Reconciling Physical and Biological Metaphysics of Structure
Comments on Waters, "How Science Can Inform Metaphysics: Insights from Biological Practice"

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The "No General Structure Thesis" (NGST) draws from examinations of historical and contemporary genetics. One distinguishing feature of Waters' view is that he draws metaphysical conclusions from an examination of biology, rather than physics. He rightly contrasts this approach with the majority of contemporary scientific metaphysics, which frequently, if not invariably, begin from an examination of so-called "fundamental physics." (This happens for some historical and some philosophical reasons, which I'll discuss shortly.)

In these comments, I'd like to connect Waters' view to those extant, physically-founded accounts. My aim, ultimately, is to lend support to his view from across the aisle. I'll discuss some physically-founded metaphysical views, in particular the ones with a clear "stake in the structure game," as it were, namely the Ontic Structural Realism of John Worrall and its development by James Layman and Don Ross. Then I will examine one instance in which the No General Structure Thesis finds traction in physical theory as a rejoinder to a problem faced by Ontic Structural Realism, using Bob Batterman and Colin Rice's recent account of Minimal Model Explanations. I'll close with some remarks on a notion I call scale-dependence, which supports Waters' No-General-Structure view.

1. Generality and the Metaphysics of Structure from a Physical Point of View

Worrall advanced his initial formulation of Ontic Structural Realism in 1989, in the well-known "Best of Both Worlds" paper [11]. The structural realism he puts forward in the paper, and which he has defended since, came about as a conciliatory alternative to scientific realism, the view that the objects posited by scientific theories exist, and scientific anti-realism, a collection of views that range from agnosticism to denial of the existence of the objects of scientific theory. The debate between these views is one of the anchor points in contemporary discussions of scientific metaphysics. The debate is often framed in terms of the key arguments presented by each side, namely the no-miracles argument for realism and the pessimistic meta-induction to anti-realism. I recognize that this summary may seem elementary to many in the room, but since this is an APA and not a PSA, it's worth taking the time to get on the same page here.

Briefly, the no-miracles argument urges that realism about the objects of scientific theory is the best explanation for the success of scientific enterprises, as it is the only explanation that does not make the success of science a miracle. On the other hand, the pessimistic meta-induction argues, one might say from hubris, that the vast majority of scientific claims made up to this point are no longer believed, so it is unlikely that current theories have gotten things right. Therefore, the present state of science gives us no reason to expect that the claims of our theories, such as about the objects that they posit, are true.

These arguments are often given by way of examples from the history and current state of various sciences, and a majority of these examples are physical. This is one of the ways in which naturalistic metaphysics has been historically tied to the physical sciences. In Worrall's own paper, for instance, he cites the accuracy of quantum-theoretical calculations of the observed Lamb shift between the 2s and 2p energy levels of hydrogen as evidence toward the no-miracle argument, and the shift from Newtonian to Einsteinium conceptions of gravity as evidence toward the pessimistic meta-induction. Further, Worrall's own structural realism is demonstrated by way of physical examples, namely from the history of 19th century optics as it moves from

Fresnel's to Maxwell's conception of the phenomena associated with the propagation of light.

Worrall recounts how first material particles, then waves, were posited to be responsible for the production of optical phenomena, with a few more flip-flops along the way. Additionally, the theoretical frameworks describing the movement of these phenomena changed alongside the phenomenological changes. Despite all the changes, Worrall argues, a set of mathematical relations persisted, and these relations are more generally what is preserved over theory change. This is the foundational principle of structural realism, that mathematical or structural relations are the thing preserved over theory change. Note how this approach is meant to reconcile the no-miracles argument with the pessimistic meta-induction. Satisfying the pessimistic meta-induction, we have no reason to expect that the particular phenomena posited by presented scientific theories are real; while satisfying the no-miracles argument, we have a non-miraculous explanation for the success of science, namely that science has empirically discovered certain *structural relationships* that really are the stuff of the natural, and naturalistically metaphysical, world.

