The Levels of Scientific Disciplines

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Abstract

I develop an account of disciplinary level in terms of truth-maker semantics. In particular, I exploit the mereological structure of states of affairs—which is central to the truth-maker approach—to provide conditions in which one discipline occupies a higher level than another.

Introduction

The philosophy of science is replete with discussions of level. Quite plausibly, physics occupies a more fundamental level than chemistry, which itself occupies a more fundamental level than biology. Practicing scientists also invoke interdisciplinary levels; it is not uncommon to encounter assertions like, 'This problem ought to be handled at the level of quantum mechanics, rather than organic chemistry.'[1] But despite the widespread appeal to levels of discipline—and despite the (modicum of) agreement over which disciplines occur at higher levels than others—there is currently no consensus on the nature of level itself. While many maintain that biology is more fundamental than psychology is, it remains entirely unclear why this is the case—what it is in virtue of that one discipline occupies a lower level than another.

One proposal is epistemic. Perhaps we ought to account for disciplinary level in terms of what is needed to understand that discipline.[2] The reason that chemistry lies at a lower

[1] One example, chosen effectively at random, is the following: "Nowadays, both theoretical and experimental investigations have presented a conclusion that the evanescent modes of the electromagnetic field can superluminally propagate. *At the level of* quantum mechanics, via tunneling analogy the superluminal propagation of evanescent modes has been described as the quantum tunneling behavior of photons, which implies that the superluminality of evanescent modes is due to a quantum effect. In this paper *at the level of* quantum field theory, we will further show that the superluminality of evanescent modes is due to a purely quantum effect, and clarify some misunderstandings on the physical properties of evanescent modes" (Wang, Xiong and He, 2008, pg. 319—emphasis mine).

[2] I am not aware of any philosopher who defends this precise interpretation of disciplinary level. However, someone who defends an epistemic notion of this sort of reduction is Chalmers (2012). Chalmers introduces the notion of scrutability; an *a priori* scrutability base for p (for a subject s) is a set of sentences Γ such that 'If Γ then p' is knowable a priori for s. Chalmers holds that physical, qualitative, indexical, and totality

level than biology, on this interpretation, is that an adequate understanding of biology requires at least some understanding of chemistry, while an understanding of chemistry requires no understanding of biology.[3] More generally, there is a perfectly intelligible interpretation according to which discipline D_1 occurs at a higher level than discipline D_2 just in case an understanding of D_1 requires an understanding of D_2, but an understanding of D_2 does not require an understanding of D_1.[4]

There is another interpretation of level—one rooted in metaphysics, rather than epistemology. On this conception, the reason physics occurs at a lower level than psychology has nothing whatsoever to do with our understanding of physical or psychological facts. Even if we were unable to understand either discipline, physics would remain more fundamental than psychology. Rather, the disciplines are so-leveled because they stand in a worldly relation to one another. An interpretation of level, on this conception, amounts to an account of what that worldly relation is.

It is my aim to provide such an account of level: to provide necessary and sufficient conditions for one discipline to occupy a higher level than another. To this end, I exploit the theoretical resources of truth-maker semantics—a burgeoning field with applications in natural-language semantics, metaphysics and the philosophy of science.[5] A bit roughly, I claim that discipline D_1 occupies a higher level than discipline D_2 just in case the state of affairs that make an object fall within the purview of D_1 are composed of states of affairs that make an object fall within the purview of D_2. For example, it may be that the states of affairs which make it the case that a substance is water are composed of states of affairs that make it the case that substances are hydrogen and oxygen. The hierarchy of disciplinary levels thus arises from the mereological structure of states of affairs. It will take time before this account can be stated any more precisely; the details of truth-maker semantics must first be appreciated.

Here, I identify disciplines with sets of predicates.[6] It may be, for example, that chem-

truths form a minimal scrutability base for all truths. It would be possible to extend Chalmers' discussion of scrutability to one that held that a discipline D_1 was at a lower level than discipline D_2 just in case the truths of D_1 formed a scrutability base for all truths in D_2 (for an arbitrary person).

[3]For the epistemic conception to be viable, this statement needs refinement. Certain areas—such as organic chemistry—directly tie into biology (and so an understanding of these areas must involve some understanding of biology). While this point is well taken, I will not engage with further refinements of this sort of account, as I am not primarily concerned with an epistemic conception of level.

[4]Arguably, this interpretation of level is intransitive. It may be that ecology is at a higher level than biology, which is at a higher level than chemistry, which is at a higher level than physics. But if an understanding of physics is not needed for an understanding of ecology, then—on this interpretation—ecology does not occur at a higher level than physics. Those inclined to this view might resolve this problem by adopting the transitive closure of the epistemic account.

[5]See Fine (2017), deRosset (2017) and Elgin (2022) for the development of this approach and its applications to puzzles in the philosophy of science.

[6]Even linguistically, disciplines contain far more than predicates. There are operators, constants, quantifiers, and more. At present, I focus on predicates for two reasons: first, they play an important role in demarcating the subject matter of a discipline. Additionally, the truthmaker semantics I rely upon has

istry is associated with {'is carbon,' 'is a molecule,' ...} and biology with {'is a mammal,' 'reproduces asexually,' ... }.[7] This is not to say that sets of predicates exhaust what the disciplines consist of. Each may have its own laws, methods, open questions, journals, and more. But for the purposes of this paper, sets of predicates will suffice. These predicates relate directly to the interests, orientations, subject matter and methods of a discipline—and so can serve to demarcate the boundaries of a field of study.[8] Of course, philosophers may well note that this assumption is an idealization. It is my hope that, in future work, this account will be expanded to encompass terms of all syntactic categories that scientists employ.

Before I turn to the details of this account, a few caveats about how it should be interpreted. I do not intend this to be a linguistic analysis of 'level' as the term is used by practicing philosophers and scientists. Given the variety of contexts in which this word occurs, I very much doubt that there is a univocal analysis to be found. Nor do I maintain that what I provide is the unique (or even the best) interpretation of level. It is perfectly conceivable that two theories adequately explicate the notion of level—perhaps even equally well. Rather, I aim to demonstrate that this account satisfies the theoretical requirements that an interpretation ought to satisfy. To this end, I do not defend this account by arguing that it is preferable to all available alternatives—but rather by outlining what I take the theoretical demands on an interpretation of level to be, and by demonstrating that this account satisfies these demands. Along these lines, some philosophers may be tempted by an account of relative level in terms of grounding, rather than truthmaking (e.g., deRosset

not yet been developed for a higher-order language (that would be capable of expressing terms of these diverse syntactic categories). Nevertheless, my hope is that, when the semantics is developed, it will be straightforward to extend the present theory to one that addresses these sorts of terms.

