¹ of objects are dispositional in nature.² What this means is that the essence of a dispositional property (disposition for short) is its relation to other properties, namely the *stimulus* and *manifestation* properties of the disposition. To take the stock example of fragility, and speaking loosely, the essence of this disposition is its relation to the stimulus of being (appropriately) stressed and the manifestation or response to the stimulus, which consists in breaking. A glass that possesses fragility will, if appropriately stressed, break. A more precise example is solubility: any solid, liquid, or gas that has the disposition of solubility in a liquid L will, when inserted into L, dissolve to form a homogeneous solution with L.³

Dispositional essentialists generally allow that not all properties are dispositional, though how to mark the distinction between the dispositional

¹ I will henceforth use the term 'property' instead of 'characteristic' in deference to contemporary usage, whilst inserting the caveat that this is strictly a misuse of the term 'property', which has a more precise meaning in Aristotelian metaphysics; see Oderberg (2007: chapter 7).

² It has been defended in various ways and to various extents by, apart from Bird (2007), Swyer (1982), Ellis and Lierse (1994), Ellis (2001), and Molnar (2003).

³ Note that by 'properties of the disposition' I do not mean that the dispositional property itself has stimulus and manifestation properties. It is not as though fragility can be either stressed or break. Rather, 'properties of the disposition' should be read as elliptical for a more complex formulation: fragility has the (second-order) property of being such that objects that possess it will, if (appropriately) stressed, break, where being stressed and breaking are first-order properties. To put it even more precisely: the stimulus and manifestation properties of a disposition are those first-order properties that figure in the conditional whose antecedent is an open sentence consisting of a variable whose range is the objects possessing the disposition, combined with the predicate term denoting the first-order stimulus property of objects within the range, and whose consequent is an open sentence whose variable has the same range, combined with the predicate term denoting the first-order manifestation property of objects within the range. This is not to say that disposition ascriptions can be exhaustively analysed in terms of such conditionals, only that such conditionals are associated with disposition ascriptions and do at least partly explain what it is for such ascriptions to be true.

objects. Identity-dependence is not only an asymmetric relation of ontological dependence: it also implies ontological *priority* on the part of the entity depended upon, with respect to the dependent entity. And this is precisely in accordance with the Aristotelian spirit of the four-category ontology, according to which individual substances – *objects*, as we are calling them – have ultimate ontological priority over entities in any of the other three categories. I suggest, then, that within the four-category ontology we need to regard modes as being ‘aspects’ of objects, to which we can attend selectively in thought or perception, by means of what Locke called a ‘partial consideration’. These aspects explain the differential behaviour of different objects: for instance, why some objects roll down an inclined plane while others do not – the former being *spherical* or *cylindrical*, the latter not. But it is, after all, *the whole object* that rolls, not its sphericity or cylindricality. Nor does it make much sense to suppose that its sphericity or cylindricality ‘drags along’ the object’s other modes with it, and thereby makes the object as whole move. To think in such terms is illicitly to *hypostatize* modes, treating them as simple substances *within* an object, rather than just as particular ‘ways’ an object is. I conclude that the four-category ontology, properly understood, has to be excluded *both* from the class of relational ontologies *and* from that of constituent ontologies. Attempts to force it into either of these camps simply turn it into some other kind of ontology altogether. Moreover, to the extent that both relational and constituent ontologies clearly run into certain difficulties which the four-category ontology escapes in virtue of belonging to neither camp, some credit must surely accrue to it.²

² I am grateful for comments received when an earlier draft of this paper was presented at a Conference on Relational versus Constituent Ontology, held at the University of Notre Dame in March 2010.

