3 Philosophy of Science and Metaphysics

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1. Introduction

Philosophy of science has a complicated relationship with metaphysics. Studying topics such as the nature of causation, laws of nature and space-time, it clearly engages in activities that merit classification as metaphysics. Yet the academic discipline itself was born in opposition to metaphysics. The positivists were united in a shared distrust of metaphysics. Their suspicion ran so deep as to motivate a search for a demarcation between science and non-science, and science and speculative metaphysics in particular. Even today, philosophy of science appears caught in what Einstein (1933) called the 'eternal antithesis between the two inseparable components of our knowledge – the empirical and the rational' (p. 271). It wants to employ metaphysical speculation, but impressed with the methods of the subject it studies, it fears overreaching. Philosophy of science thus tries to walk a fine line between scientifically grounded metaphysics and its more speculative cousins.

Here I will try to draft some of the contour of this boundary, along the way introducing the reader to some of the relevant issues. Doing so is critical today, for we are in the midst of a major collision between two very large forces in philosophy that has a significant bearing on metaphysics. Whereas metaphysics and science were once one and the same field, natural philosophy, today there is a worrisome divide between the two.

This separation is no doubt due to developments within *both* science and metaphysics. Physics, for instance, in part due to its distribution of incentives since World War II, is far less 'philosophical' than it used to be (Holton 1986). Nineteenth-century physicists debated the reality of the electric field, but today few physicists debate the updated counterparts of this question for gauge fields. The same goes for the measurement problem in quantum mechanics. Sometimes dubbed the 'reality problem', the issue is really about the proper ontology suited to quantum theory, and it's hard to imagine a question of comparable importance in previous times being shunted aside as it often is today. The same could be said for problems in many other fields of

science, too. As a result, metaphysical insight is especially needed now. Yet, instead of offering to fill the breach, many metaphysicians have adopted an approach to the field that makes it more or less autonomous from science. Not only is this a shame, given the current context within science, but it is also a bad idea, for it occasionally results in debates in metaphysics becoming sterile or even empty.

In what follows, I concentrate on the philosophical side of this increasing gulf between science and metaphysics. After tracing the origin of this gap, in part, to the resurgent idea that metaphysicians have a wider domain of study than scientists – and arguing against this – I suggest a rough and ready 'systematization' criterion that makes the above divide apparent. The criterion simultaneously allows that metaphysics is deeply infused throughout science, while also counselling that metaphysical investigations ignore science at their peril.[1]

2. The Current Clash and Its Background

There is a long tradition of worrying about overreaching by metaphysics. Kant famously attacked metaphysics as an assortment of empty sophistical tricks, a kind of perversion of the understanding. Later, seeing themselves as Kant's heirs, Carnap, Reichenbach and others took the measure of metaphysics and saw it as strikingly different from science:

> Most of the controversies in traditional metaphysics appeared to me sterile and useless. When I compared this kind of argumentation with investigations and discussions in empirical science or [logic], I was often struck by the vagueness of the concepts used and by the inconclusive nature of the arguments. (Carnap 1963, pp. 44–5)

Metaphysics came under attack for having lost contact with the empirical and for its arguments being irredeemably unsettled.

Today, metaphysics is again the target of deep suspicion. Evidence of this comes from my bookshelf. Many recent books in philosophy of science possess entire chapters strongly condemning contemporary analytic metaphysics (see, for example, van Fraassen 2002; Maudlin 2007; Ladyman and Ross 2007; Maddy 2007). What's especially remarkable about this is that the authors aren't logical positivists. They don't even embrace a common empiricist ideology – for which a distrust of metaphysics is to be expected. Rather, the authors run the full gamut of positions in philosophy of science, and each seeks to make room for some type of metaphysics. Evidence for this flare-up also exists in metaphysics. As I write, so-called 'metametaphysics' is all the rage in conferences, books and journals (see Chalmers, Manley and Wasserman

2009; Braddon-Mitchell and Nolan 2009). Never a good sign for a field, here the literature is in part devoted to whether there *are* answers to certain types of metaphysical questions.

Clearly something is up. Just as earthquakes are evidence of tectonic plates colliding, so is this dust-up evidence of a collision between two large and slow-moving trends in philosophy. Let me briefly describe the positions that are at odds.

The logical positivists' critique of metaphysics provides the backdrop. Recall that Carnap understood ontological questions as ultimately about which framework (theoretical structure) one should use. Crucially, he was a framework pluralist. Are there atoms? According to Carnap, one is always working with the entities presupposed by the framework. So if the framework presupposes atoms, the 'Are there atoms?' question doesn't arise. The question to ask instead is why use the framework one is using, but Carnap thought this a purely practical decision. Ontology gets pushed into pragmatics.

The work of Quine and Kripke, however, pulled it out of pragmatics. In our cartoon-like history, we might say that Quine cleared the room for metaphysics, while Kripke furnished it.[2]

Quine's part in this is primarily his famous assault on the analytic–synthetic distinction, the line between truths in virtue of fact and truths in virtue of meaning. If Quine (1951) is right, then there isn't a sharp distinction between conceptual/linguistic truths and factual/contingent truths. This was bad news for the conceptual analysis that dominated philosophy at the time (since there would be no purely conceptual truths). However, it was good news for the possibility of metaphysics. The reason is that Carnap's notion of a framework presupposed the analytic–synthetic distinction. No frameworks, no framework pluralism – and no place to banish metaphysics. For Quine, the concerns of metaphysicians are not any different than the concerns of scientists:

> The question of what there is is a shared concern of philosophy and most other non-fiction genres . . . What distinguishes the ontological philosopher's concern and [the zoologists', physicists' and mathematician's concerns] is breadth of categories. (1960, p. 275)

Quine tells us that ontological 'Are there X?' questions make sense, but only once the statements involved are regimented in decent logical form. That done, one learns that a theory is committed to X's just in case X's are in the domain of the variables of the theory. Add to that the claim that the theory is true, and we are doing ontology. The positivist attack on metaphysics is repelled.