[7]To the best of my knowledge, the first philosophers to suggest identifying disciplines with sets of predicates were Oppenheim and Putnam (1958). I leave it as an open question which discipline is associated with which set of predicates. Perhaps the association is determined sociologically, so that a discipline's predicates are those used by scientists practicing that discipline (my thanks to REMOVED FOR BLIND REVIEW for this suggestion). But although sociology may determine what disciplines there are, it does not determine the levels that disciplines stand in. Though it may be that disciplines are those identified with departments in universities, there is nothing in universities' structure that determines that chemistry is more fundamental than economics. Perhaps, instead, it is determined by law, so that a discipline's predicates are those that are associated with a statement of its laws (perhaps in some ideal language). See Fodor (1974) for a proposal along these lines. Or perhaps it is permissive, so that every set of predicates counts as a discipline in a broad sense, and practical factors determine which disciplines we engage with. However it is that a discipline is associated with a set of predicates, this account may proceed.

[8]Some might object on the grounds that the same discipline might be identified with various sets of predicates. For example, we might express classical mechanics with either Hamiltonians or Lagrangians. I note, first, that there may be a privileged way of expressing predicates. Perhaps, as Lewis (1983) suggests, some of these predicates are more natural than others. If so, we can select the predicates within a discipline that are the most natural. However, even if we reject the notion of relative naturalness, there is room to push back on this point. Suppose there was a discipline D that could be identified either with predicates $\{P_1, P_2, ..., P_m\}$ or predicates $\{P_n, ..., P_z\}$. In the account that follows, we could identify D with either set of predicates—so long as the states of affairs that make one set of predicates obtain are the same as the states of affairs that make the other obtain as well.

(2017)). Roughly, the thought is that discipline D_1 occurs at a higher level than D_2 if the truths of D_2 ground the truths of D_1. I am not convinced that these alternatives compete. Just as multiple explications of 'physicalism' may satisfy our theoretical demands, so too multiple explications of 'level' may satisfy our theoretical demands.[9] So, if an account in terms of grounding were to succeed, that need not imply that an account in terms of truthmaking must fail. More generally, the comparative advantages of the two accounts can only be determined after an account of ground is fully developed, which falls outside the scope of this paper.[10]

Additionally, I remain strictly agnostic about which disciplines occupy which levels—and, indeed, on whether disciplines are leveled at all. Although I occasionally appeal to intuitions about the levels of science, it is perfectly compatible with what I say that the sciences are unleveled. In this case, I provide conditions that fail to obtain; the reason that the sciences are unleveled is that disciplines do not stand in the relation that I articulate.

There are at least two senses in which philosophers might be skeptical of the notion of level. They might, first, claim that the notion of level is in some sense *unintelligible* and ought to be rejected because it is confused. Alternatively, they might claim that the notion is perfectly intelligible—but that it fails to obtain. My target with this paper is the first sort of skeptic. I aim to demonstrate how we could make sense of the notion of level, and that it is not confused in the manner some may suspect. I do not presently argue against the second skeptic. (Indeed, this paper may even be of use to that skeptic, as it clarifies what it takes for disciplines to be unleveled).

In addition to being agnostic about the levels disciplines stand in, I am also agnostic about what disciplines there are. It could be that disciplines neatly align with the way universities are structured—so that each department corresponds to its own discipline. But the study of science is often interdisciplinary, with the investigation of biophysics, quantum chemistry and the like. This theory is compatible with the claim that these areas themselves constitute disciplines in their own right, and may stand at higher or lower levels than others.[11]

It may be helpful, in characterizing this program, to recall Lewis (1970)'s discussion of the definition of theoretical terms. Lewis held that the meaning of a theoretical predicate is given by its expanded postulate: the claim that there exists a unique F that theoretically functions as F is postulated to within that theory. The expanded postulate for 'level,' then, is given by the theoretical function that levels are intended to perform. The following discussion of these theoretical functions can be understood as providing this expanded

[9] For an argument that multiple explications of 'physicalism' are adequate, see Crane and Mellor (1990).

[10] However, for an argument that ground-based interpretations of physicalism are pressured to accept an implausible form of panpsychism, see Rubenstein (Forthcoming).

[11] Of course, even if biophysics and quantum chemistry do not constitute their own disciplines (on some conception of 'discipline') there may remain practical reasons to study them. It can be fruitful to determine what impacts one discipline has on another, which may lead to interdisciplinary research—even if that research does not constitute its own discipline.

postulate—and the ensuing account constitutes a relation that witnesses this existential claim.

Theoretical Desiderata

I maintain that the following are theoretical desiderata for an account of scientific level. An account ought to:

1. Form a strict partial ordering over the disciplines.
2. Account for the reductive component of level.
3. Allow for properties to be multiply realized.
4. Remain agnostic about what the levels of science are.
5. Permit crossover in subject-matter between levels of discipline.

Let us take these in turn.

1. Form a Strict Partial Ordering over the Disciplines

A binary relation is a strict partial ordering just in case it is transitive, asymmetric and (hence) irreflexive. By claiming that an adequate account of level forms such an ordering, I thus maintain that the following obtains:

i) No discipline is at a higher level than itself.
ii) If discipline D_1 is at a higher level than discipline D_2, then discipline D_2 is not at a higher level than discipline D_1.
iii) If discipline D_1 is at a higher level than discipline D_2 and discipline D_2 is at a higher level than discipline D_3, then discipline D_1 is at a higher level than discipline D_3.

I have nothing substantial in support of this desideratum to offer. Its best defense is that it is overwhelmingly obvious that it is true. The intuition that sciences do not occur at higher levels than themselves (and that the other corresponding claims obtain) runs deep. To my mind, this is an indispensable criterion—one whose satisfaction is not merely desirable, but compulsory. Any interpretation that fails to from a strict partial ordering over the disciplines ought to be abandoned, regardless of any other theoretical benefits it might have.

2. Account for the Reductive Component of Level

If one discipline lies at a higher level than another, then there is some sense in which the former reduces to the latter.[12] If physics is the lowest-level discipline, it seems no accident that the other disciplines reduce to physics (on some notion of reduction or other). And if thermodynamics lies at a higher level than statistical mechanics, it seems no accident that thermodynamics reduces to statistical mechanics as well.[13]

It is important that the reduction at issue is *complete*. That is to say, if one discipline lies at a higher level than another, then *all* of the facts of the former reduce to facts of the latter. For example, if it were to turn out that some biological facts reduced to chemical facts—but other biological facts did not—it would not be the case that biology reduces to chemistry.

Perhaps some philosophers reject reduction because they countenance emergence. The characterization of 'emergence' is itself a contentious issue, but, roughly, the thought is that property F is emergent from property G just in case the presence of F can be partially—but not entirely—explained by G. For example, emergentists about the mental might maintain that the property of *being conscious* can be partially, but not entirely, explained by *having brain-state b*. And because there is an aspect of *being conscious* that is not explained by *having brain-state b*, it cannot be that *being conscious* reduces to *having brain-state b*.