References

- Ackrill, J. L. 1964. *Aristotle: Categories and De Interpretatione*, translated with notes. Oxford: Clarendon Press
- Allan, K. 1971. ‘A Note on the Source of *There* in Existential Sentences’, *Foundations of Language* 7: 1–18
- Aristotle. *Historia Animalium*, translated by D. W. Thompson. 1907
- Categories and De Interpretatione*, translated with notes by J. L. Ackrill. 1963 Oxford: Clarendon Press
- De Anima, Metaphysics, On the Generation of Animals, and Physics*, in *The Complete Works of Aristotle, The Revised Oxford Translation*, ed. J. Barnes. 1984 Princeton University Press
- Armstrong, D. M. 1989. *Universals: An Opinionated Introduction*. Boulder: Westview Press
1989. *A Combinatorial Theory of Possibility*. Cambridge University Press
1997. *A World of States of Affairs*. Cambridge University Press
- Armstrong, D. M., Marrin, C. B., and Place, U. T., ed. T. Crane. 1996. *Dispositions, A Debate*. London: Routledge
- Balme, D. M. 1987a. ‘The Place of Biology in Aristotle’s Philosophy’, in Gotthelf and Lennox (eds.), pp. 9–20
- 1987b. ‘Aristotle’s Use of Division and Differentiae’, in Gotthelf and Lennox (eds.), pp. 69–89
- Barker, S. 2009. ‘Dispositional Monism, Relational Constitution and Quiddities’, *Analysis* 69: 242–50
- Barnes, J. 1975. ‘Aristotle’s Theory of Demonstration’, in Barnes, Schofield, and Sorabji (eds.), pp. 65–87
1981. ‘Proof and Syllogism’, in Berti (ed.), pp. 17–59
- (ed.) 1984. *The Complete Works of Aristotle* (Vol. I and II), Bollingen Series LXXI. Princeton University Press
2002. *Aristotle: Posterior Analytics*, translated with a commentary by J. Barnes, Second Edition. Clarendon Aristotle Series. Oxford: Clarendon Press
- Barnes, J., Schofield, M., and Sorabji, R. (eds.) 1975. *Articles on Aristotle*, vol. 1 (Science). London: Duckworth
- Barwise, J. and Cooper, R. 1981. ‘Generalized Quantifiers and Natural Language,’ *Linguistics and Philosophy* 4: 159–219

- Bealer, G. 1987. 'Philosophical Limits of Scientific Essentialism', *Philosophical Perspectives* 1: 289–365
- Bealer, G. 1999. 'A Theory of the A Priori', *Philosophical Perspectives* 13: 29–55
- Ben-Yami, H. 2004. *Logic & Natural Language: On Plural Reference and Its Semantic and Logical Significance*. Aldershot: Ashgate
2009. 'Generalized Quantifiers, and Beyond', *Logique et Analyse* 208: 309–26
- Bergmann, G. 1967. *Realism: A Critique of Brentano and Meinong*. Madison, WI: University of Wisconsin Press
- Berti, E. (ed.) 1981. *Aristotle on Science: The Posterior Analytics*. Proceedings of the Eighth Symposium Aristotelicum. Padova: Edirice Antenore
- Bird, A. 2005. 'The Ultimate Argument Against Armstrong's Contingent Necessitation View of Laws', *Analysis* 65: 147–55
2007. *Nature's Metaphysics: Laws and Properties*. Oxford: Clarendon Press
- Bolton, R. 1987. 'Definition and Scientific Method in Aristotle's *Posterior Analytics* and *Generation of Animals*', in Gotthelf and Lennox (eds.), pp. 120–65
- Booth, A. and Rowbottom, D. P. In press. *Intuitions*. Oxford University Press.
- Boyd, R. 1999. 'Homeostasis, Species, and Higher Taxa', in R. A. Wilson (ed.), *Species: New Interdisciplinary Essays*, pp. 141–85. Cambridge: MIT Press
- Brentano, F. 1862. *Von der mannigfachen Bedeutung des Seienden nach Aristoteles*. Freiburg: Herder. English translation *On the Several Senses of Being in Aristotle*. Translated by R. George. Berkeley: University of California Press, 1975
- Butterfield, J. 1998. 'Determinism and Indeterminism', in E. Craig, *Routledge Encyclopedia of Philosophy*, vol. III. London: Routledge
- Campbell, K. 1990. *Abstract Particulars*. Oxford: Blackwell
- Cartwright, N. 1989. *Nature's Capacities and Their Measurement*. Oxford: Clarendon Press
2007. 'What Makes a Capacity a Disposition', in M. Kistler and B. Gnasounou (eds.), *Dispositions and Causal Powers*, pp. 195–205. Aldershot: Ashgate
- Chalmers, D. J. 1996. *The Conscious Mind: In Search of a Fundamental Theory*. Oxford University Press
- Chalmers, D. J., Manley, D., and Wasserman, R. (eds.) 2009. *Metametaphysics: New Essays on the Foundations of Ontology*. Oxford University Press
- Chappell, V. C. 1970. 'Stuff and Things', *Proceedings of the Aristotelian Society* 71: 61–76
- Charles, D. 1990. 'Aristotle on Meaning, Natural Kinds and Natural History', in Devereux and Pellegrin (eds.), pp. 145–67
2002. *Aristotle on Meaning and Essence*. Oxford: Clarendon Press
- Charles, D. (ed.) 2010a. *Definition in Greek Philosophy*. Oxford University Press
- Charles, D. 2010b. 'Definition and Explanation in the *Posterior Analytics* and *Metaphysics*', in Charles 2010a (ed.), pp. 286–328
- Chisholm, R. 1996. *A Realistic Theory of Categories: an Essay on Ontology*. Cambridge University Press
- Correia, F. 2008. 'Ontological Dependence', *Philosophy Compass* 3 (5): 1013–32
- Correia, F. and Schnieder, B. (eds.) In press. *Volume on non-causal explanation*, Cambridge University Press