Having survived the attempt on its life, metaphysics was left dangling. Quine's attack on positivism removed a reason *not* to do metaphysics, but it didn't provide a particularly clear rationale for engaging in it. Nor was the

saviour much of a fan of metaphysics. In particular, Quine attacked one of metaphysics' central subjects, (*de re*) modality. Modal claims about propositions such as 'necessarily 2 + 2 = 4' are bad enough, according to Quine, but modal claims about things themselves (that is, *de re* modality), such as 'Jack is necessarily human', are irredeemably confused, he thought.

However, in the 1960s and 1970s modality becomes respectable again. Modal logic was put on stronger foundations, and counterfactuals were given a rigorous semantics. Better than that (from the perspective of metaphysics), using various thought experiments, Kripke (1980) shows that we have robust intuitions about what is possible and that these intuitions carve out a realm of modality not obviously reducible to logical or scientific possibility, namely *metaphysical modality*. A kind of essentialism is resurrected. If water is actually H_2O, we are told, then it couldn't be anything else. The *couldn't* represents *metaphysical* necessity, and Kripke is credited with discovering a posteriori necessities.

Emboldened by this success, metaphysicians found their subject matter, and one can now find claims such as:

> metaphysics is most perspicuously characterized as *the science of essence* – a primarily a priori discipline concerned with revealing, through rational reflection and argument, the essences of entities, both actual and possible, with a view to articulating the fundamental structure of reality as a whole. (Lowe 2009)

Although not all metaphysicians would agree with Lowe, many would endorse a related division of labour, namely, that metaphysics differs from science in terms of its breadth. Whereas scientists excavate dusty field sites and mix potions in laboratories to tell us which states of affairs are *actual*, metaphysicians are concerned with what is actual and *metaphysically possible*. With philosophical intuition about metaphysical possibility unleashed, the journals gradually became filled with increasingly speculative metaphysics, much of it going well beyond Kripke's a posteriori necessities. These philosophers, I hasten to add, do not take themselves to be exploring, Strawson-style, the architecture of their concepts, but instead feel deeply that their work is no less about mind- independent reality than science is.[3]

Meanwhile, a parallel set of trends grew – also emanating from Quine – that are, by their nature, suspicious of such metaphysics (see Maddy 2007, Papineau 2009 and Ritchie 2009.). I'm thinking here of the growth of naturalism, broadly conceived, in the forms of naturalized philosophy of science and Quine's naturalized epistemology. One sees the attitude expressed nicely (and earlier) by Reichenbach:

> Modem science . . . has refused to recognize the authority of the philosopher who claims to know the truth from intuition, from insight into a world of ideas or into the nature of reason or the principles of being, or from whatever super-empirical source. There is no separate entrance to truth for philosophers. The path of the philosopher is indicated by that of the scientist. (1949, p. 310)

There is, as Quine puts it, no 'first philosophy', no 'supra-scientific tribunal' justifying the results of science (Quine 1975, p. 72). Maddy (2007) calls on us to pursue 'Second Philosophy' instead. The Second Philosopher 'simply begins from commonsense perception and proceeds from there to systematic observation, active experimentation, theory formation and testing, working all the while to assess, correct, and improve her methods as she goes' (p. 2).

This perspective is reinforced by the attack on conceptual analysis by Stich (1991) that inspired later so-called 'experimental philosophers'. Although contemporary analytic metaphysicians do not see themselves as engaging in conceptual analysis, still they lean heavily on certain modal intuitions. Experimental philosophers doubt the reliability and pervasiveness of many of these intuitions that guide much of contemporary analytic philosophy (Knobe and Nichols 2008).

Finally, another important strand is the increasing number of philosophers of science directly engaged with actual science. While this last group is a motley one, to be sure, many philosophers studying a particular scientific field feel themselves and their projects as closely allied, and even continuous, with the goals and methods of that field.

The collision between these two 'plates' was more or less inevitable. Knowledge of the modal structure of reality, when based largely on reflection and intuition, potentially offends against much of what those in the second group believe. Naturalists will want to know how creatures like us gain reliable modal knowledge, Second Philosophers will not see a separate pathway to ontology apart from science, experimental philosophers will challenge the pervasiveness of many of the modal intuitions needed for analytic metaphysics, and those engaged with actual science will see (I suspect) a radical difference between the explanatory and confirmatory aspects of science and of some metaphysics.

3. Metaphysics Walling Itself In

To evoke what he calls the 'phenomenology of shallowness' afflicting some of today's metaphysics, Manley (2009) uses a metaphysical 'problem' that he

borrows from Eli Hirsch: when I bend my fingers into a fist, have I thereby brought a new object into the world, a fist? In contemporary metaphysics, a question such as this is viewed as deep, interesting and about the structure of mind-independent reality. Comparable questions in the literature are whether a piece of paper with writing on one side by one author and on the other side by a different author constitutes two letters or one (Fine 2000), whether roads that merge for a while are two roads or one, and whether rabbit-like distributions of fur and organs (etc.) at a time are rabbits or merely temporal parts of rabbits.

Outside metaphysics, many philosophers react with horror at the suggestion that these questions are deep and important. Instead, they find them shallow. The reason is that it's hard to imagine what feature of reality determines whether a fist is a new object or not. How would the world be different if hands arranged fist-wise didn't constitute new objects? And if there are debates, aren't they easily solved? Call temporally extended distributions of fur and flesh in bunny shaped patterns 'rabbits$_1$' and non-temporally extended such patterns 'rabbits$_2$.' Use 'letter$_1$' for letters individuated by author and 'letter$_2$' for those individuated by paper. And so on. Now, is there any residual disagreement about the non-semantic world? If fists really are new objects, then one imagines that philosophers of science bring two new objects into the world whenever they read this work.