There is a deep tension between the first two desiderata. It might even be suggested that they are incompatible, and, therefore, that no account of level could consistently satisfy both. Many maintain that metaphysical reduction is closely tied to identity.[14] If one theory were to reduce to another, but facts about the former remained distinct from facts about the latter, it appears to be merely nominally reductive (at best). But if facts about two disciplines are identical, it is difficult to see how either discipline could be at a higher level than the other. That is to say, it appears that the claim that D_1 reduces to D_2 requires that $D_1 = D_2$. But if $D_1 = D_2$, then an application of Leibniz's Law ensures that every property D_1 bears is also borne by D_2.[15] By stipulation, this includes the property of *being at a higher level than* D_2, which entails that D_2 is at a higher level than itself. There is, therefore, a violation of *irreflexivity*, which I have claimed to be indispensable to a theory of level. If an account were—somehow—able to satisfy both the first and second

[12]For discussions of this point, see Oppenheim and Putnam (1958); Nagel (1961); Fodor (1974). There are numerous types of reduction that might be employed. Perhaps reduction ought to be understood in terms of causation and explanation—see Kim (1998)—organization—see Churchland and Sejnowski (1992)—relative size—see Kemeny and Oppenheim (1956); Oppenheim and Putnam (1958); Wimsatt (1976)—analysis—see Sheperd (1994)—or realization—see Gillett (2002). The point, for our purposes, is that if an account of level could find no plausible sense in which the sciences were reductive, it would be defective.

[13]See, e.g., Sklar (1993, 1999); Callender (1999); Albert (2000) for a discussion of this reduction.

[14]For recent discussions along these lines, see Dorr (2016); Correia (2017).

[15]There has been extensive recent discussion on how to revise higher-order logic in order to abandon Leibniz's Law—see, e.g., Bacon and Russell (2017); Bacon (2019); Caie, Goodman and Lederman (2020). One way to avoid the conflict between the asymmetry of reduction and the symmetry of identity is to abandon Leibniz's Law—this method was defended by Correia (2017).

desiderata, it would count substantially in its favor.

3. Allow for Properties to be Multiply Realized

It is widely believed that some properties can be *multiply realized*. A property is said to be multiply realizable just in case it can be manifested by diverse underlying configurations. Plastic shaped in the appropriate way may form a cup, but cups can also be made of metal or glass. And it may be that *being in pain* is associated with firing C-fibers in humans, but it is perfectly conceivable for organisms with other neurological profiles to experience phenomenal pain as well.

Some interpretations of level preclude the possibility of multiply realizable properties. Nagel (1961), for example, maintains that the properties of higher-level sciences are identified with properties of the lower-level sciences. In order for the biological property *being a heart* to reduce to a chemical property, there must be some chemical property to which it is identical. But if *being a heart* is multiply realizable (perhaps hearts can be composed of carbon, silicon, etc.) there may be no single chemical property to which it is identical. We can, of course, identify properties with the disjunction of their instances—perhaps to be a heart is to either be carbon shaped thus and so, silicon shaped thus and so, etc. But, as Fodor (1974) argues, these disjunctive identifications are explanatorily poor. One learns much more about the nature of hearts by learning the function that hearts perform, rather than a lengthy disjunction. And because these disjunctive identifications are explanatorily inadequate, they are poor contenders for reduction.

It is not entirely clear how to make this objection stick. It assumes that the disjuncts in an identification have nothing explanatorily significant in common. If, say, two genotypes gave rise to the same phenotype, the fact that the organism had one of the two would give some explanation of its displaying the phenotypical trait. If we knew that only organisms with one of the genotypes displayed the trait, we would know quite a lot. If we further knew that these two genotypes displayed the same vulnerability, we would be in a very good position to explain the occurrence of the trait, even if the explanation took the form 'This trait can occur in one of two ways.' In any case, whether or not higher-level properties answer to multiple configurations at a lower level seems a question for empirical science to investigate, and is not something to be decided *a priori*. That being so, a schema for levels should leave the prospect open.

4. Remain Agnostic About What the Levels of Science Are

Philosophers ought to be sensitive to the limits of philosophical inquiry—especially when discussing science. Gone are the days when we maintained that internal reflection could reveal what the laws of nature are (for example). Empirical evidence often plays an important role in scientific inquiry, and we would err if we were to make *a posteriori* claims with only *a priori* grounds. I maintain that an account of what a level of scientific discipline

consists of ought to remain neutral on what the levels actually are. The arrows of explanation may point to the very small—so that facts about large objects are explained by facts about smaller objects (and, correspondingly, that the sciences governing the small form the lowest-level disciplines). Alternatively, it could be that facts about the small are explained by facts about the large (and that the sciences governing large-scale structures form the lowest level). But whatever answer is, it is to be settled by empirical considerations: with what science determines actually performs explanatory work.

An example may help clarify this point. Some, like Weinberg (1992), argue that disciplines like quantum field theory form the lowest-level discipline—while Schaffer (2010) argues that the universe as a whole is fundamental. Both appeal to quantum mechanical considerations in their arguments (Schaffer, for example, argues that the universe as a whole is in a state of quantum entanglement—and so there is more information contained within the whole than there is within its parts). Some might suspect that these philosophers thus agree on the primacy of quantum mechanics as a field of study. But neither is guilty of the sin I have in mind—for both appeal to empirical considerations in determining what the levels of discipline are.

An example of those who *are* guilty of the sin are Oppenheim and Putnam (1958), who build in the notion of micro-reduction into the definition of scientific level. That is to say, their account of what a level consists of precludes the possibility of sciences governing large objects occupying the most fundamental level—and it does so without appeal to explanations that scientists actually find.

To be clear, I object to a metaphysical account of level that takes a stand on this debate *even if it gets the answer right* (that is to say, even if it correctly determines which discipline occupies the lowest level). If it is an account of level defended on purely *a priori* grounds, then it ought not determine which sciences occur at which levels.

I do not mean to suggest that every investigation into the levels of science ought to adhere to this agnosticism. On some approaches, the practice and interpretation of science are intertwined. It might be reasonable, on these approaches, for a philosopher (or scientist) to provide an interpretation of what the levels are in a manner that takes a stand on relative fundamentality. However, *if the interpretation of what a level consists of is carried out in an* a priori *manner* (which is primarily the approach applied here), then it ought not to determine which discipline is more fundamental than another. Without empirical information, we cannot determine which discipline explains the others. While philosophy may determine what a level of science *is*, the sciences themselves determine what the levels *are*.

5. Permit Crossover in Subject-Matter Between Levels of Discipline

The empirical sciences are a motley crew. There are no sharp dividing lines—such that the practitioners of one field dare not venture forth into another. Although 'is carbon dioxide' may be a paradigmatic predicate of chemistry, ecologists may investigate whether volcanic

explosions that release sufficient carbon dioxide trigger mass extinctions; some psychologists study how risk-averse people typically are, while behavioral economists investigate how risk-aversion affects macroeconomic trends; and astronomers and physicists alike are concerned with the implications of general relativity. If the notion of levels of science was incompatible with interdisciplinary crossover, the prospects of scientific levels would be poor.[16] Some have advocated abandoning the very notion of level on the grounds that no account could permit such interdisciplinary crossover.[17] Because it is impossible to identify the 'real level' of a phenomenon, the very notion of level may be considered suspect. However, if there were an account of level which allowed objects to occur at different levels, this objection would lose its bite.