In Worrall's own words, the structural realist "insists that it is a mistake to think that we can ever 'understand' the nature of the basic furniture of the universe." Instead, "On the structural realist view what Newton really discovered are the relationships between phenomena expressed in the mathematical equations of his theory, the theoretical terms of which should be understood as genuine primitives." [11, p. 122] Worrall grounds this view historically in the philosophies of physically-minded natural philosophers such as Duhem and Poincaré, and he follows up this discussion with a suggestion that quantum mechanics should be so interpreted, as well.

In the wake of this suggestion, structural realism has been adopted by a variety of scientific metaphysicians who draw primarily from physical theory. This happens perhaps most famously in Ladyman and Ross's 2007 book, *Every Thing Must Go*. Therein, Ladyman, Ross, and David Spurrett endorse a condition on scientific metaphysics that they call the *Primacy of Physics Constraint*, which states, "Special science hypotheses that conflict with fundamental physics, or such consensus as there is in fundamental physics, should be rejected for that reason alone. Fundamental physical hypotheses are not symmetrically hostage to the conclusions of the special sciences." [6, p. 44] Here then is a contemporary and quite explicit justification of the grounding of naturalistic metaphysics in physics. (This is, by the way, a variety of physicalism that Sandra Mitchell has lately referred to as "physics-ism," [7, p. 33] and which she, like Waters, opposes on both metaphysical and epistemological grounds.)

This, then, is what Waters is up against. As he develops his No General Structure Thesis, the burden of proof will be on him to show that conditions like the Primacy of Physics Constraint fall flat in the face of metaphysical insights gained from the special sciences. To do so, he might do well to investigate more closely the notion of "general structure" that he aims to negate. As we've seen so far, the foundations of a notion of general structure in naturalistic metaphysics lie in structural realism, which imparts ontological weight to relationships among phenomena. In some versions of structural realism, which Luciano Floridi[5] has called 'eliminativist' structural realism, these relationships are the only members of the ontological catalogue, as it were—self-subsistent individuals are not included among the existents.

How might we understand Waters' notion of "general structure" in such a view? Presumably, and Ken can correct me if I've misunderstood him here, what "general structure" is meant to capture is precisely the implication of *unification via structure* to be found these structural realist accounts. In their discussion of Floridi, Ladyman and Ross use the Primacy of Physics Condition to argue that there may very well be conditions under which an eliminative-structural-realist metaphysics is more unified, and thus more desirable, than an object-oriented metaphysics. What those conditions are, by the way, depends on one's interpretation of quantum theory. In other words, they argue toward the possibility of a metaphysics that eschews objects in favor of structural relations, in part because of the primacy, or generality, of those relations. Clearly, the defensibility of such a view is dependent on the strength of those relations. If an argument can be given against the unificatory prowess of such relations, or if the Primacy of Physics Condition can be otherwise shown to be flawed, the No General Structure Thesis becomes an ever more appealing alternative to structural realism.

To begin chipping away at these tasks, let's recall the classical dilemma in scientific realism that gave rise to structural realism in the first place. In particular, both the no-miracles argument and the pessimistic meta-induction draw their conclusions from the relationship between the success (or failure) of scientific theories and one's warrant to believe in certain features of those theories. What counts as a condition of success (or failure) for a scientific theory? Traditionally, philosophers of science have offered answers in terms of a theory's ability to fit or corroborate empirical data and its ability to *explain* certain appearances of the natural world. If those conditions are met, then we allow in some part of Kuhn's laundry list of theoretical virtues like simplicity and scope, as well. But explanatory power looms large among the criteria for assessing a theory's merit, and so it is worth considering the explanatory power of a theory as a means of assessing whether it should inform our metaphysical views.

2. Minimal Models and Generality

An upshot of structural realism is that if we want our explanations to be metaphysically sound, we must attribute explanatory power to structural relations. On an eliminative version of structural realism, *only* those relations ground metaphysically sound explanations. There are many examples in recent philosophy of science, notably from Cartwright[4], Batterman[1], and Woodward[10], but certainly from many others as well, where successful explanation is argued to appeal necessarily to something other than isomorphism between structural relations in a system and structural relations in an explanation's *explanantia*. Staunch structural realists could dismiss such accounts as simply not appealing to *genuine* or *metaphysically grounded* explanations; but in so doing, they would have to offer a decidedly anti-realist account of the purported relationship between explanation and warrant to believe in a theory, which I take it most structural realists would at least take a lengthy pause before doing.