It's worth thinking through one example in some small detail. Consider the popular topic of simples. A simple is an object with no proper parts. One question that has attracted attention is whether simples with spatial extension are possible. Some philosophers argue that spatially extended simples are not metaphysically possible. Various arguments are marshalled for this conclusion. For instance, suppose the simple has heterogeneous properties, that at one region it is red and at another region it isn't. Well, doesn't it then have two parts, the red part and the non-red part, thereby contradicting the idea that it is a simple? Certainly that's so if one invokes a principle to the effect that, necessarily, an object is red like that only if it has a proper part that is red *simpliciter* (Spencer 2008). Although we can easily find other examples in the literature, let's use this no-extended-simples argument for an illustration.

The no-extended-simples argument makes claims about the actual world, namely, that anything actually extended with heterogeneous properties is not simple. Let's now ask how this claim connects with science. On its face, it seems to contradict any science that posits non-point-like fundamental entities. For instance, on its most natural interpretation, superstring theory – one of the more promising attempts at a theory of quantum gravity – posits extended simples. I say 'most natural' because the theory was initially motivated by the fact that the topology of interacting continuous one-dimensional extended entities avoided the ultraviolet divergences that plagued graviton–graviton

scattering. The one-dimensionality of strings is a significant part of the original attraction of the theory. Despite criticism, string theory is a live possibility for describing the entities of our world; however, if you don't like this example, feel free to switch to any other theory with extended simples.

If they exist, superstrings have some of their properties heterogeneously distributed, for example, nontrivial energy densities across a string. The no-extended-simples argument therefore applies to superstrings. Followed through to its conclusion, we know that superstrings are not the basic building blocks of the world, for they have parts. Reflection on the nature of parts and simples tells us that superstrings are composite. And to the degree that superstring theory leaves out the parts, it is incomplete and not fundamental. For, recall, this argument is not about the regimentation of our concepts; if the argument is right, then strings really are composite. No new colliders need be built to test this – witness all the tax dollars potentially saved!

How do philosophers view physicists' claims that some simples are extended? Being charitable by nature, philosophers allow that physicists are confused: superstrings aren't really extended simples.[4] The theory must be reinterpreted in a manner compatible with the terms of art used by metaphysicians. Superstrings can thus be reinterpreted as composites of simple points. This theory of zero-dimensional entities is officially metaphysically possible, unlike superstring theory. But string theory is saved for practical purposes by being empirically equivalent to or best interpreted as a metaphysically possible theory, the metaphysician's version of string theory. Yet note: *the metaphysician's version must posit strange new laws to ensure that the simples stay together in stringy configurations*.

I'll develop my complaint about these metaphysical parts and the like in subsequent sections. However, let me immediately highlight that I will *not* find anything directly objectionable about the metaphysicians use of intuition, nor their suggestion of a new interpretation of the physics. Researchers may have good reason to reinterpret, challenge and add to the physics, all in the name of achieving a greater balance of theoretical virtues. My own objection will instead focus on the gruesomeness of the resulting theory described above.

To begin to see the problem, compare the parts we have just found with the 'partons' Feynmann famously suggested in 1968. Partons are the point-like elementary constituents of hadrons that eventually became interpreted as quarks. Like parts, partons are supposed to be genuine elements of certain real wholes, discovered theoretically, and immune, in a certain sense, to direct observation (thanks to the later development of quark 'confinement,' free quarks never show themselves). But there the similarities end. The parton hypothesis is discriminating, applying to hadrons, and not everything with extension. Even though initially incomplete – how partons interacted via the strong force was missing – parton theory was very richly detailed, containing

both novel predictions and novel explanations, for example, especially explaining the 'scaling phenomena' found in inelastic scattering of electrons off protons at high energies. Very generally put, its virtues depended sensitively upon what the rest of the physical world looked like. Parts, by contrast, do not. Unlike the crumbs in cookies, biting the wholes of which they are parts will not reveal them; nor will anything in the physical theory signal their presence. Nor do they offer a theoretical improvement, for the resulting theory is far less simple than one without such parts. Partons emerged 'red in tooth and claw' from the competitive jungles of science, possessing all the virtues one would expect, for example, novel prediction/explanation, unification of some of the particle zoo and more. The metaphysical principle about parts, by contrast, arises from peaceful reflection on ordinary objects and language. Metaphysical parts increase the complexity of our systemization of the world without any compensating gain in generality or other theoretical virtues. Any decent theory of scientific confirmation threatens to weed them away.[5]

How did metaphysics come to this? While deeper diagnoses are certainly possible, I find the source in a subtle shift in what the subject matter of metaphysics is. It is the idea beautifully isolated (but not necessarily endorsed) by Conee and Sider (2005):

> Metaphysics is about *the most explanatorily basic necessities and possibilities*. Metaphysics is about *what could be* and *what must be*. Except incidentally, metaphysics is not about explanatorily ultimate aspects of reality that are actual. (p. 203)

In metaphysical modality, metaphysics has found the subject matter over which it has 'exclusive claim' (ibid., p. 203). Notice the subtle change of emphasis from earlier metaphysics. Prior metaphysical investigations were primarily directed at providing reasons for believing that the *actual* world has particular entities or properties in it, for example, God, substantival space, creatures with free will, a moving now. Today, so limited a concern is passé. Metaphysics is after something bigger and more abstract, the structure of metaphysical modality. What it investigates can tell us about the actual world, but only – 'incidentally' – because the actual world is one possible world of many.