Guttman (1976) and Potochnik and McGill (2012) discuss this point at length.[18] For them, the crossover of subject-matter is not so much a problem for the analysis of level (they largely assume that levels preclude such crossover), but rather a reason to believe that disciplinary levels do not exist. One of Guttman's examples concerns the study of ecosystems. Although many traditionally conceive of ecosystems as composed of organisms, he notes that ecosystems are actually composed of numerous kinds of things. There are water and air molecules, rivers and mountains, etc. Furthermore, the study of ecosystems does not concern itself solely with the organisms therein, but rather with how organisms interact with these other features of their environment. This observation is in tension with any conception of level incompatible with interdisciplinary crossover (which, Shapiro (2022) argues, includes the view of Oppenheim and Putnam (1958)). If a concept of level requires that the levels be entirely isolated from one another, it seems unlikely that the sciences are leveled. Numerous things are objects of study in several disciplines. However, if there were a conception of scientific level that allowed for the crossover of subject-matter, it may assuage these concerns.

The criteria I have discussed are not exhaustive; there may well be further conditions that could be added—conditions that reflect any additional theoretical work that the notion of level ought to accomplish. But they are enough to begin. I now turn to current developments in truth-maker semantics, which I rely upon in this account.

An Overview of the Truth-Maker Approach

The underlying thought behind truth-maker semantics is that there exists something within the world—a state of affairs, perhaps, or a way that the world is—which verifies, or renders true, a representational entity such as a proposition or sentence. Moreover, it is held that

[16] This point is briefly endorsed by Oppenheim and Putnam (1958), when they allow for there to be crossover of language between scientific disciplines at different levels (pg. 5). However, they deny that an object at one level has parts at a higher level (pg. 9).

[17] See Wimsatt (2006).

[18] For another such discussion, see Craver (2007, 2015), who argues on these grounds that the scientific disciplines, as actually practiced, do not correspond to levels within nature.

the meanings of the representational entities can be identified with that which makes them true.[19]

When stated so generally, this may seem uncontroversial. After all, a great many philosophers—tracing back at least to Tarski (1944), and possibly as far back as Frege (1892)—have identified the meanings of sentences with their truth-conditions. What differentiates truth-maker semantics from more traditional approaches is its commitment to *exact* truth-makers. If a state of affairs verifies a proposition it does not merely necessitate its truth, nor is it merely partially relevant to its truth; rather it is *entirely* relevant to its truth. So, while the state of affairs of grass being green and the sky being blue arguably verifies 'Grass is green and the sky is blue,' it does not verify '$2 + 2 = 4$' despite necessitating the equation's truth, nor does it verify 'Grass is green' because a part of that state—the part concerning the sky being blue—is irrelevant to 'Grass is green.'

On this approach, states of affairs are structured: some are proper parts of others. It may be that the state of roses being red is a proper part of the state of roses being red and violets being blue, and it may be that the state of Jane being a fox is a proper part of the state of Jane being a vixen. Given that states are capable of mereological composition, it is desirable to describe this structure within our formalism. This is accomplished with a state-space: an ordered pair $< S, \sqsubseteq >$ where S is a set of states of affairs, and $\sqsubseteq$ is a binary relation on S, with the intended interpretation of parthood, such that '$s \sqsubseteq s'$' asserts that state s is a part of state s'. Here, I make the standard assumption that parthood is a partial ordering—i.e., that $\sqsubseteq$ satisfies the following criteria:

REFLEXIVITY:	$s \sqsubseteq s$
ANTISYMMETRY:	$(s \sqsubseteq s' \wedge s' \sqsubseteq s) \rightarrow s = s'$
TRANSITIVITY:	$(s \sqsubseteq s' \wedge s' \sqsubseteq s'') \rightarrow s \sqsubseteq s''$

The only additional restriction is that state-spaces are *complete*—that is to say, they allow for arbitrary fusion.[20]

The development of a semantics requires a language to which meaning is attributed. I restrict my attention to a simple, first-order language. This language contains predi-

[19] The development of truth-maker semantics is largely due to Fine (2013, 2016, 2017). I rely heavily on these developments within this paper.

[20] Here, I identify the fusion of states with their least upper bound. Defining this precisely requires a few additional definitions. First, we may let an *upper bound* of $T \subseteq S$ be a state that contains every state within T as a part: i.e., t is an upper bound of T iff $\forall s \in T, s \sqsubseteq t$. We then say that a state t is a *least-upper-bound* of $T \subseteq S$ iff it is an upper bound of T and is a part of all upper bounds of T: i.e., just in case if s is a least upper bound of T, then $t \sqsubseteq s$. Provably, if a set has a least upper bound, then it has a unique least upper bound. Suppose, for reductio, that a set T had two least upper bounds t and t'. Because they are both least upper bounds, they are both upper bounds. And because each least upper bound contains every upper bound as a part, it follows that $t \sqsubseteq t'$ and $t' \sqsubseteq t$. Given antisymmetry, this then entails $t = t'$. We denote the least upper bound of T as $\bigsqcup T$. A complete state-space is one in which every subset of S contains a least upper bound within S. For the purposes of this paper, I restrict my attention to complete state-spaces.

cates $F_1, F_2, ...$, of fixed adicity, and constants for individuals (so that a_1 is a constant for individual a_1, a_2 is a constant for individual a_2, etc.).[21] We also allow for the logical operators $\neg, \wedge, \vee$—each of which is defined in the standard way. Additionally, this language is equipped with infinitely many variables $x_1, x_2, ...$ and the quantifiers $\exists, \forall$, which serve both to bind the variables and to express generality.