So, if we can convince ourselves that there are cases in which appeal to structural relations fails to prove explanatory, we've found an inroad toward Waters' No General Structure Thesis. If these cases can come to us from physics, all the better, because they won't violate the Primacy of Physics Condition (at least in letter, if not in spirit), and so will be immune to that very ham-handed response to any metaphysical claims originating in the special sciences. I suggest we turn to Batterman and Colin Rice's 2014 account of *minimal model explanations*. They contrast minimal model explanations with a class of theories of explanation that they call "common features accounts." Common features accounts, on their view, are theories of explanation in which a model explains "in virtue of meeting some 'accuracy' or 'correctness' conditions,"[2, p. 356] by which they mean that representational features of the model correlate with represented features of the system. They count mechanistic and causal or difference-making accounts of explanation among the common-features accounts, as well as structural-isomorphism accounts of the role of mathematics in scientific explanation (in particular that of Chris Pincock.[8]).

Their minimal model explanations (a term they borrow from physicist and astrobiologist Nigel Goldenfeld) offer a different view of what makes a model explanatory. They argue that rather than pointing to a list of common features between the model and the target system as *justification* of explanatory efficacy, one must in addition be able to explain, among other things, *why heterogeneous details of the class of systems being modeled are irrelevant to an explanation of the class of systems.* Using an example from fluid dynamics, they appeal to the renormalization group, a mathematical strategy for abstracting away from the details of a given represented system, to make their point. The renormalization group does not represent a common feature among a class of systems being modeled, nor does it signify a definable structural relation between features of a system. Instead, it is a technique for eliminating degrees of freedom in computational models that, when repeatedly performed on a single system, produces a set of fixed points characteristic of the system not by drawing structural relations among the elements, but by eliminating many structural details that are irrelevant to an explanation of the system's behavior. In short, minimal model explanations disentangle the notion of *invariance* from that of *structure*, and they assign explanatory priority to the former. It is worth noting that they find a similar explanatory story emphasizing invariance in the modeling of biological populations via Fisher's sex ratios.

To return to our discussion of structure in scientific metaphysics, I believe minimal model explanations can cut at structural realism in two ways, and thereby provide support for the No General Structure Thesis. First, in their investigation of common features accounts, Batterman and Rice show that many of those accounts appeal to idealized structural relationships to explain phenomena. This idealization calls into question the metaphysical underpinnings of those structural relationships. This is not a new point, and it is one that Cartwright makes particularly effectively in *How the Laws of Physics Lie*. But what we can take away here is that in order to maintain a metaphysical attachment to structural relations, grounded in physics or otherwise, structural realists will need to provide an account that distinguishes genuine, ontological structural relations from the merely useful ones that nonetheless support much of scientific practice. The "destructive" nature of Waters' No General Structure thesis adds to the despair of accomplishing such a task.

There is a second lesson for Waters' thesis to draw from minimal model explanations, and I find this one at least more interesting, and perhaps more fruitful for the development of Waters' view. By prioritizing invariance over structure in at least some explanations in physics, minimal model explanations show that the notion of structure even in physics is not so general as the structural realists need it to be. Now, there's an obvious objection here, namely that computational fluid dynamics isn't a fundamental physical theory, and as such it is subject to the same metaphysical asymmetry with the fundamental theories as the special sciences. It is a bigger task than I can accomplish in my remaining time to argue that the coexistence of quantum and classical theories of matter poses at least as much of a metaphysical problem for quantum theory as it does for classical theory. But I think it sufficient for now to point out that the structural realists' aim in prioritizing quantum physics is explicitly unificatory, and in minimal-model explanations, ignoring precisely those quantum physics is what allows for unification of the description of many fluid systems by their bulk-scale dynamics.