I submit that this shift in metaphysics' direction is one major reason for the current clash between metaphysics and philosophy of science. This alternative style of metaphysical theorizing brings with it many unstated changes that offend those more connected to science. Being about what metaphysically must and could be, metaphysics on this conception is forced by the change of target into studying more general abstract principles, such as whether two objects can ever occupy the same place and same time. If the concern is whether this principle holds in the real world, science will be relevant to assessing its

truth. But why should science be relevant to assessing its truth in metaphysically possible worlds wherein science is very different? Plainly it's not: science, after all, is mostly about the metaphysically contingent.

If Kant, Reichenbach and Carnap worried about metaphysics before, they would really agonize over its contemporary form. Shouldn't intuitions of what is possible make some contact with science? (From the history of science don't we learn that many 'impossibilities' end up possible, and vice versa?) Perhaps worse, as we've just witnessed, even if it pretends to have walled itself off, still this style of metaphysics does make threatening forays into the land of the actual. Independently of what science tells us about the actual world, it purports to tell us what must and must not actually be. When it does this, aren't we entitled to inquire into the evidence base for such extra-scientific judgments of possibility? One needn't be Kant or a logical positivist to worry about this development in metaphysics.

4. What's *Not* Gone Wrong?

Kant, Carnap, Reichenbach and others criticized metaphysics for being superficial. Then they tried to do something about it, namely, forge a criterion that separates 'good' metaphysics from 'bad' metaphysics. However, none of these criteria, or any other attempts, have survived evaluation.

Recently, the field known as 'metametaphysics' has tried to diagnose what, if anything, goes wrong in these debates. Are two metaphysicians arguing over whether extended simples are metaphysically possible disagreeing about two genuinely different possible worlds? Or is the debate merely verbal? The metametaphysics community is currently divided on this question. Some think that debates like the above are genuine (Sider 2009), others that they are not (Chalmers 2009; Hirsch 2009), others that they are genuine but irresolvable (Bennett 2009), and still others believe that they're genuine but only in the way debates about fiction are genuine (Yablo 2009).

Some ontological deflationists suggest a criterion to separate the verbal from non-verbal. A debate is verbal, Hirsch (2009) claims, just in case 'each party ought to agree that the other party speaks the truth in its own language' (p. 239). The idea is natural enough: those who deny extended simples can agree that people using 'part', 'composite', 'simple' in their opponent's language speak truly when claiming that there are extended simples; but theists and atheists won't agree that the other speaks truly. Interpretative charity will map part-talk into something true, but charity only goes so far: atheists won't find a referent for God in their ontology.

While I admire much of this work, we shouldn't expect to obtain practical guidance for detecting merely verbal debates from it. What is needed is, in

effect, a theory of *metaphysical equivalence*. When do two semantically distinguishable, but observationally undistinguishable, theories describe two truly distinct metaphysically possible worlds, and when are they notational variants? History with related equivalence criteria suggests that the problem is irredeemably tricky, that we won't get anything like useful, necessary and sufficient conditions for equivalence. Philosophy of science has grappled with the related question about physically possible worlds for a long time. When do empirically underdetermined theories describe the same world? Positivists deflated the question: according to a verificationist theory of meaning, two theories that can't be observationally distinguished 'say' the same thing. Absent such a criterion, however, we have a problem. We know many theories that are observationally equivalent don't describe the same world. For instance, one could argue that Putnam's theory that you are a brain-in-a-vat, stimulated to have the experiences you do, is observationally equivalent to the theory that there is an external world governed by the physics of the Standard Model, yet no one would take them to describe the same world. However, much harder cases lurk nearby. Do Einstein's curved space-time and Weinberg's flat space-time-plus-gravitons interpretations of general relativity describe the same world? Do Hamiltonian and Lagrangian versions of classical mechanics? These are open questions. The problem, in brief, is that there are too many moving parts. What is observable is partly theory-laden, what needs and gets explanation is partly theory-laden, and more. I expect all these problems will arise again at the metaphysical level. *When the facts themselves are under dispute, interpretative charity for one group may be uncharitable for another.*

Nor do I think we can claim that 'bad' metaphysics results from asking the wrong questions (which is what Kant thought) or from relying too heavily on speculative intuition (a common claim). It's important to stress that these types of criteria might unnecessarily constrain science into taking too conservative a stance.

For example, Kepler's model of the solar system, given the context, was perfectly good science or metaphysics, despite the fact that it was both wildly speculative and, from our perspective, asked the wrong questions. Kepler wanted to know why there are six planets (the number then known) and why they are spaced as they are. His answer, on which he struggled for years, was that planets are attached to concentrically placed spherical orbs, each one of which inscribed or circumscribed one of the five Platonic solids (three- dimensional polyhedral). (See Figure 1.) By ordering these spheres in a specific way, Kepler was able to devise a model that was within 5 per cent accuracy of the then-observed planetary orbits. The theory also made rich new explanations and predictions. For instance, with it he was able to explain features of the orbital period: proceeding from inner to outer planets, the difference in orbital period is twice the difference in orb radii.

