Scientific Realism

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Outline

1. Scientific Realism
2. Ontological Problems for Scientific Realism
3. A Realistic Metaphysics
4. Realism and the Historiography of Science

Realism and Antirealism Again and Again

- How the atom undermined atomistic scientific realism.

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- By the time of The Scientific Image, scientific realism of a strong kind (often in the form of fundamentalism, physicalism and reductionism) was presupposed by much work in analytic philosophy.

Cartwright's Critique of Fundamentalism

- realism, reductionism, and fundamentalism – the tension within scientific realism

problems for the ontology of scientific realism

- scientific realism and common sense realism
- past and current theories
- the sciences of different scales
- the ontologies of the special sciences and fundamental physics

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- It is argued below that ontic structural realism, in the form of the real patterns account of ontology, offers a unified solution to them all (or at least that it is required to do so, if it is to make good on the promise of naturalised metaphysics).

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3. Realists think that the burden of proof is on the antirealist, to show that there is a reason to doubt the first-order methods of science that recommend belief in entities such as black holes and electrons.

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- If one is content to let debates within the sciences decide what unobservable entities exist, and to take their apparent ontological commitments at face value, then one is a scientific realist.

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- Boyd on the theory-ladenness of scientific methodology

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- A serious problem for scientific realism that is not addressed by (1) and (2) above, and that provides the anti-realist with a response to (3), is pressed in Larry Laudan's work (1977: 126, 1984), which argues from the history of theory change in science, and makes an empirical challenge to scientific realism that echoes Henri Poincaré (1905/1952: 160), Ernst Mach (1911: 17), and Hilary Putnam (1978: 25).

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- It is this argument, namely the 'pessimistic meta-induction', that motivates John Worrall's structural realism (1989).

The Pessimistic Meta-Induction versus the Argument from Theory Change

The Pessimistic Meta-Induction:

(i) There have been many empirically successful theories in the history of science which have subsequently been rejected, and whose theoretical terms do not refer according to our best current theories.

(ii) Our best current theories are no different in kind from those discarded theories, and so we have no reason to think they will not ultimately be replaced as well.

So, by induction we have positive reason to expect that our best current theories will be replaced by new theories according to which some of the central theoretical terms of our best current theories do not refer, and hence, we should not believe in the approximate truth or the successful reference of the theoretical terms of our best current theories.

Responding to the PMI

- Respond to PMI by reducing inductive base ruling out theories on the basis of some criteria:
- Maturity - reliance on well-entrenched background theories
- Mathematicization
- Strong empirical success:

  Quantitative precision

  Novel predictive success

Contemporary science is different

It is quite plausible to claim this:

- Hugely mathematicised
- Hugely integrated and unified especially with respect to the macrosciences and the chemistry of the periodic table
- Hugely quantitatively accurate. QED accurate to 13 significant figures.
  (have to count Newtonian gravitation - accurate to one part in 10^7 although based on data accurate to one part in 10^3)
- Exponential growth (Fahrbach)

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- Psillos (1999) p. 108: the divide and conquer strategy is needed because even if there are only a couple of examples of false and non-referring, but mature and strongly successful theories, then the "explanatory connection between empirical success and truth-likeness is still undermined".

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- "If their central theoretical terms do not refer, the realist's claim that approximate truth explains empirical success will no longer be enough to establish realism, because we will need some other explanation for success of the caloric and ether theories. If this will do for these theories then it ought to do for others where we happened to have retained the central theoretical terms, and then we do not need the realist's preferred explanation that such theories are true and successfully refer to unobservable entities." (Ladyman and Ross (2007), p. 84, Ladyman (2002))

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- Psillos' solution: 'caloric' - non-central, 'ether' - refers after all

The Argument from Theory Change

1. Successful reference of its central theoretical terms is a necessary condition for the approximate truth of a theory.
2. There are examples of theories that were mature and had novel predictive success but whose central theoretical terms do not refer.
3. So there are examples of theories that were mature and had novel predictive success but which are not approximately true.
4. Approximate truth and successful reference of central theoretical terms is not a necessary condition for the novel-predictive success of scientific theories

So, the no-miracles argument is undermined since, if approximate truth and successful reference are not available to be part of the explanation of some theories' novel predictive success, there is no reason to think that the novel predictive success of other theories has to be explained by realism. (Ladyman and Ross 2007, p.84-85)

The PMI is not an induction

- Laudan's ultimate argument from theory-change against scientific realism is not really an induction of any kind, but a reductio.
- No attempt at producing a large inductive base need be made; rather, one or two cases are argued to be counter-arguments to the realist thesis that novel predictive success can only be explained by successful reference of key theoretical terms.