Let a model $\boldsymbol{M}$ be an ordered quadruple $< S, \sqsubseteq, I, |\cdot| >$ such that $< S, \sqsubseteq >$ is a complete state-space, I is the set of individuals, and $|\cdot|$ is a valuation function. This valuation function takes each n-place predicate F and sequence of n individuals $a_1, a_2, ..., a_n$ in I as its input and has, as its output, an ordered pair $< V, F >$ subsets of S—intuitively, the states that verify that F of $a_1, a_2, ..., a_n$ and that falsify that F of $a_1, a_2, ..., a_n$ respectively. So, for example, if the valuation function were to take $<$ *is tall*, $Mary >$ as its input, its output may be the ordered pair $< \{$*Mary being tall*$\}, \{$*Mary being not tall*$\} >$—i.e., the ordered pair whose first element is the singleton set containing the state of Mary being tall, and the second element is the singleton set containing the state of Mary being not tall. With the definition of a model in place, we can then define our semantics inductively:

$i.^+$	$s \Vdash F(\mathrm{a}_1, \mathrm{a}_2, ...)$ iff $s \in \| < F, a_1, a_2, ..., a_n > \|^V$
$i.^-$	$s \dashv\Vdash F(\mathrm{a}_1, \mathrm{a}_2, ...)$ iff $s \in \| < F, a_1, a_2, ..., a_n > \|^F$
$ii.^+$	$s \Vdash \neg A$ iff $s \dashv\Vdash A$
$ii.^-$	$s \dashv\Vdash \neg A$ iff $s \Vdash A$
$iii.^+$	$s \Vdash A \wedge B$ iff there exist t, u such that $t \Vdash A$ and $u \Vdash B$ and $s = t \sqcup u$.
$iii.^-$	$s \dashv\Vdash A \wedge B$ iff either $s \dashv\Vdash A$ or $s \dashv\Vdash B$
$iv.^+$	$s \Vdash A \vee B$ iff either $s \Vdash A$ or $s \Vdash B$
$iv.^-$	$s \dashv\Vdash A \vee B$ iff there exist t, u such that $t \dashv\Vdash A$ and $u \Vdash B$ and $s = t \sqcup u$

It is my hope that this semantics is extraordinarily intuitive. Negation swaps a sentence's verifiers for its falsifiers; if the state of it being windy verifies 'It is windy' then it falsifies 'It is not windy.' Verifiers of conjunctions are fusions of verifiers of their conjuncts; if the state of the ball being red verifies 'The ball is red,' and if the state of the ball being round verifies 'The ball is round,' then the fusion of these states—the state of the ball being red and being round—verifies 'The ball is red and round.' Verifiers of disjunctions are verifiers of a disjunct; if the state of water being wet verifies 'Water is wet,' then it also verifies 'Water is wet or sand is wet.'

There are several ways to expand this semantics to clauses with quantifiers. We might,

[21] A natural objection to this is that sciences do not typically name every object that falls in their area of discourse. Ecologists may address the rate at which grass grows, but they lack a name for each blade of grass. The assumption that there is a name for each object is a simplification—but the semantics could be modified in two ways to address this point. We might, first, modify the semantics so that we do not require that each object has a name (or even avoid a language with constants at all). Alternatively, we might first define verification and falsification relative to models where each individual has a name, and then use this semantic characterization to define verification and falsification relative to arbitrary models, roughly in the manner of Fine (1978).

for example, countenance generic objects—so that a verifier of 'Everything is F' is a verifier of a generic object being F. The approach I adopt, instead, is instantial.[22] Verifiers of universal statements are fusions of verifiers of their instances. So a verifier of '$\forall xFx$' is the fusion of a verifier of 'Fa' with a verifier of 'Fb,' etc. Verifiers of existential statements are verifiers of their witnessing instances. The state of affairs that verifies '$\exists xFx$' is a state of affairs that makes it the case that a particular object is F. More formally, we have:

$v.^+$	$s \Vdash \forall x\phi x$ iff there are states s_1, s_2, ...such that $s_1 \Vdash \phi(\mathrm{a}_1)$, $s_2 \Vdash \phi(\mathrm{a}_2)$, etc. where a_1, a_2 etc. are all the constants, and $s = s_1 \sqcup s_2$...
$v.^-$	$s \dashv\Vdash \forall x\phi x$ iff there is some constant a such that $s \dashv\Vdash \phi(\mathrm{a})$
$vi.^+$	$s \Vdash \exists x\phi x$ iff there is some constant a such that $s \Vdash \phi(\mathrm{a})$
$vi.^-$	$s \dashv\Vdash \exists x\phi x$ iff there are states s_1, s_2 ...such that $s_1 \dashv\Vdash \phi(\mathrm{a}_1)$, $s_2 \dashv\Vdash \phi(\mathrm{a}_2)$, etc. where a_1, a_2 etc. are all the constants, and $s = s_1 \sqcup s_2$...

There is a wide variety of philosophical uses for this semantics. Some have argued that it underlies the logic of analytic content (see Fine (2013, 2016)), deontic logic (see Fine (2018*a*,*b*)), counterfactual conditionals (see Fine (2012)), natural language semantics (see Moltmann (2020)), epistemic closure (see Elgin (2021)), and philosophical analysis (see Correia and Skiles (2017); Elgin (2023)). But its closest application, to our present concern, occurs in Elgin (2022) who defends an interpretation of identity theory in terms of truth-maker semantics. In particular, he claims that the distinction between type-identity theory (the claim that every type is identical to a physical type) and token-identity theory (the claim that every token is identical to a physical token) is dissolved, and that this dissolution resolves canonical problems with both interpretations. The present aim, however, is not with the reflexive and symmetric relation of identity, but with an irreflexive and asymmetric relation of relative level.

The Levels of Scientific Disciplines

I seek conditions for one scientific discipline to lie at a higher level than another: for what it is that completes the biconditional *Higher Level* (D_1, D_2) *iff ...* , where both D_1 and D_2 are scientific disciplines. Recall that, for the present purpose, I identify scientific disciplines with sets of predicates—where the number of predicates within each discipline may be finite or infinite. Let us identify D_1 and D_2 with the following:

$D_1 = \{F_1, F_2, ...\}$
$D_2 = \{G_1, G_2, ...\}$

The motivation behind this account is that the relation between D_1 and D_2 arises from

[22] This approach occurs in Fine (2017).

the mereological structure of states of affairs. It may be that 'a is a water molecule' has verifiers, and that these verifiers have proper parts. Arguably, the state that verifies that a is water is itself composed of states of affairs concerning hydrogen and oxygen—i.e., perhaps the state that verifies that a is a water molecule is composed of the fusions of the state that o is an oxygen atom with ones that verify that h_1 and h_2 are hydrogen atoms (respectively) with one that verifies that o, h, and h' stand in such-and-such a configuration. If this is correct, we might account for the difference in level between chemistry and physics, for example, by appealing to the fact that the verifiers of chemical statements (i.e., statements that predicate a chemical predicate of an object or some objects) are composed of verifiers of physical statements (i.e., statements that predicate a physical predicate of an object or some objects). So, at an *extremely* rough first pass, we might claim:

Higher Level(D_1, D_2) iff
$\forall s, \forall F_n, \forall x (s \Vdash F_n\mathrm{x} \rightarrow (\forall t (t \sqsubseteq s \rightarrow \exists G_m (t \Vdash G_m\mathrm{x}))))$

This claims that D_1 is at a higher level than D_2 just in case for all states of affairs, for all predicates within D_1, and for all objects, if a state verifies that an object falls under the scope of a higher-level predicate, then if t is a part of that state, then t verifies that the object falls under the scope of some lower-level predicate.