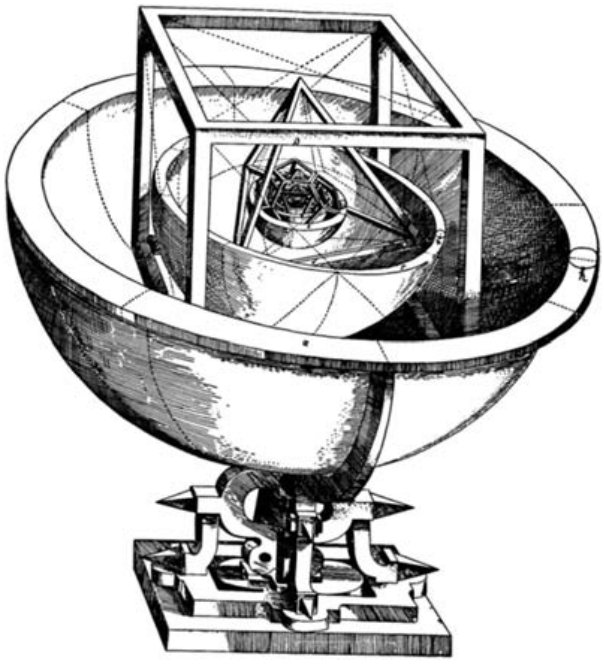

Figure 1 Kepler's model of solar system (Kepler 1981 [1596])

Unfortunately for Kepler, there are more than six planets. Even worse, there is no grand symmetry principle dictating the number of relative distances between planets.[6] The pattern of distances between planets is due to contingent initial conditions and isn't the result of any deeper principle. Intuitions about symmetry led Kepler to tackle the wrong questions and also to propose a truly wild metaphysics of the solar system. Yet intuitions about what patterns need explanation and what questions are fruitful are the lifeblood of science. In other cases, for instance, Gel-Man's 1962 symmetry argument for the omega-minus particle, intuitions of symmetry were successful: two new particles were successfully predicted. One attempt panned out, one didn't.

5. Levelling the Field

Instead of attacking our speculative abilities or pretending we know what questions are real ones, I submit that the basic problem with some metaphysics today is the idea that the philosopher and scientist doing ontology are performing fundamentally different and separate jobs. The metaphysician's picture that the scientist works in the lab, discovering the actual world's features, while the metaphysician discerns the wider universe of the metaphysically possible, isn't right. The error is thinking that the science of the actual world

doesn't affect what one thinks is possible or impossible. The history of science and philosophy amply displays that what we think is possible or impossible hangs on science. Or going in the other direction, the error is thinking that modal intuitions are reliable if they are not connected to a systematic theory of a large domain, one possessing many theoretical and empirical virtues.

Analytic metaphysicians, of course, will grant that the science of the day affects what we think is *physically* or scientifically possible, but remind us that their claim is about metaphysical possibility and assert that their intuitions are about this wider domain. We have modal intuitions about parts and composites, and these intuitions reveal what is metaphysically, not conceptually or physically, possible.

Against this, I want to claim that there is no interesting species of metaphysical modality that is largely immune to science. Our modal intuitions are historically conditioned and possibly unreliable and inconsistent. The only way to weed out the good from the bad is to see what results from a comprehensive theory that seriously attempts to model some or all of the actual world. If the intuitions are merely 'stray' ones, then they are not ones to heed in ontology. *In metaphysics we should take possibilities and necessities only as seriously as the theories that generate them*.

Is metaphysical modality independent of the usual negotiation of virtues that occurs in the various sciences? I'm afraid that I cannot, in this short space, argue convincingly that it is not. However, in addition to the positive picture sketched below, I can make two relevant points.

First, metaphysical modality is murky. Currently, it is at the juncture of many disputes in philosophy of language, mind and logic. So-called modal rationalists debate modal empiricists (with many internecine disputes), and they in turn debate conventionalists and others. On many of these views, metaphysical modality won't turn out to be separate from scientific modality and still be substantive.

Second, although Kripke gives us reason to believe in a category we might call metaphysical modality, there is nothing to be found in Kripke's examples that would warrant thinking of metaphysical possibility as something immune to actual science. Kripke himself remarks that it may be possible to understand the intuitions he is trying to capture using only *physical* possibility. True, on a narrow reading of physical possibility, whereby chemistry and macrolanguage aren't included, it can't handle the claim that 'water is H_2O' – for arguably physics doesn't have 'water' in its vocabulary. Yet this doesn't provide any ammunition for one thinking of metaphysical possibility as immune from science. The interesting feature of Kripke's necessities, after all, is that they are a posteriori. And the claim that water is H_2O comes from some science, if not solely physics. We might, following Edgington (2004), posit a realm of necessity that includes claims about the constitution of water, necessities from the

non-physical sciences, and more, and refer to it with the more inclusive moniker 'natural necessity'. This natural modality will be sensitive to science.

In the absence of reasons for thinking that metaphysical modality is independent of science, I submit that we regard this species of modality as we do nomological modality. But isn't this species of modality itself mysterious? What fact of the world makes it true that light can't go more than 299,792,458 m/s?[7] Whatever the right story, the answer doesn't rely on our concept of light. We had that concept well before we knew how fast light could travel. We instead think it's a feature of light, and even better, space-time structure, that makes this limitation on possibilities true. Let's begin, then, with the most natural answer: the laws of relativity make this restriction true. What are laws? That, of course, is controversial.[8] Yet note: no matter how they are understood, laws represent the central core of theories, and these are theories that try to systematize/explain the world. We only treat events as possible if they are parts of good systematizations of the world.[9] We think it's impossible that photons go faster than relativity claims. Why? Because our most powerful theories, the theories upon which we base our explanations and predictions – upon which we even stake our lives – say so. The possibilities for photons don't arise from stray intuitions or attempts to systematize only semantic intuitions.

What is the source of the possibilities? Some, like modern day Humeans, will think the possibilities arise from the systematization itself. For Humeans, laws are the central core principles of the best systematizations of nature. The modality flows from the systematization (see Cohen and Callender 2009). We can conceive this as a specific version of Putnam's 1962 claim that possibilities and necessities are always relative to a background theory. Never are claims possible or necessary *simpliciter*. Others, like non-Humeans, will proceed in the opposite direction: the systematization flows from the modality, not vice versa. Ontologically, the modality is basic and independent of a systemization. Space-time just doesn't allow light to travel faster than 299,792,458 m/s. Nonetheless, non-Humeans think that explanations and theories appealing to the genuine modalities explain better than those that do not. In fact, that a law explains something well is taken as a symptom that it is representing a genuine modality.