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- Hence, it is not just the empirical content or phenomenological laws of past theories that are retained, but also the lawlike relations they posit.
- The laws take mathematical form and there are special cases, such as that of Fresnel's equations, where the very same equations are reinterpreted in terms of different entities.

Neo-Popperian/Lakatosian/Post-Kuhnian View

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> phlogiston theory as an example supporting Post's 'general correspondence principle' according to which the well-confirmed empirical generalizations of old theories are retained by their successors: there are no 'Kuhn losses'.

George Gale:

- 'phlogiston theory was an extremely adequate explanatory theory'
- Explains loss of weight of wood, coal and ordinary substances when burnt.
- Charcoal leaves hardly any ash because it is almost pure phlogiston.
- Air saturated with phlogiston cannot support respiration.
- Metals are alike because they all contain phlogiston (Lavoiser's theory discouraged nineteenth century chemists from seeking explanations of this fact.)
- But the theory is wrong because phlogiston is nonexistent.

forgotten wisdom: Whewell, *History of the Inductive Sciences* 1837

- “But we must not forget how natural it was to suppose that some part of a body was destroyed or removed by combustion…It would be easy to show, from the writings of phlogistic chemists, what important and extensive truths their theory enabled them to express simply and clearly.”
- Combustion, respiration and calcination of metals are all the same kind of reaction and there is an inverse kind of reaction too.

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- Even though there is not such thing as phlogiston, the tables of affinity and antipathy of phlogistic chemistry express real patterns that we now express in terms of reducing and oxidising power (see Ladyman 2011).

Schurz

- Phlogistication - assimilation of phlogiston
- Dephlogistication - release of phlogiston

- Oxidation (in general sense) of X = formation of ionic bond with with electronegative substance
- Reduction is regaining of electrons

- If oxidising agent is oxygen, and X is a source of carbon then product is carbon dioxide ie ordinary phlogisicated air.
- If oxidising agent is an acid, then hydrogen is emitted.

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- If the oxidising agent is oxygen, and the oxidised compound is a source of carbon then the product is carbon dioxide i.e. fixed air. (combustion of fossil fuels)
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- If the oxidising agent is oxygen, and the oxidised compound is a source of carbon then the product is carbon dioxide i.e. fixed air. If the oxidising agent is an acid, then hydrogen is emitted.
- We could go further and allow that ‘phlogiston rich’ and ‘phlogiston deficient’ refer too, namely to strongly electro-negative and electro-positive molecules respectively.
- One could even argue that ‘phlogiston’ refers to electrons in the outer orbital of an atom.

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- Regardless of which terms refer, the question is whether it is plausible to say that the metaphysics and ontology of science is true or approximately true.
- The problem is that there are many cases in which successive theories use the same terms, such as ‘space’, ‘time’, ‘gravity’, ‘mass’ and ‘particle’, but the claims made about what there is in the world, and especially about the metaphysics of those theories, are very different.

Selective Realism

- “Clearly some of the modal structure of Newtonian mechanics is not retained by special relativity because, for example, the velocity addition law is completely wrong for frames between which there is relative motion at velocities anywhere near that of light. The advocate of OSR is not claiming that the structure of our current theories will be preserved simpliciter but rather that the well-confirmed relations between the phenomena will be preserved in at least approximate form and that the modal structure of the theories that underlies them, and plays the appropriate explanatory role, will also be preserved in approximate form.”

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- “The job of predicting what will be preserved and what abandoned by future science belongs to science itself not to philosophy, but our claim is that from a structuralist point of view it is possible to explicate the continuity in scientific theories that often does not hold at the level of objects and properties.”

Modal Structure

“Theories, like Newtonian mechanics, can be literally false as fundamental physics, but still capture important modal structure and relations.” Ladyman and Ross 2007 chapter 2.

2 Ontological Problems for Scientific Realism

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- The ontology of such theories remains ‘effective’, in the sense that the entities it posits are part of empirically successful descriptions and models.
- For example, in the BCS theory of superconductivity, the material in question is treated as a lattice of sites at which there may or may not be pairs of electrons, and interactions between the latter are mediated by `phonons’, which are treated as if they were genuine particles within the model.

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- Similarly, in particle physics there are effective theories, with their effective ontologies, that only apply at certain emergent scales of description.
- Indeed, the supposedly abandoned ontology of classical physics, in the form of point particles obeying Newtonian dynamics, is still a major object of study in current physics.