- Crane, T. 2001. *Elements of Mind*. Oxford University Press
- Crick, F. H. C. 1958. 'On Protein Synthesis', *Symposium of the Society for Experimental Biology* 12, 138–63.
- Crystal, D. 2004. *Making Sense of Grammar*. London: Pearson Longman
- Davies, P. C. W. 1999. *The 5th Miracle: The Search for the Origin and Meaning of Life*. Orion
2006. 'The Physics of Downward Causation', in P. Clayton and P. Davies (eds.), *The Re-Emergence of Emergence*. Oxford University Press
- Demos, R. 1948. 'Note on Plato's Theory of Ideas', *Philosophy and Phenomenological Research* 8, 456–60
- Devereux, D. and Pellegrin, P. (eds.) 1990. *Biologie, Logique et Métaphysique Chez Aristote*. Actes du Séminaire C.N.R.S. – N.S.F. 1987, Éditions du CNRS, Paris, 1990
- Dewey, J. 1920. *Reconstruction in Philosophy*. New York: Henry Holt
- Dipert, R. R. 1997. 'The Mathematical Structure of the World: The World as Graph', *Journal of Philosophy* 94: 329–58
- Dummett, M. 1981. *Frege: Philosophy of Language*, 2nd edn. Cambridge, MA: Harvard University Press
- Earman, J. 1986. *A Primer on Determinism*. Dordrecht: Reidel
- Ellis, B. and Lierse, C. 1994. 'Dispositional Essentialism', *Australasian Journal of Philosophy* 72: 27–45
- Ellis, B. 2001. *Scientific Essentialism*. Cambridge University Press
2002. *The Philosophy of Nature: A Guide to the New Essentialism*. Chesham: Acumen
- Evans, G. 1982. *The Varieties of Reference*. Oxford University Press
- Fine, K. 1994. 'Essence and Modality', J. E. Tomberlin (ed.), *Philosophical Perspectives* 8: *Logic and Language*, as the Nous Casteneda Memorial Lecture, pp. 1–16; reprinted in P. Grim (ed.) *The Philosopher's Annual for 1994*, volume 16. Stanford: CSLI
- 1995a. 'Ontological Dependence', *Proceedings of the Aristotelian Society* 95: 269–90
- 1995b. 'Senses of Essence', in Sinnott-Armstrong, Raffman and Asher (eds.), pp. 53–73
- 1995c. 'The Logic of Essence', *Journal of Philosophical Logic* 24: 241–73
2001. 'The Question of Realism', *Philosophers' Imprint* 1 (2): 1–30, URL = www.philosophersimprint.org/001001/; reprinted in A. Bottani, M. Carrara and P. Giaretta (eds.), *Individuals, Essence and Identity: Themes of Analytic Philosophy*, pp. 3–41. Dordrecht: Kluwer
2009. 'The Question of Ontology', in Chalmers, Manley, and Wasserman (eds.), pp. 157–77
- In press. 'A Guide to Ground', forthcoming in Correia and Schnieder (eds.)
- Forbes, G. 1985. *The Metaphysics of Modality*. Oxford: Clarendon Press
- Foster, J. 1982. *The Case for Idealism*. London: Routledge & Kegan Paul
- Frankel, J. 1989. *Pattern Formation: Ciliate Studies and Models*. Oxford University Press