Whatever the story is here regarding the deep question of the source of modality, all hands agree that the reason we have to think photons have certain properties arises from their role in a powerful, explanatorily and predictively accurate theory. Being connected to a good systemization of the world is either *constitutive* or *symptomatic* of serious possibilities.

We don't have to be too strict about this. Scientists are free to devise models of the world wherein (say) the absolute speed of light is not constant. To be taken seriously, however, the comment is not an idle one, but rather one embedded in an alternative systematization of a comparable range of phenomena.

In fact, it's interesting that one way this possibility is challenged (e.g. Ellis and Uzan 2005) is by pointing out how much the rest of the system hangs on the speed of light being constant – it's a way of showing that the scientist hasn't yet discharged her obligation to fit the new possibility into a large and equally good system. We may have all sorts of intuitions about the 'essence' of light, but my proposal is that we take such intuitions only as seriously as the theory of which they are a part.

6. The 'Systems' Demarcation, or: Are There Laws of Metaphysics?

I began this essay by describing the problematic attitude some philosophers have toward metaphysics. But in the ensuing discussion we have now seen a path that will help us steer between the Scylla of shallow metaphysics and the Charybdis of successful metaphysics. In principle, the division is quite simple; in practice it is difficult.

When trying to figure out what to believe about what there is, there are better and worse theories available to guide one. Not surprisingly, I urge that we rely on the best ones. How do we recognize these? A generation's worth of philosophers sought and failed to find a clean demarcation between science and non-science. For our purposes, it's better to describe this as the line between epistemically worthy and unworthy pursuits. No plausible necessary and sufficient conditions were ever found for being epistemically worthy. That doesn't mean there isn't a distinction, however. There is a large difference between the modern synthesis in biology and creationism, between chemistry and homeopathy, and so on. The failure to articulate a sharp division means only that what we count as epistemically worthy is quite diverse and assessed along so many dimensions that it's hard to narrow the criteria down to something simply state-able. That's why the demarcation project failed, why the instances of pseudo-sciences are easily picked out, but the criteria hard to state. The marks of success are clear: empirical adequacy, simplicity, novel predictions, novel explanations, unification, consilience and more. The metric by which we tolerate trade-offs among these virtues is less clear.

Let's agree to call the theory or theories that strike the best balance among the above virtues the Best Theory. The Best Theory can be carved up according to various coarse classifications. For instance, if thinking of the standard model in physics, we might divide it up into its theoretical and experimental sides. Such a division is crude, of course, for the experimental aspects contain much theory, and the theoretical aspects must mesh well with experiment. As a result, the partition between the two is not sharp. Another division that one can make is between 'metaphysics' and 'science'. I regard this as merely

a more extreme version of the theoretical versus empirical distinction. To a rough approximation, we can treat metaphysical claims as parts of the Best Theory that are more abstract and distantly related to experiment than the bulk of the theory, that is, science. Through experiment, confirmation and disconfirmation seeps upward through theory, but some bits – such as spatiotemporal continuity – are fairly well insulated. Bear in mind that there is, of course, a lot of theory and meta-theory even in empirical science, but at some point we start classifying the theory and meta-theory 'metaphysics'.

I like this way of characterizing metaphysics because I am convinced that it is a mistake to think one can just *see* in isolation that an entity or claim is metaphysical. Modern science is filled with all kinds of odd entities, for example, quarks, but some of these play crucial roles in extraordinarily powerful theories. One can only see that an entity is metaphysical, and further, good or bad metaphysics, by looking at its role in the overall theory. Is a soul metaphysics? Good or bad metaphysics? What about a top quark? Stare at either in isolation and you can't tell.

With these two divisions – that between epistemically worthy and unworthy pursuits and that between metaphysics and 'science' – I can make two claims. First, the metaphysics we ought to strive for should fall on the epistemically worthy side of the first divide. Or, using older terminology, it ought to count as 'science' rather than pseudo- or non-science. Here I hasten to add that this means only that it passes muster with our standards for good theories.

Second, I then claim that the metaphysics on the right side of this criterion *almost inevitably will be responsive to and deeply connected with the 'science' also falling on the right side of this line*. This result is almost inescapable, because in our theories we prize unification, cohesion and so on, but also empirical virtues. For a theory to be a good one, it had better meet with some empirical success; but since we value unification, cohesion and so on, the 'metaphysical' aspects of the theory will be sensitive to the aspects responsible for empirical success. Our demand for theories on the right side of the demarcation line means that our best theories will possess certain theoretical virtues. These virtues then provide a kind of glue between the more and less theoretical and empirical aspects of our best theories.

I say that this result is 'almost' inevitable because, of course, it's logically possible to detach aspects of the best theory from the theory itself. Experimentalists, statisticians and theorists can also detach themselves from the big picture of the standard model of particle physics being tested at CERN. Similarly, mathematicians, scientists and philosophers can detach the Lagrangian framework or the propensity interpretation of probability from any particular theory and study it alone. This is simply the normal division of cognitive labour. Work on both of these examples is, to a large extent, independent of particular scientific theories. But if we're actually going to believe in the Lagrangian

framework or propensities and their corresponding modalities, then they still need to earn their way into the best theory like everything else.

