Representation vs. Interpretation: Divorcing Laws from Generalizations in Science

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Are there laws of nature? Are there laws in biology or any of the sciences? The form of these questions is deceptive in that it invites us to treat them as if they concerned determinations of fact — *are* there or *aren't* there laws in biology? In order to arrive at such determinations, philosophers typically begin by noting that there are true or highly probable generalizations in the sciences, that many of these generalizations are not just accidental, but support counterfactuals, that they are genuinely explanatory and prove to be resilient or invariant, stable or robust, etc. Since scientists themselves label some of these generalizations "laws", the philosopher's task is to identify the criteria by which the subset of laws is to be picked out from the set of generalizations. Any generalization that meets those criteria satisfies the necessary and perhaps sufficient conditions for "law".[2]

I will argue that this entire approach rests on a category-mistake. The laws of science or nature are not a subset of generalizations. Though some generalizations are taken to be laws and though most laws look like generalizations, it is wrong to identify a law as a species or kind of generalization. Indeed, once one appreciates the category-mistake in question, the problem of discovering the criteria for lawfulness emerges as yet another pseudo-problem for a philosophy of science that once set out to rid itself of pseudo-problems. Like the classical pseudo-problems that were identified by Wittgenstein and the logical empiricists, this one gives rise to unnecessary confusion. If, for example, one mistakenly takes laws to form a subset of empirical generalizations, one must then find it puzzling that many so-called laws function like axioms, definitions, or inference rules.

This paper aims to expose the category-mistake and thus to reorient philosophical questioning concerning the relation between generalizations and laws. It draws on Sandra Mitchell's (1997, 2000) and James Woodward's (2000, 2001) recent proposals. While both of their attempts to recast the issue fall short in instructive ways, they set the stage for an account of lawfulness that does not commit the mistake while doing justice to the (linguistic) practice of science.

Incommensurable Language Games

A cursory glance at present and past discussions of "laws of nature" quickly establishes that they deal with a family of questions concerning contingency and necessity, causality and probability, the constancy of nature, ontology. If nineteenth century philosophers of science debated consilience and the *vera causa* principle, their successors suggest that laws support counterfactuals, have causal or nomic necessity, are truly explanatory, exceptionless, and projectible, yet empirical, *a posteriori*, etc. The successors of Thomas Kuhn, in the meantime, focus less on criteria but on the relation between definitions, principles, axioms, and laws of nature (*cf.* Mitchell 2000, 247) or the relation between divine, social, and natural law *(cf.* Daston and Park 1998; Böhme *et al.* 1972; Giere 1999, 86-90). Do laws serve primarily to rationalize our knowledge of nature (*cf.* Meyerson 1930), or do they constitute a fundamental, ultimate reality to be discovered by science?[3] Incomplete as it is (among the questions to be added are those concerning reductionism or teleology, *cf.* Ayala 1995), this enumeration already suggests that implicated in these debates are metaphysical issues, conceptions of nature, questions concerning the character and aim of science itself.

Such debates differ from determinations of probability or truth. "Is there natural necessity?" and claims of lawfulness provoke one kind of response. Another kind of response is prompted by a proposed generalization and the question "Is this hypothesis empirically adequate?” If the establishment of generalizations has one context of meaning and use, if claims of lawfulness inaugurate another, a brief characterization of these two contexts gives us what the later Wittgenstein would have called the philosophical grammar of “law” as opposed to “generalization”. Indeed, a brief characterization of the two language games exhibits the incommensurability of the two concepts.

Generalizations have more or less scope, they depend more or less on contingent conditions, they are more or less invariant, resilient, universal, stable, etc. Ranging from "accidental generalizations" to exceptionless statements that support counterfactuals, they form a continuum that need not be smooth in that particular rankings are typically contested and justified by appeal to threshold-criteria. However, even low-level generalizations (“sugar is soluble”) have some predictive and explanatory power.

The validation of generalizations typically requires data collection, experimentation, and the like. The validation of a generalization that refers to a causal relationship and supports counterfactuals will take a different course than that of a simple accidental generalization. But *what* is validated is always just the generalization itself or a body of statements with empirical import. Once a causal relation is established, for example, it remains an open question whether one should think of this in terms of constant conjunction or natural necessity.