- Frede, M. 1994. 'Aristotle's Notion of Potentiality in *Metaphysics* Θ ', in T. Scaltas, D. Charles, and M. L. Gill (eds.), *Unity, Identity, and Explanation in Aristotle's Metaphysics*, pp. 173–93. Oxford University Press
- Frege, G. 1879. Begriffsschrift. Halle: Louis Nebert, translated by S. Bauer-Mengelberg as Concept Script, a Formal Language of Pure Thought Modelled Upon That of Arithmetic, in J. van Heijenoort (ed.), *From Frege to Gödel: A Source Book in Mathematical Logic, 1879–1931*. Cambridge, MA: Harvard University Press, 1967
1884. *Die Grundlagen der Arithmetik*, translated by J. L. Austin as *Foundations of Arithmetic*, second revised edition. Oxford: Blackwell, 1974
- Geach, P. T. 1980. *Reference and Generality*, 3rd edn. Ithaca, NY: Cornell University Press
- Gendler, T. S. and Hawthorne J. (eds.) 2002. *Conceivability and Possibility*. Oxford University Press
- Geurts, B. and Beaver, D. I. 2007. 'Discourse Representation Theory', The Stanford Encyclopedia of Philosophy (Summer 2007 Edition), E. N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/sum2007/entries/discourse-representation-theory/>
- Gilbert, S. F., Opitz, J. M., and Raff, R. A. 1996. 'Resynthesizing Evolutionary and Developmental Biology', *Developmental Biology* 173: 357–72
- Gill, M. L. 1989. *Aristotle on Substance, The Paradox of Unity*. Princeton University Press
- Gillies, D. A. 2000. *Philosophical Theories of Probability*. London: Routledge
- Glymour, C. 2003. 'Foraging Theory and Chancy Selection', in Andreas Hütteman (ed.), *Determinism in Physics and Biology*, pp. 76–90. Paderborn: Mentis
- Gothelf, A. 1987. 'First Principles in Aristotle's *Parts of Animals*', in Gothelf and Lennox (eds.), pp. 167–98
- Gothelf, A. and Lennox, J. G. (eds.) 1987. *Philosophical Issues in Aristotle's Biology*. Cambridge University Press
- Gross, J.L. and Yellen, J. (eds.) 2004. *Handbook of Graph Theory*. Boca Raton, FL: CRC Press
- Guenin, L. M. 2008. *The Morality of Embryo Use*. Cambridge University Press
2011. 'Probabilistic Projection of Total Developmental Potential' (in press)
- Hamburger, V. 1957. 'The Concept of Development in Biology', in D. B. Harris (ed.), *The Concept of Development: An Issue in the Study of Human Behavior*, pp. 49–58. Minneapolis: University of Minnesota Press
- Harary, F. 1969. *Graph Theory*. Reading, MA: Addison-Wesley Publishing Co.
- Heil, J. 2003. *From an Ontological Point of View*. Oxford: Clarendon Press
2009. 'Relations', in R. Le Poidevin and R. Cameron (eds.), *Routledge Companion to Metaphysics*, pp. 310–21. London: Routledge
2010. 'Language and Thought', in B. P. McLaughlin (ed.), *Oxford Handbook of the Philosophy of Mind*, pp. 631–47. Oxford: Clarendon Press
- In press. 'Universals in a World of Particulars', forthcoming in G. Galluzzo, M. J. Loux, and E. J. Lowe (eds.), *Universals*