My picture is thus entirely symmetric between 'metaphysics' and 'science'.[10] Science ought to be on the right side of the demarcation line between epistemically worthy and unworthy pursuits. When it is, it, too, will inevitably be responsive to and deeply connected with metaphysics. Indeed, I think that what we conventionally call science in ordinary affairs is inextricably infused with metaphysics from top (theory) to bottom (experiment). Metaphysics is deeply important to science. Laying bare the metaphysical assumptions of our best theories of the world is a crucial and important part of understanding the world. And metaphysical speculation, when anchored in systematic theorizing connected to epistemically worthy pursuits, can aid our search for new and better theories of the world, and hence, better science.

One might reply that science proceeds perfectly well, while leaving many metaphysical questions unresolved. In a sense that may be correct, especially if one regards 'perfectly well' as only making good predictions. However, if we count explanation and understanding as crucial parts of a good theory, as we should, then I don't agree. Bohr's quantum mechanics is an excellent predictive theory, but it's leaving so many metaphysical questions open or confused comes at great cost to explanation and understanding.

In slogan form, my claim is that metaphysics is best when informed by good science, and science is best when informed by good metaphysics.

Once the strict autonomy of metaphysics from science is abandoned, then it may be thought that claims about parts – used in my illustration of 'shallow' metaphysics – and such might be vindicated by the same methods that science uses. Perhaps there are laws of metaphysics comparable to the laws of particular sciences? I am here thinking of the metaphysician who claims to be using the same methods as the scientist, namely, a form of inference to the best explanation (Sider 2009).

The answer, of course, is that yes, indeed, in principle parts could play a role in laws of metaphysics. Posit gods, discrete spaces, universals, tropes, quiddities and more. So long as they pay their way, they are fine. There is nothing *intrinsically* wrong with any of them as posits about the world.

The question, then, is simply whether the putative laws of metaphysics truly survive the 'red in tooth and claw' selection scientific norms impose. Here there is nothing general to say. We must simply look at examples and see how they play out. Lacking a theory of 'metaphysical equivalence', we can expect cases wherein reasonable people sharing roughly the same epistemic values will disagree. Even in science, this happens regularly. Superstring theory, for instance, is currently under attack for being too distant from various theoretical, and especially empirical, virtues. So is neo-classical economics

under attack from behavioural economics. These debates are a normal part of discovering a systematization of a domain.

The 'teeth' of the criterion lay only in the fact – and I think it is one – that in many cases in contemporary metaphysics, the question of whether the possibilities envisioned survive the norms of scientific theory appraisal is as clear as can be. For roughly the same reasons that I don't subscribe to the possibilities and necessities dictated by various pseudo-sciences – the theories lack too many virtues – I don't treat as genuine the possibilities and necessities posited by some metaphysics.

What is known as Locke's Thesis is taken by many to be effectively a law of metaphysics. Locke's Thesis says that no two things of the same sort can be in the same place at the same time. Is this a core principle of a powerful theory? Give the generalization its due: its simply state-able and certainly seems true of most commonly acknowledged macro-objects. One needs to look hard for counter-examples. As a rule of thumb, certainly one could do worse than employ this generalization. Perhaps it plays a role in finding one's keys in the morning. Maybe it is even a 'law' playing a role in the systematization of one's life. So if one is interested in the metaphysics of the social world or macro-world, then perhaps a principle such as this may play a role in systematizing.

But the same can be said for the generalization that space is Euclidean. Indeed, the case of mereology in metaphysics is usefully compared with the case of Euclidean geometry. So ingrained in our thinking is this geometry that it took two millennia to see that space could be non-Euclidean. And still today, for local and macroscopic navigation, the possibilities and necessities in Euclid's geometry hold pretty well. But if we're interested in the fundamental modal features of space, and most metaphysicians are concerned with the world's fundamental level, Euclid just isn't right. The parallel postulate doesn't have to hold, no matter how intuitive. How do we learn this? We discover that the world does not conform to our Euclidean intuitions by devising a comprehensive theory. Meeting the standards imposed by good theorizing can overturn even the most deeply felt and prima facie modal intuitions.

Assume metaphysicians are after the fundamental structure of reality. In that context, Locke's Thesis plays no role. Not, at least, since the Pleistocene era has the concept 'thing' played a role in any putatively fundamental theory. 'Things' are way too vague and general to be useful kinds. Substitute 'quantum field' for 'thing' and then we can ask what QED says about the principle. The principle's truth or falsity then follows from a broadly systematized area, not isolated intuitions about whether it's true. Alternatively, one can choose to define 'thing' such that things are, when of the same sort, never in the same place at the same time. That kind of regimentation is fine, so long as one notes that it is indeed regimentation.

7. Conclusion

This chapter has focused largely on the negative. I haven't had space to properly motivate a 'scientific metaphysics'. Let me end by briefly defending scientific metaphysics from a common complaint and hinting at how much productive and exciting work there is to be done.

First, the complaint. Does a scientific metaphysics have room for philosophy, for metaphysics, or does metaphysics become the 'handmaiden' of science on my picture? My reply is that there is definitely room for philosophy, indeed, a demand for philosophy and metaphysics. As described, good science is informed by good metaphysics. Often, critics of 'naturalistic' philosophy paint a picture of scientific metaphysics as being reducible to science, lacking prescriptive force, or merely dotting the i's in science. This picture has *too narrow a view of science*, and ironically, *too modest a view of philosophy*. It is too modest because sometimes just the reverse direction of influence has been the case: science has followed where metaphysics led. Metaphysical assumptions underlie science, and as Friedman (2001) argues, thinking about these (e.g. absolute simultaneity, infinitesimals) often drives revolutionary science. The view has too narrow a view of science because adopting (in ontology) the same general norms that operate in science leaves us an awful lot to do. Remember, these norms are very wide-ranging – they're just ordinary reasoning ratcheted up in a systematic way. They permit wildly speculative theoretical science, such as inflationary cosmology, alongside experimental science. As for prescriptive force, look at science. Its norms call for unrelenting criticism of rival views, among other things. The journals are filled with critical reviews, analyses, meta-analyses and more. To be in favour of scientifically-informed metaphysics is not to endorse a merely descriptive – a glorified journalistic – take on science. Instead, people knowledgeable of science but trained in philosophy, with its emphasis on logic, clarity, norms of following an argument wherever it leads and so on, can offer distinctive and valuable perspectives on all these questions. The methods of any particular science at any particular time don't exhaust the ways of properly studying the world.