The standards by which one judges the invariance, stability, strength, resiliency of generalizations vouch for the objectivity of scientific knowledge and serve to demarcate science from metaphysics or pseudo-science. However, in and of themselves they do not determine whether or not some proposition is a law or what it would mean for it to be a law. Once a generalization is taken as a general principle that features in the derivation of other principles, it remains an open question whether this principle is dependent on a particular state of the world, whether it expresses a law of nature, serves to rationalize experience, or assumes a central position in an axiomatic system. Is there natural necessity? Is there stability, causality, symmetry, hierarchy, structure, instantiation, uniformity in nature? These questions arise with the establishment of generalizations because the establishment of generalizations leaves them unanswered. One can agree on the relative merits of a hypothesis without having to settle whether or not it would properly be called a law. The methods of hypothesis-testing and scientific representation — all that scientists minimally and necessarily do to establish predictions, explanations, and interventions — are not designed to answer these questions. They can only raise them.

As opposed to the establishment of generalizations, *claims of lawfulness* do not issue in determinations of fact. Empirical hypotheses inaugurate a language game that involves determining judgments: According to such and such criteria, what is the relative strength or resiliency of this generalization? A different language game is inaugurated by questions concerning lawfulness. This language game involves reflecting judgments: Should this generalization, rule, or principle be thought under a particular idea of nature? Reflecting reasoning interprets the standing of a proposition in regard to a conception of science or nature, maintaining, for example, that it is "deeper" or "more fundamental" than other propositions, that it is "truly" explanatory, that it picks out a structural property, etc.[4]

While generalizations serve as descriptive representations of nature, the concept of law is an interpretive category used to assess the (philosophical) meaning of generalizations, rules, or principles (*cf.* Giere 1999, 84). Questions of meaning are not answered on a scale of "more or less". Though the discussion of such questions typically remains inconclusive and open-ended, one can only answer "yes or no" to the interpretive question whether an observed regularity is an instantiation of a more general fact, or to the question whether an established causal relation expresses natural necessity.[5] Thus, when for a generalization one might ask whether the evidence in its favor is sufficiently strong, whether the conditions upon which it is contingent are relatively stable, or whether its probabilistic formulation renders it too weak for certain predictive purposes, the questions introduced by claims of lawfulness require an answer of yes or no: Do laws attribute dispositional properties to nature? Does the (*e.g.*, inverse-square) form of a law express a structural feature of nature? Do laws require deeper-level explanations of their own? Are laws requisite for normal science? Can a law have evolved? And, of course, is this generalization a law?

Incommensurability is literally the lack of common measure. While generalizations are measured on a graduated scale of greater and lesser strength, probability, stability, resiliency, etc., the open-ended questions regarding lawfulness are judged in the dichotomized space of yes and no. This incommensurability does not preclude saying of some generalization that for such and such reasons it is a law of nature. It does indicate, however, that this reasoning is categorically different from the process that led to the establishment of the generalization in the first place.[6] Thus, that the two language games are complementary and that the search for laws may prompt the discovery of generalizations, does not detract from their fundamental incommensurability.

Lawlike Generalizations and Science without Laws

The fundamental division between the two language games is reflected in the development of modern science and in contemporary philosophical discussions.

Scientists and philosophers of science have been working hard to distinguish the professional scientist from the natural philosopher. Accordingly, the defining features of modern science now set it apart from its ancestors natural philosophy and metaphysics. The methodological standards that govern scientific inquiry and distinguish it from natural philosophy, pseudoscience, or just bad science allow for consensus-formation on intersubjectively controlled (determining) judgments about the reliability of generalizations. In contrast, open-ended interpretive reflections about the empirical findings of science are of interest and may motivate scientists, but are not considered distinctively scientific. They are not what sets the scientific enterprise apart from, say, philosophy. The question whether some generalization deserves the title “law” is therefore of no concern to science *qua* science. Instead it belongs to the tradition of natural philosophy to the extent that it continues to accompany and inform scientific practice, narrowly conceived.

The advancement of science *qua* science does not require agreement on questions of natural philosophy. For this reason, probably, many working scientists consider the distinction between generalizations and laws a matter merely of semantics. This view is informed by a particular philosophical stance: If for the advancement of science one need not agree on the question of law, then law-talk itself is ultimately redundant for the purposes of science.

Ron Giere articulated this view most forcefully. Rather than postulate laws to which nature must conform, science first asks, then determines whether, for example, the moon in its orbit around the earth is sufficiently like a stone hurled around at the end of a string such that one might say about moon and stone that in relevant respects they are like things manifesting like behavior in like situations. To establish such likeness relations and render them salient, science helps itself by creating intermediary objects of its own, *i.e.*, models (Giere 1999, 93). But whether or not abstract objects intervene, the relevant sense of "likeness" always needs to be determined along its various dimensions and these determinations will vary in strength. As generalizations of lesser or greater stability, resiliency, invariance, or strength are established, the web of regularities gradually extends its reach.