- Hempel, C. G. 1965. *Aspects of Scientific Explanation*. New York: Free Press
1978. 'Dispositional Explanation', in R. Tuomela (ed.), *Dispositions*, pp. 137–46. Dordrecht: Reidel
- Hendry, R. F. 2006. 'Elements, Compounds, and Other Chemical Kinds', *Philosophy of Science* 73: 864–75
- Hoffman, J. In press. 'Metametaphysics and Substance: Two Case Studies', *Axiomathes*
- Hoffman, J. and Rosenkrantz, G. S. 1991. 'Are Souls Unintelligible?' *Philosophical Perspectives*, 5: 183–212
1994. *Substance Among Other Categories*. Cambridge University Press
1997. *Substance: Its Nature and Existence*. London and New York: Routledge
- Hofweber, T. 2005. 'A Puzzle about Ontology', *Noûs* 39: 256–83.
2009. 'Ambitious, Yet Modest, Metaphysics', in Chalmers, Manley, and Wasserman (eds.), pp. 260–89.
- Husserl, E. 1900–01. *Logical Investigations*, translated by J. N. Findlay, revised edn. London: Routledge, 2001
- Huxley, J. and de Beer, G.R. 1934. *The Elements of Experimental Embryology*. Cambridge University Press
- Ingarden, R. 1948/49. Spór o istnienie świata [*The Controversy over the Existence of the World*], Kraków: Polska Akademia Umiejętności, I 1947, II 1948, III 1961. German translation *Der Streit um die Existenz der Welt*. Tübingen: Niemeyer, I, II/1, II/2 1964, III 1961. Partial English translation *Time and Modes of Being*, translated by H. R. Michajda. Springfield: Charles Thomas, 1964
- Irwin, T. 1988. *Aristotle's First Principles*. Oxford University Press
- Jackson, F. 1998. *From Metaphysics to Ethics: A Defense of Conceptual Analysis*. Oxford: Clarendon Press
2010. *Language, Names and Information*. Chichester: Wiley-Blackwell
- Kim, J. 1993. *Supervenience and Mind*. Cambridge University Press
- Koslicki, K. 2008. *The Structure of Objects*. Oxford University Press
- In press. 'Varieties of Ontological Dependence', forthcoming in Correia and Schneider (eds.)
- Kripke, S. 1980. *Naming and Necessity*. Cambridge, MA: Harvard University Press
- Ladyman, J. 2007. 'Structural Realism', The Stanford Encyclopedia of Philosophy (Winter 2007 Edition), E. N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2007/entries/structural-realism/>
- Ladyman, J. and Ross, D. 2007. *Every Thing Must Go: Metaphysics Naturalized*. Oxford University Press
- Laycock, H. 1972. 'Some Questions of Ontology', *Philosophical Review* 81: 3–42
1975. 'Theories of Matter', *Synthese* 31: 411–42
2006. *Words Without Objects*. Oxford University Press
- Lennox, J. G. 1987. 'Divide and Explain: The Posterior Analytics in Practice', in Gothelf and Lennox (eds.), pp. 90–119
1990. 'Notes on David Charles on HA', in Devereux and Pellegrin (eds.), pp. 169–84