3. Generality and Scale-Dependence

I'd like to close with a few comments on the notion of generality that appears Waters' view. Waters suggests that there is no scale-invariant notion of general structure to be gleaned from the biological world, which problematizes the idea of general structure in scientific metaphysics more generally. His view is supported by the fact that certain objects of investigation in biology, such as genes, lack general, overall structure. He writes that this also shows that, "A world cannot be partitioned into fundamental parts." [9, p. 17] I'd like to say two things about this view.

First, it is not clear to me who might hold the view he is arguing against. There may yet be reductionists out there who want to hold onto quantum fields or quantum foam or some such as the foundation, and perhaps the sole member, of their ontologies, but this is certainly not the upshot of the structural realist view I've been considering so far in these comments. The ultimate view of the structural realists we've considered, which they deem "Rainforest Realism" (following Wimsatt), may actually be able to accommodate Waters' thesis. I'll give you their view in their own words, then explain what I mean. Ladyman and Ross, writing with Spurrett, write:

> All scientific disciplines except mathematics and, arguably, some parts of physics, study temporally and/or spatially bounded regions of spacetime. ... Let us reflect on the epistemological and metaphysical implications of this institutional fact. What accounts for the specific selection of spacetime regions, at specific scales, to which disciplines are dedicated is obviously, to a very great extent, a function of practical human concerns. Scientific institutions organized by dolphins wouldnt devote more than 40 per cent of their total resources to studying human-specific diseases. There is no puzzle as to why far more scientific attention is lavished on the dry parts of the Earths surface than on the waterlogged parts. To some extent this same consideration explains why more information is gathered about the Earth than about the Moon. Self-absorption and convenience, however, account only partly for the distribution of scientific activity. It is also important, in the third instance above, that the Earth is a great deal more complex than the Moon. ... [T]here are far more real patterns to be discovered by isolating specific spacetime regions, and scales of resolution on those regions, and treating them as relatively encapsulated from other regions and scales, on Earth than on the Moon. This was true before life on Earth began, and is the main part of the explanation for why life did begin on the Earth but not on the Moon; but the extent to which the ratio of real patterns to possible physical measurements on Earth has increased relative to that on the Moon has been made staggeringly great by the progress of first biological, and then social and cultural, evolution. [6, pp. 45–46]

So the structural realists seek out real patterns, which need not be repeated elsewhere (we don't need two or seventeen Earths for the pattern that is the Earth to be recognized as real). These patterns needn't be explicitly quantum or relativistic, though the patterns that are may be more reliably repeated across broader regions of spacetime. If anything is a fundamental part of nature, they think, it is the notion of a pattern. I do not think the No General Structure Thesis can avoid this conclusion. Recall Waters' analogy about the city maps: Calgary has overall, general structure, while Arles doesn't. It may be true that Calgary is easier for a tourist to navigate using certain sorts of inferences about road structure (I've not been myself so I can't say with certainty). But both Calgary and Arles have maps; to a structural realist, the roads in each city are instances of real patterns just as much as the pattern of organs in a typical human or the pattern of electronic symmetries in ionized sodium, or the distribution of planets in the solar system.

That said, I think Waters' view gets something very right in recommending a certain *attitude* toward scientific metaphysics, which we would not get from the structural realists. Out of the No General Structure Thesis we get the notion that structural relations are indexed to particular length, time, and energy scales. Elsewhere [3] I have argued that concepts and models in nanoscience (a largely physical science) are scale-dependent, that is, that genuinely novel phenomena arise at new length, time, and energy scales, and that the conceptual infrastructure of science must likewise follow a scale-dependent pattern of development. Scale-dependence presents an alternative not just to traditional reductive or emergent conceptions of scientific metaphysics, but to the broader idea of a mereological or compositional view of naturalistic ontologies wholesale. So it strikes me that the destruction Waters is committing in advancing the No General Structure Thesis is a destruction of mereological or part–whole-focused approaches to the ontology that metaphysicians may read off of science. And I think we should welcome the carnage.

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