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- In this sense, much of physics is like special science. The special sciences in general deal with a plethora of emergent entities, properties and processes.
- Scientific realism as such has no account of the relationship between ontologies, nor of the relationship between causation and law, at different levels in different sciences, and this is problematic for its formulation and defence.

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- Many philosophers, scientific realists among them, argue for the elimination of all such entities in favour of the fundamental physical stuff. It is often argued that such emergent entities lack any genuine causal powers, these all necessarily residing at the fundamental physical level, and so are merely devices to be adopted for pragmatic reasons.
- Hence, the antirealist can argue that even the scientific realist must allow that taking a pragmatic, but non-realist attitude to reference to theoretical entities is reasonable (this argument is also made by Paul Teller (forthcoming).)

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- Furthermore, scientific realism cannot be defended by appeal to the first-order practices of science as in (3) above, if the latter can be taken as delivering ontological commitments that are ultimately to be repudiated as mere epistemologically useful fictions.
- It is ironic that scientific realism taken to extremes, in the form of the view that only the fundamental physical stuff is real, is now the major form of instrumentalism about much of the ontology of the special sciences.

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- However, it is not necessary to advocate disunity or a patchwork view to reject fundamentalism, and reductionism, and to maintain realism at the level of the special sciences.
- Ladyman and Ross defend the latter's `rainforest realism' by conjoining it with ontic structural realism in the philosophy of physics, adopting scientific realism about effective ontology, and modifying the theory of real patterns to provide a criterion of existence.

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- Waves are very ephemeral real patterns, like currents and tides, but rocks and sandbanks are more durable.
- In physics, quasi-particles like phonons are taken to exist when their half-life is effectively infinite relative to the scale of the interactions that are being studied.

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- The above account could be interpreted as of the pragmatics of an ultimately epistemological kind of emergence, but if there is not, or might not be a fundamental level of reality, nor ultimate individuals of which everything else is made, then all real patterns are on a par.

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- The table is a real pattern at macroscopic scales, but at the microscopic scale it dissolves into molecules that are bound together by electromagnetic potentials.
- There is a rough correspondence between the everyday object and the bound state of the particles that compose it, but there is not even token identity between them, since they have different modal properties (the table would exist even if some of the relevant particles did not but the bound state would be different), and because they have different persistence conditions (the table could have a leg replaced but the bound state would not survive such an operation).

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- Composition is often dynamical, especially in science, but the time scale of the interactions of the parts is very short compared to the time scale characteristic of the whole.
- Generation and corruption are not events at the level of the parts, but real patterns can indeed be created and destroyed by changes in the behaviour of other real patterns, and they can also persist over long time scales relative to the scale of the interactions of their parts.

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- Reductionism is arguably not plausible and is certainly not popular among scientific realism.
- Pluralism is the option many scientific realists take. For example, Teller (forthcoming) thinks in terms of a multitude of simplified models of a much more complex reality, each of which gives a partially but not completely correct picture. Such models, though not completely correct, capture aspects of the modal structure of the world. For him, and many others, there is no one right form of description.

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- Pluralists are right that there are multiple models, often at different scales and in different regimes, however, this not withstanding there is often one theory choice that is right - oxygen over phlogiston being a good example.
- Moreover, as Ladyman and Ross argue, pluralism does not do justice to the unity of science, nor does it take account of the special status of physics. The need for theories to be compatible where they overlap is a methologically productive driver of scientific advancement suggestive of a non-pluralist metaphysics.

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- Modality is the key to the real patterns account of ontology that harmonises entity realism and ontic structural realism, because featuring in projectible models and/or statements is taken to be the criterion of reality.
- The real patterns account also explains why focusing on issues of reference across theory change is a red herring for the realist, because reference can always be secured to some extent whenever there are real patterns that are carried over as approximations.

- The issue remains as to whether effective ontology is deserving of being called ontology at all, however, as it is arguably just an epistemological gloss in lieu of a full description.

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- Weak forms of emergence allow that emergent entities are epistemologically and semantically irreducible, but take it that strong emergence, and full ontological status, would be ruled out by any claim that genuine causal power resides only at the fundamental level.
- However, if the latter claim is false then that modal structure at all scales could be considered real. Explicating how that is possible requires further elaboration, but given that it presents the most promising way to resolve many of the issues facing scientific realism, I suggest that the present focus of the scientific realism debate should be on providing such an account of the relationship between the modal structures found in scientific theories at different ontological scales.

- For both French and Ladyman ontic structural realism has been from the outset about modal structure. However, French is an eliminativist about all ontology except the structures of physics, while the real patterns account is ecumenical.