A refinement is in order. It need not be the very same object which satisfies the higher-level predicate that also satisfies the lower-level predicate. If an object is a water molecule, different objects satisfy the predicate 'is a water molecule' and 'is hydrogen.' So, instead of requiring that a state that verifies that an object is F is composed of states which verify that *the very same object* is G, I allow for these states to verify that some object or other is G, i.e.:

Higher Level(D_1, D_2) iff
$\forall s, \forall F_n, \forall x (s \Vdash F_n\mathrm{x} \rightarrow (\forall t (t \sqsubseteq s \rightarrow \exists G_m \exists y (t \Vdash G_m\mathrm{y}))))$

Perhaps some suspect that further restrictions are needed. After all, if an object is a water molecule, it is not merely the case that some-objects-or-other are hydrogen and oxygen; rather, the parts of that very water molecule are hydrogen and oxygen. So, perhaps we ought to impose the further requirement that the objects that satisfy the predicates of the lower-level discipline compose the objects that satisfy the predicate of the higher-level discipline.

This is not an approach I take. I note that, as the formalism currently stands, the relation of mereological composition is not defined upon the set of objects; it is a relation that holds between states of affairs. In order to describe mereological relations between objects, the semantics would need to be revamped—to reintroduce a notion of composition that holds between objects. Of course, nothing would stop us from modifying the semantics in this way, but this theory is incapable of stating this without further refinement.

We now face the elephant in the room: the variable t. As it stands, binding t with a universal quantifier (as in the formulations above) is too strong for our purposes. The problem is perhaps easiest to appreciate by shifting back to the (arguably more conventional) way of understanding mereology as a relation between objects. If a water molecule is composed of hydrogen and oxygen, it is not the case that every part of that water molecule is either hydrogen or oxygen. After all, these atomic parts can themselves be decomposed into their subatomic constituents. An electron that partially composes the oxygen atom is itself a part of the water molecule, but the electron is neither hydrogen nor oxygen. This problem resurfaces when mereology is understood as a relation between states. Suppose that state s is the state of *a being a water molecule*, and that this state verifies 'a is a water molecule.' It may be that this state can be decomposed into states concerning atomic objects—i.e., states concerning hydrogen and oxygen. These states may themselves be decomposed into states which verify that objects are electrons, protons, quarks, and the like. If this is so, then state s has parts that do not verify that an object satisfies the predicates of atomic objects. Some of its parts concern *subatomic* objects, rather than atomic objects. And so, on the present proposal, this would ensure that chemistry is not at a higher level than the study of atomic objects. But, surely, this is not the kind of thing that should prevent one discipline from occupying a higher level than another. So the universal quantifier doesn't work; it's just too strong.

Exchanging the universal for an existential quantifier is hardly an improvement. Such a proposal could not hope to accommodate the reductive component of levels. Suppose, for example, that there were a discipline that involved the interactions of atomic objects with disembodied minds. A state verifies 'Fa' in this discipline, just in case a part of it verifies that there is a disembodied mind and another part verifies that a is a hydrogen atom. In this case, a part of a verifier of 'Fa' concerns atomic objects, so this discipline would occupy a higher level than atomic objects (assuming that other verifiers acted appropriately as well). But it would be absurd to take this to lend support to the claim that facts about this discipline reduce to atomic physics. After all, a part of its subject-matter is disembodied minds; something which has nothing at all to do with atomic physics. And so, while the universal quantifier is far too strong, the existential quantifier is far too weak. Some intermediate position is required in their place.[23]

For the sake of clarity, let us once again revert to a notion of mereology as a relation between objects. What does it mean to claim that two hydrogen and one oxygen atoms compose a water molecule? It is not the claim that every part of the water molecule are hydrogen and oxygen atoms; after all, the parts of these atoms are themselves parts of that molecule. Rather, it is the claim that the hydrogen and oxygen atoms so-configured leave

[23]It might also be suggested that we require a notion of normality or typicality: perhaps a typical part of a verifier of the higher-level discipline involves a verifier of the lower level discipline. I am skeptical that this strategy will succeed. It seems eminently plausible to me that a typical verifier of 'a is a hydrogen atom' involves subatomic, rather than only atomic particles—after all, every helium atom is composed of subatomic particles.

nothing out. The object that is composed of the hydrogen and oxygen atoms misses no part of the water molecule; it is identical to it. A similar approach can be applied to the mereology of states of affairs. The claim that the parts of state s verify that something is G does not amount to the claim that *all* parts of s verify that something is G. Rather, it is the claim that we can fully describe state s—we can leave nothing out—when describing it in terms of its parts that verify that something is G. That is to say, there are parts of s—each of which verifies that something is G—whose fusion is identical to s.

There are (at least) two ways to represent this formally, one of which employs plural quantification and the other of which quantifies over sets. I will primarily address the formulation in terms of set-quantification, but I mean nothing metaphysically robust by that choice. As before, allowing S to be the set of states of affairs, results in the following condition:

Higher Level(D_1, D_2) iff
$\forall s, \forall F_n, \forall x(s \Vdash F_n\text{x} \rightarrow \exists T \subseteq S(\bigsqcup T = s \wedge \forall t \in T, \exists G_m, \exists y(t \Vdash G_m\text{y})))$

The notation is becoming more cumbersome, but the underlying thought (hopefully) remains intuitive. If a state of affairs verifies that an object is F (where F is a predicate of the higher-level discipline), then there exists some set of states of affairs, the fusion of which is identical to s, such that each element of that set verifies that an object is G (where G is a predicate of the lower-level discipline). This is perfectly compatible with the claim that s has parts that don't verify that something is G; all that is required is that s is identical to some fusion of states that *do* verify that something is G. If these states themselves have parts that are unrelated to G, that need not undermine the claim that one discipline is at a higher level than the other. This also resolves the problem that plagued the existential quantifier—of a discipline concerning atomic physics and disembodied minds. If a state s cannot be decomposed into states within the scope of atomic physics (because, perhaps, one part of s verifies that an object is a disembodied mind), then it does not satisfy the present condition. Even if disciplines have no predicates in common, that does not guarantee that they occur on the same level. If the states that make one disciplines' predicates obtain partially constitute states that make another disciplines' predicates obtain, then—on this account—the former discipline occurs at a lower level than the latter.

At long last, we have arrived at a putative account of what it takes for a discipline to be at a higher level than another. It is now possible to examine its theoretical virtues—to determine whether it satisfies the desiderata for a theory of level. The first, and arguably most indispensable, criterion was that an account ought to form a strict partial ordering over the disciplines—that it ought to be irreflexive, transitive and asymmetric. So, how does the present account fare?

Not well, unfortunately. The relation is transitive, all right, but it's also reflexive. That is to say, not only is this account *compatible* with the claim that a discipline is at a higher

than itself, but rather it *entails* that every discipline is at a higher level than itself.[24]

Something has gone wrong, and rather catastrophically so. It cannot be correct as it stands, for it fails to satisfy a central requirement for a theory of level.