2010. 'Bios and Explanatory Unity in Aristotle's Biology', in Charles (ed.), pp. 329–55
- Levinson, J. 1978. 'Properties and Related Entities', *Philosophy and Phenomenological Research* 39: 1–22
- Lewis, D. 1997. 'Finkish Dispositions', *Philosophical Quarterly* 47: 143–58
- Loeb 1962. *Aristotle: The Categories, On Interpretation, Prior Analytics*, ed. and trans. H.P. Cook and H. Tredennick. London: William Heinemann Ltd
- Loux, M. J. 2006 'Aristotle's Constituent Ontology', in D. Zimmerman (ed.), *Oxford Studies in Metaphysics*, vol. II, pp. 207–50. New York: Oxford University Press
- Lowe, E. J. 1995. 'Potentiality', in T. Honderich (ed.), *The Oxford Companion to Philosophy*, p. 708. Oxford University Press
1998. *The Possibility of Metaphysics*. Oxford University Press
2002. 'Metaphysical Nihilism and the Subtraction Argument', *Analysis* 62: 62–73
2003. 'Individuation', in M. Loux and D. Zimmerman (eds.), *The Oxford Handbook of Metaphysics*. Oxford University Press
2006. *The Four-Category Ontology: A Metaphysical Foundation for Natural Science*. Oxford: Clarendon Press
- 2009a. *More Kinds of Being*. Oxford: Wiley-Blackwell
- 2009b. 'Modes of Exemplification', in B. Langlet and J.-M. Monnoyer (eds.), *Gustav Bergmann: Phenomenological Realism and Dialectical Ontology*, pp. 173–92. Frankfurt: Ontos
2010. 'Ontological Dependence', *The Stanford Encyclopedia of Philosophy* (Spring 2010 Edition), E. N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2010/entries/dependence-ontological/>
2011. 'The Rationality of Metaphysics', *Synthese* 178: 99–109
- Lowe, E. J. and Rami, A. (eds.) 2009. *Truth and Truth-Making*. Stocksfield: Acumen
- Mackie, J. L. 1976. 'The Riddle of Existence', *Proceedings of the Aristotelian Society*, Supplementary Volume 50: 247–65
- Maienschein, J. 2005. 'Epigenesis and Preformationism', *The Stanford Encyclopedia of Philosophy* (Winter 2005 Edition), E. N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2005/entries/epigenesis/>
- Makin, S. 2006. *Aristotle, Metaphysics Θ*, translation with introduction and commentary. Oxford: Clarendon Press
- Martin, C. B. 1994. 'Dispositions and Conditionals', *The Philosophical Quarterly* 44: 1–8
- McGinn, C. 2001. *Logical Properties*. Oxford University Press
- McKay, T. J. 2008. 'Critical Notice of Henry Laycock, *Words Without Objects*', *Canadian Journal of Philosophy* 38: 301–24
- McNally, L. In press. 'Existential Sentences', forthcoming in C. Maibenborn, K. von Heusinger and P. Portner (eds.) *Semantics: An International Handbook of Natural Language Meaning*. The Hague: de Gruyter

- Meinong, A. 1904. 'On the Theory of Objects', translated by I. Levi, D. B. Terrell, and R. Chisholm, in R. Chisholm (ed.) *Realism and the Background of Phenomenology*. Atascadero, CA: Ridgeview, 1981
- Mellor, D. H. 1974. 'In Defense of Dispositions', *Philosophical Review* 83: 157–81
- Millikan, R. 1999. 'Historical Kinds and the "Special Sciences"', *Philosophical Studies* 95: 45–65
- Molnar, G. 2003. *Powers: A Study in Metaphysics*, ed. S. Mumford. Oxford University Press
- Moro, A. 2007. 'Existential Sentences and the Expletive "There"', in M. Everaert and H. van Riemsdijk (eds.) *Blackwell Companion to Syntax*, vol. II, pp. 210–36. Oxford: Blackwell
- Mumford, S. 1998. *Dispositions*. Oxford University Press
- Nagel, E. 1961. *The Structure of Science*. New York: Harcourt, Brace & World
1979. *Teleology Revisited and Other Essays in the Philosophy and History of Science*. New York: Columbia University Press
- Neale, S. 1990. *Descriptions*. Cambridge, MA: MIT Press
- Needham, J. 1950. *Biochemistry and Morphogenesis*. Cambridge University Press
- Oderberg, D. S. 2007. *Real Essentialism*. London: Routledge
- Oppenheim, P. and Putnam, H. 1958. 'Unity of Science as a Working Hypothesis', in H. Feigl, M. Scriven, and G. Maxwell (eds.), *Concepts, Theories, and the Mind-Body Problem*. Minnesota Studies in the Philosophy of Science, vol. II pp. 3–36. Minneapolis: University of Minnesota Press
- Parsons, J. 2009. 'Are there Irreducibly Relational Facts?', in E. J. Lowe and E. Rami (eds.), *Truth and Truth-Making*, pp. 217–26. Stocksfield: Acumen Press
- Peters, S. and Westerståhl, D. 2006. *Quantifiers in Language and Logic*. Oxford: Clarendon Press
- Popper, K. 1934. *The Logic of Scientific Discovery*, translation 1959. London: Hutchinson
1957. 'The Propensity Interpretation of the Calculus of Probability, and the Quantum Theory', in Stephan Körner (ed.), *Observation and Interpretation*. London: Butterworths
1959. 'The Propensity Interpretation of Probability', *British Journal for the Philosophy of Science* 10: 25–42
- Priest, G. 2005. *Towards Non-Being*. Oxford University Press
- Prior, E., Pargetter, R., and Jackson, F. 1982. 'Three Theses About Dispositions', *American Philosophical Quarterly* 19: 251–7
- Quine, W. V. 1939. 'A Logical Approach to the Ontological Problem', *Journal of Unified Science* 9; reprinted in Quine, W. V., *The Ways of Paradox*, pp. 197–202. Cambridge, MA: Harvard University Press
1948. 'On What There Is', *Review of Metaphysics* 2: 21–28; reprinted in *From a Logical Point of View*, 2nd edn., pp. 1–19. Harvard, MA: Harvard University Press
1953. 'Three Grades of Modal Involvement', *Actes du XIème Congrès International de Philosophie*, Volume XIV, Volume complémentaire et