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- On the other hand, alternatives to structuralism involving theories of dispositions, essences and powers have been developed in conjunction with the defence of scientific realism by Alexander Bird, Nancy Cartwright, Anjan Chakravartty and Brian Ellis.

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- On the other hand, alternatives to structuralism involving theories of dispositions, essences and powers have been developed in conjunction with the defence of scientific realism by Alexander Bird, Nancy Cartwright, Anjan Chakravartty and Brian Ellis.
- At the very least, this all seems to lend credence to van Fraassen's claim that scientific realism is essentially a metaphysical position of some kind.

- While, Barry Loewer, David Papineau and Stathis Psillos are Humeans and deny that scientific realism requires any notion of natural necessity, Berenstain and Ladyman (2012) argue that the arguments for scientific realism are undercut without it.

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- This metaphysical issue is taken as the fundamental one for the realism debate by van Fraassen, and he is right: metaphysics in general, and modal metaphysics in particular, are the crux of scientific realism.

4. Realism and the Historiography of Science

Kuhn and Whigg history

- Despite Kuhn's subsequent clarifications of his own view of science, his book inspired schools of history and sociology of science that deny that theory-change is to be explained in terms of evidence or experimental results. It is standard for explanations for theory choice in science, in so far as they are offered, to appeal to economic, psychological and social factors rather than the tribunal of experiment.

- In the history of science celebrated recent studies have emphasised the rationality of the losers and the psychological and social influences on the victors.

Revisionist History

- Phlogiston
- Bohm theory

- The orthodoxy in current historiography is that actors and their social networks in the history of science should be represented sympathetically, and that their perspective be adopted in describing the relevant evidence and theories.

- The opening lines of Harvard's STS website describe the field as an "approach to historical and social studies of science, in which scientific facts were seen as products of scientists' socially conditioned investigations rather than as objective representations of nature."

Chang on Whiggism versus Triumphalism

Whiggism: judging past theories by the lights of present ones

Triumphalism: dismissing the successes of abandoned theories

- `Triumphalist' in the sense of celebrating the success of science, does not imply denigrating or ignoring the success of abandoned or rival theories as we saw with Whewell, Koertege and Gale on phlogiston.

Whiggism is triumphalist and teleological and internalist.

And requires Presentism (using current knowledge to interpret past science)

Presentism plus Internalism does not entail triumphalism or teleology.

- Cummulativism and progressivism and internalism the rationality of theory change are compatible with the rejection of triumphalism and teleology.

Baker, Erik and Naomi Oreskes
"It's No Game: Post-Truth and the Obligations of Science Studies"
Social Epistemology Review and Reply Collective 6, no. 8 (2017): 1-10

- In short, science studies scholars' ascetic refusal of standards of good and bad science in favor of emergent judgments immanent to the "games" they analyze has vitiated critical analysis in favor of a weakened proceduralism that has struggled to resist the recent advance of neoliberal and conservative causes in the sciences. It has led to a situation where creationism is defended as an equally legitimate form of science, where the claims of think tanks that promulgate disinformation are equated with the claims of academic scientific research institutions, and corporations that have knowingly suppressed information pertinent to public health and safety are viewed as morally and epistemically equivalent to the plaintiffs who are fighting them.

- Far from rendering science studies Whiggish or simply otiose, we believe that a willingness to discriminate, outside of scare quotes, between knowledge and ignorance or truth and falsity is vital for a scholarly agenda that respects one of the insights that scholars like Jasanoff have repeatedly and compellingly championed: in contemporary democratic polities, science matters. In a world where physicists state that genetic inferiority is the cause of poverty among black Americans, where lead paint manufacturers insist that their product does no harm to infants and children, and actresses encourage parents not to vaccinate their children against infectious diseases, an inability to discriminate between information and disinformation—between sense and nonsense (as the logical positivists so memorably put it)—is not simply an intellectual failure. It is a political and moral failure as well.

- But if scientists are to make such judgments, then we, as science studies scholars, must be able to judge the scientists—positively as well as critically. Lives are at stake. We are not here merely to stand on the sidelines insisting that all we can do is ensure that all voices are heard, no matter how silly, stupid, or nefarious.

- The atom of the chemist is now a reality; but this does not mean that we are about to arrive at the ultimate elements of matter. When Democritus invented the atoms, he considered them as absolutely indivisible elements beyond which there is nothing to seek. That is what that means in Greek; and it is for this reason, after all, that he had invented them. Behind the atom, he wanted no more mystery. The atom of the chemist would therefore not have given him any satisfaction; for this atom is by no means indivisible; it is not truly an element; it is not free of mystery; this atom is a world.

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