By focusing only on what scientists do, Giere’s account leaves out how science reflects itself, what scientists say and think about what they do. And indeed, only by leaving this out does Giere arrive at his “science without laws”. His claim is not that scientists do nothing but establish generalizations, construct models, or design experiments, it is only that this is what they do *qua* scientists. After all, the activities picked out by his characterization of science are the ones that fall under the scope of demarcation criteria of science. The distinction between "establishing generalizations" and "claiming lawfulness" is thus established by exclusion of the latter from Giere’s minimalist characterization of science.

Many of those who disagree with Giere nevertheless end up underscoring the fundamental division between the two language games. In an attempt to show that the various sciences successfully identify laws, they consider paradigm “laws” and formally identify their shared characteristics. However, since these characteristics pick out an unknown subset of generalizations, whatever meets the criteria is only said to be *lawlike* and not necessarily what scientists consider a law. Thus, an implicit allowance is made that the necessary and sufficient conditions for "lawlikeness" are only necessary conditions for "law", that an unspecified something else may be needed to turn a lawlike generalization into a law.[7] At the same time, it is assumed that the notion of "lawlikeness" is quite sufficient to characterize the relevant practice of science *qua* science, *i.e.*, that it is entirely unnecessary to enter into the inevitably metaphysical debate as to possible differences between "lawlikeness" and "law".

Discussions of lawlikeness and the criteria identified in these discussions thus pertain to science *qua* science and the practices associated with "establishing generalizations”. This is particularly evident in Brian Skyrms's analysis of “nomic force” which provides a fine-grained tool-set for the assessment of generalizations, but which leaves open whether there is a difference between law, lawlikeness, and highly resilient generalizations (Skyrms 1980). These discussions are therefore much closer than they first appear to Giere’s minimalist conception of science which characterizes strictly what scientists do and finds that an appeal to laws is not necessary for such characterizations.

Pragmatic Approaches

The discussion of whether there are laws in biology can serve as a more detailed case study that testifies to the incommensurability of language games. It also serves as a reminder, however, that a fully satisfactory account of scientific activity requires an integrated view of what scientists do *qua* scientists (establish generalizations) and how they orient scientific research through their reflections about the goals and findings of science (for example, by claiming lawfulness).

It has been argued for decades (*e.g.* Smart 1963) that biology has not formulated laws of nature which would satisfy the criteria of the logical empiricists. Of the two prime candidates, the Hardy-Weinberg law applies probabilistically only to a certain type of organism and on most construals lacks necessity and scope, while Darwin's "law" of evolution by natural selection can be interpreted as a situational logic (Popper 1972, 168), rule for the game of life (Eigen 1980), algorithm (Dennett 1995), explanatory schema (Kitcher 1993), or "process law" (Sober 1997) but not easily as an "empirical law" (it has little or no predictive power and may not be falsifiable). John Beatty's "evolutionary contingency thesis" revived Smart's claim: To the extent that evolutionary processes are contingent and to the extent that the phenomena encountered by biologists are therefore products of an evolutionary history that could have taken a different course, biology is distinct from physics precisely in that it describes how things turned out rather than how they must be according to law (Beatty 1995).

Beatty's implied opposition of laws of physics and biological generalization was challenged by Martin Carrier (1995) and Sandra Mitchell (1997, 2000). The laws of physics, they and others argue, are themselves rarely, perhaps never entirely free of contingency. In Mitchell's words, the normative approach to "law" which is indebted to logical empiricism "privileges a form of generalization which occurs only rarely, if at all, even in physics" (1997, S476). Since even the broadest generalizations are predicated upon certain specifiable conditions, the question appears to be rather one of more or less contingency, stability or strength for the laws and generalizations of physics and biology. One might therefore represent these degrees of contingency, stability or strength in the "continuum of contingency" proposed by Sandra Mitchell. It begins with accidental generalizations for which no one would claim lawfulness and ascends toward the perhaps elusive ideal of a true law which is logically contingent but nomically necessary, which holds for everything at all times and all places (Mitchell 2000, 253).[8]

If one does not want to stop talking about laws altogether, Mitchell argues, one must adopt a pragmatic approach. After all, if only the periodic law, mass-energy conservation, or the second law of thermodynamics meet the criteria of lawfulness[9], the notion of law may have been emptied out beyond recognition and the philosophers' definition is no longer in accord with the customary use of the term. While some, Ron Giere among them, embrace this consequence willingly, Mitchell offers the pragmatic approach as an alternative.