- communications du Colloque de Logique, North-Holland Publishing Company, Amsterdam 1953, and Éditions E. Nauwelaerts, Louvain, 1953, pp. 65–81
1960. *Word and Object*. Cambridge: MIT Press
1961. 'Reference and Modality', in *From a Logical Point of View*, 2nd edn., pp. 139–59. New York: Harper and Row
1969. 'Existence and Quantification', in *Ontological Relativity and Other Essays*. New York: Columbia University Press
1974. *The Roots of Reference*. LaSalle, IL.: Open Court
1976. 'Necessary Truth', in *The Ways of Paradox and Other Essays*, rev. edn. Cambridge: Harvard University Press
- Rescher, N. 1962. 'Plurality-Quantification: Abstract', *Journal of Symbolic Logic* 27: 373–4
- Robinson, H. 1982. *Matter and Sense*. Cambridge University Press
- Rosenkrantz, G. S. 2001. 'What is Life?', in Tian Yu Cao (ed.) *Proceedings of the Twentieth World Congress of Philosophy*, 10: *Philosophy of Science*, pp. 124–34. Bowling Green, OH: Philosophy Documentation Center
- Ross, W. D. 1924. *Aristotle's Metaphysics, A Revised Text with Introduction and Commentary*. Oxford: Clarendon Press
- (ed.) 1964. *Aristotelis Analytica Priora et Posteriora*, edited with critical annotations by W.D. Ross, with preface and appendix by L. Minio-Paluello. Oxford Classical Texts. Oxford: Clarendon Press
2004. *Aristotle*, 6th edn. London: Routledge
- Russell, B. 1903a. 'Asymmetrical Relations', in *The Principles of Mathematics*, pp. 218–26. London: Routledge. Reprinted 1997
- 1903b. *The Principles of Mathematics*. Cambridge University Press
1919. *Introduction to Mathematical Philosophy*. London: George Allen and Unwin
1959. *My Philosophical Development*. London: George Allen and Unwin
- Ryle, G. 1949. *The Concept of Mind*. London: Hutchinson
- Sawyer, J. 1973. 'Existential Sentences: A Linguistic Universal?', *American Speech* 48: 239–45
- Schaffer, J. 2009. 'On What Ground What', in Chalmers, Manley, and Wasserman (eds.), pp. 347–383
- Scheffler, I. 1985. *Of Human Potential*. London: Routledge & Kegan Paul
- Schneider, L. 2009. 'The Logic of the Ontological Square', *Studia Logica* 91: 25–51
- Simons, P. 1987. *Parts: A Study in Ontology*. Oxford University Press
- Sinnott-Armstrong, W., Raffman, D., and Asher, N. (eds.) 1995. *Modality, Morality, and Belief: Essays in Honor of Ruth Barcan Marcus*. New York, NY: Cambridge University Press
- Smith, Q. and Craig, W.L. 1993. *Theism, Atheism and Big Bang Cosmology*. Oxford: Clarendon Press
- Soames, S. 2003. *Philosophical Analysis in the Twentieth Century*. Princeton University Press