Second, the advertisement. Science doesn't cover everything metaphysical that it could or should. As I mentioned at the outset, science often leaves theories only partially interpreted or with significant questions unanswered. Serious gaps in our understanding of gauge fields, quantum theory, evolution and more require our attention. Let me also stress that metaphysics can be prospective as well as retrospective. It needn't only follow where science leads. It's very optimistic to think that a new quantum theory of gravity, for instance, won't be, in part, sensitive to the ontology of quantum mechanics or electromagnetism. And by exploring different conceptions of time, philosophers open up new possibilities to consider in devising a theory of quantum gravity.

Finally, metaphysics can range generally over several scientific fields, asking distinctive questions about how they relate and what they have in common. These aren't questions usually tackled in a science itself, for obvious sociological reasons, but they are no less important for it.

There are plenty of significant areas of metaphysics in which to work, philosophers are needed for this work, and one hopes that they can sometimes make a distinctive positive contribution.[11]

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Notes

1 The standard philosophy curriculum badly reflects the fact – which I believe is no accident – that the 'great' metaphysicians were each conversant with and participants in contemporary science. Although the cognoscenti won't learn anything new, perhaps the following game will stimulate some readers to investigate this side of philosophy further. Connect the following scientific works with the metaphysician: (a) price theory in economics, (b) a steam engine and calculator (but also calculus, advances in physics, geology, embryology and hydrodynamics), (c) the (alleged) medical benefits of pine tar, (d) advances in thermodynamics and the vacuum, (e) optics and analytic geometry (but also almost everything else), (f) experimental properties of potassium nitrate, (g) the physics of elliptical nebulae and galactic clustering, and physical geography (but also much in the foundations of physics). Answers are in the second to last footnote.

2 For a more thoughtful account, see Price (2009) and the many fine papers on this time period by authors connected with HOPOS: http://www.hopos.org/.

3 The so-called 'Canberra Plan' (Braddon-Mitchell and Nola 2009) applied to metaphysics is a bit of a halfway house between traditional and Strawsonian metaphysics. Conceptual analysis determines the Ramsey sentence that best describes the role we want some X to play, for example, causation, but then science tells us what the world is like and whether there is anything that actually realizes that role. The enterprise of metaphysics is then very modest, for Canberra Plan metaphysics assumes that we know what the world is like. But that was what metaphysics originally was supposed to tell us!

4 Hudson (2005): 'One can also find physicists who apparently endorse the actuality of extended simples, but I can't help but think that this endorsement often arises from confusing the concept of an indivisible object with that of a mereological simple. Whereas having no parts may certainly be one explanation of the indivisibility of a material object – a law of nature prohibiting certain kinds of separation is another. . . . It may be the physicist's job, for example, to tell us whether the fundamental entities that physics appeals to are physically indivisible one-dimensional strings, but it is the

job of the metaphysicians to tell us whether those uncuttable things are composite' (p. 107).

5 As I believe Glymour's 1980 bootstrapping theory would, for instance.

6 Kepler was hardly alone in thinking this. Even later astronomers were impressed by the distances between planets described by Bode's Law. From the sun, the planets have distances in proportion to the numbers 4, 4+3, 4+2.3, 4+4.3, 4+16.3, and 4+32.3 (and later, with the discovery of Uranus, 4+64.3). Where is the planet corresponding to 4+8.3, the planet between Mars and Jupiter? Symmetry and intuition tell us it must be there; and to good measure, astronomers agreed. However, as pointed out by Hegel, who is unjustly accused of having decreed that there are necessarily seven planets (Craig and Hoskin 1992), another progression of numbers fits the data just as well, namely, the series 1, 2, 3, 4, 9, 16, 27 from the *Timaeus*. According to this series, there should not be a planet between Mars and Jupiter.

7 Hudson (2005), incidentally, argues that 'objects' can go faster than light, after all. Fortunately for relativity, none of these objects have well-defined masses, energies and so forth.

8 If you're a philosopher of science who doesn't believe in laws, you have no debate with me here. You probably still believe in causal principles, mechanisms, invariances or other counterfactual-supporting generalizations, and any of these can be substituted for laws in the following argument.

9 Compare with Leeds (2007, p. 463): 'What gives the physical modalities their specific content–what makes them the physical modalities – are their rules of use: the kind of reasoning that the physicalist takes to be relevant to a claim of necessity or possibility. Most importantly, our physicalist will take as supporting a claim of necessity the kind of reasoning we all use when we argue that a particular statement is a law of nature . . . What leads us to classify a statement as a law are, in addition to our conviction that it is true, considerations having to do with its generality, its systematic import, its simplicity and explanatory power.'

10 Note how sharply this view therefore contrasts with Ladyman and Ross (2007). Although similarly motivated, they would make metaphysics inherently parasitic upon science: 'Any new metaphysical claim that is to be taken seriously should be motivated by, and only by, the service it would perform, if true, in showing how two or more specific scientific hypotheses jointly explain more than the sum of what is explained by the two hypotheses taken separately, where a "scientific hypothesis" is understood as an hypothesis that is taken seriously by institutionally *bona fide* current science' (p. 30).

11 Answers to footnote 1: a, Hume; b, Leibniz; c, Berkeley; d, Hobbes; e, Descartes; f, Spinoza; g, Kant.

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