Fortunately, the fix for the problem is straightforward. The present account is both transitive and reflexive. But shifting from a transitive and reflexive relation to an irreflexive one is simple: by appending a requirement that the converse does not hold. That is to say, if R is transitive and reflexive, we may define a relation S such that Sab iff $Rab \wedge \neg Rba$. Relation S is then transitive and asymmetric and (hence) irreflexive. In the present case, we may define the relation of being at a higher level than another as:

Higher Level(D_1, D_2) iff
$\forall s, \forall F_n, \forall x(s \Vdash F_n\text{x} \rightarrow \exists T \subseteq S(\bigsqcup T = s \wedge \forall t \in T, \exists G_m, \exists y(t \Vdash G_m\text{y}))) \wedge$
$\neg\forall s, \forall G_n, \forall x(s \Vdash G_n\text{x} \rightarrow \exists T \subseteq S(\bigsqcup T = s \wedge \forall t \in T, \exists F_m, \exists y(t \Vdash F_m\text{y})))$

The first theoretical desideratum is satisfied: this account forms a strict partial ordering.

On one conception, if there were disciplines D_1 and D_2 such that D_1's predicates were a proper subset of D_2's, D_1 would fall at a higher level than D_2.[25] How tenable this depends (at least partially) on how the predicates of one discipline are determined. If a discipline's predicates are those that figure in a statement of it's laws, then for this to occur, one discipline's laws would have a narrow scope than another's (which might render the claim that the discipline with a broader scope is more fundamental more tenable).[26]

The second requirement was that an account of level ought to explain the sense in which higher-level sciences reduce to lower-level sciences. If chemistry is at a higher level than physics, there ought to be a way in which chemical truths can be reduced to physical truths.

This is a requirement the present account easily accommodates. If chemistry occupies a higher level than physics, then states of affairs that verify that an object is F (for a chemical predicate F) are composed of states of affairs that verify that an object is G (for a physical predicate G). The fusion of the states of affairs that make lower-level predicates obtain is identical to a state that makes a higher-level predicate obtain. And it is because higher-level states are identical to fusions of lower-level states that the disciplines reduce.[27]

[24] To see why this is the case, select an arbitrary discipline D, which may be identified with the predicates $F_1, F_2, \ldots$. Select an arbitrary s, F_n and o such that $s \Vdash F_n o$—i.e., an arbitrary state of affairs that an arbitrary object is F for an arbitrary F. In this case, there is a $T \subseteq S$ (in particular, $\{s\}$) such that $\bigsqcup T = s$ (i.e., $\bigsqcup\{s\} = s$) and every element of T verifies that some object or other is F_n (i.e., $\exists x(s \Vdash F_n x)$).

[25] My thanks to an anonymous reviewer for pressing me on this point.

[26] For those still concerned by this problem, it is possible to modify the account so that the states that verify that higher-level predicates obtain have *proper* parts that verify that lower-level predicates obtain, but I will not pursue that additional modification here.

[27] There are those, like Schaffer (2010), who hold that composite objects are more fundamental than their parts. What I say is strictly compatible with that view—as I consider a mereological relation between states, rather than objects. However, I acknowledge that priority monists may be dissatisfied with this type of reduction.

Relatedly, although I endorse the claim that levels are reductive (in some important sense of the word), this does not cut against an explanatory link between the levels. It is natural to hold that there is an important sense in which facts about higher-level disciplines are explained by facts about lower-level disciplines—for example, that if chemistry occurs at a higher level than physics, then chemical facts are metaphysically explained by physical facts. This explanation ought to be compatible with reduction in a satisfactory account of level.

Accounts of level walk a tight line. On the one hand, they ought to allow a certain amount of autonomy of higher-level disciplines. Sociology, for example, can get by perfectly well without explicitly discussing the arrangement of molecules in society. At the same time, an account ought to allow for a sense in which higher levels bottom out in lower levels. On this account, the notion of reduction at issue is identity. Verifiers of higher-level states are identical to fusions of lower-level states. But there remains an important degree of autonomy for disciplines. This account says nothing about which states cause others to obtain. It is perfectly possible that a causal explanation of a higher-level discipline can be accomplished solely with higher-level predicates (though what makes each of these predicates obtain must be identical to fusions of states that verify lower-level predicates). So, while there is reduction, there is also autonomy.

A few points at this stage: recall that it seemed unclear how any account could be both irreflexive and reductive—and yet this is a criterion that the present account easily accommodates. It is irreflexive in that it forms a strict partial ordering, and yet reductive in its use of mereological structure. I take it that this is a strong mark in favor of this theory. However, it is worth emphasizing the respects in which this account is *not* reductive. It does not, for example, entail that the laws of the higher-level disciplines reduce to laws of lower-level disciplines. Those who doubt that the laws reduce may nevertheless maintain that the disciplines are leveled if they adopt this interpretation. In contrast, those who seek a reduction of law must adopt some other notion of reduction for their demand to be met.

The third criterion is that an account of scientific level ought to allow for predicates to be multiply realized. It may be that 'heart' is a biological predicate, yet hearts may be composed of many types of things. Perhaps carbon shaped thus-and-so constitutes a heart in many cases, but an artificial heart composed of plastic counts as well. Minimally, an account of level ought not preclude the possibility that some predicates may be multiply realized.

There is no requirement, on this approach, that the truth-makers of predicates resemble one another in any way. The claim 'John has a heart' may have a truth-maker that is vastly dissimilar from truth-makers of 'Jane has a heart.' For a higher-level predicate F, all that is required is that, for an arbitrary name a, 'Fa' be verified by states that are decomposable into states concerning lower-level predicates G. There is no requirement that these be the same lower-level predicates into which verifiers of 'Fb' are decomposable. It may be that a verifier of 'Fa' concerns predicates $G_1 - G_m$, while a verifier of 'Fb'

concerns predicates $G_n - G_o$. That is, what makes it the case that a is F may concern some lower-level predicates, and what makes it the case that b is F may concern *different* lower-level predicates. So long as each instance can be decomposed into states concerning some lower-level predicates or other, the present conditions are satisfied.

It was important, when developing this account, to place the quantifiers correctly. Consider the following alternative, which simply shifts the placement of an existential quantifier in a previous interpretation:

Higher Level(D_1, D_2) iff
$\forall s, \forall F_n, \forall x, \exists G_m (s \Vdash F_n x \rightarrow \exists T \subseteq S(\bigsqcup T = s \wedge \forall t \in T, \exists y (t \Vdash G_m y)))$

This account is poorly equipped to accommodate multiple realizability. It requires that, for every predicate of the higher-level science, there be some lower-level predicate such that states that verify statements with the higher-level predicate are decomposable into states that verify statements with the lower-level predicate. If a state that verifies 'John has a heart' can be decomposed into states concerning 'Carbon,' then 'Jane has a heart' must be decomposable into states concerning 'Carbon' as well (on the assumption that biology is at a higher level than chemistry).

This alternative is far more restrictive than the original account that, in contrast, has no difficulty in accounting for predicates which are multiply realized.