Giere wishes to altogether do away “with law talk even though it departs from the ways scientists themselves often present their science”, reasoning that “this can provide us (philosophers and historians) with a better understanding of what they (scientists) are doing” (Giere 1999, 250, *cf.* 86-90). Unhappy with the normative stance implicit in this separation of “us” vs. “them”, Mitchell’s pragmatic approach sets out to defend customary use:

“[I]t is not a mistake on the part of scientists that a variety of knowledge claims in the sciences are designated ‘laws’” (Mitchell 2000, 250, *cf.* 243).

> By focusing discussion on laws *vs.* accidental generalizations, natural necessity *vs.* contingency, one is saddled with a dichotomous conceptual framework that fails to display important differences between the kinds of causal structure found in our world and differences in the corresponding scientific representations of those structures. (Mitchell 2000, 254f.)

Mitchell’s concern is echoed by James Woodward. Noting that many “mere” generalizations provide explanations, he calls for a “new way of thinking about generalizations and the role they play in explanation that allows us to recognize intermediate possibilities besides laws and accidents and to distinguish among these with respect to their degree and kind of contingency” (2000, 198).

Mitchell’s pragmatic strategy responds to Woodward’s call by dissolving the dichotomy between laws and accidents.

> The working biologist or chemist or social scientist makes do with knowledge claims that fall short of the philosopher's ideal. The appropriate response, I argue, is not to impugn biology, chemistry, and the social sciences for failing to deliver the philosophically valued goods. Rather, this "failure" invites the philosopher to explore just how it is that we manage to explain, predict, and intervene on the basis of these "lesser" variants of lawful relations. How universal, exceptionless, necessarily true generalizations explain, predict, and allow successful intervention is a relatively simple matter compared with how "lesser" variants *actually used in these sciences* manage to perform those same functions. (Mitchell 2000, 249)

At this point, however, Mitchell's strategy encounters an unresolvable dilemma. Even "lesser" generalizations like "sugar dissolves when immersed in water" arguably fulfill the functions of explanation, prediction, and intervention.[10] Mitchell can either allow for all such lesser generalizations to be considered "laws" *or* discover somewhere, perhaps context-specifically, a threshold or distinction which renders them "not-quite-laws”. If she takes the latter route and chooses to discover thresholds or distinctions after all, "law" would be detached from the continuum of contingency and the dichotomy restored that was to be undermined in the first place. If, however, she treats all generalizations as "laws", the distinction between generalization and law would be surrendered, "law" collapsed into the continuum of contingency, and the issue conceded to those who consider lawfulness a redundant notion. It then becomes impossible to understand the linguistic practice of scientists who label certain knowledge claims "law" rather than "equation", "model", "rule", "principle", "algorithm", "theory", "regularity" or "generalization". Their usage would now appear to involve the failure to give meaning to the term. Such a failure may be a harmless mistake on their part, but a mistake nonetheless.

Open Questions

Mitchell ends up considering as laws all those generalizations that are sufficiently stable to ground and inform expectations in a variety of ways. She thus arrives at a notion of "law" which is indistinguishable from that of "simple generalization". Despite her pragmatic commitment she renders law talk simply redundant.[11]

James Woodward does not explicitly share Mitchell's pragmatic commitment, indeed, appears perfectly willing to jettison it. And yet it catches up with him to undermine his position.

Acknowledging the incommensurability of language games, Woodward begins to explore its implications for the relation between generalizations and laws: "Unlike lawfulness, invariance comes in degrees" (2000, 197, *cf.* 251, 226). Like Mitchell, he views more or less invariant generalizations as somewhere between laws and accidents. By establishing their degree of invariance one can also judge their explanatory power. As opposed to exceptionlessness (2000, 227, 248), the character of invariance is thus a necessary condition also for laws in their explanatory capacity. Unlike Mitchell, this does not lead him to absorb the notion of "law" into a continuum of generalizations (2000, 223). Having removed lawfulness as a requirement for successful explanation, Woodward has no stake in determining what a law is.

> [I]t simply doesn't matter, independently of whether or not generalizations like Mendel's are invariant, whether we choose to regard them as genuine laws. We can, if we wish, stipulate that the word "law" must be used in such a way that all invariant generalizations are laws. If so [...] Mendel's laws [...] will qualify [...]. Alternatively, we may choose to regard similarity to paradigmatic laws and satisfaction of the traditional criteria as necessary for lawhood. If so, generalizations like Mendel's will probably not count as laws. (2001, 6; *cf.* 2000, 198, 223, 239, 241f.)