- Sober, E. 2000. *Philosophy of Biology*, 2nd edn. Boulder, CO: Westview Press
- Spemann, H. 1938. *Embryonic Development and Induction*. New Haven: Yale University Press
- Stalnaker, R. 1984. *Inquiry*. Cambridge, MA: MIT Press
- Stanley, J. and Z. G. Szabó 2000. 'On Quantifier Domain Restriction', *Mind and Language* 15: 219–61
- Swoyer, C. 1982. 'The Nature of Natural Laws', *Australasian Journal of Philosophy* 60: 203–23
- Tahko, T. E. 2008. 'A New Definition of A Priori Knowledge: In Search of a Modal Basis', *Metaphysica* 9: 57–68
- 2009a. 'The Law of Non-Contradiction as a Metaphysical Principle', *The Australasian Journal of Logic* 7: 32–47
- 2009b. 'On the Modal Content of A Posteriori Necessities', *Theoria: A Swedish Journal of Philosophy* 75: 344–57
- Tartar, V. 1956. 'Pattern and Substance in Stentor', in D. Rudnick (ed.) *Cellular Mechanisms in Differentiation and Growth*, pp. 73–100. Princeton University Press
1961. *The Biology of Stentor*. New York: Pergamon Press
1962. 'Morphogenesis in Stentor', *Advances in Morphogenesis* 2: 1–26
- Trendelenburg, A. 1845. *Geschichte der Kategorienlehre*. Repr. Hildesheim: Olms, 1979
- Trudeau, R. J. 1976. *Dots and Lines*. The Kent State University Press
- van Fraassen, B. C. 1970. *An Introduction to the Philosophy of Time and Space*. New York: Random House. 2nd edn. New York: Columbia University Press, 1985
1989. *Laus and Symmetry*. Oxford University Press
- van Inwagen, P. 1990. *Material Beings*. Cornell University Press
2002. 'The Number of Things', *Philosophical Perspectives* 12, Realism and Relativism: 176–96
2003. 'Existence, Ontological Commitment and Fictional Entities', in M. Loux and D. Zimmerman (eds.) *The Oxford Handbook to Metaphysics*. Oxford University Press
2008. 'McGinn on Existence', *Philosophical Quarterly* 58: 36–58
- Weiss, P. 1939. *Principles of Development*. New York: Holt
- Westerkhoff, J. 2005. *Ontological Categories: Their Nature and Significance*. Oxford University Press
- Westerstahl, D. 2007. 'Quantifiers in Formal and Natural Languages', in D. M. Gabbay and F. Guenther (eds.) *Handbook of Philosophical Logic*, 2nd edition, pp. 223–338. Berlin: Springer, volume 14
- Wheeler, J. A. 1998. *Geons, Black Holes, and Quantum Foam*. New York: W. W. Norton & Company
- Whithead, A. N. 1929. *Process and Reality*. London: Macmillan. Corrected edition, ed. D. R. Griffin and D. W. Sherburne. New York: Free Press, 1978
- Wiggins, D. 1980. "'Most" and "All": Some Comments on a Familiar Programme, and on the Logical Form of Quantified Sentences' in M. Platts (ed.),

- Reference, Truth and Reality: Essays on the Philosophy of Language*. London: Routledge and Kegan Paul
1995. 'The Kant-Russell-Frege View of Existence: Toward the Rehabilitation of the Second-Level View' in Walter Sinnott-Armstrong *et al.* (eds.), *Modality, Morality and Belief: Essays in Honor of Ruth Barcan Marcus*. Cambridge: Cambridge University Press
- Williams, D. C. 1959. 'Universals and Existents', a paper delivered to the Yale Philosophy Club and published posthumously in *The Australasian Journal of Philosophy* 64 (1986): 1-14
- Williamson, T. 2007. *The Philosophy of Philosophy*. Oxford: Blackwell
- Wilson, R. J. 1996. *Introduction to Graph Theory*, 4th edn. Harlow: Addison Wesley Longman Ltd
- Wittgenstein, L. 1922. *Tractatus Logico-Philosophicus*. Translated by C. K. Ogden, London: Routledge & Kegan Paul. Originally published as 'Logisch-philosophische Abhandlung', in *Annalen der Naturphilosophische*, XIV (3/4), 1921. Translated by D. F. Pears and B. F. McGuinness, London: Routledge & Kegan Paul, 1961
- Wolpert, L. 1969. 'Positional Information and the Spatial Pattern of Cellular Differentiation', *Journal of Theoretical Biology* 25: 1-47
1971. 'Positional Information and Pattern Formation', *Current Topics in Developmental Biology* 6: 183-224
- Wolterstorff, N. 1970. 'Bergmann's Constituent Ontology', *Noûs* 4: 109-34

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