An objection might be raised.[28] This account of level functions only if truths at one level completely compose truths at another. Suppose that 'is happy' is a sociological predicate that can be realized biologically (in humans) or technologically (in some sort of sophisticated robot or AI program). On this account, sociology would not occupy a higher level than biology, since some truthmakers of sentences including 'is happy' are composed of technological, rather than biological, states of affairs. Because not *all* truthmakers for sociological predicates can be decomposed into truthmakers for biological predicates, sociology does not occur at a higher level than biology.

There are a few responses to this objection. First, if sociological predicates can be satisfied by something other than biological entities, there seems no hope for reducing sociology to biology. Second, and more importantly, while this may be a case in which sociology does not occur at a higher level than biology, it might still be the case that sociology occurs at a higher level than the conjunction of biology and technology. That is, if all satisfiers of sociological predicates can be decomposed into truthmakers for biological or technological predicates, sociology could be understood as occupying a higher level than the hybrid discipline that combines biology with technology.[29]

[28] Thanks to an anonymous referee for pressing this point.

[29] For those who prefer, I note that it is also possible to refine this account still further, so that if a discipline D_1 occurs at a higher level than the conjunction of both D_2 and D_3 (and this is nonvacuous—i.e., that predicates in both D_2 and D_3 are needed to identify truthmakers for those in D_1), then discipline D_1 occurs at a higher level than D_2.

The fourth requirement was that an account ought not to take a stand on what the levels of the empirical sciences actually are. One cannot, simply by reflecting upon the concept of level, come to realize that ecology is at a higher level than physics.

This is an area where the shift to discussions of mereology in terms of states of affairs, rather than objects, proves beneficial. It is natural to think of the mereology of states as mirroring, perhaps imperfectly, the mereology of objects. So if hydrogen and oxygen atoms compose a water molecule, one might suspect that states of affairs concerning hydrogen and oxygen compose states of affairs concerning water. And, indeed, many examples I have used throughout this paper take that precise form. However, there is nothing in the truth-maker approach that requires this alignment. It may be that the mereology of states of affairs comes entirely apart from the mereology of objects. Perhaps oxygen and hydrogen atoms compose a water molecule, but states of affairs about water compose states of affairs about oxygen and hydrogen. This possibility is unintuitive, but there is nothing from a semantic perspective that precludes it from being the case.[30] And so, this account does *not* assume that sciences concerning smaller objects are the only candidates for lower-level sciences. Of course, it may turn out that these types of objects lie at the more fundamental level, but this is not something that follows from the analysis of level alone.

There is an additional advantage to shifting from a conception of mereology that applies to objects to one that applies to states. Some disciplines (like physics) address objects of various sizes; quantum mechanics has implications for very large objects (like Neutron stars) as well as very small objects (like electrons). If we were to attempt to understand relative level in terms of object-mereology, it would be unclear where these disciplines stood. On the present conception, however, the mereology of states may come apart from the mereology of objects. So, even if an object like a neutron star is composed of many smaller parts, some of the states of how that neutron star is may not be composed of states governing how its parts are. Disciplines concerning both very large and very small objects may thus occupy low levels of disciplines.

The final criterion is that there should be some crossover between the subject matters of disciplines at different levels. Coming to recognize that two fields are compatible may increase our general understanding, but compatibility is not itself to guarantee that the sciences operate at different levels from one another. Crossover is achieved by allowing the same predicates to occur within disciplines occupying different levels. If both ecology and chemistry employ the predicate 'hydrogen,' then they may be disciplines that both concern hydrogen. And the more predicates that disciplines have in common, the greater the overlap in their subject matters.

[30]Perhaps some suspect that the unintuitive character of separating the mereology of states from objects counts against this view—and so constitues the sort of *a priori* consideration I sought to avoid. However, I maintain that this does not violate the previous desideratum, because it does not *settle* which discipline occurs at a higher level than another. Empirical considerations can outweigh the oddity of separating the mereology of states from the mereology of objects. As such, this does not preclude the possibility that sciences governing large objects occur at a lower level than sciences governing small objects.

Some may be skeptical of an account of levels of discipline that depends on mereological composition of objects.[31] If objects compose universally, then there are many objects that seem not to fall neatly into any level of categorization—such as the object composed of an electron at the end of my nose and the Andromeda Galaxy. A natural question is whether moving to a mereology of states of affairs is any improvement. It might seem that the same problem arises. State-spaces, as I have described them allow for universal fusion. So if there is a state of the Andromeda Galaxy being large and the state of Max's nose being snub, there is a state consisting of the Andromeda Galaxy being large and Max's nose being snub. It might seem then, that an interpretation of levels in terms of truthmakers fares as poorly as one given in terms of objects. But on the present account, these composite states are relevant to disciplinary level if they verify that some scientific predicate obtains. If there is no discipline whose predicate is verified by the state consisting of the Andromeda Galaxy's being large and Max's nose being snub, while this state exists, it has no bearing on the levels of scientific discipline. While my theory allows for universal composition, the results of that composition bear on the levels of scientific disciplines only if they verify scientific predicates.

Fine (2017) outlines an account of subject-matter in terms of truthmaker semantics, partially in response to Yablo (2014). Fine is primarily concerned with the subject-matter of sentences, rather than disciplines. He identifies the subject-matter of sentences with the fusions of their verifiers. Let us suppose that 'Roses are red or violets are blue' has two verifiers—the state of roses being red and the state of violets being blue. In this case, the subject-matter of the sentence—what the sentence is about—is the state of affairs of roses being red and violets being blue. Any other sentence whose fusion of verifiers is the same (e.g., the sentence 'Roses are red and violets are blue') is about precisely the same thing. Some sentences have a subject matter that is a part of others. If the only verifier of 'Roses are red' is the state of roses being red, then the subject-matter of 'roses are red' is a part of the subject matter of 'Roses are red or violets are blue.' The subject-matter of the atomic sentence is a literal part of the subject-matter of the disjunctive sentence.

It is readily possible to expand this account of subject-matter to disciplines. Once we identify disciplines with sets of predicates, we might identify the subject matter of a discipline with the fusion of the verifiers of all sentences within that language. So, for example, if chemistry consists partially in 'is Nitrogen' and 'is Helium,' then the subject-matter of chemistry will be the fusion of states of affairs that verify that a is nitrogen with those that verify that b is Helium, etc.

The contention that leveled disciplines are about the same thing can be interpreted almost literally on the present approach. The states of affairs that make it the case that higher-level predicates obtain are all composed of states that make lower-level predicates obtain. So the subject matter of a higher-level discipline is literally a part of the subject-matter of the lower-level discipline. And so this accounts for leveled disciplines to share

[31] Thanks to an anonymous referee for pressing this point.

the same subject-matter.

It has been my aim to explicate an account of scientific level on the truth-maker approach. This account, I maintain, satisfies numerous plausible criteria that a theory of scientific level ought to satisfy. As such, it is a worthy candidate.

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