Woodward goes on from here to challenge Beatty's evolutionary contingency thesis. As long as Mendel's law is invariant in the right way, he argues, "it doesn't matter whether it has exceptions or is contingent on the course of evolution [...] it can still be used to explain" (2001, 13). However, this is an argument against Beatty's thesis only on an assumption that Beatty doesn't share, namely, that all that matters in the "terminological dispute" over the honorific "law" is what it takes for a generalization to be explanatory (2001, 4).[12] According to Beatty, "whatever laws are, they are supposed to be more than just contingently true" (1995, 46). In other words, when discussing the question of lawfulness in biology, it is not enough to provide an adequate account of generalizations, their degree of invariance, and how this invariance renders them explanatory. Aside from what it takes to establish a highly invariant generalization, there remains the open question what place, if any, there is in biology for propositions that are not just contingently true.

Are there laws of nature? Are there laws in biology or any of the sciences? This paper has shown that these questions are not meaningful as questions *about* science. They do not help characterize what scientists *do*. Another paper will have to show just how they are meaningful nonetheless, namely as open questions *for* science, philosophical questions that arise when scientists think and talk about the meaning of what they do, when they orient scientific inquiry.[13]

Notes

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2 This characterization also holds for the carefully qualified discussion by Lange (2000). It offers no simple set of criteria but promises to unpack the "root commitment" implicit in the appeal to laws. According to Lange, laws are generalizations rendered salient by the best inductive strategies.

3 On the debate between regularists and necessitarians *cf.* Swartz 1985; on the ontological dimensions of this debate especially pp. 202f.

4 I am loosely referring to Kant's distinction here. Determining judgments subsume, schematize, offer special grounds for causality, are objectively valid "for the possibility of this sort of thing"; they are the subject of his first critique with its elaboration of constitutive principles. Reflecting judgments invoke the regulative principles of the third critique. Both in regard to beauty and purpose they involve the concept of nature as a whole, adding "to the use of reason another kind of research besides that in accordance with mechanical laws" (Kant [1790] 2000, 66f., Akad. 5:179f., 379-385, 413f.).

5 See the discussion of "lawlikeness" below to see why Brian Skyrms's notion of "nomic force" does not, in fact, construe a more or less of lawfulness.

6 Note that, as throughout, the establishment of a generalization includes its justification in reference to criteria.

7 To be sure, this "something else" might be truth. But even those who suggest that all true lawlike generalizations are laws keep asking about

true generalizations whether they are “lawlike”. Also, at issue in the discussion of laws is precisely whether they need to be true, exceptionless, etc. Compare, *e.g.*, Lange 1993, 1 and 8.

8 Mitchell’s ranking ascends from “All the coins in Goodman’s pocket are made of copper”, via “Galileo’s law of free fall” and the “periodic law” to the “Law of conservation of mass-energy.”

9 According to Mitchell, even these laws don't live up to stringent normative criteria (Mitchell 2000, 255-257).

10 While this statement might not be "truly” explanatory of the dissolution of a piece of sugar, it can serve as a placeholder for a more satisfying explanation.

11 See Mitchell 1997, S476 and S478, and Mitchell 2000, 245, 259, 249, 256f., and 262.

12 By determining what really matters in discussions of lawfulness, Woodward thus seeks to specify, after all, what a law is. Indeed, where he does attempt a further characterization of lawfulness, Woodward reverts to the position which he set out to undermine. Following standard procedure, he seeks to discover the distinctive traits of laws by contrasting paradigmatic or “genuine” laws (Maxwell’s equations, the ideal gas law, the gravitational inverse square law) with other invariant generalizations (2000, 223, 239): “On this way of looking at matters, the differences between [some invariant generalization], on the one hand, and paradigmatic laws like Maxwell’s equations, on the other, although real, look very much like differences in degree (of scope and of range of interventions and changes in background conditions over which these generalizations are invariant) rather than of kind. Paradigmatic laws are simply generalizations with wide scope that are invariant under a large and important set of changes that can be given a theoretically perspicuous characterization. We are willing to regard other invariant generalizations as laws to the extent that we judge that they resemble these paradigms in these respects” (2000, 241, *cf.* 223). It is difficult to understand how while, as opposed to generalizations, laws do not come in degrees, the difference between invariant generalizations and laws is to be one of degree.

13 See Nordmann 2001.

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